EUROPEAN COMMUNITY

COMPETITIVE AND SUSTAINABLE
GROWTH PROGRAMME

SOURDINE II

D4.2-3

Safety Assessment of Approach Procedure V and Departure Procedure 2 on Barajas Airport

Project acronym:	SOURDINE II
Project full title:	"Study of Optimisation procedURes for Decreasing the Impact of NoisE II"
Project number:	GRD2-2000-30105
Contract number:	G4RD-CT-2000-00394
Start date:	12 November 2001
Duration:	45 months

Sourdine II Consortium:

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AENA	Aeropuertos Españoles y Navegación Aérea	*ESP*
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EUROCONTROL	*European Organisation for the safety of Air Navigation*	*INT*
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INECO	*Ingenieria y Economia del Transporte*	*ESP*
SICTA	*Sistemi Innovativi per il Controllo del Traffico Aereo*	*IT*

Document Change Log

Release	Author	Affected Sections / Comments	Document Nature	Date
0.0	AENA	Doc creation	Confidential	31/08/04
0.1	AENA	Issue for SII Internal review	Confidential	09/02/05
0.2	AENA	Internal review	Confidential	20/04/05
0.3	AENA	Incorporates comments by NLR & INECO	Confidential	28/04/05
0.4	AENA	Incorporates dep. Proc. 2 assessment	Confidential	18/05/05
0.5	AENA	Incorporates comments by NLR	Confidential	23/05/05
0.6	AENA	Incorporates comments by NLR	Confidential	24/05/05
1.0	AENA	Doc formal issue (following consortium internal review)	Confidential	03/06/05
1.1	AENA	Clarifications to comments by NLR	Confidential	14/06/05
2.0	AENA	Inclusion of EC approval	Public	01/08/05

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Review and Approval of the Document

Organisation Responsible for Review	Reference of comment documents	Date
INECO		24/04/05
Organisation Responsible for Approval	**Name of person approving the document**	**Date**
Project Manager	Ruud den Boer	03/06/05
Work Package Leader	Pablo Sánchez	03/06/06
EC Official	Morten Jensen	28/07/05

Document Information	
Document title	**Safety Assessment of Approach Procedure V and Departure Procedure 2 on Barajas Airport**
Version	2.0
Date	01/08/05
Classification	Public
Workpackage	WP4
Document identification	SII WP4 D4.2-3.appV depII C AENA V2.0.doc

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Executive Summary

This document describes the safety assessments carried out by AENA (Aeropuertos Españoles y Navegación Aérea) considering the extrapolation of the Sourdine II approach Procedure V (CDA with constant speed, variable FPA segment at intermediate configuration) and departure Procedure 2 (take off power up to 800ft, OEI setting up to 3000ft with steeper climb gradient flown up to 5000ft, cleaning up and accelerating until 250kts) to Barajas airport, considering the most probable parallel runway scenario in 2015.

From a pure operational point of view, some hypotheses have been considered on the approach procedure when performing the assessment, before considering the safety perspective. Prior to the safety assessment, a modification to the NAP was required to overcome a significant constraint when extrapolating the vertical profiles described in SII to the future Barajas approach scenario. The Barajas parallel runways approach operations will be based on vertical separation and a clear incompatibility would arise if "pure" CDA to both approaches was to be applied as the runway heads are not sufficiently staggered in distance to ensure a 1000ft vertical separation while performing independent continuous descent approaches. The adopted solution following extensive consultations with operational experts has been to modify the SII procedure:

- ✓ Apply a pure SII-V for approaches to RWY 33L, starting at 8000 feet
- ✓ Apply SII-V with a horizontal level flight leg in the intermediate approach for the approaches to RWY 33RThe hazard identification has been carried out through brainstorming sessions with operational personnel and further analysis with safety experts. The information captured during the sessions was processed and as a result, twenty-two identified hazards in the approach procedure were grouped into categories based on the phase of flight within the approach stage: TMA transition, approach intermediate – localiser intercept, approach intermediate – localizer establish, approach final and TMA overall. For the departure procedure, ten hazards were identified.

During the risk analysis the previously identified hazards have been evaluated in terms of their estimated frequency of occurrence and classified according to the severity of their effects. Subsequently, their risk tolerability has been determined according to ESARR4 and ED-78A classification schemes. In the Approach procedure, nineteen of the grouped risks have been classified as "Acceptable". The remaining three risks were analysed with an event tree, resulting in two possibly unacceptable risks related to failed localiser interception and wake vortex encounters.

The qualitative assessment shows that the SII-NAP-V procedure adapted to the future Barajas Airport parallel runway configuration exhibits some safety significant issues that are in need of a more detailed and quantitative analyses. It is recommended that such analyses take into consideration the inclusion of decision support tools such as an Arrival Manager (AMAN) to support arrivals sequencing on both runways. It is also suggested that a safety-net additional functionality is considered in order to monitor potential localiser overshoots and longitudinal breaches of separation for consecutive localiser-established aircraft.

On the other hand, the qualitative high level safety assessment shows that the Sourdine II departure procedure 2 exhibits some safety issues. These issues are related to the fact that noise reduction is achieved by operating the aircraft at reduced power settings and are associated to any failure that may cause airport obstacle limiting surface infringements that could lead to loss of separation with obstacles and/or ground. The conducted high level assessment has concluded with all identified risks having been preliminarily classified as "Acceptable" in the present procedure adaptation to the Barajas Airport configuration. Given the high level nature of the assessment in terms of number of participating experts, it is recommended that further analysis is undertaken to increase the confidence in the resulting risk classification.

Table of Contents

1. Introduction

1.1. Objective of the document

The objective of this document is to describe the safety assessments performed on the Sourdine II approach procedure V and departure procedure 2 applied to the Barajas airport operations around year 2015. These procedures are described in detail in [SII D3-1]. The document is focused on providing an overview of the risks associated with these operations, presenting preliminary conclusions that need to be considered together with the other results of WP4 to provide an overall assessment of the procedures.

1.2. Background

The continuous expansion of the big cities has put airports, which were located on the outskirts of towns, increasingly next to densely populated areas.

Neighbours have to face the unstoppable growth of aircraft operations and one of its main inconveniences, NOISE.

The increase in population affected by air traffic in the vicinity of airports has led to the development of several procedures, the objectives of which are to mitigate the aircraft noise over the population. Nowadays three different procedures to solve the problem are used: mainly conceived for jet engine aircraft, they are applied when there is a necessity to solve a noise problem, and not as a general rule.

SOURDINE II has been testing several options considering all the points of view.

1.3. Structure of the document

This document has the following structure:

Section 1. Document introduction

Section 2. Safety assessment methodology description

Section 3. Safety Assessment for Sourdine II approach procedure V (description of operations, hazards and risk analysis)

Section 4. Safety Assessment for Sourdine II departure procedure 2 (description of operations, hazards and risk analysis)

Section 5. Safety assessments conclusions

1.4. Glossary

AIC	Aeronautical Information Circular
AMAN	Arrival Manager
AMJ	Advisory Material Joint
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATIS	*Aeronautical Traffic Information Services*
ATM	Air Traffic Management
CAS	Calculated Air Speed
CDA	Continuous Descent Approach
CFIT	Controlled Flight Into Terrain
CNS	Communication, Navigation, Surveillance
CONOPS	CONcepts of OPerationS
EATMP	European Air Traffic Management Programme
ESARR	Eurocontrol Safety Regulatory Requirement
EUROCAE	European Organization for Civil Aviation Electronic Equipment
FAP	Final Approach Point
FAS	Final Approach Speed
FMS	Flight Management System
FPA	Flight Path Angle
Ft	Feet
GSI	Glide Slope Indicator
IAF	Initial Approach Fix
IFR	Instrumental Flight Rules
IFS	Intermediate Flap Speed
ILS	Instrument Landing System
JAA	Joint Aviation Authorities
KTS	Knots
MAD	Madrid
MLS	Microwave Landing System
NAP	Noise Abatement Procedure
NM	Nautical Mile
NTZ	Non-Transgression Zone
RA	Resolution Advisory

RNAV	aRea NAVigation
RNP	Required Navigation Performance
RPM	Runway Precision Monitoring
RT	Radio Telephony
RTCA	Radio Technical Commission for Aeronautics
RWY	Runway
SAM	Safety Assessment Methodology
SOURDINE	Study of Optimisation procedURes for Decreasing the Impact of NoisE
STAR	Standard Terminal ARrival
STCA	Short Term Conflict Alert
TA	Traffic Alert
TCAS	Traffic Collision Avoidance System
TLS	Target Level of Safety
TMA	Terminal Manoeuvre Area

1.5. Relations with other documents

The current document, D4.2-3, contains the safety assessments for approach procedure V and departure procedure 2. D4.2-1 is the top-level document of the safety work for Sourdine II. It contains the overall approach, the main results and the conclusions. The document is supported by documents in which the more detailed safety assessments are described. The safety assessment of approach procedure II-A is described in the documents constituting D4.2-2. Accordingly, the main deliverable structure is:

D4.2-1	Safety assessment of Sourdine II procedures (Top-level document).
D4.2-2	Safety assessment of approach procedure II-A on Schiphol airport.
D4.2-3	Safety assessment of approach procedure V and departure procedure 2 on Barajas airport.

D4.2-2 is further subdivided into four parts:

Safety assessment of approach procedure II-A on Schiphol airport

[S II D4.2-2a]	Main document
[S II D4.2-2b]	Argumentation-based analysis
[S II D4.2-2c]	Simulation-based analysis
[S II D4.2-2d]	Collection of expert interviews

The interrelations between all these documents are as represented in the following figure:

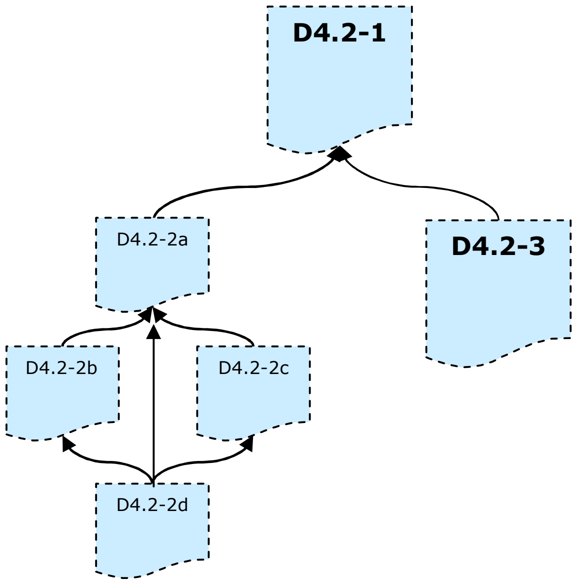


Figure 1: Overview of the Sourdine II D4.2 deliverables and their relations. At the left the relations between D4.2-1 to D4.2-3; at the right the relations within D4.2-2.

1.6. Reference Documents

LIST OF REFERENCE DOCUMENTS	
Short Reference	**Author / Organisation, Title, Edition, Date and Reference**
[SII D3-1]	Sourdine II, *Definition of new noise abatement procedures*, version 1.0, 10-03 2003, INECO.
[TMA-MAD]	Espacio Aéreo del Terminal de Madrid; Aena, February 2003
[ESARR4]	Eurocontrol Safety Regulatory Requirement ESARR4, Risk Assessment and Mitigation in ATM
[ED-78A]	EUROCAE ED78-A, Guidelines For Approval Of The Provision And Use Of Air Traffic Services Supported By Data Communications
[SRC DOC 20]	Assessment of EUROCAE ED78A as a means of compliance with ESARR4
[EATMP SAM]	EATMP Safety Assessment Methodology v1.0
[JAA AMJ]	JAA-AMJ 25-1309
[EAM4 GUI]	Explanatory Material on ESARR4 Requirements

2. Safety Assessment Methodology and Safety Criteria

The objective of this safety study has been to undertake a qualitative risk assessment for one of the Sourdine II Noise abatement procedures applied to a realistic scenario at Barajas airport circa 2015. At that time it is expected that the new parallel runways will be in full operation enabling approximately 120 movements per hour.

The SII-NAP safety assessment has been carried out following a methodology consistent with ESARR4 [ESARR4] requirements. Expert sessions with the participation of pilots, ATC officers and safety personnel familiar with the Barajas Airport future parallel runway planned operations have been held to introduce the concept of operations and to identify the failures and the hazards that the SII-NAP would pose to ATM operations. Subsequently, the identified hazards have been assigned a severity and an estimated occurrence frequency in order to determine their risk tolerability. No attempt has been made to numerically quantify the frequency occurrence. The safety assessment process is illustrated in the figure below. For unacceptable risks, either procedure modifications or risk mitigations are recommended.

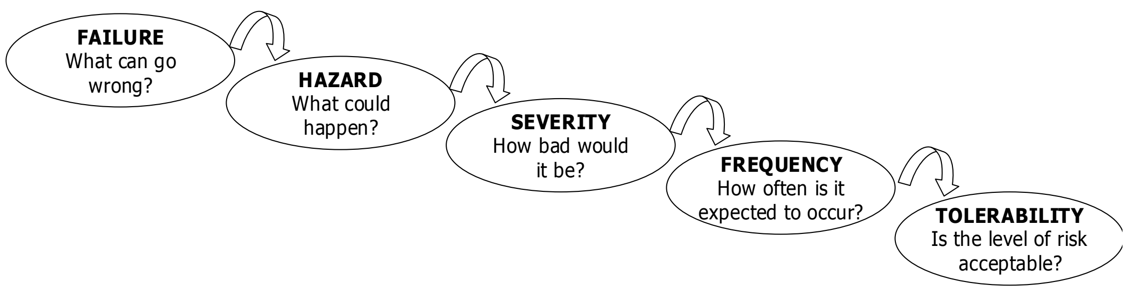


Figure 2. Safety Assessment Process

With regards to severity classification, the ESARR4 scheme has been employed to classify the identified hazards, consisting of the following Severity Classes: (1) Accidents, (2) Serious Incidents, (3) Major Incidents, (4) Significant Incidents and (5) No Immediate effect on Safety. Unfortunately, the risk classification scheme (or matrix) provided by ESARR4 is still under development and an alternative scheme must have been selected to complete the risk analysis. The risk classification scheme selected corresponds to ED-78A “Guidelines For Approval Of The Provision And Use Of Air Traffic Services Supported By Data Communications” [ED-78A] (Figure 3).

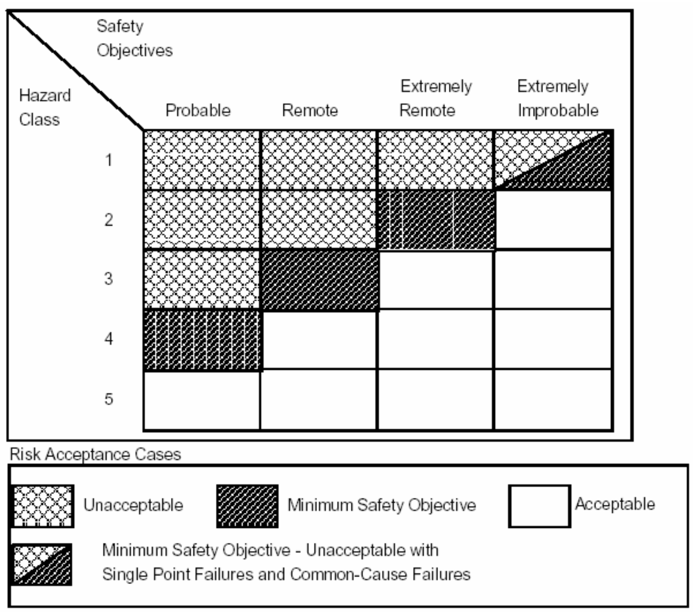


Figure 3. ED78-A Hazard Classification and Safety Objectives Relationship

The safety assessment methodology and safety criteria employed (ESARR4 and ED-78A) necessarily needs of some assumptions to be made. The ED-78A guideline hazard classification is somewhat different to ESARR4 severity classification scheme, as identified in SRCs Assessment of EUROCAE ED78A as a means of compliance with ESARR4 [SRC Doc 20]. Both schemes are compared against each other in Table 1. However, with regards to ESARR4 hazard identification, risk assessment and mitigation processes, ED-78A is found in agreement with ESARR4 in terms of an assessment of the effects they may have on the safety of aircraft, as well as an assessment of the severity of those effects once Annex E is taken into account. For the purposes of this safety assessment, the differences between severity classification schemes are not deemed significant in order to obtain a preliminary assessment of risk tolerability regardless of their acceptability. Should a more in-depth NAP safety analysis be developed based on the present assessment, it is recommended to analyse the classification scheme differences in detail before reaching any judgements on risk tolerability.

