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Summary

This document summarises results of the Sourdine II WP5.3 single event noise calculations. This study has been performed to provide noise exposure analysis for operational procedures defined in Sourdine II WP3. This analysis was performed to identify procedures that are efficient in terms of noise reduction for large commercial jet aircraft. The outcome should provide a basis for more detailed definition of procedures for further evaluation in the Sourdine II fast time simulations on airport scale.

The study is focused on assessment of noise exposure for noise abatement approach and departure procedures, allowing both identification of efficient concepts and analysis of relation between noise exposure and operational flight parameters. This has been accomplished using Airbus performance and noise calculation tools. Aircraft included in the study are the A320-211 and the A340-313. Evaluated procedures are based on WP3 proposals, outcome of the Sourdine project and results of two 2002 Sourdine II expert workshops.

The study is primarily devoted to approach procedures due to the complexity of the evaluated approach procedures and because of expected noise reduction potential compared to conventional approach procedures. The benefits of part of the proposed departure procedures in WP3 have already been demonstrated in the Sourdine project.

All evaluated noise abatement approach procedures are Continuous Descent Approach Procedures, defined as procedures consisting of a continuous descent from 6000ft along which deceleration and configuration and gear changes are effectuated. After determination of maximum descent angles and deceleration performance a number of procedures have been evaluated on noise benefits. Most significant noise reduction below flight path was found for steepest variants, either with increased glide slope or due to steep intermediate segments, with local maximum noise (DBAmax) relief varying between 5-8 dBA. Local effects of configuration changes on noise are significant and configuration change schedules should therefore be subject of further study and optimisations.

Among evaluated departure procedures are standard PANS-OPS procedures, optimised procedures studied in the former Sourdine project and additional procedures proposed in WP3. Sourdine optimised procedures featuring progressive thrust increase for thrust restoration after deep cutbacks prove efficient in terms of noise reduction. These procedures should be tested on airport scale in Sourdine II WP4.

Note: All procedures have been evaluated using manufacturer performance tools and resulting trajectories reflect performance characteristics of the aircraft. The procedures remain nevertheless theoretical. Operational feasibility, regulatory and pilot perception aspects were not subject of this study and should be examined to determine operational feasibility for these procedures.

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1. Introduction

1.1. Purpose and structure

The operational noise study performed in Task 5.1 on basis of procedures defined in Sourdine II WP3 3 enables first assessment of potential benefits of these procedures before their evaluation in the WP4 airport noise studies. The objective is to identify promising candidate procedures and filter out non-efficient concepts, prior to the WP4 airport studies.

The analysis carried out in Task 5.1 consists of single event noise calculation for some aircraft types that are representative for today's large commercial jet aircraft. The procedures evaluated in task 5.1 are based on the procedures described in the WP3 procedures matrix and have been further defined during the analysis. Aircraft selected for the analyses are the A320, a medium-range twinjet, and the A340, a long-range four engine aircraft.

The tool used for noise calculations is the Airbus Noise Level Calculation Program (NLCP), developed for the purpose of single event noise assessment for operational procedures. Trajectories were calculated using performance simulation software developed for calculation of operational trajectories. To calculate noise for operational approaches with multiple segments additional post-processing software was used.

Although both approach and departure procedures were defined in WP3, a considerable amount of time has been devoted in task 5.1 to approach procedures, which can all be described as Continuous Descent Approach procedures. This is mainly due to the complex nature of these procedures and their expected noise reduction potential with respect to current standard vertical approach procedures. Departure procedures studied are the known ICAO procedures as well as Sourdine I optimised procedures.

The document is structured as follows. Chapter 2 describes the method and tools applied for the study as well as study parameters. Chapter 3 provides results for the noise abatement approach procedures studied whereas chapter 4 describes the results for noise abatement departure procedures. Chapter 5 contains the conclusions. Details on the evaluated procedures are given in tabular and graphical form in the appendices.

1.2. Glossary

Term	Description
AFE	Above Field Elevation
ATD	Along Track Distance
Air traffic	All aircraft in flight or operating within the manoeuvring area of an aerodrome
Air traffic management	The equipment, manpower, and processes required to enable aircraft operators to meet their planned times of departure and arrival and adhere to their preferred flight profiles with minimum constraints, without compromising existing safety levels
ATM	Air Traffic Management
CAS	Calibrated Airspeed
CDA	Continuous Descent Approach A noise abatement technique for arriving aircraft in which the pilot, when given descent clearance below the Transition Altitude by ATC, will descend at the rate he judges will be best suited to the achievement of continuous descent. Whilst meeting the ATC speed control requirements, the objective being to join the glide-path at the appropriate height for the distance without recourse to level flight. [ANMAC]
BR	Brake release
DBAmax	Maximum A-weighted sound level, also denoted as L_{Amax}
EC	European Community
EPNL	Effective Perceived Noise Level
FAA	Federal Aviation Administration
FMS	Flight Management System
GS	Glide slope
ICAO	International Civil Aviation Organisation
ISA	International Standard Atmosphere
Ldg	Landing gear
NADP	Noise Abatement Departure Procedure
NAAP	Noise Abatement Approach Procedure
NAP	Noise Abatement Procedure
NLCP	Airbus Noise Level Calculation Program
N1	Low pressure fan speed (percentage of maximum number of rounds per minute)
OEI	One Engine Inoperative
PMP	Power Management Parameter
SEL	Sound Exposure Level (A-weighted)

TOGA	Take Off Go Around
V2	Takeoff safety speed ensuring safe climbout in case of One Engine Operative and live engines developing full takeoff thrust

1.3. Reference Documents

LIST OF REFERENCE DOCUMENTS	
Short Reference	**Author / Organisation, Title, Edition, Date and Reference**
[ANMAC]	Anon. “Noise From Arriving Aircraft – An Industry Code of Practice”, BAA Stansted, BAA Gatwick, BAA Heathrow, September 2001.
[D1]	AN-WP/7673 (App C), ICAO amended document Doc8168 Nov. 2001
[D3v83]	Sourdine I report D 3: Establishment of noise abatement solutions.
[D5v1.6]	Final Report Sourdine I
[D8168_I]	ICAO: *Procedures for air navigation services – Aircraft Operations*. PANS-OPS Doc. 8168, Vol. I: *Flight Procedures*, 4th edition, 1993
[D8168_II]	ICAO: *Procedures for air navigation services – Aircraft Operations*. PANS-OPS Doc. 8168, Vol. II: *Construction of visual and instrument flight procedures*, 4th edition, 1993
[SII_D3-1.1]	Sourdine II, D3-1.1, *Definition of new noise abatement procedures*
[SII_DOW]	Sourdine II, Description of Work

2. Operational noise study

The purpose of this chapter is to describe the Task 5.1 noise study. Section 2.1 summarises the candidate noise abatement procedures. Section 2.2 provides information on selected baseline procedures. Section 2.3 describes the aircraft involved in the study, operational parameters and atmospheric conditions. Section 2.4 describes applied noise metric and section 2.5 identifies applied performance and noise tools.

2.1. Candidate noise abatement procedures

The initial definition of the candidate procedures is performed in WP3. Matrices of candidate noise abatement approach and departure procedures developed in WP3 and given in [SII_D3-1.1] were used to define procedures for the noise study for approach and departure operations.

The emphasis of the study was put on approach procedures. Whereas noise abatement approach procedures represent a real opportunity to reduce airport noise, the modelling and analysis of these procedures and the various noise abatement concepts that can be included are complicated, due to the large amount of parameters that have to be defined.

All approach procedures proposed by WP3 are Continuous Descent Approach (CDA) procedures, which consist of continuous descent without level segments from 6000ft AFE to runway threshold, during which the aircraft decelerates to landing speed and deploys flaps/slats and gear on schedule.

Figure 1 visualises in a schematic way the parameters used in the WP3 definition of approach procedures.

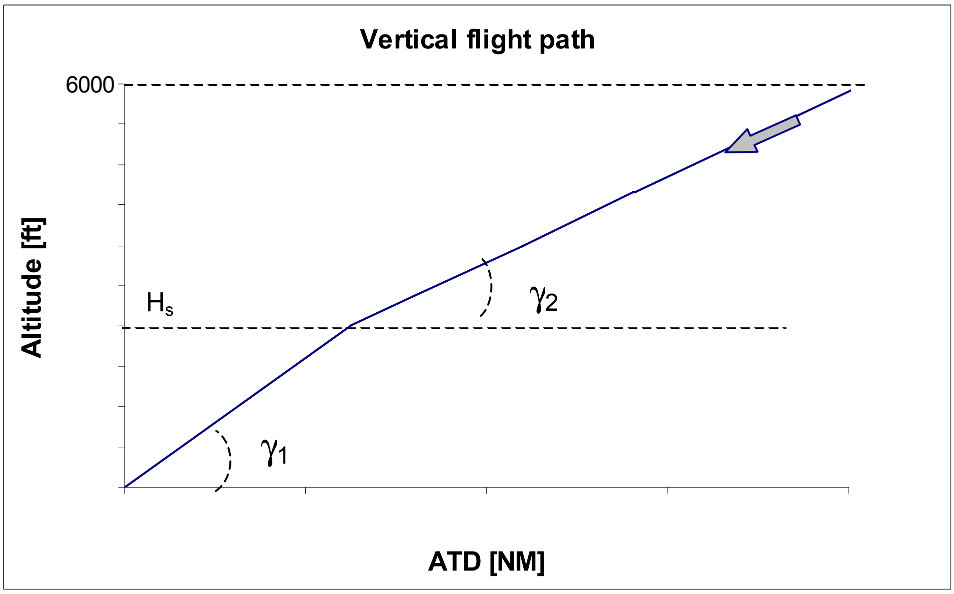

Figure 1: WP3 parameterisation of CDA procedures (Variable Thrust and Variable Speed variants) [SII_D3-1.1]

Table 1 provides parameter values for the approach procedures. A more detailed matrix is available in [SII_D3-1.1], providing exact combinations proposed in WP3.