<table>
<tr><th>Severity Class</th><th colspan="2">ESARR4</th><th colspan="2">ED-78A</th></tr>
<tr><td rowspan="3">1
(most severe)</td><td>Effect on Operations</td><td>Accidents</td><td>Effect on Operations</td><td>Total loss of flight control, mid-air collision, flight into terrain or high speed surface movement collision.</td></tr>
<tr><td rowspan="2">Examples of effects on operations include</td><td rowspan="2">❑ one or more catastrophic accidents,
❑ one or more mid-air collisions
❑ one or more collisions on the ground between two aircraft
❑ one or more Controlled Flight Into Terrain
❑ total loss of flight control. No independent source of</td><td>Effect on Occupants</td><td>Multiple fatalities</td></tr>
<tr><td>Effect on Air Crew</td><td>Fatalities or incapacitation</td></tr>
</table>

		recovery mechanism, such as surveillance or ATC and/or flight crew procedures can reasonably be expected to prevent the accident(s).	*Effect on Air Traffic Services*	Total loss of separation
2	*Effect on Operations*	Serious Incidents	*Effect on Operations*	Large reduction in safety margins or aircraft functional capabilities.
	Examples of effects on operations include	❑ large reduction in separation (e.g., a separation of less than half the separation minima), without crew or ATC fully controlling the situation or able to recover from the situation. ❑ one or more aircraft deviating from their intended clearance, so that abrupt manoeuvre is required to avoid collision with another aircraft or with terrain (or when an avoidance action would be appropriate).	*Effect on Occupants*	Serious or fatal injury to a small number of passengers or cabin crew.
			Effect on Air Crew	Physical distress or excessive workload impairs ability to perform tasks.
			Effect on Air Traffic Services	Large reduction in separation or a total loss of air traffic control for a significant period of time.
3	*Effect on Operations*	Major Incidents	*Effect on Operations*	Significant reduction in safety margins or aircraft functional capabilities.
	Examples of effects on operations include	❑ large reduction (e.g., a separation of less than half the separation minima) in separation with crew or ATC controlling the situation and able to recover from the situation. ❑ **minor** reduction (e.g., a separation of more than half the separation minima) in separation without crew or ATC fully controlling the situation, hence jeopardising the ability to recover from the situation (without the use of collision or terrain avoidance manoeuvres).	*Effect on Occupants*	Physical distress, possibly including injuries.
			Effect on Air Crew	Physical discomfort, possibly including injuries or significant increase in workload.
			Effect on Air Traffic Services	Significant reduction in separation or significant reduction in air traffic control capability.
4	*Effect on Operations*	Significant Incidents	*Effect on Operations*	Slight reduction in safety margins or aircraft functional capabilities.
	Examples of effects on operations include	❑ increasing workload of the air traffic controller or aircraft flight crew, or slightly degrading the functional capability of the enabling CNS system. ❑ **minor** reduction (e.g., a separation of more than half the separation minima) in separation with crew or ATC controlling the situation and fully able to recover from the situation.	*Effect on Occupants*	Physical discomfort.
			Effect on Air Crew	Slight increase in workload.
			Effect on Air Traffic Services	Slight reduction in separation or slight reduction in air traffic control capability. Significant increase in air traffic controller workload.
5 (Least Severe)	*Effect on Operations*	No immediate effect on safety	*Effect on Operations*	No effect on operational capabilities or safety
	Examples of effects on operations include	No hazardous condition i.e. no immediate direct or indirect impact on the operations	*Effect on Occupants*	Inconvenience

			Effect on Air Crew	No effect on flight crew.
			Effect on Air Traffic Services	Slight increase in air traffic controller workload.

Table 1 ESARR4 and ED-78A Severity and Hazard classification schemes

ED-78A is not prescriptive with regards to occurrence frequency or probability. Note that these are not quantified either in ESARR4, with the exception of the by now well known 1.55E-08 per flight hour figure for the Accident class, the rest pending on sufficient safety data collection in accordance to ESARR2. The guidelines use the following frequency terms for risk classification: Probable, Remote, Extremely Remote and Extremely Improbable. The rationale for classifying an event in each of those these categories has been from a qualitative assessment based on the likelihood of occurrence within the lifetime of the procedure (in flight hours), ranging from relatively frequent to extremely rare occurrences.

Finally, the rationale for the choice of ED78-A before EUROCONTROL SAM (Safety Assessment Methodology) [EATMP SAM] has been that at the time of the analysis, the EATMP methodology was in the process of being updated. Additionally, the main difference between the safety assessment performed by NLR and the present one arises from the usage of the Joint Aviation Authorities standard [JAA AMJ]. Given that both assessments aim at being consistent with ESARR4 and the similarities between the standards severity, probability and risk tolerability classifications, their outcomes are deemed to be directly comparable.

3. Safety assessment of approach procedure V

3.1. Concept of Operation

The operation under study corresponds to the Sourdine II Approach Procedure V (CDA with idle thrust) extrapolated to Barajas in an anticipated 2015 scenario, with two sets of parallel runways. The study focuses on the most commonly used North Configuration at Barajas, 33L and 33R for approaches and 36L and 36R for departures as displayed in Figure 4

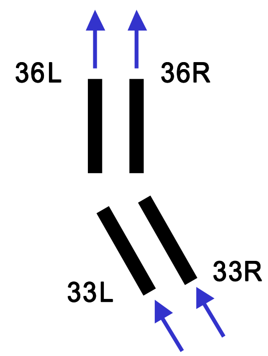


Figure 4. Barajas airport parallel runway north configuration

The scenario under consideration presents the following characteristics:

- ✓ Two sets of parallel runways.
- ✓ The arrivals and the departures are segregated.
- ✓ The distance between Runways enables independent departures as well as independent arrivals procedures. There are some dependencies between arrivals to RWY 33R and departures from 36L due to the missed approach procedures from the 33R (in North configuration).

During the description of the operation for the Sourdine II Approach Procedure V applied to Barajas, the following hypotheses have been considered:

- ✓ The RWYs used for arrivals in North Configuration are 33R and 33L
- ✓ It has been considered only from the IAFs to the missed approach fix, of both RWYs
- ✓ From a technological point of view:
    - o Communications: Mainly voice communication. Probably for 2015 there will be more datalink applications but this study is focused on the CDA for Barajas rather than on technological improvements
    - o Navigation: RNP1 in TMA and RNP0.3 in final approach (ILS segment). All the aircraft following the procedure will be equipped.
    - o Surveillance: Mode S. There is an NTZ (non Transgression Zone) with additional equipment (high resolution radar screen)
- ✓ Aircraft equipped with new generation FMS, that allows to follow the procedure as it is described in [S II D3-1]

- ✓ Fleets: A320 and A340. The rationale for choosing these fleet is data availability
- ✓ Roles:
  - o Ground:
    - ▪ Directors controllers (one per RWY): West for 33L and East for 33R. Only for arrival traffic to each of the RWYs.
    - ▪ Final approach (one per RWY): West for 33L and East for 33R; they are in charge of NTZ surveillance. Only for arrival traffic to each of the RWYs.
  - o Air:
    - ▪ Pilot flying
    - ▪ Pilot not flying

The procedure V (CDA with constant speed, variable FPA segment at intermediate configuration), considering the vertical profile, is described in the following table, from the data provided in the project:

Condition	Parameter values
7000 ft (Fixed height)	– Speed 250 KTS CAS – Level flight – Clean configuration – Landing Gear up
	– Idle thrust – Decelerate and change to intermediate configuration – Decelerate to intermediate flap speed (IFS)
Intermediate configuration reached (Resulting FPA)	– Descend at constant speed (IFS) to 3000ft – Idle thrust
3000 ft (Fixed height)	– Fixed descent angle of 3°. – Landing gear down – Decelerate and change to landing configuration (++) – Decelerate to final approach speed (FAS)
Landing configuration and speed reached (Resulting height, minimum 1000ft)	– Adapted thrust for descent at 3° – Constant speed (FAS) descent to 50ft

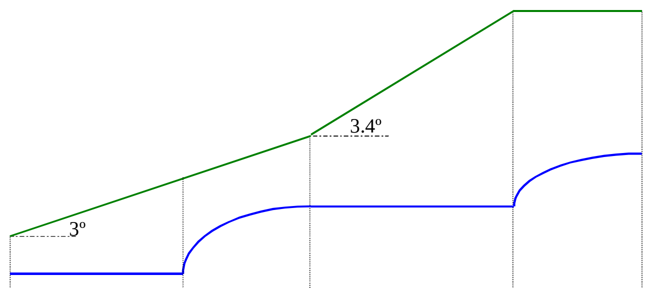
(+) To maximum allowable speed to select landing configuration

(++) Minimum allowable flap deployment

Table 2. Vertical description of SII Procedure V

A representation from the above information can be seen in Figure 5 for A-340 and in **Figure 6** for A-320

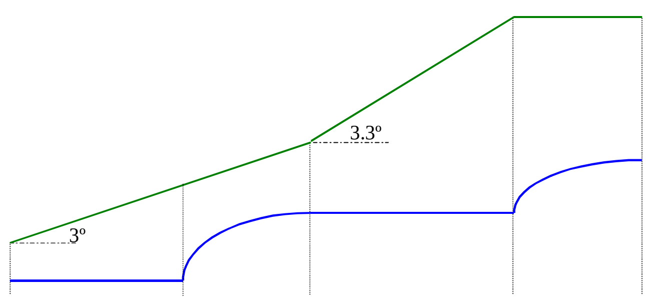
SII – Procedure V for A-340



STAR Point	00		10		20		30		40
Speed (Kt)	131		131		167		167		250
Height (ft)	50		2113		3000		7000		7000
Distance (NM)	0		6.5		9.3		20.4		26.6

Figure 5. Description of the vertical profile of Procedure V for the Airbus 340

SII – Procedure V for A-320



STAR Point	00		10		20		30		40
Speed (Kt)	128		128		185		185		250
Height (ft)	50		1999		3000		7000		7000
Distance (NM)	0		6.1		9.3		20.7		27.4

Figure 6. Description of the vertical profile of Procedure V for the Airbus 320

Note: STAR point in the figures 4 ad 5 identifies the distance from the runway threshold.

When extrapolating these vertical profiles to the future Barajas scenarios, there is a pure operational constraint: the current description of the future Barajas operations for approaches to parallel runways are based in vertical separation, so there is a clear incompatibility with applying a pure CDA to both approaches. This constraint was previous to the safety analysis.

The solution adopted following operational expert consultation has been to:

- ✓ Apply a pure SII-V for approaches to RWY 33L, starting at 8000 feet
- ✓ Apply SII-V with a horizontal leg in the intermediate approach for the approaches to RWY 33RThere is more population close to the approach area to the RWY 33L than

to the RWY 33R; for that reason was chosen to apply a pure CDA to RWY 33L in order to reduce noise where it is more necessary.

The following figures shows the application of this CDA V to Barajas future scenario (horizontal profiles), starting with the baseline and then showing the different possibilities depending on the approach route.

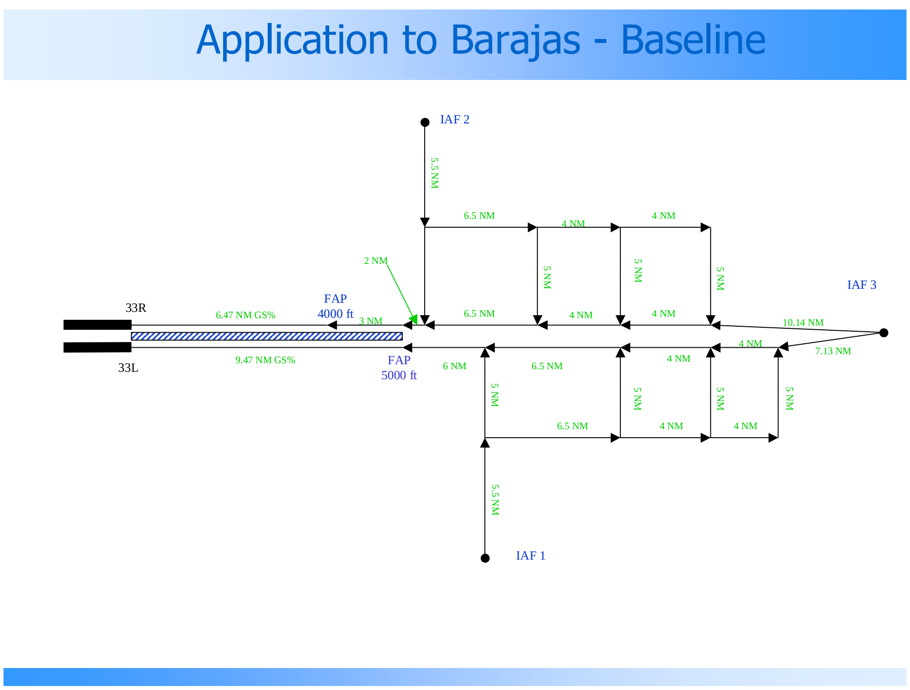


Figure 7. Baseline.

The baseline provides the complete set of procedures that are proposed to be used in the future Barajas airport, considering only the horizontal layout. The baselines shows an arrays approach, that allows to take advantage of the capacity of the runway having possibilities for high and low number of arrivals, depending on the length of the approach. It is used as the starting point to apply the vertical profiles defined in SII- Proc V.

There are three IAFs: the IAF1 for aircraft approaching from the south-west area, the IAF2 used by aircraft approaching form the south-east area and the IAF 3, used to balance East and West traffic when necessary.

All the aircraft have to be aligned with the ILS localiser before reaching the area parallel to the NTZ. When the aircraft reaches the area parallel to the NTZ, there is, at least, 1000 ft of vertical separation between the two parallel approaches. From the FAP, in both approaches, the aircraft descent according to the glide slope (3º).

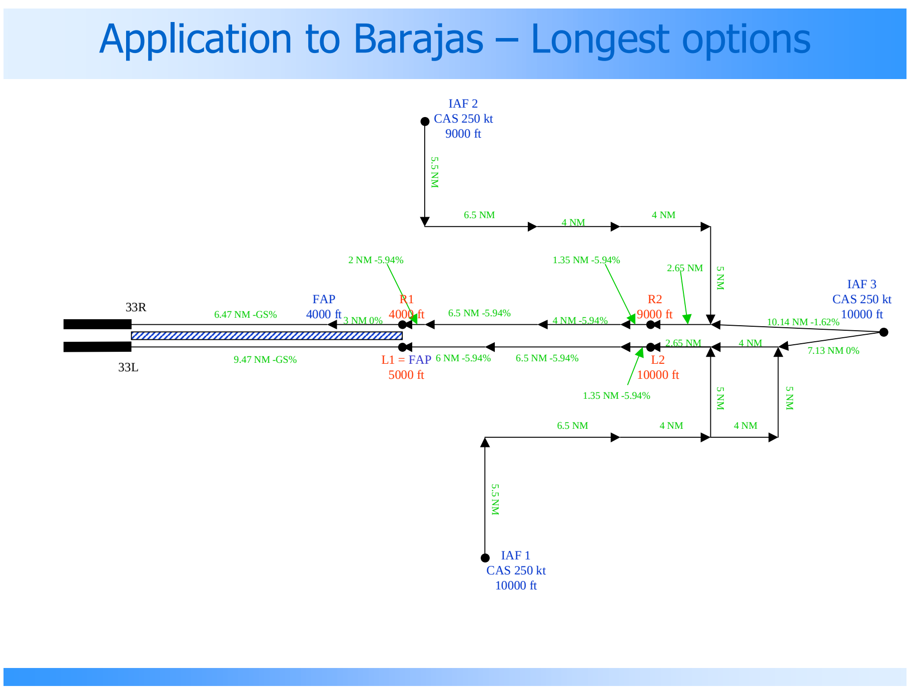


Figure 8. Approaches through the longest options

The figure 8 shows the extrapolation of the SII Procedure V, as described in the table 1, considering the longest options from the arrays described in the baseline. In both cases, approaches to 33R and 33L, the CDA starts when the aircraft are aligned with the axis of the RWY.

For RWY 33R, the CDA starts in the point R2 at an altitude of 9000ft and finishes in the point R1, just in the frontier of the area parallel to the NTZ, with an altitude of 4000ft. Then there is a section of horizontal flight (3 NM) till the FAP where the aircraft starts descending again according to the glide slope.

For RWY 33L, the CDA starts in the point L2 at an altitude of 10000ft and finishes in the point L1, just in the frontier of the area parallel to the NTZ, with an altitude of 5000ft. Then the aircraft starts descending again according to the glide slope.

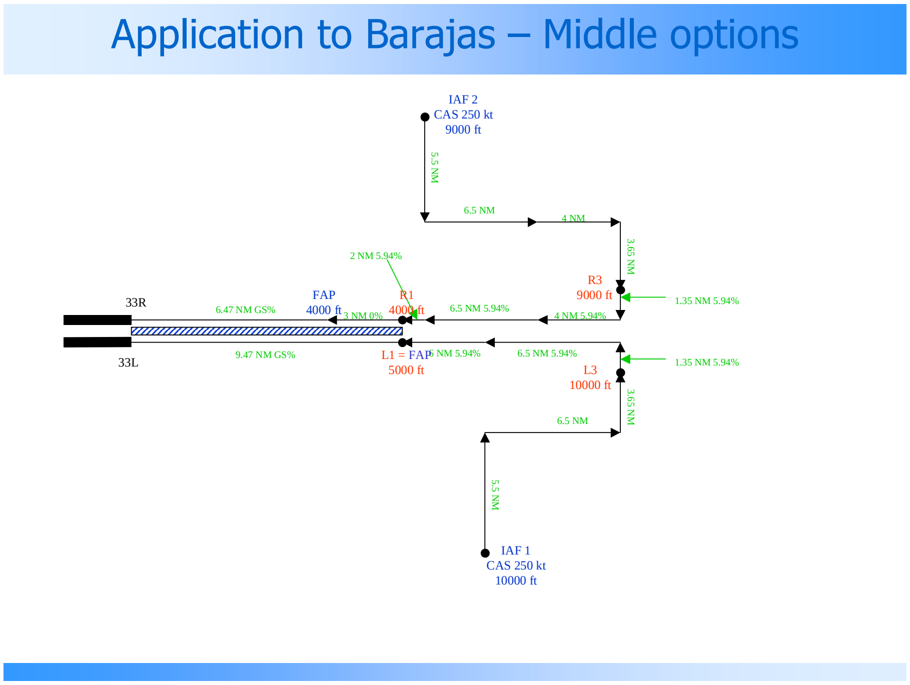


Figure 9. Approaches using the middle options

The figure 9 shows the extrapolation of the SII Procedure V, as described in the table 1, considering the middle options from the arrays described in the baseline. In both cases, approaches to 33R and 33L, the CDA starts before the aircraft are aligned with the axis of the RWY; the aircraft have to turn to intercept the ILS localizer when following the CDA.

For RWY 33R, the CDA starts in the point R3 at an altitude of 9000ft and finishes in the point R1, just in the frontier of the area parallel to the NTZ, with an altitude of 4000ft. Then there is a section of horizontal flight (3 NM) till the FAP where the aircraft starts descending again according to the glide slope.

For RWY 33L, the CDA starts in the point L3 at an altitude of 10000ft and finishes in the point L1, just in the frontier of the area parallel to the NTZ, with an altitude of 5000ft. Then the aircraft starts descending again according to the glide slope.

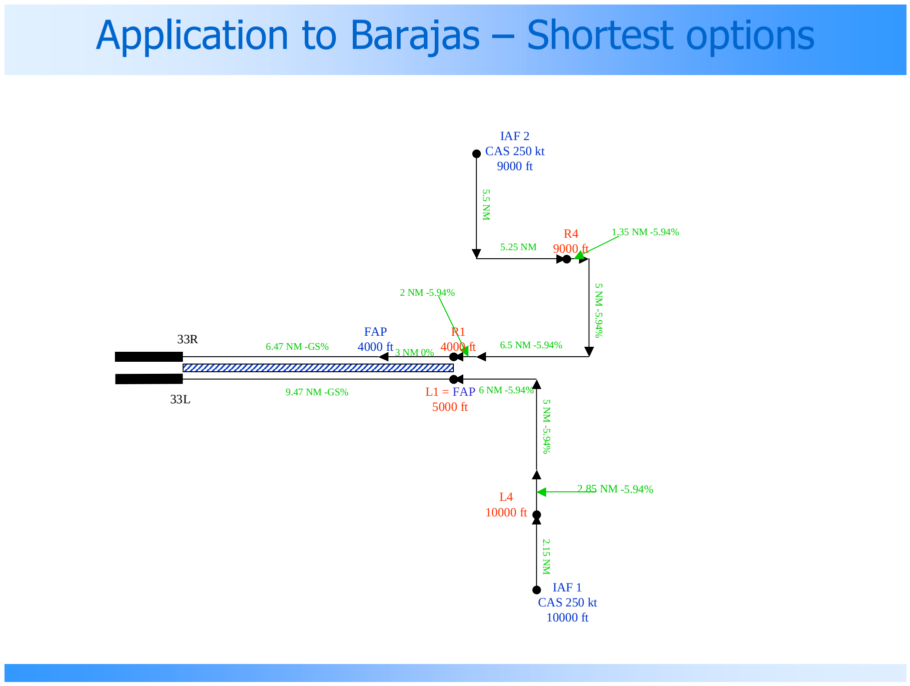


Figure 10. Approaches using the shortest options

The figure 10 shows the extrapolation of the SII Procedure V, as described in the table 1, considering the shortest options from the arrays described in the baseline. In both cases, approaches to 33R and 33L, the CDA starts before the aircraft are aligned with the axis of the RWY; the aircraft have to turn to intercept the ILS localizer when following the CDA.

For RWY 33R, the CDA starts in the point R4 at an altitude of 9000ft and finishes in the point R1, just in the frontier of the area parallel to the NTZ, with an altitude of 4000ft. Then there is a section of horizontal flight (3 NM) till the FAP where the aircraft starts descending again according to the glide slope.

For RWY 33L, the CDA starts in the point L4 at an altitude of 10000ft and finishes in the point L1, just in the frontier of the area parallel to the NTZ, with an altitude of 5000ft. Then the aircraft starts descending again according to the glide slope.

Finally, some special issues to be taken into account for all the procedures:

- ✓ Conditions to transfer aircraft from Director controller to Approach controller:
  - o Horizontal separation of at least 5 NM
  - o Shortly before being aligned with the RWY. There is no exact point but when the aircraft is aligned with the RWY the Approach controller should have the responsibilities.
- ✓ The Director controllers clearance the pilots to use the allocated STARs, depending on the traffic and the characteristic of the different aircraft and flights (probably there will be an AMAN tool to establish the best sequence). Before the IAF, the pilots know which STAR (considering the options described above: long, medium or short) have to follow. If it is necessary, the approach controller can change that clearance to take advantage of the RWY capacity (not used when following CDA) or for safety reasons.

3.2. Hazard Identification

In order to identify potential hazards associated with the SII NAP, expert sessions were held with participation from pilots, ATC officers and safety personnel. An introduction was given on the parallel runway planned concept of operations at Barajas Airport (currently under development), modified to accommodate the SII NAP as described in section 3.1. The expert sessions participants were instructed to identify potential procedure failures and hazards only directly related to the SII NAP or whose consequences would be worsened by the implementation of the NAP. It must be emphasized that hazards completely independent of the NAP have not been considered, as the purpose of the study was to assess the safety of the SII procedure only. Taking these facts into account, the present safety assessment (neither in part nor in its entirety) cannot be construed in any way as the safety assessment of the planned Barajas Airport concept of operations to enter its operational stage in the near future.

3.2.1. Scope and Assumptions

The SII NAP scope and boundaries are defined by the following assumptions:

1. ATM-related hazards only (those inherent to the ATM system or impacting its capacity to maintain safety)
2. From approach clearance issued (in TMA) to missed approach decision point.
3. All aircraft capable of RNAV with RNP1 in TMA and RNP0.3 in final Approach
4. All aircraft capable of flying SII NAP vertical profile
5. IFR only
6. Means of monitoring the Non Transgression Zone (NTZ), such as Runway Precision Monitoring (RPM) equipment or equivalent
7. Parallel runway independent operation
8. Adequate range of environmental / weather conditions present when SII NAP is flown
9. Established TMA / Final Approach separation minima adequate to sustain SII NAP operations
10. Airport equipped with independent 2 x ILS (or MLS)
11. Barajas Airport North configuration
12. ATCO and Flight Crew personnel trained on SII NAP Runway changes prior to IAF points only, else missed approach is executed***Identified Hazards***

Two expert sessions with pilots, ATC Officers (one of them participated in the design of the Barajas Airport parallel runway Concept of Operations) and safety personnel were held at AENA premises. Additionally, an internal preparatory session was also held. Notes from all sessions can be found in Appendix A.

The information captured during the sessions was processed and as a result, twenty-two identified hazards were grouped into categories based on the phase of flight within the approach stage, from TMA to missed approach decision point. These categories are as follows:

- **TMA Transition,** from approach clearance issued to aircraft sequencing manoeuvres within the approach transition zone
- **Approach Intermediate – Localiser Intercept,** related to localiser intercept
- **Approach Intermediate – Localiser Established,** from localiser intercept to glide slope intercept
- **Approach Final,** from glide slope intercept to missed approach decision point.

- **TMA Overall,** overall hazards independent of flight stage within aircraft approach

The hazard distribution as a function of approach category is presented in Table 3.

Approach Category	Identified Hazards
TMA Transition	4
Approach Intermediate – Localiser Intercept	3
Approach Intermediate – Localiser Established	11
Approach Final	3
TMA Overall	1

Table 3. Hazard distribution as a function of Approach flight stage

The identified hazards are presented in the following subsections. Each hazard has been assigned a numerical identification (ID), the approach stage or action, a label (Label) and a causing failure event description (Failure Event). An additional cross-reference (CR) to the expert session notes (ESN) (in Appendix A), has also been allocated for traceability purposes. Other hazards incorporated after the expert sessions and have not been allocated any cross-reference. During the expert sessions, the main objective was to identify as many hazards as possible in the limited time available without fully evaluating the potential consequences. A detailed analysis of each hazard potential outcome was carried out in the risk analysis to be presented later.

3.2.2.1. TMA Transition Hazards

Hazard ID	**1**
Stage	Transition sequencing
Label	Deviation from arrival sequence due to data input error
Failure Event	Incorrect data introduction in FMS by pilot about cleared route within the transition zone grid.
Hazard CR	*ESN 0306-7 & 2705-4*

Hazard ID	**2**
Stage	Transition sequencing
Label	Outdated FMS Database
Failure Event	Deviations / non-adherence to procedure’s required vertical and lateral trajectory
Hazard CR	*ESN 1706-7*

Hazard ID	**3**
Stage	Transition sequencing
Label	RT read back error

Failure Event	Read back error by pilot not detected by ATCO. As a result aircraft may fly an unauthorised trajectory and start SII-NAP-V (CDM) earlier / later than anticipated.
Hazard CR	---

Hazard ID	**4**
Stage	Transition sequencing
Label	ATC clearance error
Failure Event	ATC (Director controller) inadvertently issues an aircraft an incorrect / unintended clearance route within the transition zone
Hazard CR	---

3.2.2.2. Approach Intermediate (Localiser Intercept) Hazards

Hazard ID	**5**
Stage	Localiser Intercept
Label	Localiser overshoot
Failure Event	Late turn into / overshoot the localiser path / runway heading alignment while performing CDA. Aircraft failing to turn or performing a very late turn while performing CDA could intrude into opposing Approach sector.
Hazard CR	*ESN 1706-2 & 0306-5*

Hazard ID	**6**
Stage	Localiser Intercept
Label	Introduction of incorrect ILS localiser frequency
Failure Event	Introduction of incorrect ILS localiser frequency
Hazard CR	*ESN 1706-3*

Hazard ID	**7**
Stage	Localiser Intercept
Label	Localiser failed alignment
Failure Event	Erroneous ILS localiser signal (e.g. strong reflection) may cause aircraft to turn early into wrong localiser path.
Hazard CR	*ESN 1706-4*

3.2.2.3. Approach Intermediate (Localiser Established) Hazards

Hazard ID	**8**

Stage	Localiser established
Label	SII-NAP-V procedure vertical deviation
Failure Event	Deviations / non-adherence to procedure’s required speed and/or vertical profiles (e.g. different aircraft performances, aircraft overload etc)
Hazard CR	*ESN 0306-1, 1706-1 & 2705-1*

Hazard ID	**9**
Stage	Localiser established
Label	SII-NAP-V procedure longitudinal deviation
Failure Event	Deviations / non-adherence to procedure’s required speed and/or descent rate profiles (e.g. different aircraft performances, aircraft overload etc)
Hazard CR	*ESN 0306-1, 1706-1 & 2705-1*

Hazard ID	**10**
Stage	Localiser established
Label	SII-NAP-V procedure lateral deviation
Failure Event	Deviations / non-adherence to procedure’s required lateral flight profile while established on the localiser path
Hazard CR	---

Hazard ID	**11**
Stage	Localiser established
Label	Loss of FMS
Failure Event	FMS navigational assistance loss
Hazard CR	*ESN 0306-2, 1706-6*

Hazard ID	**12**
Stage	Localiser established
Label	Loss of on-board RNP capability causing inability to adhere to SII-NAP-V descent trajectory
Failure Event	FMS navigational assistance loss
Hazard CR	*ESN 2705-2*

Hazard ID	**13**
Stage	Localiser established
Label	Loss of RNP capability
Failure Event	Loss of off-board RNP capability (e.g. augmentation system)
Hazard CR	*ESN 2705-2*

Hazard ID	**14**
Stage	Localiser established
Label	SII-NAP-V vertical path deviation
Failure Event	Small deviations in vertical and or horizontal trajectory (slight non adherence to NAP profile) may trigger nuisance TCAS Traffic and alerts
Hazard CR	*ESN 0306-6 2705-6*

Hazard ID	**15**
Stage	Localiser established
Label	Loss of surveillance data
Failure Event	Inability to monitor separation as a consequence of loss of surveillance
Hazard CR	---

Hazard ID	**16**
Stage	Localiser established
Label	Loss of RT communication
Failure Event	Inability to communicate with aircraft through RT Director and/or Approach frequencies
Hazard CR	---

Hazard ID	**17**
Stage	Localiser established
Label	Approach controller alertness (human factor)
Failure Event	SII-NAP-V calls for aircraft to perform CDA within established routes without the need of vectoring / speed instructions to avoid noise-rich manoeuvres. The fact that W/E Approach controllers are left with separation monitoring tasks may impact their alertness and situational awareness levels with time.
Hazard CR	---

Hazard ID	**18**
Stage	Localiser established
Label	Wake vortex encounter
Failure Event	Aircraft to fly into preceding adjacent aircraft wake vortex
Hazard CR	---

3.2.2.4. Approach Final Hazards

Hazard ID	**19**
Stage	Glide Slope Intercept

Label	Glide-slope undershoot
Failure Event	ILS glide-slope interception through descent angles > 3º may cause aircraft to undershoot glide slope.
Hazard CR	*ESN 1706-5*

Hazard ID	**20**
Stage	Glide Slope Intercept
Label	ILS false capture
Failure Event	ILS harmonic / sidelobe interception may cause GSI indications to switch polarity (e.g fly down instead of fly up)
Hazard CR	*ESN 0306-4 & 2705-3*

Hazard ID	**21**
Stage	Glide Slope Intercept / Established
Label	Unexpected extreme meteorological conditions
Failure Event	Sudden change in meteorological conditions (e.g. windshear, strong cross winds, thunderstorms etc.) may impact applicability / adherence to procedure.
Hazard CR	*ESN 0306-8 & 2705-5*

3.2.2.5. TMA Overall Hazards

Hazard ID	**22**
Stage	any
Label	Loss of ATIS
Failure Event	Loss of ATIS (unavailability of ILS frequency broadcast)
Hazard CR	---

3.3. Risk Assessment

The previously identified hazards have been evaluated in terms of its estimated frequency of occurrence and have been classified according to the severity of their effects. Subsequently, their risk tolerability has been determined according to ED-78A classification scheme in Figure 3.

Occurrence frequency classifiers of Probable, Remote, Extremely Remote and Extremely Improbable have been used. The rationale for classifying an event in one of those these categories has been made on a qualitative assessment by operational experts based on the likelihood of occurrence within the lifetime of the procedure (in flight hours), ranging from relatively frequent to extremely rare occurrences.

With regards to hazard severity classification, a rationale has been developed for each hazard aiming at describing the hazard credible consequences and “demonstrating the most probable effect of hazards, under the worst case scenario” as instructed by ESARR4. Prior to any Accident (1) severity class classification, such rationale must have demonstrated that “the total ATM System has exhausted its possibilities to affect what continues to happen and only chance determines if the consequence will be a collision or not” (Explanatory Material on ESARR4 Requirements [EAM 4 GUI]).

In ED-78A, acceptability for Accident (1) class hazards of Extremely Improbable frequency depends on the presence of single point or common cause failures. When establishing the tolerability of such hazards, acceptable tolerability has been noted with the “Minimum Safety Objective” ED-78A notation.

Finally, two of the identified hazards have required the development of an event tree (applicable to both hazards of different nature yet of equivalent consequences) for their classification.

3.3.1. Risk Analysis

The classified risks derived from all identified hazards are presented in the following subsections. Each risk has been assigned an identifier, which in all cases corresponds to the previous hazard numerical identification. Besides the originating hazard approach stage, label and failure event, the hazard consequences, estimated frequency of occurrence, assigned severity together with its assignation rationale and their final risk tolerability are also presented. Additionally, an “observations” field is also included for any pertinent complementary information (such as potential mitigations etc).

For those hazards for which an event tree has been developed, the risk identifier incorporates a sub-field (e.g. risk ID x.y) leading to a different risk tolerability depending on the variations in hazard frequency and severity classifications for the various branches in the event tree.

3.3.1.1. TMA Transition Risks

Risk ID	**1 (Hz ID 1)**
Stage	Transition sequencing
Label	Deviation from arrival sequence due to data input error
Failure Event	Incorrect data introduction in FMS by pilot about cleared route within the transition zone grid.
Hazard Consequences	Introducing an incorrect cleared route within FMS may cause aircraft to fly an unauthorised trajectory and start SII-NAP-V (CDA) earlier / later than anticipated, which may result in *loss of horizontal and/or vertical separation*.
Frequency	**Remote**

Severity	**Major Incident (3)**	*Rationale*	ATC likely to rapidly detect deviation, which could lead to significant breaches of separation within the transition zone, and take remedy action to restore separation.
Risk Tolerability	Acceptable (Minimum Safety Objective)		
Observations	Double check procedures between Flying Pilot & Non-Flying Pilot Early ATC detection		

Risk ID	**2 (Hz ID 2)**		
Stage	Transition sequencing		
Label	Outdated FMS Database		
Failure Event	Deviations / non-adherence to procedure's required vertical and lateral trajectory		
Hazard Consequences	Flight crew could inadvertently deviate from intended clearances while believing compliance, which could result in *loss of horizontal and/or vertical separation*.		
Frequency	**Remote**		
Severity	**Major Incident (3)**	*Rationale*	ATC likely to rapidly detect deviation, which could lead to significant breaches of separation within the transition zone, and take remedy action to restore separation.
Risk Tolerability	Acceptable (Minimum Safety Objective)		
Observations	Mitigation: RNAV equipment certification standard, adequate airline upgrading procedures and early ATC deviation detection. (Note: Req. in EUROCAE/RTCA ED-76/DO-200A & Eurocontrol Standard Document on Area Nav Equipment Operational Requirements and Functional Requirements)		

Risk ID	**3 (Hz ID 3)**		
Stage	Transition sequencing		
Label	RT read back error		
Failure Event	Read back error by pilot not detected by ATCO. As a result aircraft may fly an unauthorised trajectory and start SII-NAP-V (CDM) earlier / later than anticipated.		
Hazard Consequences	Undetected read back error may cause aircraft to fly an unauthorised trajectory and start SII-NAP-V (CDM) earlier / later than anticipated, which may result in *loss of horizontal and/or vertical separation*.		
Frequency	**Extremely Remote**		
Severity	**Serious Incident (2)**	*Rationale*	ATC likely to rapidly detect deviation, which could lead to significant breaches of separation within the transition zone, and take remedy action to restore separation.
Risk Tolerability	Acceptable (Minimum Safety Objective)		
Observations	Mitigation: Adherence to RT procedures and likelihood of deviation early detection		

	by either Director or Approach controller

Risk ID	**4 (Hz ID 4)**		
Stage	Transition sequencing		
Label	ATC clearance error		
Failure Event	ATC (Director controller) inadvertently issues an aircraft an incorrect / unintended clearance route within the transition zone		
Hazard Consequences	Aircraft flying unintended route may result in *loss of horizontal and/or vertical separation.*		
Frequency	**Major Incident (3)**		
Severity	**Extremely Improbable**	*Rationale*	ATC likely to rapidly detect clearance error, which could lead to significant breaches of separation within the transition zone, and take remedy action to restore separation.
Risk Tolerability	Acceptable		
Observations	Mitigation: likelihood of deviation early detection by either Director or approach controller		

3.3.1.2. Approach Intermediate (Localiser Intercept) Risks

Risk classification of hazards ID 5 & 6 has required the development of an event tree as the hazard most credible consequences widely diverged from the worst-case scenario. However, because of the potential outcome of the latter its analysis could not be completely disregarded.