ACDA Type	γ_1 (°)	γ_2 (°)	H_s (ft)	Velocity
Variable thrust	3.0	2.0	500	High, fixed
Variable vertical path	4.0	3.0	1500	Low, fixed
Variable speed	-	4.0	3000	-
-	-	6.0	-	-

Table 1: WP3 CDA type parameterisation [SII_D3-1.1]

Variable thrust procedures are defined by imposing speed and vertical path and determining the thrust that satisfies these constraints. Variable path procedures are defined determining the vertical path that satisfies speed and thrust constraints. Variable speed procedures are defined determining the speed that satisfies vertical path and thrust constraints. Evaluating these techniques their compatibility with flight systems architecture has to be considered.

Descent angle values in Table 1 are WP3 proposed values. The first activity in Task 5.1 was to define maximum descent angles for initial and final approach segments along which the aircraft can decelerate.

Proposed glide slope intercept heights have been used as guidelines. The 500ft height value has not been used since it is considered unfeasible.

Not all approach procedures defined in WP3 are therefore practically feasible with applied study aircraft. The first phase of the evaluation therefore consisted in filtering out all unfeasible variants. The time required to model flight paths for the different variants using desktop performance software was considerable due to the large set of parameters that need to be defined.

The evaluation of noise abatement departure procedures was more straightforward. The single event analyses performed in the first Sourdine project already uncovered promising concepts. To avoid duplication in Sourdine II, this study consisted in an analysis of a part of the WP3 departure procedures.

2.2. Reference approach and departure procedures

The baseline approach procedure defined in Sourdine II Work Package 3 [SII_D3-1.1] consists of three parts as shown in Figure 2.

The initial point is at 6000ft AFE and the speed is 250ktCAS. The first part is a descent at constant speed to 3000ft at Flight Idle and clean configuration. The second part is a horizontal segment using same engine rating, allowing the aircraft to decelerate and change configuration to intermediate flaps. The length of this part, until interception of the glide slope, is about 5NM. During the last part along the standard glide slope (3°), the aircraft further decelerates to reference landing speed, changing configuration to landing configuration upon schedule. Upon reaching the landing speed the aircraft is stabilised and continues its descent at constant speed using adapted thrust.

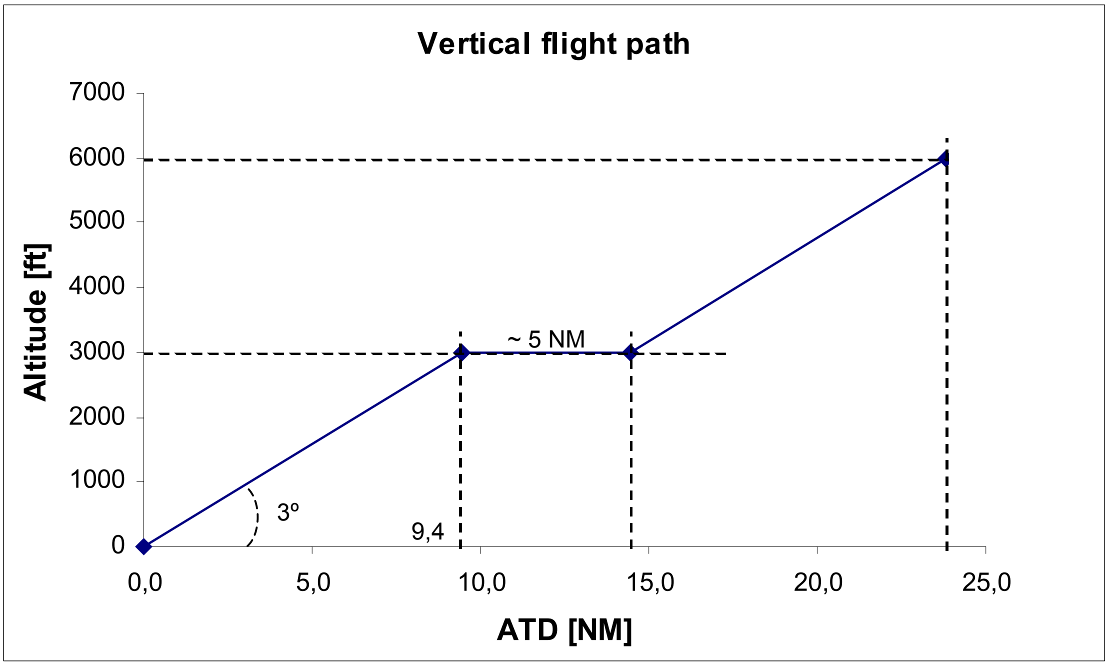

Figure 2: Baseline approach procedure

The assumption that the aircraft is decelerating using Flight Idle thrust throughout the horizontal segment will result in relatively low noise impact compared to level flight at constant speed where a higher adapted thrust level is required. The latter may be the case in daily operations where aircraft are flying procedures prescribed by air traffic control. Noise abatement approach procedures that provide noise relief with regard to this reference procedure will therefore provide as much or more noise relief in daily practice.

The departure reference procedure selected in Work Package 3 [SII_D-3.1] is the former PANS-OPS ICAO A procedure. Although the ICAO A procedure was replaced in ICAO guidance by the NADP1 procedure in 2001, the procedure is still applied at numerous airports and can therefore be regarded as a suitable reference procedure. Figure 3 gives a schematic representation of the ICAO A procedure.

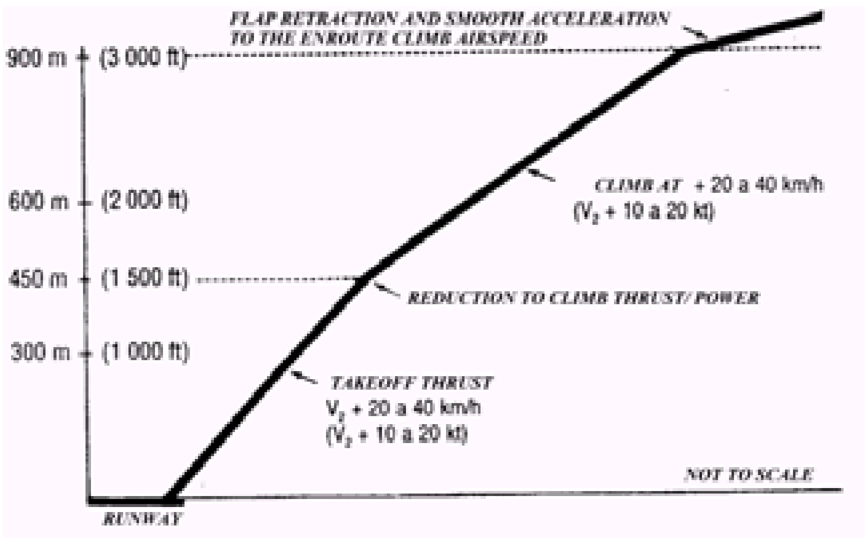

Figure 3: Baseline departure procedure (ICAO A Procedure)

Table 2 provides a description of the procedures as applied for the study aircraft. The aircraft accelerates from the roll out and climbs at a speed of V2 + 10kt at Take-Off thrust, where V2 is the takeoff safety speed. At 1500 ft, thrust is reduced to climb thrust after and the aircraft climbs further at constant speed to reach 3000 ft. Upon reaching 3000ft the aircraft accelerates to a climb out speed of 250kt, retracts flaps and slats on schedule. Upon attaining this speed the climb out at constant speed to 10000ft is initiated.

Procedure Altitude (ft)	ICAO A
0	TOGA (Takeoff Go Around) thrust CONF 1+F. Climb out at V2+10kt
1500	Reduce to Climb thrust Maintain V2+10kt
3000	Acceleration to 250kt, retracting flaps/slats on schedule Climb to 10000 ft

Table 2: ICAO A Procedure

2.3. Aircraft types and operational parameters

Noise abatement procedures have been evaluated for two aircraft:

The A340-313 with CFM56-5C4 engines: this is a long range, four engines aircraft that until 2002 was the largest in-service aircraft of the Airbus fleet (in 2002 the larger A340-600 entered service).