Both hazards lead to a potential localiser overshoot as illustrated in Figure 11. Given the proximity between both localiser paths, the severity of the potentially ensuing conflict is highly dependent on detection and remedy action instruction and reaction times. This scenario could bring the two conflicting aircraft into multiple conflicting trajectories. A potential conflict is illustrated displaying vertical profiles in Figure 12.

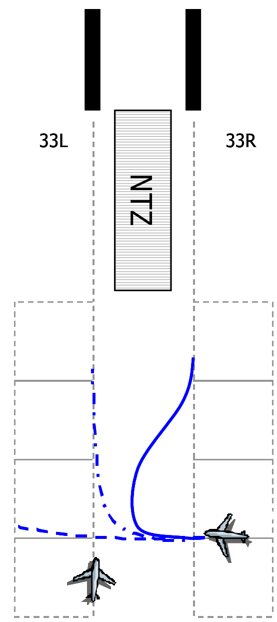


Figure 11. Potential flight paths following ILS Localiser overshoot

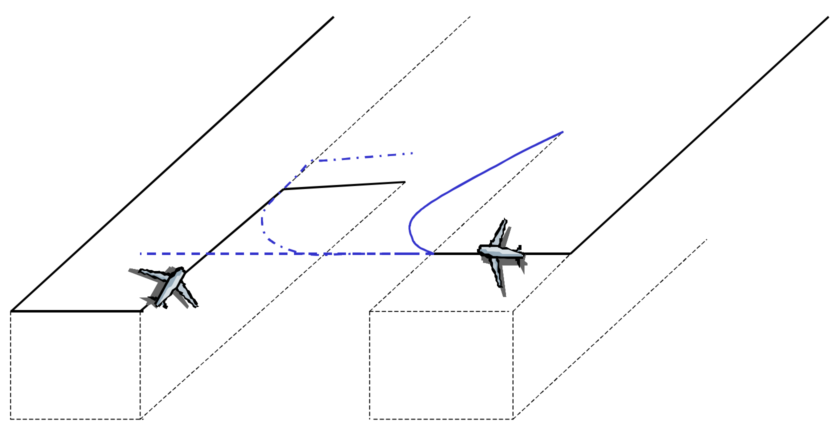


Figure 12. Potential flight paths following ILS Localiser overshoot (potential vertical profile shown)

The event tree (displayed in Figure 13) has been constructed to encompass the three main chronological events following a localiser overshoot sequence whose occurrence or not may lead to three different outcomes. These events are:

- ATC prompt overshoot detection and remedy action issuance
- Crew prompt overshoot awareness and remedy action initiation
- Existence of immediate conflicting traffic in opposing final approach sector

The combinations of these events may lead to 6 different outcomes, which may be grouped into three classes of increasing severity. The least severe outcome obviously corresponds to both ATC and Crew prompt detection and reaction ending in the overshooting aircraft rapidly establishing in its intended localiser. On the other hand, the most severe one corresponds to the one in which either the lack of detection or reaction by either party and the presence of traffic in the opposing final approach sector generates an immediate conflict. No attempt has been made to quantify any tree branch probabilities, as this was beyond the scope of the present qualitative assessment.

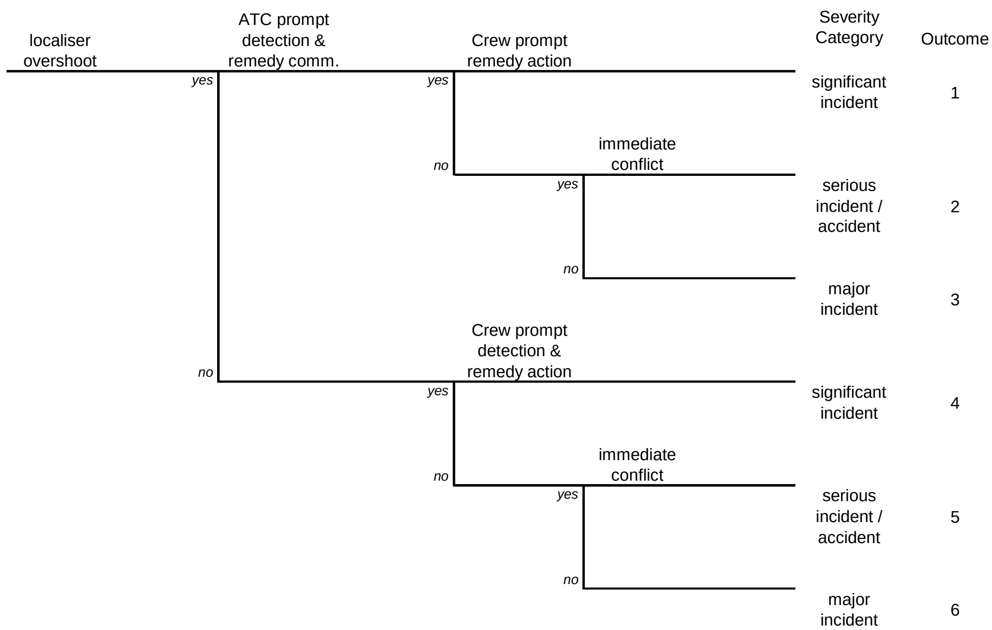


Figure 13. ILS Localiser overshoot event tree

Risks ID 5 and 6 incorporate a sub-field (e.g. risk ID 5.1, 5,2 etc) representing different risk tolerability depending on the variations in hazard frequency and severity classifications according to the corresponding event tree branch outcome.

Risk ID	**5.1 (Hz ID 5)**		
Stage	Localiser Intercept		
Label	Localiser overshoot		
Failure Event	Late turn into / overshoot the localiser path / runway heading alignment while performing CDA. Aircraft failing to turn or performing a very late turn while performing CDA could intrude into opposing Approach sector.		
Hazard Consequences	Aircraft overshooting while performing continuous descent may result in *simultaneous loss of vertical and horizontal separation* with aircraft on opposed approach sector		
Frequency	**Remote**		
Severity	**Significant Incident (4)**	*Rationale*	Severity rationale: ATC promptly

			detects deviation from localiser and instructs remedy action. Flight crew acts upon reception of remedy instruction and returns to establish on localiser, with an associated workload increase (event tree outcome 1). Flight Crew detects deviation and returns to establish on localiser without ATC intervention, with an associated workload increase (event tree outcome 4)
Risk Tolerability	Acceptable		
Observations			
Risk ID	**5.2 (Hz ID 5)**		
Frequency	**Extremely Improbable**		
Severity	**Major Incident (3)**	*Rationale*	If aircraft overshoot is not rapidly detected by ATC (or flight crew) vertical and horizontal separation with aircraft in adjacent approach sector would be quickly eroded. Should the overshoot progress in the absence of immediate conflict, the flight path deviation would be eventually detected and redressed by ATC (event tree outcomes 3 & 6)
Risk Tolerability	Acceptable		
Observations			
Risk ID	**5.3 (Hz ID 5)**		
Frequency	**Extremely Improbable**		
Severity	Serious Incident (2) / Accident (1)	*Rationale*	If aircraft overshoot is not rapidly detected by ATC (or flight crew) with the overshoot developing into sector intrusion in the presence of immediate conflict (e.g. aircraft established on localiser in adjacent approach sector), the E/W Approach controller inability to address or issue complementary resolution instructions (e.g. vertical resolution) to both aircraft in conflict as intruding aircraft would be tuned into different approach R/T frequency combined with TCAS Resolution Advisories would inevitably involve a workload increase for both approach controllers to coordinate action with little reaction time available, as separation amongst aircraft within intruded transition zone may deteriorate rapidly leading to avoidance manoeuvres causing multiple conflicts (event tree

			outcomes 2 & 5)
Risk Tolerability	Possibly Unacceptable		
Observations			

Risk ID	**6.1 (Hz ID 6)**		
Stage	Localiser Intercept		
Label	Introduction of incorrect ILS localiser frequency		
Failure Event	Introduction of incorrect ILS localiser frequency		
Hazard Consequences	Incorrect ILS localiser frequency will cause aircraft to miss turn to align into the localiser path that could lead to an intrusion into the opposed approach sector and may result in *simultaneous loss of vertical and horizontal separation.*		
Frequency	**Extremely Improbable**		
Severity	**Significant Incident (4)**	*Rationale*	ATC promptly detects deviation from localiser and instructs remedy action. Flight crew acts upon reception of remedy instruction and returns to establish on localiser, with an associated workload increase (event tree outcome 1). Flight Crew detects deviation and returns to establish on localiser without ATC intervention, with an associated workload increase (event tree outcome 4)
Risk Tolerability	Acceptable		
Observations			
Risk ID	**6.2 (Hz ID 6)**		
Frequency	**Extremely Improbable**		
Severity	**Major Incident (3)**	*Rationale*	If aircraft overshoot is not rapidly detected by ATC (or flight crew) vertical and horizontal separation with aircraft in adjacent approach sector would be quickly eroded. Should the overshoot progress in the absence of immediate conflict, the flight path deviation would be eventually detected and redressed by ATC (event tree outcomes 3 & 6)
Risk Tolerability	Acceptable		
Observations			
Risk ID	**6.3 (Hz ID 6)**		
Frequency	**Extremely Improbable**		
Severity	**Serious Incident (2) / Accident (1)**	*Rationale*	If aircraft overshoot is not rapidly detected by ATC (or flight crew) with the overshoot developing into sector

			intrusion in the presence of immediate conflict (e.g. aircraft established on localiser in adjacent approach sector), the E/W Approach controller inability to address or issue complementary resolution instructions (e.g. vertical resolution) to both aircraft in conflict as intruding aircraft would be tuned into different approach R/T frequency combined with TCAS Resolution Advisories would inevitably involve a workload increase for both approach controllers to coordinate action with little reaction time available, as separation amongst aircraft within intruded transition zone may deteriorate rapidly leading to avoidance manoeuvres causing multiple conflicts (event tree outcomes 2 & 5)
Risk Tolerability	Possibly Unacceptable		
Observations	Mitigation: ILS localiser frequencies broadcast on ATIS. Pilots confirm given ILS localiser frequencies on RT following approach clearance instruction (which includes localiser frequency). Mitigation: The Standard Operating Procedures on the Airbus 320/340 fleet, the ILS frequency is auto-tuned when pilot selects the appropriate APP procedure in the FMGS. Other aircraft types using advanced FMS systems also use this procedure. However manual tuning is possible in case of navigation database errors		

Risk ID	**7 (Hz ID 7)**		
Stage	Localiser Intercept		
Label	Localiser failed alignment		
Failure Event	Erroneous ILS localiser signal (e.g. strong reflection) may cause aircraft to turn early into wrong localiser path.		
Hazard Consequences	Inadvertent establishment into incorrect localiser path may result in *loss of vertical and/or horizontal separation.*		
Frequency	**Extremely Improbable**		
Severity	**Serious Incident (2)**	*Rationale*	Aircraft approaching runway beyond the localiser path could risk inadvertently descending below safe altitudes and coming into the proximity of obstacles requiring sudden manoeuvres to avoid CFIT. Scenario aggravated during low visibility procedures.
Risk Tolerability	Acceptable		
Observations	Mitigation: mandatory to indicate areas of erroneous localiser signals in arrival charts.		

3.3.1.3. Approach Intermediate (Localiser Established) Risks

Risk ID	**8 (Hz ID 8)**		
Stage	Localiser established		
Label	SII-NAP-V procedure vertical deviation		
Failure Event	Deviations / non-adherence to procedure’s required speed and/or vertical profiles (e.g. different aircraft performances, aircraft overload etc)		
Hazard Consequences	Deviations from required profiles may cause aircraft to *breach vertical separation* that would result in *ATC workload increase*, as instructions would be required to restore separation.		
Frequency	**Probable**		
Severity	**Significant Incident (4)**	*Rationale*	ATC likely to rapidly detect breach of separation, such as vertical separation breached between two aircraft established on localisers for parallel runways, and take remedy action to restore vertical separation.
Risk Tolerability	Acceptable (Minimum Safety Objective)		
Observations	CONOPS. Within SII-NAP-V adapted procedure, W/E Approach controllers do not ensure separation through vectoring; separation is established through adequate sequencing by W/E Director controllers within and aircraft adherence to NAP procedure (CDA).		

Risk ID	**9 (Hz ID 9)**		
Stage	Localiser established		
Label	SII-NAP-V procedure longitudinal deviation		
Failure Event	Deviations / non-adherence to procedure’s required speed and/or descent rate profiles (e.g. different aircraft performances, aircraft overload etc)		
Hazard Consequences	Deviations from required profiles may cause aircraft to *breach horizontal (e.g. longitudinal separation between aircraft) separation* leading to aircraft catching up aircraft ahead/falling behind trailing aircraft, that would result in *ATC workload increase*, as instructions would be required to restore separation.		
Frequency	**Probable**		
Severity	**Significant Incident (4)**	*Rationale*	ATC likely to rapidly detect breach of longitudinal separation, and take remedy action to restore separation, though trailing aircraft remains at risk of flying into preceding aircraft wake vortex.
Risk Tolerability	Acceptable (Minimum Safety Objective)		
Observations			

Risk ID	**10 (Hz ID 10)**

Stage	Localiser established		
Label	SII-NAP-V procedure lateral deviation		
Failure Event	Deviations / non-adherence to procedure's required lateral flight profile while established on the localiser path		
Hazard Consequences	Lateral deviations from required profiles (e.g drifts) may cause aircraft to *depart from the established localiser path,* and instructions would be required to restore separation, abort landing or to break away.		
Frequency	**Remote**		
Severity	**Major Incident (3)**	*Rationale*	ATC likely to rapidly detect breach of lateral separation, and take remedy action to restore separation/break away.
Risk Tolerability	Acceptable (Minimum Safety Objective)		
Observations	Mitigation: early NTZ warning while on final approach + negligible FTE (Flight Technical Error)		

Risk ID	**11 (Hz ID 11)**		
Stage	Localiser established		
Label	Loss of FMS		
Failure Event	FMS navigational assistance loss		
Hazard Consequences	Following FMS loss, flight crew will revert to manual flight and would be unable to adhere to SII-NAP-V speed & vertical profiles, which could result in *ATC and flight crew workload increase*.		
Frequency	**Extremely Improbable**		
Severity	**Significant Incident (4)**	*Rationale*	Early detection by flight crew, who notify on RT about FMS loss and ATC to instruct to abandon NAP, restore separation if breached and revert to alternative procedure (separation with other ensured by vectoring & speed/descent rate instructions)
Risk Tolerability	Acceptable		
Observations	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP. (Note: Req in JAA TGL-10)		

Risk ID	**12 (Hz ID 12)**
Stage	Localiser established
Label	Loss of on-board RNP capability causing inability to adhere to SII-NAP-V descent trajectory
Failure Event	FMS navigational assistance loss
Hazard Consequences	Loss of RNP capability would be associated with an aircraft inability to adhere to SII-NAP-V speed & vertical profiles, which could result in *loss of horizontal and/or vertical separation*.
Frequency	**Extremely Improbable**

Severity	**Significant Incident (4)**	*Rationale*	Early detection by flight crew, who notify on RT about RNP loss and ATC to instruct to abandon NAP, restore separation if breached and revert to alternative procedure (separation with other aircraft ensured by vectoring & speed/descent rate instructions)
Risk Tolerability	Acceptable		
Observations	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP. (Note: Req in JAA TGL-10)		

Risk ID	**13 (Hz ID 13)**		
Stage	Localiser established		
Label	Loss of RNP capability		
Failure Event	Loss of off-board RNP capability (e.g. augmentation system)		
Hazard Consequences	Loss of overall RNP capability would be associated with aircraft inability to adhere to SII-NAP-V speed & vertical profiles, which could result in *loss of horizontal and/or vertical separation*.		
Frequency	**Extremely Improbable**		
Severity	**Significant Incident (4)**	*Rationale*	Early detection by ATC, who notify on RT about RNP loss and ATC to instruct to abandon NAP, restore separation if breached and revert to alternative procedure (separation ensured by vectoring & speed/descent rate instructions)
Risk Tolerability	Acceptable		
Observations	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP.		

Risk ID	**14 (Hz ID 14)**		
Stage	Localiser established		
Label	SII-NAP-V vertical path deviation		
Failure Event	Small deviations in vertical and or horizontal trajectory (slight non adherence to NAP profile) may trigger nuisance TCAS Traffic and alerts		
Hazard Consequences	Deviations would result in *flight crew and ATC workload increase*, as monitoring and instructions may be required to restore separation.		
Frequency	**Probable**		
Severity	**Significant Incident (4)**	*Rationale*	Small deviations in vertical trajectory when aircraft are established on parallel localiser tracks, albeit no risk bearing, would increase workload to monitor situation and issue additional instructions.
Risk Tolerability	Acceptable (Minimum Safety Objective)		

Observations	Safety Net (e.g. STCA) and improved functionality in future TCAS algorithmic/versions may mitigate risk. Note. TA/RA availability not yet established within CONOPS.		