The A320-211 with CFM56-5A1 engines: one of the most operated versions of the A320 medium-range single aisle twinjet family.

The selection of these two typical aircraft types comprises a mayor part of maximum takeoff weight range of the in-service Airbus family, short haul and long haul and both 2 and 4 engine configurations, thereby providing a representative sample for this study.

The approach procedures have been performed for landing weight of 90% of the Maximum Landing Weight given in Table 3. This weight is commonly used for operational studies, averaging operational weights used in daily practice.

Aircraft	Landing weight (tonnes)
A340-313	171
A320-211	58

Table 3: Applied Landing Weights

The initial configuration for all approach procedures is clean configuration, CONF 0, with landing gear retracted. As landing configuration CONF FULL is selected. The intermediate configurations are CONF 1, 2, and 3 (CONF 3 can also be used as landing configuration).

This report contains results for MTOW departures for both A340-313 and A320-211. Using the MTOW and maximum ratings results in highest noise levels for a given procedure. In real practice aircraft are operated at lower operational takeoff weights using flex takeoff thrust. Flex takeoff thrust means that for a given takeoff weight an adapted (reduced) thrust level is determined depending on temperature, that enables same takeoff performance as MTOW operation with maximum thrust rating. For the same source observer distance, the reduced thrust setting results in a slightly lower noise level compared to the MTOW with maximum rating case.

Table 4 contains the corresponding take-off weights respectively for the A320-211 and the A340-313.

Aircraft	MTOW (tonnes)
A340-313	260
A320-211	73.5

Table 4: Applied Takeoff Weights

The takeoff configuration used in the analysis for both aircraft is CONF 1+F, which is the lowest selectable flap angle for takeoff

The following values have been used for the atmospheric conditions:

Temperature: ISA
Relative humidity: 70%
Wind speed: 0kt

2.4. Noise metrics

The noise impact of procedures is examined on basis of noise below flight path. The main indicator used to evaluate noise impact is the maximum A-weighted noise level, dBAmax. This metric enables accurate determination of local noise impact differences for different procedures and facilitates the correlation of noise exposure changes to events along the flight path (configuration changes, thrust reduction/increase).

To provide additional indication on duration effects the Sound Exposure Level has been calculated. Noise footprints have been calculated to visualise noise impact differences on lateral positions.

2.5. Applied tools

The operational noise calculations have been performed using two tools, one for calculation of trajectories for given procedures and a noise calculation tool. Tools applied for the analysis are Airbus OCTOPUS/OCTOPER performance software for calculation of aircraft trajectories and the Airbus Noise Level Calculation Program for noise computations.

Operational trajectories are computed using the OCTOPER performance simulation program in order to provide input for the noise calculation program. OCTOPER generates this trajectory from parameters describing the aircraft configuration, flight procedures including configuration changes, airspeed and height targets and atmospheric conditions. Regulatory parameters and speeds such as V1 and V2 are calculated using the OCTOPUS certified regulatory performance program, a computerised version of the Aircraft Flight Manual.

From the trajectory generated by OCTOPER and aircraft/engine combination specific noise database derived from static and flight test noise measurements, operational noise levels are computed at user defined observer points, using the NLCP.

3. Results approach procedures

This section summarises the different types of approach procedures that have been evaluated for the A340 and A320 and that appeared to have noise reduction potential. Approach procedures are reviewed in this section and short procedure descriptions and main performance and noise results are given in appendices A and B. The main noise parameter used for this study was maximum A-weighted noise level, DBAmax, below flight path.

With exception of the baseline procedures all evaluated approach procedures lack horizontal segment below the initial point, at or above 6000ft, and are therefore considered as Continuous Descent Approaches.

3.1. A340 study

3.1.1. Baseline

The A340 baseline procedure is described in appendix A1 procedure 1. The procedure consists as described in section 2.2 in three phases, an initial descent at constant speed, followed by a horizontal decelerating segment and finally a descent along standard glide slope to the runway threshold.

The height and speed profile are given in Figure A 1. The height profile is repeated in all other figures of appendix A.

Performance for the baseline procedure:

- The angle at which the aircraft descends during the initial descent is 2.2°, which is a result of the descent at 250ktCAS in clean configuration for the given weight. This angle is significant for the definition of CDA procedures since it indicates the maximum angle at which the aircraft is capable of maintaining a constant speed in clean configuration without use of airbrakes.
- The length of the level segment is determined by the time required to decelerate to advised speed for the intermediate configuration CONF 2, which results for this case in a 5NM long level segment.
- The aircraft is stabilized slightly above 1500ft AFE (1521ft) as can be seen in the flight path details for procedure 1.

Noise below flight track:

- Noise measured below flight track, given in Figure A 2, increases steadily during the initial descent to 3000ft AFE due to shortening source observer distance.
- Configuration changes to intermediate and landing configuration and gear extension result in significant overall noise (DBAmax) increase, due to increasing airframe noise.
- In landing configuration, the A340 airframe noise component masks the impact of engine noise increase, associated with thrust change from Flight Idle to Adapted, on overall noise.
- Airframe noise decreases with decreasing speed. Between –8NM and –5NM, the aircraft is descending along the glide slope and decelerating to landing speed. The simultaneous decrease in speed and source-observer distance results in maximum noise levels remaining constant during that phase.

3.1.2. Continuous Descent Approach

The baseline procedure's initial segment indicates that the aircraft descent angle for given configuration and initial parameters for a constant speed is 2.2°. This implies that descending at angles higher than 2°, with same conditions, deceleration will be difficult and require a considerable amount of extra time during which a large horizontal distance is flown. This means that the procedures proposed in the WP3 matrix incorporating descent angles greater than 2° for the initial segment, either decelerated or at constant speed, are practically unfeasible for this aircraft under given conditions.

For the initial descending deceleration segments, it was therefore decided to consider descent angles of 2° and reduce speed at the initial point at 6000ft AFE for the CDA procedures from 250ktCAS to a lower speed of 230ktCAS or the advised configuration change speed for CONF 1, which is about 220ktCAS for the applied landing weight. To ensure enough deceleration performance the configuration CONF1 is selected immediately.

3.1.3. CDA with standard final glide slope

The CDA procedure given here is procedure 2, which is a fixed path procedure. This procedure can be divided in two phases. During the first phase a fixed descent angle of 2° is maintained. The aircraft decelerates and changes configuration upon schedule (this means changing to a specific configuration as soon as the advised configuration change speed corresponding to that configuration is attained). Upon reaching the landing configuration and reference landing speed the aircraft continuous at constant speed with adapted thrust setting. The second phase starts upon interception of the glide slope and consists of a stabilised descent in landing configuration to the runway threshold.

Figure A 2 provides noise profiles baseline and procedure 2. The procedure 2 produces less noise during the initial segment than the baseline up to 13NM to threshold where landing flaps and gears are deployed. Further deceleration results in less airframe noise and therefore less overall noise. Between -10 and -5NM procedure 2 produces considerably less noise due to the lower speed (see also Figure A 1).

It can be observed that increased engine noise due to the increased adapted thrust around 10NM, is masked by airframe noise. The thrust increase therefore has no recognisable impact on the overall noise.

3.1.4. CDA with increased final glide slope

The first Sourdine project demonstrated that the increase of glide slope with respect to the standard 3° glide slope is efficient for noise exposure reduction below flight track. This is mainly the result of increased source-observer distance and, to a lesser extent, due to a lower required engine rating reducing engine noise.

Combing CDA with increased glide slope was considered to combine noise reductions of both concepts.

Procedure 10 is an example of a CDA procedure with a 4° glide slope for the final approach. This value is selected for two reasons. First, the 4° glide slope angle is proposed in the WP3 procedure matrix and second, it has been identified in Sourdine as providing significant noise reduction.

Considering this procedure it should be taken into account that aspects like operational feasibility, handling qualities and pilot perception are not covered in task 5.1 study and should be covered separately in the Sourdine II project, as they determine maximum operational glide slope angle.

Procedure 10 has an initial speed of 220ktCAS. The deceleration to landing speed and flap deployment procedure are completed prior to glide slope interception (Figure A 3). Subsequently, the speed profile indicates that procedure 10 is significantly slower than the reference procedure.

The DBAmax noise profile of procedure 10 shows overall noise reduction relative to the reference procedure except for the configuration change point at –10NM (Figure A 4). During initial approach the reduction is about 2.5dB. The maximum reduction is 7dBA at –8NM. The difference gradually decreases towards the threshold due to decreasing height differences.

The noise peak along the flight track at –10NM for procedure 10 is generated by gear and landing configuration deployment and subsequent deceleration to landing speed.

3.1.5. Variable path segment

Another procedure resulting in a high steep profile identified during the study includes variable path segments. This type of segment is realised flying at a constant speed and configuration using flight idle thrust. The corresponding descent angle satisfying these conditions is calculated. The angle and therefore the steepness of the segment depend on selected speed and configuration. The resulting descent angles are generally higher than for decelerating segments under same conditions, resulting in a steeper and therefore higher overall approach profile.

This technique was applied for a set of different operational parameters including two glide slope intercept altitudes and several configuration change schedules. These procedures all consist of three phases:

- An initial level segment, starting at 6000ft or 7000ft AFE and 220ktCAS, where the aircraft decelerates and changes configuration to an intermediate or landing configuration;
- A variable path segment , i.e. a constant speed, flight idle thrust segment with variable descent angle varies as function of the selected configuration;
- A final phase along 3° glide slope where, if required, the aircraft decelerates further to landing speed and changes to landing configuration using adapted thrust. Glideslope intercepts at 2000 and 3000ft AFE have been evaluated.

Procedures 19 to 22 all have their initial point at 7000ft AFE, allowing a longer constant speed segment to glide slope intercept than the 6000ft AFE initial point.

Procedures 19 to 20 effectuate the constant speed segment using different configurations and at different speeds (Figure A 5). Procedure 19 decelerates and changes configuration to CONF2 advised speed and CONF 2. Procedure 20 effectuates this segment at landing speed and landing configuration. Procedure 20 is therefore the slowest and steepest procedure of the two. Glide slope intercept is at 2000ft AFE.

Procedure 20 produces considerably smaller maximum noise levels throughout the trajectory until –4.5NM (Figure A 6). Maximum differences with the baseline are about 8dBA and occur at several places along the flight track. A significant noise peak is observed for procedure 20 at the time of landing flaps and gear deployment, at –16.5NM.

Procedures 21 and 22 are similar to procedures 19 and 20 with different glide slope intercept at 3000ft. This results in a modified altitude profile, especially for procedure 22, and configuration change schedule, mainly for procedure 2, with respect to procedure 19 and 20 (Figure A 7).

Procedures 21 and 22 produce lower maximum sound levels below track than the baseline (Figure A 8). The reductions relative to the reference are slightly smaller than for procedures 19 and 20, but still have a maximum of about 7dBA. The variation of the configuration change procedures has a clear effect on the maximum noise level signature.

3.1.6. Footprint area results

Appendix A.4 contains DBAmax footprints plots for the A340 approach procedures for 65dBA. This level is higher than the noise levels for the initial approach part and should be considered mainly as indicator for the final approach part. These figures do not visualise benefits of the continuous descent part along the initial approach for which lower footprint levels would be required.

For all noise abatement procedures the 65dBA footprint areas are smaller than the reference 65dBA footprints areas. Only for procedure 21 the footprint is slightly longer (and narrower) than the reference due to the position of landing configuration transient. It should be noted also that for the final stabilised part 65dBA footprints are as wide for increased glide slope procedures as they are for the reference 3° glide slope procedure (lateral attenuation taken into account).

3.2. A320 study

3.2.1. Baseline

The A320 baseline procedure, described in appendix B (Procedure 1), is slightly different from the A340 baseline approach, in that the initial altitude is set to 7000ft and the level segment is used to decelerate to landing speed and deploy CONF FULL and landing gear instead of an intermediate configuration.

The descent angle found for the initial constant-speed descent segment in clean configuration is 2.7°, which as for the A340 study delimits the upper limit of the descent angle for decelerating segment for given flight parameters.

Noise below flight track for the baseline procedure is given in Figure B 2. Calibrated Airspeed and aircraft configuration are constant during both descent segments, resulting in a continuously increasing noise level towards the runway threshold. During the horizontal deceleration the positive effect of speed and flap and slats angles on measured noise is visible.

3.2.2. CDA standard final glide slope

The CDA procedures evaluated here and in section 3.2.3 are all fixed path procedures. The initial part has a fixed descent angle and Flight Idle thrust and can therefore be considered variable speed. The second segment is fixed to the glide slope with a fixed speed and can be considered variable thrust.

The first two CDA procedures, described in appendix B1, have an initial descent segment with a fixed descent angle of 2°, followed by a segment along a standard glide slope of 3°. The procedures differ in configuration change schedule and glide slope intercept height. Height and speed profiles are given in Figure B 1

For procedure 2 configuration changes are initiated at maximum allowable speeds for the intermediate configurations, in order to generate drag for deceleration. The glide slope intercept is at 3700ft AFE and the aircraft is stabilised just above 2400ft.

The noise reduction of procedure 2 at the beginning of the procedure relative to the baseline and other procedures is due to the height difference (Figure B 2). Deployment of intermediate flaps at speed just below placard speed, generates increased airframe noise levels that around –20NM make overall noise increase and noise reduction relative to the baseline small.

Procedure 4 applies a different flap change schedule, using advised flap change speeds, and a lower glide slope intercept height than procedure 2.

Procedure 4 provides significant noise relief with a maximum of 6dBA, until –11NM. Afterwards its maximum noise levels are higher due to landing flap deployment.

3.2.3. CDA increased final glide slope

Using the standard glide slope angle, procedures 2 and 4 provide no noise relief with respect to the baseline close to the airport. This is where noise levels increase to more significant levels. A number of procedures have been evaluated with similar initial segments as procedures 2 and 4, followed by a final approach using an increased glide slope angle of 4°. This results in higher trajectories than obtained for first two procedures.

The example given here is procedure 7, which has a reduced initial airspeed, 230ktCAS, requiring less time to decelerate and change configuration and stabilise. The glide slope is intercepted and the aircraft is stabilised at 3200ft AFE. For this procedure not airspeed but N1 is given in Figure B 3. The figure indicates that less thrust is required to maintain the 4° glide slope than is required for the standard glide slope.

Due to the lower initial speed and higher elevation procedure 7 is least noisy up to –14NM, where configuration change is initiated. This procedure has lower maximum noise levels throughout the major part of the approach, with maximum differences of about 7dBA noise relief for initial approach. On final approach reduced thrust and higher source observer distance contribute to the noise reduction, which has a maximum of 3dBA.

3.2.4. CDA adapted to A340 procedures

After first review of the A340 procedures, the Sourdine II group selected a number of procedures for further evaluation. To evaluate noise reduction efficiency of these procedures when used with the A320, they have been simulated with the A320. The procedures reviewed here are procedures 10, 20 and 21. Descriptions and results can be found in appendix B.3.

Compared to procedures in sections 3.2.2 and 3.2.3 these procedures use a reduced initial airspeed of 220ktCAS like the A340 procedures, and may therefore initiate the very first configuration change to CONF1 without any deceleration.

Procedure 10 immediately initiates the configuration change to CONF 1, conform the A340 procedure, with the actual initial speed being close to the advised configuration change speed. Landing speed and configuration is reached at 3700ft, which represents a significantly shorter deceleration path length than required for the A340. Adapted thrust is applied prior to reaching the glide intercept height at 3000ft to maintain the 2° flight path angle. The aircraft is stabilised along the entire final approach following the increased glide slope.

Procedure 10 DBAmax levels are significantly lower than reference levels along the major part of the track due to the height difference between baseline and procedure 10 (Figure B 5). The maximum difference during the first part of the flight, prior to glide slope intercept, is about 3 dBA. This reduction then becomes slightly negative (less than 1dBA) during the configuration changes phases between -12NM and -13NM from the runway threshold. Procedure 10 noise levels for the stabilised part along the glide slope are about 1.5dBA lower than the reference levels until touch down.

Procedure 20 uses a level flight segment at 7000ft height in order to achieve the configuration change to CONF FULL and reach landing speed (Figure B 6). Then a flight idle/constant speed path is followed resulting in a steep descent angle of 5.8° before reaching the glide slope intercept at 2000ft. A standard glide slope is then followed to reach the runway threshold.

The height difference between procedure 20 and reference trajectories result in important noise reduction for procedure 20 between –18NM and -7NM, with maximum differences of 7-9 dBA (Figure B 6). Noise levels become identical to reference noise levels as soon when the glide slope is joined.

Procedure 21 is equivalent to procedure 20 with as main difference the configuration at which the constant speed descent segment from 7000ft to glide slope intercept height is carried out. The applied configuration and speed are CONF 2 and corresponding speed. This results in a less steep segment with a -3.8° flight path angle. Configuration changes to CONF FULL are then achieved and reference speed reached on the final glide slope.

For procedure 21 the maximum reduction at the beginning of the trajectory is about 5dBA. Between –20NM and –10NM DBAmax levels for this procedure are up to 4dBA lower than reference noise levels. The noise peak around –9NM due to the configuration change to CONF FULL for procedure 21results in slightly higher noise level than reference.

A320 and A340 performance is not the same for these procedures with for example more rapid deceleration for the A320 along given trajectories. A320 noise levels for these procedures however show similar tendencies as observed for the A340. Use of increased glide slope (procedures 10 and 11) and variable path segment (procedures 20 and 21) provide significant noise relief. Concerning noise reduction potential of the procedures the A320 results confirm results for the A340.