Risk ID	**15 (Hz ID 15)**		
Stage	Localiser established		
Label	Loss of surveillance data		
Failure Event	Inability to monitor separation as a consequence of loss of surveillance		
Hazard Consequences	Inability to monitor non-adherences to SII-NAP-V speed & vertical profiles resulting in *loss of horizontal and/or vertical separation* would significantly erode safety margins.		
Frequency	**Extremely Improbable**		
Severity	**Major Incident (3)**	*Rationale*	ATC unable to monitor and detect significant breaches of separation
Risk Tolerability	Acceptable		
Observations	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP. Overlapping radar coverage and resilient data-comms architecture		

Risk ID	**16 (Hz ID 16)**		
Stage	Localiser established		
Label	Loss of RT communication		
Failure Event	Inability to communicate with aircraft through RT Director and/or Approach frequencies		
Hazard Consequences	Aircraft *vertical and horizontal separations to deteriorate* very rapidly.		
Frequency	**Extremely Improbable**		
Severity	**Serious Incident (2)**	*Rationale*	ATC unable to communicate wih aircraft directly.
Risk Tolerability	Acceptable		
Observations	Mitigation: Multiple Tx/Rx sites with overlapping coverage, emergency frequency, resilient data-comms architecture. Contingency Procedures		

Risk ID	**17 (Hz ID 17)**
Stage	Localiser established
Label	Approach controller alertness (human factor)
Failure Event	SII-NAP-V calls for aircraft to perform CDA within established routes without the need of vectoring / speed instructions to avoid noise-rich manoeuvres. The fact that W/E Approach controllers are left with separation monitoring tasks may impact their alertness and situational awareness levels with time.
Hazard Consequences	Reduction in alertness levels may prevent early detection of loss of horizontal and/or vertical separation resulting in *ATC workload increase*, as instructions may be required to restore separation.
Frequency	**Remote**

Severity	**Significant Incident (4)**	*Rationale*	ATC likely to rapidly detect separation breaches as they occur and unlikely to miss rapidly deteriorating separation, thus retaining ability to de-conflict situation.
Risk Tolerability	Acceptable		
Observations	Mitigation: Training and availability of safety net (e.g. STCA)		

Risk ID	**18 (Hz ID 18)**		
Stage	Localiser established		
Label	Wake vortex encounter		
Failure Event	Aircraft to fly into preceding adjacent aircraft wake vortex		
Hazard Consequences	Aircraft aerodynamic performance impaired		
Frequency	**Extremely Remote**		
Severity	**Accident (1)**	*Rationale*	Potential loss of flight control with catastrophic consequences, especially if close to ground.
Risk Tolerability	(Possibly) Unacceptable		
Observations	Further mitigation is required		

3.3.1.4. Approach Final Risks

Risk ID	**19 (Hz ID 19)**		
Stage	Glide Slope Intercept		
Label	Glide-slope undershoot		
Failure Event	ILS glide-slope interception through descent angles > 3º may cause aircraft to undershoot glide slope.		
Hazard Consequences	Flight crew will need to establish level flight to regain glide-slope path, with an associated increase in workload. .		
Frequency	**Probable**		
Severity	**Significant Incident (4)**	*Rationale*	Undershoot quickly detected and workload is increased to ascend/level to intercept glide-slope
Risk Tolerability	Acceptable (Minimum Safety Objective)		
Observations	Mitigation: early detection through GSI (Glide Slope Indicator)		

Risk ID	**20 (Hz ID 20)**
Stage	Glide Slope Intercept
Label	ILS false capture

Failure Event	ILS harmonic / sidelobe interception may cause GSI indications to switch polarity (e.g fly down instead of fly up)		
Hazard Consequences	Switched GSI indications while keeping such descent rate could cause flight crew to inadvertently descend below minimum glide slope safe angle with significant *CFIT* likelihood.		
Frequency	**Extremely Improbable**		
Severity	**Accident (1)**	*Rationale*	Aircraft descending at significant rate, polarity switch between instructions would indicate wrong direction to resolve the conflict (e.g. aircraft below glide-slope would receive GSI indication to descend in order to intercept, thus deteriorating the situation).
Risk Tolerability	Acceptable (Minimum Safety Objective)		
Observations	First false signal would appear approximately at 6 degrees (UK AIC 34/1997, Pink 147). Since SII-NAP-V descent rate is not associated with such steep descent angles its occurrence is not deemed realistic.		

Risk ID	**21 (Hz ID 21)**		
Stage	Glide Slope Intercept / Established		
Label	Unexpected extreme meteorological conditions		
Failure Event	Sudden change in meteorological conditions (e.g. windshear, strong cross winds, thunderstorms etc.) may impact applicability / adherence to procedure.		
Hazard Consequences	Sudden changes may cause non adhere to SII-NAP-V speed & vertical profiles, which could result in sudden *loss of horizontal and/or vertical separation*.		
Frequency	**Extremely Remote**		
Severity	**Serious Incident (2)**	*Rationale*	Sudden extreme meteorological conditions (e.g. squall) may bring about reductions in separation and aircraft deviating from their intended clearance with the possibility of large reductions in separation taking place
Risk Tolerability	Acceptable (Minimum Safety Objective)		
Observations	Mitigation: suitable meteorological conditions range will dictate procedure applicability, beyond which would dictate immediate reversion to fall back procedure to abandon SII-NAP. Barajas lack of extreme weather conditions.		

3.3.1.5. TMA Overall Risks

Risk ID	**22 (Hz ID 22)**
Stage	Any
Label	Loss of ATIS
Failure Event	Loss of ATIS (unavailability of ILS frequency broadcast)
Hazard	Loss of ATIS is associated with unavailability of redundant means to check ILS localiser frequency.

Consequences			
Frequency	**Extremely Remote**		
Severity	**Significant Incident (4)**	*Rationale*	CNS system capability slightly degraded
Risk Tolerability	Acceptable		
Observations	Broadcast of ILS localiser frequencies acts as mitigation for risk no.6 Localiser failed alignment		

4. Safety Assessment of Departure Procedure 2 (Optimised Close-In)

4.1. Concept of Operation

The operation under study corresponds to the Sourdine II Departure Procedure II (Optimised Close-In) extrapolated to Barajas in an anticipated 2015 scenario, with two sets of parallel runways. The study focuses on the most commonly used North Configuration at Barajas, 33L and 33R for approaches and 36L and 36R for departures as displayed in Figure 14

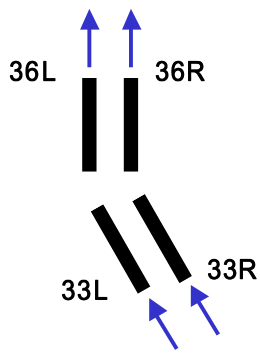


Figure 14. Barajas airport parallel runway north configuration

The scenario under consideration presents the following characteristics:

- ✓ Two sets of parallel runways.
- ✓ The arrivals and the departures are segregated.
- ✓ The distance between runways enables independent departures as well as independent arrivals procedures. There are some dependencies between arrivals to RWY 33R and departures from 36L due to the missed approach procedures from the 33R (in North configuration).

During the description of the operation for the Sourdine II Approach Procedure II applied to Barajas, the following hypotheses have been considered:

- ✓ The RWYs used for departures in North Configuration are 36R and 36L
- ✓ It has been considered only from the threshold to approximately 48 MN since lift-off.
- ✓ From a technological point of view:
  - o Communications: Mainly voice communication. Probably for 2015 there will be more datalink applications but this study is focused on the CDA for Barajas rather than on technological improvements
  - o Navigation: RNP1 in TMA. All the aircraft following the procedure will be equipped.
  - o Surveillance: Radar separation for departure.

- ✓ Aircraft equipped with new generation FMS, that allows to follow the procedure as it is described in [S II D3-1]
- ✓ Fleets: A340. The rationale for choosing these fleet is data availability
- ✓ Roles:
  - o Ground:
    - ▪ Departure controllers (one per RWY): West for 36L and East for 36R.
  - o Air:
    - ▪ Pilot flying
    - ▪ Pilot not flying

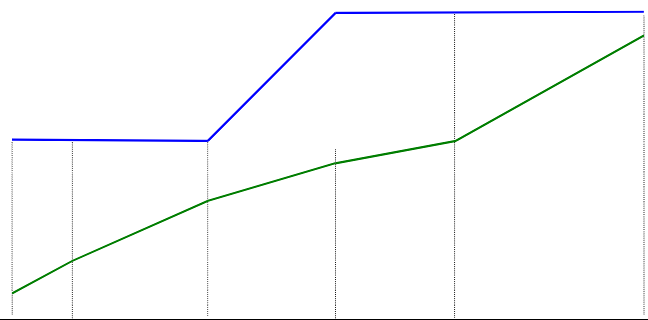
The departure procedure II (Optimised Close-In), considering the vertical profile, is described in the following table, from the data provided in the project:

Condition	Parameter values
0 ft	– TOGA (Take-off Go Around) thrust – Brake release and acceleration to rotation speedRotation and lift-off
	– Retraction of undercarriage – Climb out at speed of V2 + 10-20 KTS IAS
1000 ft	– Reduce thrust to OEI climb gradient or max climb (the lowest) – Maintain V2 + 10-20 KTS IAS
3000 ft	– If OEI climb gradient thrust was selected, gradually change to thrust to climb thrust – Maintain V2 + 10-20 KTS IAS
5000 ft	– Accelerate and retract flaps/slats on schedule to clean configuration – Continue acceleration to 250 KTS – Climb to 15000 ft

Table 4. Vertical description of SII Departure Procedure II

A representation from the above information can be seen in Figure 15 for A-340.

S –II Departure Procedure II Description



SID Point	00		10		20		30		40		50
Speed (Kt)	173		173		173		173		250		250
Height (ft)	0		1000		5000		7500		8340		15000
Distance from lift off (NM)	0		1.7		15.6		23.2		29.8		48.1

Figure 15. Description of the vertical profile of Departure Procedure II for the Airbus 340

The proposed structure of the future Madrid TMA, considering the new set of runways, includes new routes and procedures that will connect the airfield with the airways network, supplying the services levels required for the foreseen traffic demand.

The design conditions for the SIDs from RWYs 36R and 36L have the objective of achieving independence in departure operations. However there are some environmental conditions that impose restrictions. There are a high number of departure procedures and combination of departures considering both departure runways.

Most of the departure procedures from RWY 36L use routes towards the North and towards the West; these procedures are completely independent from the departures form RWY 36R.

With the objective of minimising the acoustic impact from the departures from RWY 36L, there is a procedure that is to be used by noisy aircraft that will go to the West or North. This procedure, called NAVAS LARGA, interferes with the departures from RWY 36R, considering the current ICAO rules. It consists on a departure climbing on runway heading with further turn to the right to follow 028º magnetic heading until intercepting and following radial VOR/DME BRA. This procedure includes a dead reckoning segment that interferes with the departures form the RWY 36R.

The following figures shows the set of departure procedures that are planned to be used in the future Barajas airport, North configuration, highlighting with the blue arrows the ones described above.

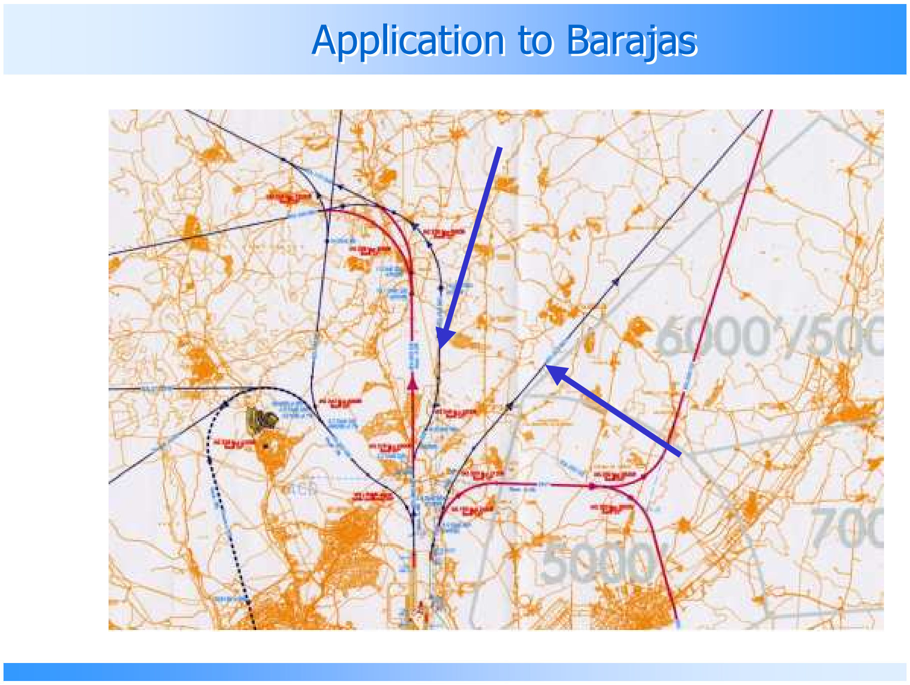


Figure 16. Future departure procedures in Barajas Airport.

The SII Departure Procedure II will be followed in all the SIDs, but the safety analysis described in this document focuses only on aircraft departing from this pair of departure procedures, which are not completely in line with the current standards regarding independent departure procedures but that could be treated as independent. They are considered as independent departures.

As another hypothesis, it has been considered total independence from Torrejón airport. In the real world, there are dependencies between RWY 36L departures and Torrejón airport.

4.2. Hazard Identification

In order to identify potential hazards associated with the SII departure NAP, one expert session was held with participation from a pilot, an ATC officer and safety personnel. An introduction was given on the parallel runway planned concept of operations at Barajas Airport (currently under development), modified to accommodate the SII NAP as described in section 4.1. The expert session participants were instructed to identify potential procedure failures and hazards only directly related to the SII NAP or whose consequences would be worsened by the implementation of the NAP. It must be emphasized that hazards completely independent of the NAP have not been considered, as the purpose of the study was to assess the safety of the SII procedure only. Taking these facts into account, the present safety assessment (neither in part nor in its entirety) cannot be construed in any way as the safety assessment of the planned Barajas Airport concept of operations to enter its operational stage in the near future.

4.2.1. Scope and Assumptions

The SII NAP scope and boundaries are defined by the following assumptions:

1. ATM-related hazards only (those inherent to the ATM system or impacting its capacity to maintain safety)
2. From runway threshold to reaching 15,000 feet.
3. All aircraft capable of RNAV with RNP1 in TMA and RNP0.3 in departures
4. All aircraft capable of flying SII NAP vertical profile
5. IFR only
6. Parallel runway independent operation
7. Range of adequate environmental / weather conditions present when SII NAP is flown
8. Departures from 36L and 36R (Barajas Airport North configuration)
9. ATCO and Flight Crew personnel trained on SII NAP

4.2.2. Identified Hazards

The information captured during the expert session was processed and as a result, ten hazards were identified applicable to the overall extent of the departure procedure. Thus, no categorisation as a function of phase of flight was deemed necessary.

The identified hazards are presented in the following subsection. Each hazard has been assigned a numerical identification (ID), the approach stage or action, a label (Label) and a causing failure event description (Failure Event). An additional cross-reference (CR) to the expert session notes (ESN) (in Appendix B), has also been allocated for traceability purposes. Note that some of the hazards identified in the arrival procedure safety analysis are also applicable for the departure NAP. Other hazards incorporated after the expert sessions have not been allocated any particular cross-reference label. During the expert sessions, the main objective was to identify as many hazards as possible in the limited time available without fully evaluating the potential consequences. A detailed analysis of each hazard potential outcome was carried out in the risk analysis to be presented later.

Hazard ID	**1**
Label	Engine Failure / Bird Strike
Failure Event	Engine failure may impact applicability / adherence to procedure
Hazard CR	*ESN 0617-3*

Hazard ID	**2**
Label	Unexpected extreme meteorological conditions
Failure Event	Sudden change in meteorological conditions (e.g. temperature inversions, windshear, strong cross winds, thunderstorms etc.) may impact applicability / adherence to procedure.
Hazard CR	*ESN 0617-3*

Hazard ID	**3**
Label	Flight Crew Error
Failure Event	Deviations / non-adherence to procedure’s required lateral trajectory (overruling FMS)
Hazard CR	*(internal safety assessment)*

Hazard ID	**4**
Label	Missed Approach conflict
Failure Event	Failure in go-around procedure following a missed approach on 33R
Hazard CR	*(internal safety assessment)*

Hazard ID	**5**
Label	Co-ordination error
Failure Event	Failure in Co-ordinating 36L departures with helicopter Region (Delta Colmenar)
Hazard CR	*ESN 0617-1*

Hazard ID	**6**
Label	Outdated FMS Database
Failure Event	Deviations / non-adherence to procedure's required vertical and/or lateral trajectory
Hazard CR	*ESN 0617-2*

Hazard ID	**7**
Label	Loss of FMS
Failure Event	FMS navigational assistance loss
Hazard CR	*ESN 0306-2, 1706-6*

Hazard ID	**8**
Label	Loss of RNP capability
Failure Event	Loss of on-board RNP capability causing inability to adhere to SII-NAP-II ascent trajectory
Hazard CR	*ESN 2705-2*

Hazard ID	**9**
Label	Loss of surveillance data
Failure Event	Inability to monitor separation as a consequence of loss of surveillance
Hazard CR	---

Hazard ID	**10**
Label	Loss of RT communication
Failure Event	Inability to communicate with aircraft
Hazard CR	---

4.3. Risk Assessment

The previously identified hazards have been evaluated in terms of its estimated frequency of occurrence and have been classified according to the severity of their effects. Subsequently, their risk tolerability has been determined according to ED-78A classification scheme in Figure 3.