3.2.5. Footprint area results

The 65dBA footprints included in Appendix B.4 for the procedures of section 3.2.4 mainly concern the final approach part of the procedures. The CDA noise reduction potential is not visible using this level for the A320. The reference 65dBA footprint area is larger than footprint areas for the three noise abatement procedures.

The increased glide slope procedure 10 is virtually as wide as the reference procedure footprint. This indicates that on lateral position noise levels are the same, at least around the 65dBAmax footprint. The influence of lateral attenuation (noise attenuation that increases with decreasing angle between the earth surface and sound ray) is not significant enough to result in larger 65dBAmax levels.

4. Results departure procedures

Results for noise abatement departure procedures have been gathered in appendices C and D for the A340 and A320 respectively. The appendices contain descriptions of flight procedures and performance and noise results for procedures mentioned in this section.

4.1. A340 study

The baseline procedure for the A340 study is described in section 2.2. A short description is given also in appendix C.

The acceleration law that is selected during acceleration segments defines the climb rate during these segments. For this study the energy sharing option is used, which determines the ratio between the increase in potential energy and kinetic energy per unit time.

Figure 4 provides the height (AFE) and speed (CAS) profile for the A340-313 baseline ICAO A departure. Clearly visible in the height profile are the pitch-over at 1500ft AFE where the engine regime is changed from TOGA to Max Climb thrust, and the pitch-over at 3000ft AFE, where the acceleration segments starts.

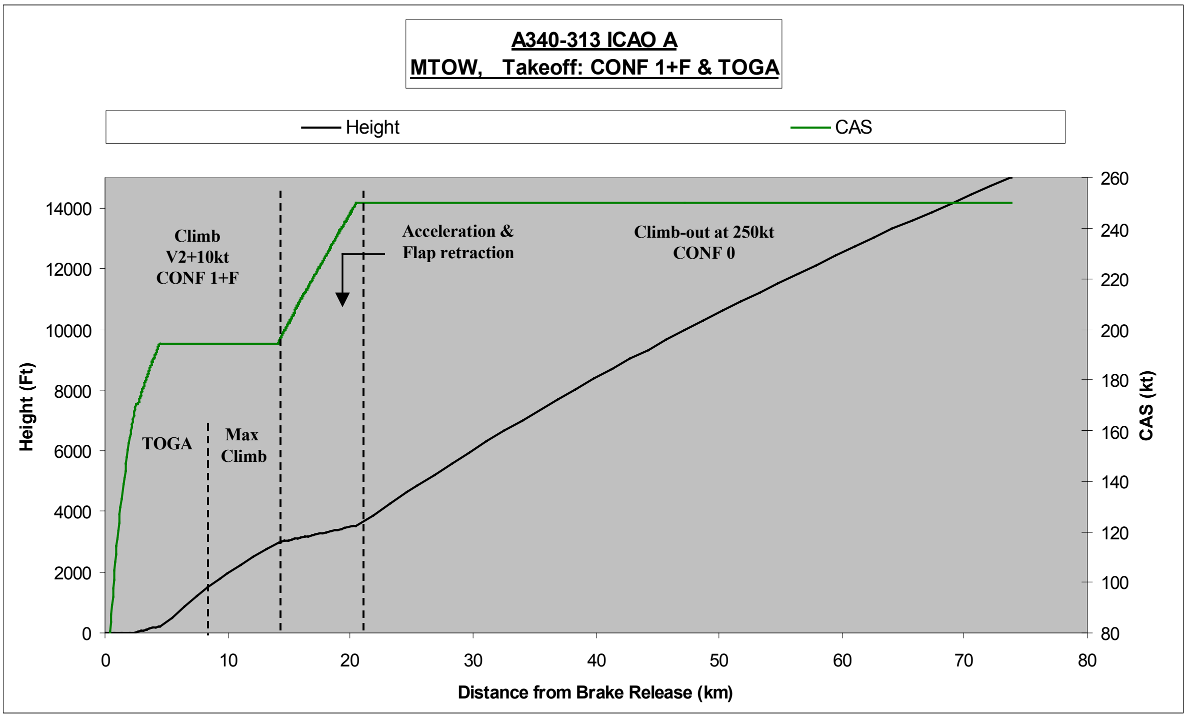

Figure 4: Height and speed profile for A340-313 ICAO A departure

The first procedures that are evaluated in appendix C.1 are standard ICAO PANS-OPS Noise Abatement Departures 1 and 2 (NADP1 and NADP2). Secondly optimised procedures developed in Sourdine are reviewed. All procedures end upon reaching 15000ft AFE. This is to be able to fully study the impact of optimised procedures.

The procedures have been evaluated using operational assumptions listed in section 2.3. Trajectories have been calculated for MTOW departures using the procedures described below and in appendix C.1.

Procedure 2, NADP1:

The main difference in trajectory for this NADP1 and the ICAO A procedure is the end of the first segment, at 800ft minimum instead for 1500ft AFE. The NADP1 procedure is designed to provide noise relief for relative short distance along track from brake release, compared to the NADP2.

Procedure 3, NADP2:

The NADP2 procedure has been added to the analysis to compare noise results for both procedures present in current PANS-OPS guidance. Of the two alternatives the NADP2 is designed for noise relief at larger distance (below flight track) from brake release. These distances will be quantified during evaluation of the noise results.

Procedure 4, Sourdine Optimised Close-In:

This procedure features a deep thrust cutback, initiated at 1000ft AFE, with an ensuing climb at constant speed to 5000ft, above which thrust is progressively increased. The thrust is reduced to the minimum level that satisfies 1.7% OEI (One Engine Inoperative) climb requirements. The progressive thrust increase consists of a stepwise increase of N1 to Climb thrust, defined in Sourdine. At the end of the thrust increase the aircraft accelerates and retracts flaps and slats. After acceleration to en route speed climb to 15000ft AFE is initiated.

The progressive thrust increase is defined as a gradual (stepwise) increase of N1 from its cutback value to N1 corresponding to the Max Climb rating. The design of this progressive thrust increase has to enable elimination of noise increase along the flight track during the transition from cutback thrust to Max Climb thrust. This implies balancing of engine noise increase due to thrust augmentation and noise relief due to increasing climb performance and propagation distance.

Procedure 5, Sourdine Optimised Distant:

This procedure includes a deep cutback and progressive thrust increase, similar to that of procedure 4, after a first acceleration phase, initiated at 1000ft AFE, during which flaps and slats are retracted. After a climb to 5000ft AFE using cutback thrust, the aircraft further accelerates to en route speed progressively increasing thrust to Climb thrust. Climb thrust is restored at 9000ft and the procedure ends with a climb to 15000ft AFE.

Procedure 6, NADP2 with adapted thrust under 3000ft:

This procedure is similar to the NADP2 procedure with different thrust setting for the climb to 3000ft AFE after first acceleration and flaps/slats retraction. During this part of the climb the adapted thrust is the minimum thrust that satisfies OEI climb requirements. Upon attaining 3000ft AFE thrust is instantaneously increased to Climb thrust.

Procedure 7, NADP1 with adapted thrust under 3000ft:

This procedure is similar to the NADP1, with the second climb segment between 800ft and 3000ft effectuated using the minimum thrust that satisfies OEI climb requirements.

For comparison of the noise impact of the different procedures these procedures have been grouped in Close-in and Distant categories according to expected zones of noise relief.

Close-in procedures 1, 2, 4 and 7:

Results of procedures 1, 2, 4 and 7 have been grouped into the category of Close-in procedures. Figure C 2 provides maximum A-weighted noise levels below flight track. Following observations can be made:

- Noise profiles of NADP1 and baseline ICAO A procedures are very similar compared to the other procedures, except for some noise relief for the NADP 1 before 4NM from BR (brake release) due to thrust reduction at 800 instead of 1500ft AFE.
- Due to the adapted thrust setting, procedure 7 provides significant noise relief with regard to the baseline up to 10NM from BR where Climb thrust is restored. Source noise reduction due to lower power setting is greater than the propagation distance effect, resulting in maximum reduction of 5dBA at 4NM.
- Procedure 4 provides noise reduction for the same reason as procedure 7 does. In addition it does not generate the same noise increase as procedure 7 does around 10NM since the adapted thrust segment ends at 5000ft instead of 3000ft AFE, after which thrust is progressively increased. Maximum noise relief is 6dBA and occurs at 4.5NM.
- Due to better overall climb performance baseline and NADP1 procedures are less noisy than procedures 4 and 7 at distances from BR greater than 14NM, where overall noise levels are generally lower.

The fact that optimised Close-In procedures evaluated here provide noise reduction compared to baseline should be taken into account when comparing baseline against Distant procedures below.