Occurrence frequency classifiers of Probable, Remote, Extremely Remote and Extremely Improbable have been used. The rationale for classifying an event in one of those these categories has been made on a qualitative assessment by operational experts based on the likelihood of occurrence within the lifetime of the procedure (in flight hours), ranging from relatively frequent to extremely rare occurrences.

With regards to hazard severity classification, a rationale has been developed for each hazard aiming at describing the hazard credible consequences and "demonstrating the most probable effect of hazards, under the worst case scenario" as instructed by ESARR4.

4.3.1. Risk Analysis

The classified risks derived from all identified hazards are presented in the following subsections. Each risk has been assigned an identifier, which in all cases corresponds to the previous hazard numerical identification. Besides the originating hazard label and failure event, the hazard consequences, estimated frequency of occurrence, assigned severity together with its assignation rationale and their final risk tolerability are also presented. Additionally, an "observations" field is also included for any pertinent complementary information (such as potential mitigations etc).

Risk ID	**1 (Hz ID 1)**		
Label	Engine Failure / Bird Strike		
Failure Event	Engine failure may impact applicability / adherence to procedure		
Hazard Consequences	Aircraft flying NAP-II procedure are close to their "stall speed" (OEI power setting) for obvious noise reduction purposes. Engine failure may cause non adhere to SII-NAP-II speed & vertical profiles, which could result in sudden *loss of separation with ground/obstacles*. Emergency procedures would result in *ATC and flight crew workload increase*		
Frequency	**Extremely Improbable**		
Severity	**Significant Incident (4)**	*Rationale*	Modern aircraft are capable of sustaining an engine failure without major impact on airworthiness. Emergency procedures would apply for aircraft to return / fly to nearest airport.
Risk Tolerability	Acceptable		
Observations			

Risk ID	**2 (Hz ID 2)**
Label	Unexpected extreme meteorological conditions
Failure Event	Sudden change in meteorological conditions (e.g. temperature inversions, windshear, strong cross winds, thunderstorms etc.) may impact applicability / adherence to procedure.
Hazard	Aircraft flying NAP-II procedure are close to their "stall speed" (OEI power

Consequences	setting) for obvious noise reduction purposes. Sudden meteorological changes may cause sudden drop in airspeed / lift followed by non adherences to SII-NAP-II speed & vertical profiles, which could result in sudden *loss of separation with ground/obstacles*. Emergency procedures would result in *flight crew workload increase*		
Frequency	**Extremely Remote**		
Severity	**Major Incident (3)**	Rationale	Sudden extreme meteorological conditions (e.g. squall) may bring about reductions in separation and aircraft deviating from their intended clearance with the possibility of large reductions in separation taking place
Risk Tolerability	Acceptable		
Observations	Mitigation: suitable meteorological conditions range will dictate procedure applicability, beyond which would dictate immediate reversion to fall back procedure to abandon SII-NAP. Barajas lack of extreme weather conditions.		

Risk ID	**3 (Hz ID 3)**		
Label	Flight Crew Error		
Failure Event	Deviations / non-adherence to procedure's required lateral trajectory (overruling FMS)		
Hazard Consequences	Flight crews departing from SID trajectory (performing early, late turns or no turn at all) would breach parallel runway divergence requirements and could result in *loss of horizontal and/or vertical separation* with aircraft departing from opposing runway.		
Frequency	**Extremely Improbable**		
Severity	**Significant Incident (4)**	*Rationale*	ATC likely to rapidly detect deviation, which could lead to significant breaches of separation if it continued to develop, and take remedy action to restore separation.
Risk Tolerability	Acceptable		
Observations	Risk identified within AENA internal Barajas work performed by INECO. SII-NAP unlikely to have any detrimental impact (e.g. reduction of safety margins / manoeuvrability) in conflict resolution		

Risk ID	**4 (Hz ID 4)**
Label	Missed Approach conflict
Failure Event	Failure in go-around procedure following a missed approach on 33R
Hazard Consequences	Departures from 33L will be co-ordinated with arrivals into 33R. In case of a missed approach from 33R, ATC will adopt special procedure to manage the go-around. ATC or Flight crew miss-application in the go-around procedure may lead to *loss of horizontal and/or vertical separation* with aircraft previously departed from runway 33L.

Frequency	**Extremely Improbable**		
Severity	**Significant Incident (3)**	*Rationale*	Severity rationale: ATC likely to rapidly detect any potential conflict with previously departed aircraft and co-ordinate and implement remedy action.
Risk Tolerability	Acceptable		
Observations	SII-NAP unlikely to have any detrimental impact (e.g. reduction of safety margins / manoeuvrability) in conflict resolution		

Risk ID	**5 (Hz ID 5)**		
Label	Co-ordination error		
Failure Event	Failure in Co-ordinating 36L departures with helicopter Region (Delta Colmenar)		
Hazard Consequences	Aircraft departures from 36L need to co-ordinate with helicopter region (Colmenar). Any failure in co-ordination combined with aircraft drift may lead to *loss of horizontal and/or vertical separation.*		
Frequency	**Extremely Improbable**		
Severity	**Significant Incident (4)**	*Rationale*	ATC likely to rapidly detect potentially conflicting traffic in helicopter region and take remedy action to restore separation
Risk Tolerability	Acceptable		
Observations	Significant drifts highly unlikely with RNP capabilities As this particular region would be encounter above 5000ft along the SID, aircraft is already in clean configuration and thus SII-NAP unlikely to have any detrimental impact (e.g. reduction of safety margins / manoeuvrability) in resolution.		

Risk ID	**6 (Hz ID 6)**		
Label	Outdated FMS Database		
Failure Event	Deviations / non-adherence to procedure’s required vertical and/or lateral trajectory		
Hazard Consequences	Flight crew could inadvertently deviate from intended clearances while believing compliance, which could result in *loss of horizontal and/or vertical separation or loss of separation with ground/obstacles*.		
Frequency	**Remote**		
Severity	**Major Incident (3)**	*Rationale*	ATC likely to rapidly detect deviation, which could lead to significant breaches of separation within the transition zone, and take remedy action to restore separation
Risk Tolerability	Acceptable (Minimum Safety Objective)		

Observations	Mitigation: RNAV equipment certification standard, adequate airline upgrading procedures and early ATC deviation detection. (Note: Req. in EUROCAE/RTCA ED-76/DO-200A & Eurocontrol Standard Document on Area Nav Equipment Operational Requirements and Functional Requirements)		

Risk ID	**7 (Hz ID 7)**		
Label	Loss of FMS		
Failure Event	FMS navigational assistance loss		
Hazard Consequences	Following FMS loss, flight crew will revert to manual flight and would be unable to adhere to SII-NAP-II speed & vertical profiles, which could result in *ATC and flight crew workload increase*.		
Frequency	**Extremely Improbable**		
Severity	**Significant Incident (4)**	*Rationale*	Early detection by flight crew, who notify on RT about FMS loss and ATC to instruct to abandon NAP, restore separation if breached and revert to alternative procedure (separation with other ensured by vectoring & speed/ascent rate instructions)
Risk Tolerability	Acceptable		
Observations	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP		

Risk ID	**8 (Hz ID 8)**		
Label	Loss of RNP capability		
Failure Event	Loss of on-board RNP capability causing inability to adhere to SII-NAP-II ascent trajectory		
Hazard Consequences	Loss of RNP capability would be associated with an aircraft inability to adhere to SII-NAP-V speed & vertical profiles, which could result in *loss of separation with ground/obstacles*.		
Frequency	**Extremely Improbable**		
Severity	**Significant Incident (4)**	*Rationale*	Early detection by flight crew, who notify on RT about RNP loss and ATC to instruct to abandon NAP, restore separation if breached and revert to alternative procedure (separation with other aircraft ensured by vectoring & speed/ascent rate instructions)
Risk Tolerability	Acceptable		
Observations	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP.		

	(Note: Req in JAA TGL-10)

Risk ID	**9 (Hz ID 9)**		
Label	Loss of surveillance data		
Failure Event	Inability to monitor separation as a consequence of loss of surveillance		
Hazard Consequences	Inability to monitor non-adherences to SII-NAP-II speed & vertical profiles could result in undetected *loss of horizontal and/or vertical separation or loss of separation with ground/obstacles* would significantly erode safety margins.		
Frequency	**Extremely Improbable**		
Severity	**Major Incident (3)**	*Rationale*	ATC unable to monitor and detect significant breaches of separation.
Risk Tolerability	Acceptable		
Observations	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP. Overlapping radar coverage and resilient data-comms architecture		

Risk ID	**10 (Hz ID 10)**		
Label	Loss of RT communication		
Failure Event	Inability to communicate with aircraft		
Hazard Consequences	Aircraft *vertical and horizontal separations may deteriorate* very rapidly.		
Frequency	**Extremely Improbable**		
Severity	**Serious Incident (2)**	*Rationale*	ATC unable to communicate with aircraft directly.
Risk Tolerability	Acceptable		
Observations	Mitigation: Multiple Tx/Rx sites with overlapping coverage, emergency frequency, resilient data-comms architecture. Contingency Procedures		

5. Safety Assessments Conclusions

Qualitative safety assessments have been performed to analyse potential operational hazards associated with two approach Sourdine II noise abatement procedures. SII NAP arrivals procedure V and departures procedure 2 have been adapted to the parallel runway planned concept of operations at Barajas Airport (currently under development). Pilots, ATC, Procedure Designers and Safety personnel have contributed through expert sessions in the development of the present assessment. The main purpose of the assessments has been to evaluate the SII procedures safety implications when introduced into a realistic airport scenario. Only hazards directly related to the SII NAPs or whose consequences would be made worse by its implementation have been considered. Thus, the present safety assessments need to be considered within its intended scope and cannot be understood to cover, either partially or totally, any safety aspect of the future Barajas Airport operations.

5.1. Conclusions on Approach Procedure V Safety Assessment

When trying to extrapolate the vertical profiles described in SII to the future Barajas scenarios, a significant constraint was found. The future Barajas operations under current consideration for approaches to parallel runways are based in vertical separation. Therefore, a clear incompatibility arises when applying “pure” CDA to both approaches as the runway heads are not sufficiently staggered in distance to ensure a 1000ft vertical separation while performing independent continuous descent approaches to both runways. The adopted solution following extensive consultations with operational experts has been to modify the SII procedure with a level flight leg in the intermediate approach for approach to RWY 33R, due to the lower population density in the runway vicinity. In RWY 33L a pure SII- V procedure has been applied. This procedure modification was carried out prior to undertaking the safety assessment.

Identified hazards have been grouped as a function of the phase of flight within the approach stage into the following categories (the number of derived risks appear between brackets):

- TMA Transition (4)
- Approach Intermediate – Localiser Intercept (3)
- Approach Intermediate – Localiser Established (11)
- Approach Final (3)
- TMA Overall (1)

The outcome of the safety assessment has revealed a series of safety significant issues, which they are recommended to be analysed further. A distinction is made between those related to the inherent characteristics of the SII-NAP-V and those for which the particular parallel runway set-up is the determining factor when performing simultaneous and independent CDAs to both runways.

5.1.1. SII-NAP-V safety issues:

1. The fact that final approach controllers will only monitor separation rather than issue vectors to implement separation (except in conflict situations) makes that non-adherences to CDA speed descent profiles may cause aircraft to breach longitudinal separation (e.g. catch up aircraft ahead or be caught up by trailing aircraft). As a potential result, the probability of wake vortex encounters is likely toincrease. A simulation exercise for final approach standard separations for different traffic mixes at peak times will be required to determine whether CDAs could be sustained without being detrimental to airport capacity. Mitigation emergency procedures will also be required to manage breaches of separation during the final approach stage prior to the NTZ and the impact of

any aborted approaches on departures analysed. The risk of wake vortex encounter has been classified as possibly unacceptable (Risk ID 18) without further mitigation. Additionally, while some of the NAP deviation risks have been assessed as acceptable (Risks ID 8 & 9) , it must be noted that this tolerability is based on the minimum safety requirement established by ED78-A. The construction of a simulation model is recommended to evaluate the frequency of occurrence in more detail.

5.1.2. Parallel Runway Safety Issues

2. Within the final approach stage once established in the localiser, separation is ensured vertically. Thus, non-adherences to vertical CDA profiles may breach the 1000ft vertical separation that by design, should be maintained at all times between aircraft established on the parallel localisers prior to entering the NTZ. While the associated risk of such occurrences would be low, it would constitute a significant erosion of safety margins according to current safety standards and any subsequent non-adherence to the horizontal flight profile could rapidly develop into a serious incident with very little reaction time available.

3. Independent CDA-based approaches to parallel runway airport configurations exhibit a safety significant issue related to failed localiser intercepts, commonly known as localiser “overshoots”. In the future Barajas airport configuration, separation between aircraft established on the parallel localisers is based on 1000ft vertical separation at all times prior to entering the NTZ. As a consequence, small-excursion overshoots followed by rapid localiser interceptions would only be associated with an erosion of safety margins as vertical separation would be maintained with opposing traffic. However, wide-excursion overshooting developing into wrong localiser interception or adjacent sector non-authorised incursion would pose a safety critical issue as while continuously descending vertical separation with other aircraft in the vicinity would rapidly be eroded. The outcome of the safety assessment has showed that there may be UNACCEPTABLE risks associated with localiser-failed interceptions (Risk Ids 5.3 & 6.3). It is also recommended that a simulation model be constructed in order to obtained a more detailed risk quantification and established the most severe incidents likelihood of occurrence.

As a consequence, the qualitative assessment shows that the SII-NAP-V procedure adapted to the future Barajas Airport parallel runway configuration exhibits some safety significant issues that are in need of a more detailed and quantitative analysis. It is recommended that the analysis takes into consideration the inclusion of decision support tools such as an Arrival Manager (AMAN) to manage the arrival sequences on both runways. It is also suggested that a safety-net additional functionality is considered in order to monitor potential longitudinal breaches of separation for localiser-established consecutive aircraft.

5.2. Conclusions on Departure Procedure 2 Safety Assessment

The hazard identification has been carried out through a aingle brainstorming session with operational personnel and further analysis with safety experts. It must be noted that resource constraints limited the number of operational experts involved in this particular departure procedure analysis. For this reason the assessment has been termed as a high level safety assessment. Ten hazards were identified during the expert session for the Sourdine II Departure Procedure 2, adapted to the future Barajas airport layout. Given the number of hazards and the characteristics of the procedure, the hazards were not classified into any particular categories. Five of the identified hazards are inherently characteristic of the departure procedure and the remaining five are of a more general nature and are also applicable to departures as well as to arrivals procedures.

The SII NAP departure procedure 2 aims at reducing the noise impact around the SID footprint at ranges closest to the runway, causing the aircraft to operate at reduced performance with OEI (One Engine Inoperable) power settings. This fact necessarily imposes that the main procedure risks will be associated with airport obstacle limiting surface infringements that may lead to loss of separation with obstacles and/or ground. The main emphasis of the assessment was placed on whether the procedure-induced departure from the aircraft optimal climbing performance could erode safety margins. In particular, the assessment has taken into account whether aircraft flying the SII departure 2 procedure could easily recover from other failures, even though flying at OEI power settings.

The safety assessment concludes that the most significant risks associated with the SII NAP Departure 2 procedure are due to either engine loss (such as a catastrophic malfunction or malfunction caused by a bird strike) or sudden adverse meteorological conditions (such as windshear or thunderstorm turbulence) that could impair the aircraft airworthiness. However, it is deemed that aircraft could recover from these situations despite flying at reduced power settings and therefore, the procedure does not degrade safety margins. The combination of both hazards (engine loss and adverse meteorological conditions) could have a significant safety impact, however this could be mitigated by restricting the range of meteorological conditions in which the SII NAP Departure 2 procedure may be flown.

The conducted high level assessment has concluded with all identified risks having been preliminarily considered as acceptable. Given the high level nature of the assessment in terms of number of participating experts, it is recommended that further analysis is undertaken to increase the confidence in the resulting risk classification.

Appendix A Expert Sessions Notes – Approach Procedure V

SII WP4.2 - HAZARD IDENTIFICATION SESSION 0 (INTERNAL)
27th May 2004

Attendees

D. Alfredo Gómez de Segura	SII, AENA DDSNA	Da. Marifé Antón Cruz	SII, AENA DDSNA
D. Juan A Herrería García	AENA DDSNA	D. Lluís Vinagre Solans	SII, AENA DDSNA
D. Manuel Abellán Madrid	AENA DDSNA		

Agenda

10:00	Agenda
	SII NAP-V Procedure – Barajas adaptation Introduction
	Safety and Risk Analysis
	Objectives
	Hazard Identification Session
12:00	End

SESSION NOTES

Id	Notes	Derived Hazards / Actions
1	Aircraft performance may not support CDA while turning (turn increases descent speed)	Check with Airbus
2	Non-adherence to CDA may cause loss of separation.	2705-1
3	A fallback procedure to abandon the SII would mitigate the loss of RNP capability.	2705-2
4	ILS glideslope interception “from above” (through a descent angle > 3º). Possibility for ILS harmonic / sidelobe interception.	2705-3
5	Incorrect data introduction in FMS may cause aircraft to fly unintended trajectory within the transition zone and start SII-NAP-V (CDM) earlier / later than anticipated.	2705-4
6	Sudden change in meteorological conditions (e.g. windshear) may impact adherence to procedure.	2705-5
7	Manual SII-NAP-V procedure would be associated with a very high increase in workload. Assumption is that SII only applies with FMS flight control and not manual.	---
8	CDA begins within different points within the routes in the transition grid, difficult to monitor	(risk of early / late CDA beginning)
9	Different fleet mix, not all aircraft may be capable of flying SII-NAP-V	2705-1

	procedure	
10	Change of runways may cause confusion to pilot	
11	Small vertical trajectory deviations may trigger TCAS nuisance TA and/or RA. It was noted that future ACAS / TCAS functionality will reduce nuisance alarm rate in by reducing the height difference required to trigger an alert to 500ft in Terminal Area.	2705-6
12	Missed approach (effect of the previous missed approaches)	

SII WP4.2 - HAZARD IDENTIFICATION SESSION 1

Attendees

D. José Pérez Pérez	Retired Pilot, ISDEFE	Da. Marifé Antón Cruz	SII, AENA DDSNA
D. Ramón Expósito Puertas	ATCO, AENA DT	D. Lluís Vinagre Solans	SII, AENA DDSNA

Agenda

10:00 Agenda

SII NAP-V Procedure – Barajas adaptation Introduction

Safety and Risk Analysis

Objectives

Hazard Identification Session

12:00 End

SESSION NOTES

Id	Notes	Derived Hazards / Actions
13	ATCOs can only control descent through rate of descent instructions and not through mandating descent angles. CONOPS. Within SII-NAP-V adapted procedure, E/W Approach controllers do not ensure separation through vectoring; separation is maintained through adequate sequencing by E/W Director controllers within and aircraft adherence to NAP procedure (CDM). While ATCOs are responsible for maintaining separation, there was concern the S-NAP-V allowed room for pilots to deviate (advertently or inadvertently) from the procedure. It was noted that future FMS capability would be required for the aircraft to accurately fly the required trajectory	0306-1 0306-2
14	There was consensus on SII-NAP-V imposed aircraft configuration to follow mandated vertical trajectory could not impact negatively (e.g. delay) the aircraft ability to undertake an evasion manoeuvre.	---
15	ICAO Doc. 8168 Flight Procedures specifies a period of level flight prior to ILS interception. It was noted that SII-NAP-V trajectory lacked this level flight stage and that added complexity would be added by ILS glideslope interception “from above” (through a descent angle > 3º). Possibility for ILS harmonic / sidelobe interception.	0306-3 0306-4 Check equipment performance / previous incidents
16	The perpendicular or turn legs between the upwind & downwind circuits	0306-5

	within the transition zone are opposed between the East and West grids in the current design. Aircraft about to turn into the localizer path in one approach sector may not be able to establish visual contact with an aircraft overshooting the turn into the opposed localiser path. Despite the fact that vertical separation should be maintained any deviation in trajectory may cause a loss of separation.	
17	E / W Approach controllers monitor separation and issue R/T instructions on their sectors on separate independent frequencies. A scenario in which an E Approach sector aircraft was in conflict with a W Approach sector (e.g. unauthorised sector intrusion), each controller could only issue conflict resolution instructions to their own aircraft.	0306-5
18	Small vertical trajectory deviations may trigger TCAS nuisance TA and/or RA. It was noted that future ACAS / TCAS functionality will reduce nuisance alarm rate in by reducing the height difference required to trigger an alert to 500ft in Terminal Area.	0306-6
19	Incorrect data introduction in FMS may cause aircraft to fly unintended trajectory within the transition zone and start SII-NAP-V (CDM) earlier / later than anticipated.	0306-7
20	It was noted that aircraft IAS were relatively low during approach.	Check with Airbus
21	Sudden change in meteorological conditions (e.g. windshear) may impact adherence to procedure.	0306-8

SII WP4.2 - HAZARD IDENTIFICATION SESSION 2
17th June 2004

Attendees

D. Jenaro López Íñiguez	Active Pilot	Da. Marifé Antón Cruz	SII, AENA DDSNA
D. José Puente Abelleira	Supervisor, AENA DT	D. Lluís Vinagre Solans	SII, AENA DDSNA

Agenda

10:00	Agenda
	SII NAP-V Procedure – Barajas adaptation Introduction
	Safety and Risk Analysis
	Objectives
	Hazard Identification Session
12:00	End

SESSION NOTES

Id	Notes	Derived Hazards / Actions
22	Dependency between departures from Torrejon Air Base and arrivals at Barajas[1].	Outside scope of study
23	RNAV navigation will facilitate aircraft crew tasks during approach, but may introduce ATCO confidence issues in the sense that without CDA approaches, ATCO is responsible for vectoring to maintain separation (usually introducing extra separation as a comfort “buffer”) whereas with CDA, while ATCO is still responsible for separation, s/he only monitors the separation and would issue a resolution instruction in case separation was breached.	1706-1
24	Weight may impact aircraft performance during CDA (e.g. overload), which may difficult ability to adhere to SII-NAP-V trajectory.	1706-1

1 While the identified dependency constitutes an obvious hazard, the objective of this safety study concentrates on the potential safety implications of the noise abatement procedure (i.e. the dependency between Torrejón and Barajas exists independently of the SII procedure given their close proximity).

25	All aircraft within the fleet may not be capable of flying CDA with equivalent performances.	1706-1
26	It was noted that aircraft IAS were relatively low during approach (especially if aircraft was to be overloaded)	Check with Airbus
27	Overshooting aircraft performing a CDA (aircraft would keep descending while performing the late turn) with consequent risk of breaching vertical and horizontal separation simultaneously. Were two aircraft to become in conflict (e.g. overshooting in W approach sector and approaching on localiser path in E approach sector) would have the controller responsible for the overshooting aircraft to instruct a return to localiser path while the other approach controller may issue instructions for appropriate avoiding action. If overshoot developed into a sector intrusion, any conflicting aircraft would be on different RT frequencies and either controller could not issue resolution instructions to the aircraft without coordinating with opposite approach controller. Should TCAS RA capabilities be active and RA issued on both aircraft, controllers could not issue resolution instructions and RA may cause either aircraft to enter into other conflicts with other approaching aircraft within the intruded sector transition zone.	1706-2
28	Failure to introduce the correct localiser frequency would cause approaching aircraft to overshoot the localiser path, which may cause a conflict with approaching aircraft in opposing sector.	1706-3
29	False localiser signals (e.g. reflections) may cause aircraft to turn early into false localiser path.	1706-4
30	Current ILS interception equipment makes it straightforward to intercept glisdeslope on autopilot while flying level. It was deemed that ILS glideslope interception angle “from above” (through a descent angle > 3º) may increase the probability of undershoot the glideslope.	1706-5
31	It was deemed that ILS glideslope interception angle “from above” (through a descent angle > 3º) was not sufficiently large to have a risk of harmonic / sidelobe interception.	---
32	Loss of FMS would imply the inability to adhere to CDA procedure	1706-6
33	Failure to update FMS database with newest information upgrades (waypoints, stars etc) may cause unintended aircraft trajectories.	1706-7
34	It was deemed that aircraft could comply with required CDA performance while in turn.	---
35	QNH corruption, although deemed very rare, could impact adherence to CDA. It was noted that aircraft would notice loss of height prior to the approach stage.	---

Appendix B Expert Sessions Notes – Departure Procedure 2

SII WP4.2 - HAZARD IDENTIFICATION SESSION 1 -DEP
17th June 2005

Attendees

D. Gonzalo Torres	Pilot
D. Ramón Vega Alonso	AENA ACC Madrid
Da. Marifé Antón Cruz	SII, AENA DDSNA
D. Lluís Vinagre Solans	SII, AENA DDSNA

Agenda

10:00 Agenda
SII NAP-II-DEP Procedure – Barajas adaptation Introduction
Safety and Risk Analysis
Objectives

BREAK

Hazard Identification Session
12:00 End

SESSION NOTES

Id	Notes	Derived Hazards / Actions
36	Dependency between departures from Barajas and arrivals at[2] Torrejón Air Base	Outside scope of study
37	Impact of the procedure on some existing Military areas that require coordination	0617-1
3	For safety reasons, turns at departure cannot be done with speeds higher than 210 Knots IAS (for some A/C)	
4	Failures in communications. NO direct impact on safety but big impact on number of operations	
5	Differences in on-board and on-ground data	0617-2

[2] While the identified dependency constitutes an obvious hazard, the objective of this safety study concentrates on the potential safety implications of the noise abatement procedure (i.e. the dependency between Torrejón and Barajas exists independently of the SII procedure given their close proximity).

6	Mix of traffic can lead the controller to clear operations without the minimum separation due to wake vortex. There are limitations in the diversion due to parallel runways operating dependently.	
7	Due to the terrain configuration, some diversion manoeuvrings can break the minimum vertical distance with the terrain.	0617-3
8	If aircraft departing from the 36R do not turn and go straight ahead (several reasons: engine failure, birds, FMS wrong data, ….), the diversion manoeuvrings can need coordination between the two departure controllers; this coordination will be very easy because they will be sitting together but some extra delay is introduced.	Hot lines with APP
9	SII procedure makes the aircraft fly close to their “stall speed” . This requires an extra time for reaction if any unforeseen event appears.	0617-3
10	This procedure is complex and, without FMS; it would increase the workload of the pilot	Not relevant for the study (FMS working)

Appendix C SII WP4.2, Barajas Parallel Runway SII-NAP-V (CDA) Hazards, Risk and Tolerability Table

SII WP4.2 – Barajas Parallel Runway SII-NAP-V (CDA) Hazards, Risk and Tolerability Table

ID	*Phase of Flight – (Task)*	*Hazard Label*	*Failure Event / Mode*	*Hazard Consequences*	*Frequency (estimated)*	*Severity (assigned)*	*Risk Tolerability*	*Observations*
1	TMA Transition (Sequencing)	Deviation from arrival sequence due to data input error	Incorrect data introduction in FMS by pilot about cleared route within the transition zone grid.	Introducing an incorrect cleared route within FMS may cause aircraft to fly an unauthorised trajectory and start SII-NAP-V (CDA) earlier / later than anticipated, which may result in *loss of horizontal and/or vertical separation*. Severity rationale: ATC likely to rapidly detect deviation, which could lead to significant breaches of separation within the transition zone, and take remedy action to restore separation.	Remote	Major Incident (3)	Acceptable (Minimum Safety Objective)	Double check procedures between Flying Pilot & Non-Flying Pilot Early ATC detection
2	TMA Transition - (Sequencing)	Outdated FMS Database	Deviations / non-adherence to procedure's required vertical and lateral trajectory	Flight crew could inadvertently deviate from intended clearances while believing compliance, which could result in *loss of horizontal and/or vertical separation*. Severity rationale: ATC likely to rapidly detect deviation, which could lead to significant breaches of separation within the transition zone, and take remedy action to restore separation.	Remote	Major Incident (3)	Acceptable (Minimum Safety Objective)	Mitigation: RNAV equipment certification standard, adequate airline upgrading procedures and early ATC deviation detection. (Note: Req. in EUROCAE/RTCA ED-76/DO-200A & Eurocontrol Standard Document on Area Nav Equipment Operational Requirements and Functional Requirements)
3	TMA Transition - (Sequencing)	RT read back error	Read back error by pilot not detected by ATCO. As a result aircraft may fly an unauthorised trajectory and start SII-NAP-V (CDM) earlier / later than anticipated.	Undetected read back error may cause aircraft to fly an unauthorised trajectory and start SII-NAP-V (CDM) earlier / later than anticipated, which may result in *loss of horizontal and/or vertical separation*. Severity rationale: ATC likely to rapidly detect deviation, which could lead to significant breaches of separation within the transition zone, and take remedy action to restore separation.	Extremely Remote	Serious Incident (2)	Acceptable (Minimum Safety Objective)	Mitigation: Adherence to RT procedures and likelihood of deviation early detection by either Director or Approach controller

ID	*Phase of Flight – (Task)*	*Hazard Label*	*Failure Event / Mode*	*Hazard Consequences*	*Frequency (estimated)*	*Severity (assigned)*	*Risk Tolerability*	*Observations*
4	TMA Transition - (Sequencing)	ATC clearance error	ATC (Director controller) inadvertently issues an aircraft an incorrect / unintended clearance route within the transition zone	Aircraft flying unintended route may result in *loss of horizontal and/or vertical separation.* Severity rationale: ATC likely to rapidly detect clearance error, which could lead to significant breaches of separation within the transition zone, and take remedy action to restore separation.	Extremely Improbable	Major Incident (3)	Acceptable	Mitigation: likelihood of deviation early detection by either Director or approach controller
5	Approach Intermediate – (Loc intercept)	Localiser overshoot	Late turn into / overshoot the localiser path / runway heading alignment while performing CDA. Aircraft failing to turn or performing a very late turn while performing CDA could intrude into opposing Approach sector.	Aircraft overshooting while performing continuous descent may result in *simultaneous loss of vertical and horizontal separation* with aircraft on opposed approach sector.				
				Severity rationale: ATC promptly detects deviation from localiser and instructs remedy action. Flight crew acts upon reception of remedy instruction and returns to establish on localiser, with an associated workload increase. (event tree outcomes 1 & 4)	Remote	Significant Incident (4)	Acceptable	
				Severity rationale: if aircraft overshoot is not rapidly detected by ATC (or flight crew) vertical and horizontal separation with aircraft in adjacent approach sector would be quickly eroded. Should the overshoot progress in the absence of immediate conflict, the flight path deviation would be eventually detected and redressed by ATC. (event tree outcomes 3 & 6)	Extremely Improbable	Major Incident (3)	Acceptable	

ID	Phase of Flight – (Task)	Hazard Label	Failure Event / Mode	Hazard Consequences	Frequency (estimated)	Severity (assigned)	Risk Tolerability	Observations
				Severity rationale: if aircraft overshoot is not rapidly detected by ATC (or flight crew) with the overshoot developing into sector intrusion in the presence of immediate conflict (e.g. aircraft established on localiser in adjacent approach sector), the E/W Approach controller inability to address or issue complementary resolution instructions (e.g. vertical resolution) to both aircraft in conflict as intruding aircraft would be tuned into different approach R/T frequency combined with TCAS Resolution Advisories would inevitably involve a workload increase for both approach controllers to coordinate action with little reaction time available, as separation amongst aircraft within intruded transition zone may deteriorate rapidly leading to avoidance manoeuvres causing multiple conflicts. (event tree outcomes 2 & 5)	Extremely Improbable	Serious Incident (2) / Accident (1)	(Possibly) Unacceptable	
6	Approach Intermediate – (Loc intercept)	Introduction of incorrect ILS localiser frequency *Haz Ids 1706-3*	Introduction of incorrect ILS localiser frequency	Incorrect ILS localiser frequency will cause aircraft to miss turn to align into the localiser path that could lead to an intrusion into the opposed approach sector and may result in *simultaneous loss of vertical and horizontal separation.*				Mitigation: ILS localiser frequencies broadcast on ATIS. Pilots confirm given ILS localiser frequencies on RT following approach clearance instruction (which includes localiser frequency). The Standard Operating Procedures on the Airbus 320/340 fleet, the ILS frequency is auto-tuned when pilot selects the appropriate APP procedure in the FMGS. Other aircraft types using
				Severity rationale: ATC promptly detects deviation from localiser and instructs remedy action. Flight crew acts upon reception of remedy instruction and returns to establish on localiser, with an associated workload increase. (event tree outcome 1 & 4))	Extremely Improbable	Significant Incident (4)	Acceptable	

ID	*Phase of Flight – (Task)*	*Hazard Label*	*Failure Event / Mode*	*Hazard Consequences*	*Frequency (estimated)*	*Severity (assigned)*	*Risk Tolerability*	*Observations*
				Severity rationale: if aircraft overshoot is not rapidly detected by ATC (or flight crew) vertical and horizontal separation with aircraft in adjacent approach sector would be quickly eroded. Should the overshoot progress in the absence of immediate conflict, the flight path deviation would be eventually detected and redressed by ATC. (event tree outcomes 3 & 6)	Extremely Improbable	Major Incident (3)	Acceptable	advanced FMS systems also use this procedure. However manual tuning is possible in case of navigation database errors
				Severity rationale: if aircraft overshoot is not rapidly detected by ATC (or flight crew) with the overshoot developing into sector intrusion in the presence of immediate conflict (e.g. aircraft established on localiser in adjacent approach sector), the E/W Approach controller inability to address or issue complementary resolution instructions (e.g. vertical resolution) to both aircraft in conflict as intruding aircraft would be tuned into different approach R/T frequency combined with TCAS Resolution Advisories would inevitably involve a workload increase for both approach controllers to coordinate action with little reaction time available, as separation amongst aircraft within intruded transition zone may deteriorate rapidly leading to avoidance manoeuvres causing multiple conflicts. (event tree outcomes 2 & 5)	Extremely Improbable	Serious Incident (2) / Accident (1)	(Possibly) Unacceptable	
7	Approach Intermediate – (Loc intercept)	Localiser failed alignment *Haz Ids 1706-4*	Erroneous ILS localiser signal (e.g. strong reflection) may cause aircraft to turn early into wrong localiser path.	Inadvertent establishment into incorrect localiser path may result in *loss of vertical and/or horizontal separation.* Severity rationale: Aircraft approaching runway beyond the localiser path could risk inadvertently descending below safe altitudes and coming into the proximity of obstacles requiring sudden manoeuvres to avoid CFIT. Scenario aggravated during low visibility procedures.	Extremely Improbable	Serious Incident (2)	Acceptable	Mitigation: mandatory to indicate areas of erroneous localiser signals in arrival charts.