Distant procedures 3, 5 and 6:

Figure C 5 and Figure C 6 contain DBAmax and SEL noise profiles for baseline and procedures 3, 5 and 6. The following observations can be made:

- For distances smaller than 10NM from BR, the ICAO A baseline procedure, Close-In type, produces significantly smaller maximum noise levels than the Distant NADP2. For distances greater than 10NM (8.5NM for SEL results, Figure C 6) the NADP2 is less noisy than ICAO A. This is a typical difference between Close-In and Distant procedures that use same power settings (TOGA and Max Climb in this case). The baseline is about 8dBA or 5dB SEL less noisy than NADP2 at 5NM from BR, which explains the benefit of using this procedure to reduce noise in zones close to airports.
- Procedure 6 provides significant noise reduction relative to the baseline between 6NM and 12NM from BR, with a maximum of about 4.5dB (5.5dB SEL) at 11NM. As soon as Max Climb is restored, procedure 6 noise increases to remain higher for the rest of the track.
- Procedure 5 provides similar noise relief as procedure 6 but over a longer distance interval, up to 21 NM, due to use of adapted thrust up to 5000ft AFE. In addition, due to the use of progressive thrust increase instead of instantaneously above 5000ft AFE, noise levels do not increase but remain constant until 30NM from brake release to decrease after. SEL results show slightly varying tendencies. Procedure 5 provides a noise relief up to 27NM rather than 21NM.
- The optimised procedure 5, using adapted thrust, provides noise relief with respect to the Close-in baseline between 6 and 21NM. Procedures without reduced thrust, i.e. using Max Climb as cutback thrust, have better overall climb performance resulting in higher propagation distance and therefore less noise at larger distance from BR.

Appendix C.2 provides DBAmax footprint plots for baseline and optimised Sourdine procedures 4 and 5. The 80dBA footprints are used as indicator for noise reduction at high levels at positions along flight track relatively close to the brake release point. The 65dBA footprints are indicators for lower noise levels, therefore for noise reduction potential of Distant-type procedures.The optimised Close in procedure 4 has a smaller 80dBA footprint compared to the reference (Figure C 7). The optimised Distant procedure 5 has a significantly smaller, both narrower and shorter, footprint than the reference procedure for the 65dBA level (Figure C 10).

4.2. A320 study

The A320 baseline procedure is the former ICAO A procedure described in section 2.2 and appendix D, procedure 1. The end of the procedure is at 10000ft AFE. During acceleration segments the same acceleration technique is used as for the A340, which is energy sharing.

For the A320 standard noise abatement departure procedures with varying segment-end heights and thrust cutback levels were calculated, using MTOW. NADP1 and NADP2 type procedures were evaluated with initial climb segment heights 800, 1000 and 1500ft AFE using Max Climb as cutback thrust setting. Comparisons between trajectories using Max Climb thrust and minimum thrust satisfying the 1.2% OEI (One Engine Inoperative) climb gradient requirements showed very small margins. Noise reductions obtained using this 1.2% OEI climb gradient requirement are very small. For lower operational weights, the margin will be bigger allowing deeper cutback than Max Climb and eventual progressive thrust increase features.

Appendix D shows the example of the comparison of the reference ICAO A procedure against three NADP2 variants. The NADP2 variants have different heights, 800, 1000 and 1500ft AFE, at which the initial acceleration is initiated. The corresponding procedures 3, 19 and 20, are described in appendix D and height and speed profiles are given in Figure D 1.

The following observations can be made looking at the noise result, given in Figure D 2:

- The ICAO A procedure produces less noise at observer points closer than 7.3NM to BR, with maximum differences of 5-8dBA depending on procedure. For greater distances the Distant procedures produce about 2dBA less noise.
- The different pitch over altitudes for the NADP2 procedures results in differences in noise profiles, locally between 2 and 4 NM from BR. The procedure that pitches over at highest altitude, 1500ft, produces least noise of the three, mainly due to the associated higher flight path.

5. Conclusion

The objective of this single event noise calculation was to identify operational approach and landing procedures that are efficient in terms of noise exposure reduction, on basis of procedures proposed by WP3.

The evaluation of the vertical noise abatement approach procedure has been given priority because of the expected potential to reduce noise overall with regard to conventional approach procedures, mainly designed upon air traffic control requirements. The complexity of Continuous Descent Approach procedures and detailed departure procedures analysis already performed in Sourdine II were additional reasons.

The procedures evaluated here remain theoretical and conclusions are purely noise impact related. The data presented in this report do not allow any kind of conclusions on operational feasibility, safety, navigation and pilot perception aspects, for which further research is required.

5.1. Approach procedures

A number of conclusions can be made concerning noise reduction potential of Continuous Descent Approach procedures studied for the A340 and A320 aircraft:

- A340 CDA procedures featuring increased glide slope angles or steep intermediate segments create significant noise relief below flight path, with respect to conventional approach featuring level segments. This noise relief varies from 5 to 8 dBA throughout long parts of the flight track.
- A320 CDA procedures featuring increased glide slope, provide noise relief below flight path ranging from 5 to 8dBA during initial descent and 3dBA during final approach. Combined with standard 3° glide slope, noise reductions during initial approach are still evident but smaller than 5dBA.
- For both aircraft, the maximum initial descent angles for given initial aircraft configurations, speeds and weights that allow deceleration are limited to 2 to 2.5°. Use of spoilers or early deployment of high lift devices to create extra drag could not be considered in the project. This eliminates an important number of WP3 procedures.
- CDA procedures generally provide noise relief at distances from the airport where noise levels are between 50 and 70dBA. In combination with increased glide slope, noise relief is also obtained close to the threshold where noise is in the 70-90dBA zone.
- A340 airframe noise masks engine noise effects to a great extent. For A320 engine noise is a more important factor, contributing for increased glide slope to overall noise reduction.
- Timing of configuration changes and gear extension have important impact on noise profile shape. Noise peaks occurring at locations were configuration changes or landing gear is deployed can locally eliminate noise relief obtained with the CDA procedure, due to the strong dependence of airframe noise on aircraft speed. Optimisation of configuration change schedules are required to attenuate these airframe noise peaks.

Further research should be oriented towards optimisation of configuration change schedules and exploration of capability to maintain increased descent angles for A320 and A340 aircraft during the initial approach.

5.2. Departure procedures

The departure procedures study has reconfirmed several aspects related to noise abatement departure procedures.

- Noise reductions obtained with identical procedures depend much on aircraft type and weight.
- The progressive thrust increase demonstrated for the A340 at MTOW is efficient as noise mitigation function. For lower operational weights its efficiency is expected to increase due to larger difference between minimum N1 and Max Climb rating N1.
- Variation of pitch over altitudes (either for acceleration or thrust cutback) results in redistribution of noise, which can be exploited to provide noise relief at specific locations.
- Close-In procedures provide considerable noise relief for distances smaller than 8 (A320 MTOW) or 10NM (A340 MTOW) from brake release with respect to the Distant procedures. At longer distances the Distant procedures provide noise relief.
- The Sourdine optimised procedures, both Close-In and Distant result in long zones of noise reduction, with maximum noise relief up to 6dBA. For the Distant this zone stretches to 21NM from BR relative to the ICAO A baseline.

These conclusions support the continued research and development effort aimed at modernising flight management systems to enable further automation of Noise Abatement Departure Procedures.

Appendices

A. A340 approach procedures

A.1. Standard Glide Slope (3°)

1- Reference, Vinit=250kt, HS = 3000ft
2- CDA Standard glide slope

Aircraft type and nomenclature Altitude (ft)	A340 - 313 **1- Reference**
6000 ft (Fixed height value)	- Initial point: 250kt CAS, Flight Idle, Conf 0, Ldg Up - Descent constant CAS
3000 ft (Fixed height value)	- Level flight - Flight Idle - Decelerate/change configuration to Conf 1, Ldg Up
	- Flight Idle - Fixed descent angle 3° - Decelerate/change configuration to Conf FULL, Ldg Down and Vref
1521 ft (Resulting height value)	- Adapted Thrust for descent gradient -5.241% (-3°) - Descent at constant speed to 50ft

Aircraft type and nomenclature Altitude (ft)	A340 – 313 **2- CDA Standard glide slope**
6000 ft (Fixed height value)	- Initial point: 218kt CAS, Flight Idle, Conf 0, Ldg Up - Descent at fixed 2° descent angle, decelerate and change to Conf FULL, Landing Gear Down and Vref
3230 ft (Resulting height value)	- Adapted Thrust - Fixed descent angle 2° - Descent at constant speed to 3000 ft
3000 ft (Fixed height value)	- Adapted Thrust for descent gradient -5.241% (-3°) - Descent at constant speed to 50ft

Procedures 1 and 2 : CAS and DBAmax

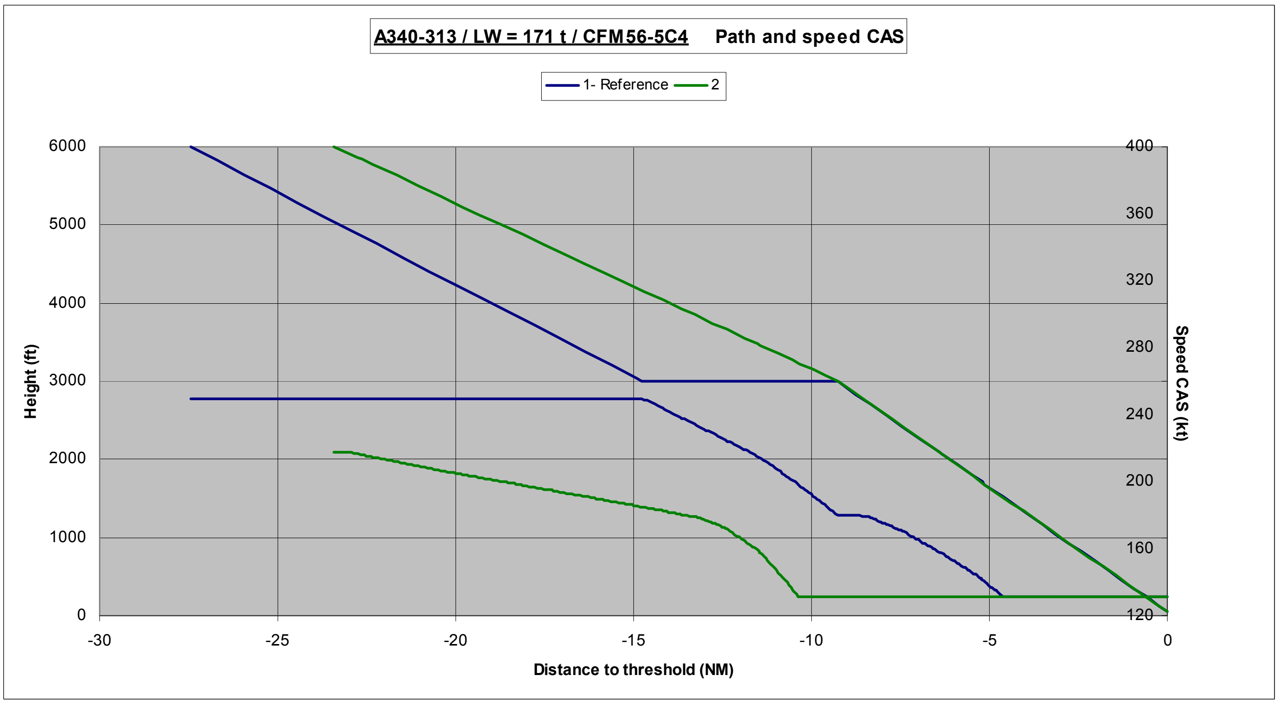

Figure A 1

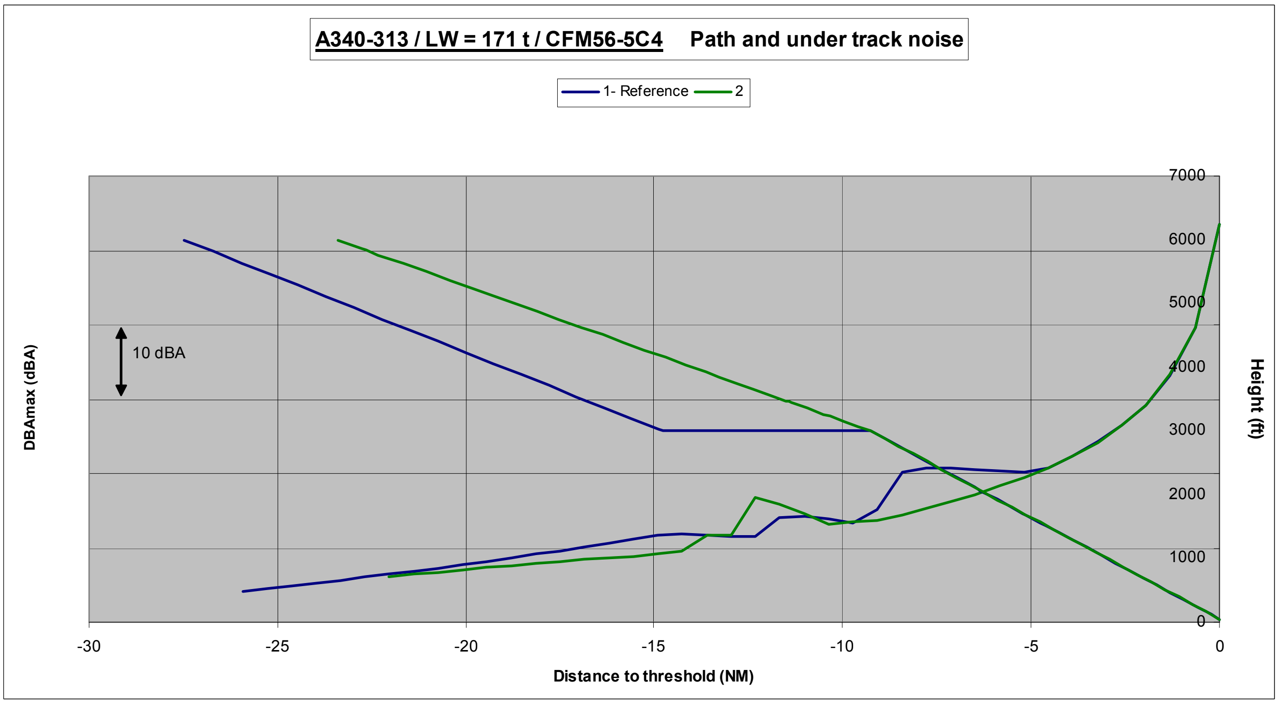

Figure A 2

A.2. Increased Glide Slope (4°)

1- Reference
10- CDA 4° glide slope

Aircraft type and nomenclature Altitude (ft)	A340 - 313 **10- CDA 4° glide slope**
6000 ft (Fixed height value)	- Initial point: 220kt CAS, Flight Idle, Conf 0, Ldg Up - Fixed descent gradient -3.492% (-2°) - Decelerate/change configuration to Conf FULL, Ldg Down and Vref
3152 ft (Resulting height value)	- Adapted Thrust - Fixed descent angle -3.492% (-2°) - Descent at constant speed to 3000 ft
3000 ft (Fixed height value)	- Adapted Thrust for descent gradient -6.993% (-4°) - Descent at constant speed to 50 ft