ID	*Phase of Flight – (Task)*	*Hazard Label*	*Failure Event / Mode*	*Hazard Consequences*	*Frequency (estimated)*	*Severity (assigned)*	*Risk Tolerability*	*Observations*
8	Approach Intermediate/ (Loc established)	SII-NAP-V procedure vertical deviation *Haz Ids 0306-1, 1706-1 & 2705-1*	Deviations / non-adherence to procedure's required speed and/or vertical profiles (e.g. different aircraft performances, aircraft overload etc)	Deviations from required profiles may cause aircraft to *breach vertical separation* that would result in *ATC workload increase*, as instructions would be required to restore separation. Severity rationale: ATC likely to rapidly detect breach of separation, such as vertical separation breached between two aircraft established on localisers for parallel runways, and take remedy action to restore vertical separation.	Probable	Significant Incident (4)	Acceptable (Minimum Safety Objective)	CONOPS. Within SII-NAP-V adapted procedure, W/E Approach controllers do not ensure separation through vectoring; separation is established through adequate sequencing by W/E Director controllers within and aircraft adherence to NAP procedure (CDA). Potential detrimental impact to capacity.
9	Approach Intermediate/ (Loc established)	SII-NAP-V procedure longitudinal deviation *Haz Ids 0306-1, 1706-1 & 2705-1*	Deviations / non-adherence to procedure's required speed and/or descent rate profiles (e.g. different aircraft performances, aircraft overload etc)	Deviations from required profiles may cause aircraft to *breach horizontal (e.g. longitudinal separation between aircraft) separation* leading to aircraft catching up aircraft ahead/falling behind trailing aircraft, that would result in *ATC workload increase*, as instructions would be required to restore separation. Severity rationale: ATC likely to rapidly detect breach of longitudinal separation, and take remedy action to restore separation, though trailing aircraft remains at risk of flying into preceding aircraft wake vortex.	Probable	Significant Incident (4)	Acceptable (Minimum Safety Objective)	
10	Approach Intermediate/ (Loc established)	SII-NAP-V procedure lateral deviation	Deviations / non-adherence to procedure's required lateral flight profile while established on the localiser path	Lateral deviations from required profiles (e.g drifts) may cause aircraft to *depart from the established localiser path,* and instructions would be required to restore separation, abort landing or to break away. Severity rationale: ATC likely to rapidly detect breach of lateral separation, and take remedy action to restore separation/break away.	Remote	Major Incident (3)	Acceptable (Minimum Safety Objective)	Mitigation: early NTZ warning while on final approach + negligible FTE (Flight Technical Error)

ID	*Phase of Flight – (Task)*	*Hazard Label*	*Failure Event / Mode*	*Hazard Consequences*	*Frequency (estimated)*	*Severity (assigned)*	*Risk Tolerability*	*Observations*
11	Approach Intermediate/ (Loc established)	Loss of FMS *Haz Ids 0306-2, 1706-6*	FMS navigational assistance loss	Following FMS loss, flight crew will revert to manual flight and would be unable to adhere to SII-NAP-V speed & vertical profiles, which could result in *ATC and flight crew workload increase*. Severity rationale: early detection by flight crew, who notify on RT about FMS loss and ATC to instruct to abandon NAP, restore separation if breached and revert to alternative procedure (separation with other ensured by vectoring & speed/descent rate instructions)	Extremely Improbable	Significant Incident (4)	Acceptable	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP. (Note: Req in JAA TGL-10)
12	Approach Intermediate/ (Loc established)	Loss of RNP capability *Haz Ids 2705-2*	Loss of on-board RNP capability causing inability to adhere to SII-NAP-V descent trajectory	Loss of RNP capability would be associated with an aircraft inability to adhere to SII-NAP-V speed & vertical profiles, which could result in *loss of horizontal and/or vertical separation*. Severity rationale: early detection by flight crew, who notify on RT about RNP loss and ATC to instruct to abandon NAP, restore separation if breached and revert to alternative procedure (separation with other aircraft ensured by vectoring & speed/descent rate instructions)	Extremely Improbable	Significant Incident (4)	Acceptable	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP. (Note: Req in JAA TGL-10)
13	Approach Intermediate/ (Loc established)	Loss of RNP capability *Haz Ids 2705-2*	Loss of off-board RNP capability (e.g. augmentation system)	Loss of overall RNP capability would be associated with aircraft inability to adhere to SII-NAP-V speed & vertical profiles, which could result in *loss of horizontal and/or vertical separation*. Severity rationale: early detection by ATC, who notify on RT about RNP loss and ATC to instruct to abandon NAP, restore separation if breached and revert to alternative procedure (separation ensured by vectoring & speed/descent rate instructions)	Extremely Improbable	Significant Incident (4)	Acceptable	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP.

ID	*Phase of Flight – (Task)*	*Hazard Label*	*Failure Event / Mode*	*Hazard Consequences*	*Frequency (estimated)*	*Severity (assigned)*	*Risk Tolerability*	*Observations*
14	Approach Intermediate/ (Loc established)	SII-NAP-V vertical path deviation *Haz Ids 0306-6 2705-6*	Small deviations in vertical and or horizontal trajectory (slight non adherence to NAP profile) may trigger nuisance TCAS Traffic and alerts	Deviations would result in *flight crew and ATC workload increase*, as monitoring and instructions may be required to restore separation. Severity rationale: Small deviations in vertical trajectory when aircraft are established on parallel localiser tracks, albeit no risk bearing, would increase workload to monitor situation and issue additional instructions.	Probable	Significant Incident (4)	Acceptable (Minimum Safety Objective)	Safety Net (e.g. STCA) and improved functionality in future TCAS algorithmic/versions may mitigate risk. Note. TA/RA availability not yet established within CONOPS.
15	Approach Intermediate/ (Loc established)	Loss of surveillance data	Inability to monitor separation as a consequence of loss of surveillance	Inability to monitor non-adherences to SII-NAP-V speed & vertical profiles resulting in *loss of horizontal and/or vertical separation* would significantly erode safety margins. Severity rationale: ATC unable to monitor and detect significant breaches of separation.	Extremely Improbable	Major Incident (3)	Acceptable	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP. Overlapping radar coverage and resilient data-comms architecture
16	Approach Intermediate/ (Loc established)	Loss of RT communication	Inability to communicate with aircraft through RT Director and/or Approach frequencies	Aircraft *vertical and horizontal separations to deteriorate* very rapidly. Severity rationale: ATC unable to communicate wih aircraft directly.	Extremely Improbable	Serious Incident (2)	Acceptable	Mitigation: Multiple Tx/Rx sites with overlapping coverage, emergency frequency, resilient data-comms architecture. Contingency Procedures
17	Approach Intermediate/ (Loc established)	Approach controller alertness (human factor)	SII-NAP-V calls for aircraft to perform CDA within established routes without the need of vectoring / speed instructions to avoid noise-rich manoeuvres. The fact that W/E Approach controllers are left with separation monitoring tasks may impact their alertness and situational awareness levels with time.	Reduction in alertness levels may prevent early detection of loss of horizontal and/or vertical separation resulting in *ATC workload increase*, as instructions may be required to restore separation. Severity rationale: ATC likely to rapidly detect separation breaches as they occur and unlikely to miss rapidly deteriorating separation, thus retaining ability to de-conflict situation.	Remote	Significant Incident (4)	Acceptable	Mitigation: Training and availability of safety net (e.g. STCA)
18	Approach Intermediate/ (Loc established)	Wake vortex encounter	Aircraft to fly into preceding adjacent aircraft wake vortex	Aircraft aerodynamic performance impaired Severity Rationale: Potential loss of flight control with catastrophic consequences, especially if close to ground.	Extremely Remote	Accident (1)	(Possibly) Unacceptable	Further mitigation is required

ID	*Phase of Flight – (Task)*	*Hazard Label*	*Failure Event / Mode*	*Hazard Consequences*	*Frequency (estimated)*	*Severity (assigned)*	*Risk Tolerability*	*Observations*
19	Approach Final – (G/S intercept)	Glide-slope undershoot *Haz Ids 1706-5*	ILS glide-slope interception through descent angles > 3º may cause aircraft to undershoot glide slope.	Flight crew will need to establish level flight to regain glide-slope path, with an associated increase in workload. . Severity rationale: Undershoot quickly detected and workload is increased to ascend/level to intercept glide-slope	Probable	Significant Incident (4)	Acceptable (Minimum Safety Objective)	Mitigation: early detection through GSI (Glide Slope Indicator)
20	Approach Final – (G/S intercept)	ILS false capture Haz Ids 0306-4 & 2705-3	ILS harmonic / sidelobe interception may cause GSI indications to switch polarity (e.g fly down instead of fly up)	Switched GSI indications while keeping such descent rate could cause flight crew to inadvertently descend below minimum glide slope safe angle with significant *CFIT* likelihood. Severity rationale: Aircraft descending at significant rate, polarity switch between instructions would indicate wrong direction to resolve the conflict (e.g. aircraft below glide-slope would receive GSI indication to descend in order to intercept, thus deteriorating the situation).	Extremely Improbable	Accident (1)	Acceptable (Minimum Safety Objective)	First false signal would appear approximately at 6 degrees (UK AIC 34/1997, Pink 147). Since SII-NAP-V descent rate is not associated with such steep descent angles its occurrence is not deemed realistic. However, this hazard becomes crucial for SII-NAP-IV.
21	Approach Final	Unexpected extreme meteorological conditions *Haz Ids 0306-8 & 2705-5*	Sudden change in meteorological conditions (e.g. windshear, strong cross winds, thunderstorms etc.) may impact applicability / adherence to procedure.	Sudden changes may cause non adhere to SII-NAP-V speed & vertical profiles, which could result in sudden *loss of horizontal and/or vertical separation*. Severity rationale: Sudden extreme meteorological conditions (e.g. squall) may bring about reductions in separation and aircraft deviating from their intended clearance with the possibility of large reductions in separation taking place	Extremely Remote	Serious Incident (2)	Acceptable (Minimum Safety Objective)	Mitigation: suitable meteorological conditions range will dictate procedure applicability, beyond which would dictate immediate reversion to fall back procedure to abandon SII-NAP. Barajas lack of extreme weather conditions.
22	TMA Overall - (Information Service)	Loss of ATIS	Loss of ATIS	Loss of ATIS is associated with unavailability of redundant means to check ILS localiser frequency. Severity rationale: CNS system capability slightly degraded	Extremely Remote	Significant Incident (4)	Acceptable	Broadcast of ILS localiser frequencies acts as mitigation for risk no.6 Localiser failed alignment

Appendix D SII WP4.2, Barajas Parallel Runway SII-NAP- Departure 2 (Optimised Close-in) Hazards, Risk and Tolerability Table

SII WP4.2 – Barajas Parallel Runway SII-NAP- Departure 2 (Optimised Close-in) Hazards, Risk and Tolerability Table

ID	*Hazard Reference*	*Failure Event / Mode*	*Hazard Description*	*Hazard Frequency (estimated)*	*Hazard Severity (assigned)*	*Tolerability*	*Comments*
1	Engine Failure / Bird Strike	Engine failure may impact applicability / adherence to procedure.	Aircraft flying NAP-II procedure are close to their "stall speed" (OEI power setting) for obvious noise reduction purposes. Engine failure may cause non adhere to SII-NAP-II speed & vertical profiles, which could result in sudden *loss of separation with ground/obstacles*. Emergency procedures would result in *ATC and flight crew workload increase* Severity rationale: Modern aircraft are capable of sustaining an engine failure without major impact on airworthiness. Emergency procedures would apply for aircraft to return / fly to nearest airport.	Extremely Improbable	Significant Incident (4)	Acceptable	
2	Unexpected extreme meteorological conditions	Sudden change in meteorological conditions (e.g. temperature inversions, windshear, strong cross winds, thunderstorms etc.) may impact applicability / adherence to procedure.	Aircraft flying NAP-II procedure are close to their "stall speed" (OEI power setting) for obvious noise reduction purposes. Sudden meteorological changes may cause sudden drop in airspeed / lift followed by non adherences to SII-NAP-II speed & vertical profiles, which could result in sudden *loss of separation with ground/obstacles*. Emergency procedures would result in *flight crew workload increase* Severity rationale: Sudden extreme meteorological conditions (e.g. squall) may bring about reductions in separation and aircraft deviating from their intended clearance with the possibility of large reductions in separation taking place	Extremely Remote	Major Incident (3)	Acceptable	Mitigation: suitable meteorological conditions range will dictate procedure applicability, beyond which would dictate immediate reversion to fall back procedure to abandon SII-NAP. Barajas lack of extreme weather conditions.

ID	*Hazard Reference*	*Failure Event / Mode*	*Hazard Description*	*Hazard Frequency (estimated)*	*Hazard Severity (assigned)*	*Tolerability*	*Comments*
3	Flight Crew Error	Deviations / non-adherence to procedure's required lateral trajectory (overruling FMS)	Flight crews departing from SID trajectory (performing early, late turns or no turn at all) would breach parallel runway divergence requirements and could result in *loss of horizontal and/or vertical separation* with aircraft departing from opposing runway. Severity rationale: ATC likely to rapidly detect deviation, which could lead to significant breaches of separation if it continued to develop, and take remedy action to restore separation.	Extremely Improbable	Significant Incident (4)	Acceptable	Risk identified within AENA internal Barajas work performed by INECO. SII-NAP unlikely to have any detrimental impact (e.g. reduction of safety margins / manoeuvrability) in conflict resolution
4	Missed Approach conflict	Failure in go-around procedure following a missed approach on 33R	Departures from 33L will be co-ordinated with arrivals into 33R. In case of a missed approach from 33R, ATC will adopt special procedure to manage the go-around. ATC or Flight crew miss-application in the go-around procedure may lead to *loss of horizontal and/or vertical separation* with aircraft previously departed from runway 33L. Severity rationale: ATC likely to rapidly detect any potential conflict with previously departed aircraft and co-ordinate and implement remedy action.	Extremely Improbable	Significant Incident (4)	Acceptable	SII-NAP unlikely to have any detrimental impact (e.g. reduction of safety margins / manoeuvrability) in conflict resolution
5	Co-ordination error	Failure in Co-ordinating 36L departures with helicopter Region (Delta Colmenar)	Aircraft departures from 36L need to co-ordinate with helicopter region (Colmenar). Any failure in co-ordination combined with aircraft drift may lead to *loss of horizontal and/or vertical separation.* Severity rationale: ATC likely to rapidly detect potentially conflicting traffic in helicopter region and take remedy action to restore separation	Extremely Improbable	Significant Incident (4)	Acceptable	Significant drifts highly unlikely with RNP capabilities As this particular region would be encounter above 5000ft along the SID, aircraft is already in clean configuration and thus SII-NAP unlikely to have any detrimental impact (e.g. reduction of safety margins / manoeuvrability) in resolution.

ID	*Hazard Reference*	*Failure Event / Mode*	*Hazard Description*	*Hazard Frequency (estimated)*	*Hazard Severity (assigned)*	*Tolerability*	*Comments*
6	Outdated FMS Database	Deviations / non-adherence to procedure's required vertical and/or lateral trajectory	Flight crew could inadvertently deviate from intended clearances while believing compliance, which could result in *loss of horizontal and/or vertical separation or loss of separation with ground/obstacles*. Severity rationale: ATC likely to rapidly detect deviation, which could lead to significant breaches of separation within the transition zone, and take remedy action to restore separation.	Remote	Major Incident (3)	Acceptable (Minimum Safety Objective)	Mitigation: RNAV equipment certification standard, adequate airline upgrading procedures and early ATC deviation detection. (Note: Req. in EUROCAE/RTCA ED-76/DO-200A & Eurocontrol Standard Document on Area Nav Equipment Operational Requirements and Functional Requirements)
7	Loss of FMS	FMS navigational assistance loss	Following FMS loss, flight crew will revert to manual flight and would be unable to adhere to SII-NAP-II speed & vertical profiles, which could result in *ATC and flight crew workload increase*. Severity rationale: early detection by flight crew, who notify on RT about FMS loss and ATC to instruct to abandon NAP, restore separation if breached and revert to alternative procedure (separation with other ensured by vectoring & speed/ascent rate instructions)	Extremely Improbable	Significant Incident (4)	Acceptable	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP.
8	Loss of RNP capability	Loss of on-board RNP capability causing inability to adhere to SII-NAP-II ascent trajectory	Loss of RNP capability would be associated with an aircraft inability to adhere to SII-NAP-V speed & vertical profiles, which could result in *loss of separation with ground/obstacles*. Severity rationale: early detection by flight crew, who notify on RT about RNP loss and ATC to instruct to abandon NAP, restore separation if breached and revert to alternative procedure (separation with other aircraft ensured by vectoring & speed/ascent rate instructions)	Extremely Improbable	Significant Incident (4)	Acceptable	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP. (Note: Req in JAA TGL-10)

ID	*Hazard Reference*	*Failure Event / Mode*	*Hazard Description*	*Hazard Frequency (estimated)*	*Hazard Severity (assigned)*	*Tolerability*	*Comments*
9	Loss of surveillance data	Inability to monitor separation as a consequence of loss of surveillance	Inability to monitor non-adherences to SII-NAP-II speed & vertical profiles could result in undetected *loss of horizontal and/or vertical separation or loss of separation with ground/obstacles* would significantly erode safety margins. Severity rationale: ATC unable to monitor and detect significant breaches of separation.	Extremely Improbable	Major Incident (3)	Acceptable	Mitigation: early detection allows immediate reversion to fall back procedure to abandon SII-NAP. Overlapping radar coverage and resilient data-comms architecture
10	Loss of RT communication	Inability to communicate with aircraft	Aircraft *vertical and horizontal separations may deteriorate* very rapidly. Severity rationale: ATC unable to communicate with aircraft directly.	Extremely Improbable	Serious Incident (2)	Acceptable	Mitigation: Multiple Tx/Rx sites with overlapping coverage, emergency frequency, resilient data-comms architecture. Contingency Procedures