Procedures 1 and 10: CAS and DBAmax

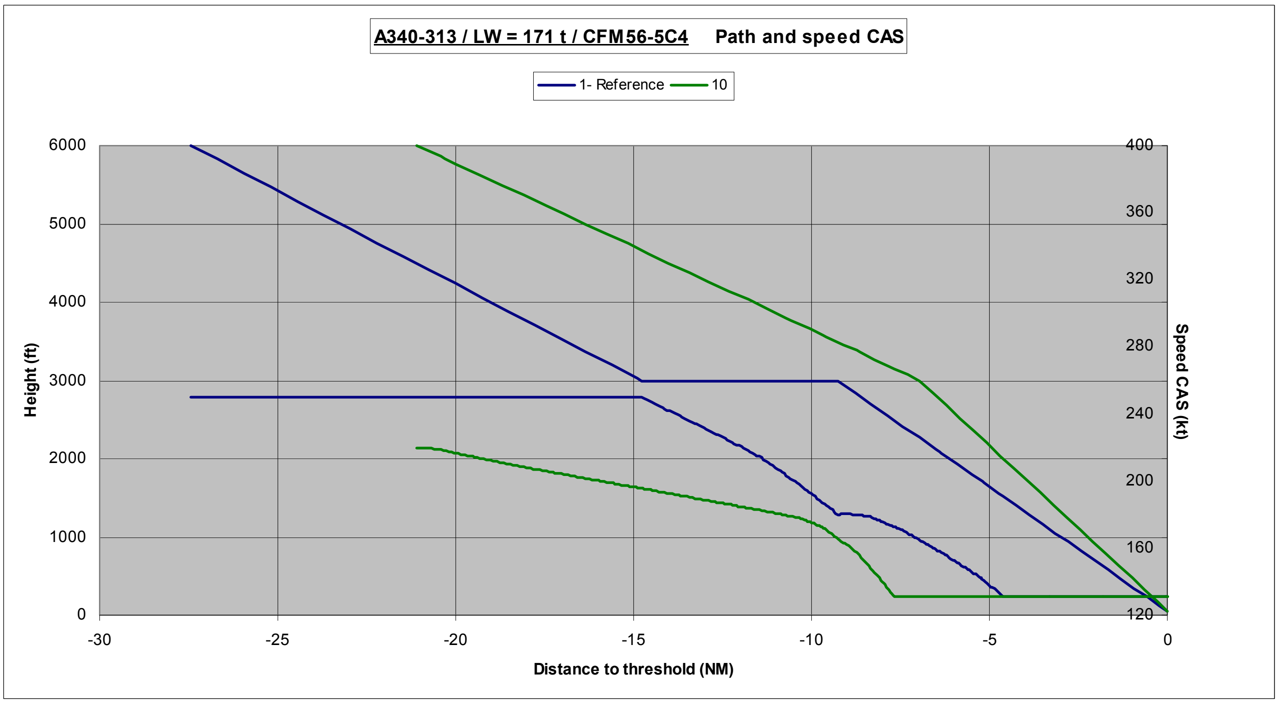

Figure A 3

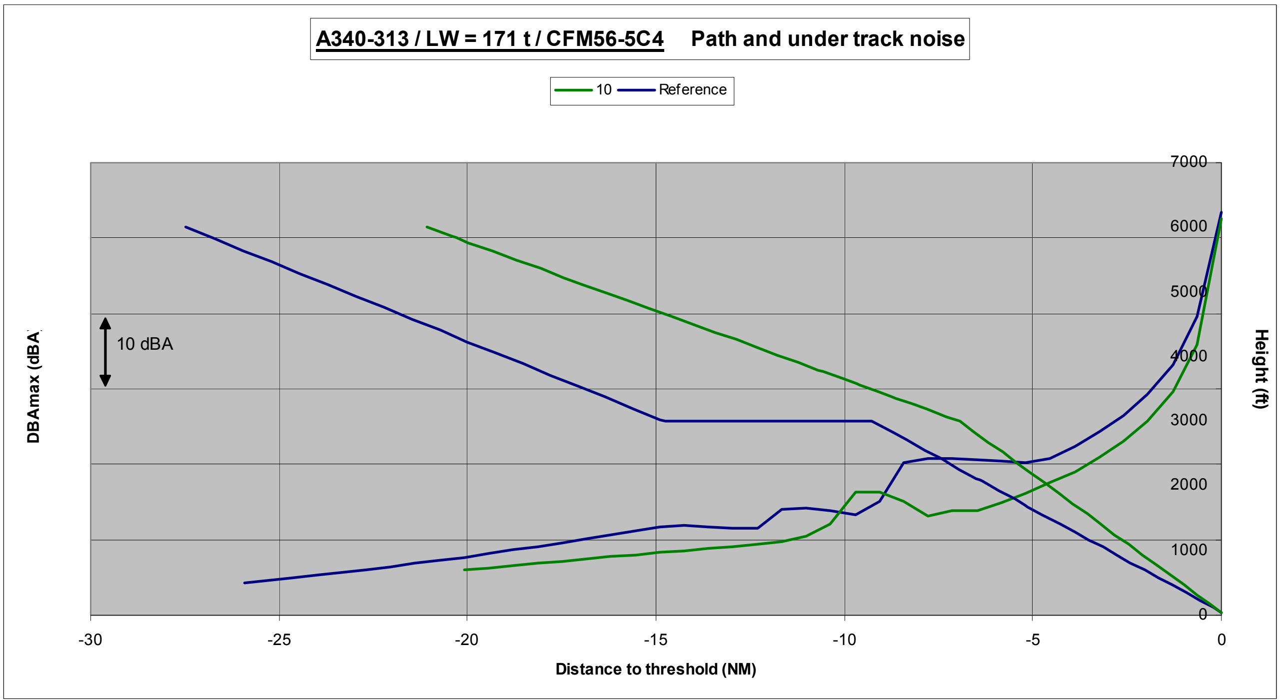

Figure A 4

A.3. Variable path segment

19- Variable path segment at Conf2 L/G up and Flight Idle, HS 2000ft
20- Variable path segment at Conf FULL L/G down and Flight Idle, HS 2000ft
21- Variable path segment at Conf2 L/G up and Flight Idle, HS 3000ft
22- Variable path segment at Conf FULL L/G down and Flight Idle, HS 3000ft

Aircraft type and nomenclature Altitude (ft)	A340 – 313 **19- Variable path segment at Conf2 L/G up and Flight Idle**, HS 2000ft
7000 ft (Fixed height value)	- Initial point: 220kt CAS, Flight Idle, Conf 0, Ldg Up - Level flight - Decelerate/change configuration to Conf 2, Ldg Up
	- Flight Idle - Descent at constant speed to 2000 ft
2000 ft (Fixed height value)	- Flight Idle - Fixed descent gradient -5.241% (-3°) - Decelerate/change configuration to Conf FULL, Ldg Down and Vref
1137 ft (Resulting height value)	- Adapted Thrust for descent gradient -5.241% (-3) - Descent at constant speed to 50 ft

Aircraft type and nomenclature Altitude (ft)	A340 – 313 **20- Variable path segment at Conf FULL L/G down and Flight Idle**, HS 2000ft
7000 ft (Fixed height value)	- Initial point: 220kt CAS, Flight Idle, Conf 0, Ldg Up - Level flight - Decelerate/change configuration to Conf FULL, Ldg Down and Vref
	- Flight Idle - Descent at constant speed to 2000 ft
2000 ft (Fixed height value)	- Adapted Thrust for descent gradient -5.241% (-3) - Descent at constant speed to 50 ft

Aircraft type and nomenclature Altitude (ft)	A340 – 313 **21- Variable path segment at Conf2 L/G up and Flight Idle**, HS 3000ft
7000 ft (Fixed height value)	- Initial point: 220kt CAS, Flight Idle, Conf 0, Ldg Up - Level flight - Decelerate/change configuration to Conf 2, Ldg Up
	- Flight Idle - Descent at constant speed to 3000 ft
3000 ft (Fixed height value)	- Flight Idle - Fixed descent gradient -5.241% (-3°) - Decelerate/change configuration to Conf FULL, Ldg Down and Vref
2113 ft (Resulting height value)	- Adapted Thrust for descent gradient -5.241% (-3) - Descent at constant speed to 50 ft

Aircraft type and nomenclature Altitude (ft)	A340 – 313 **22- Variable path segment at Conf FULL L/G down and Flight Idle**, HS 3000ft
7000 ft (Fixed height value)	- Initial point: 220kt CAS, Flight Idle, Conf 0, Ldg Up - Level flight - Decelerate/change configuration to Conf FULL, Ldg Down and Vref
	- Flight Idle - Descent at constant speed to 3000 ft
3000 ft (Fixed height value)	- Adapted Thrust for descent gradient -5.241% (-3) - Descent at constant speed to 50 ft

Procedures 1, 19 and 20 CAS and DBAmax

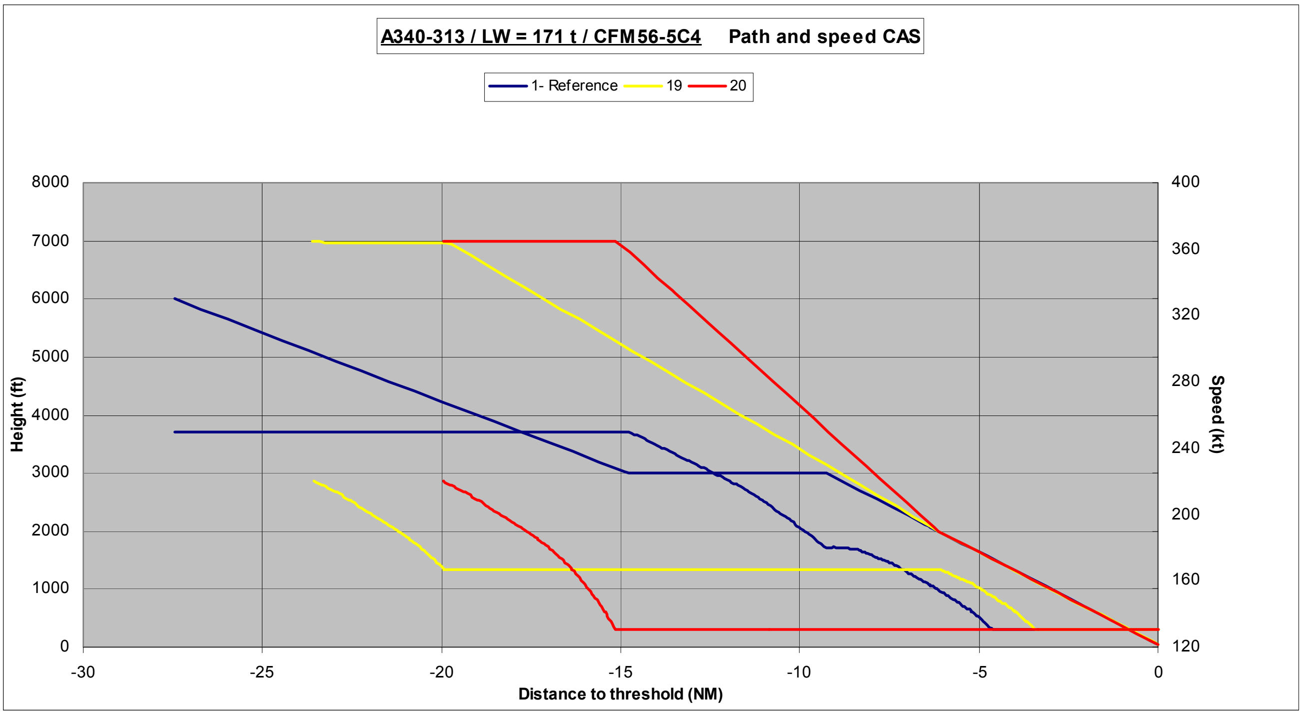

Figure A 5

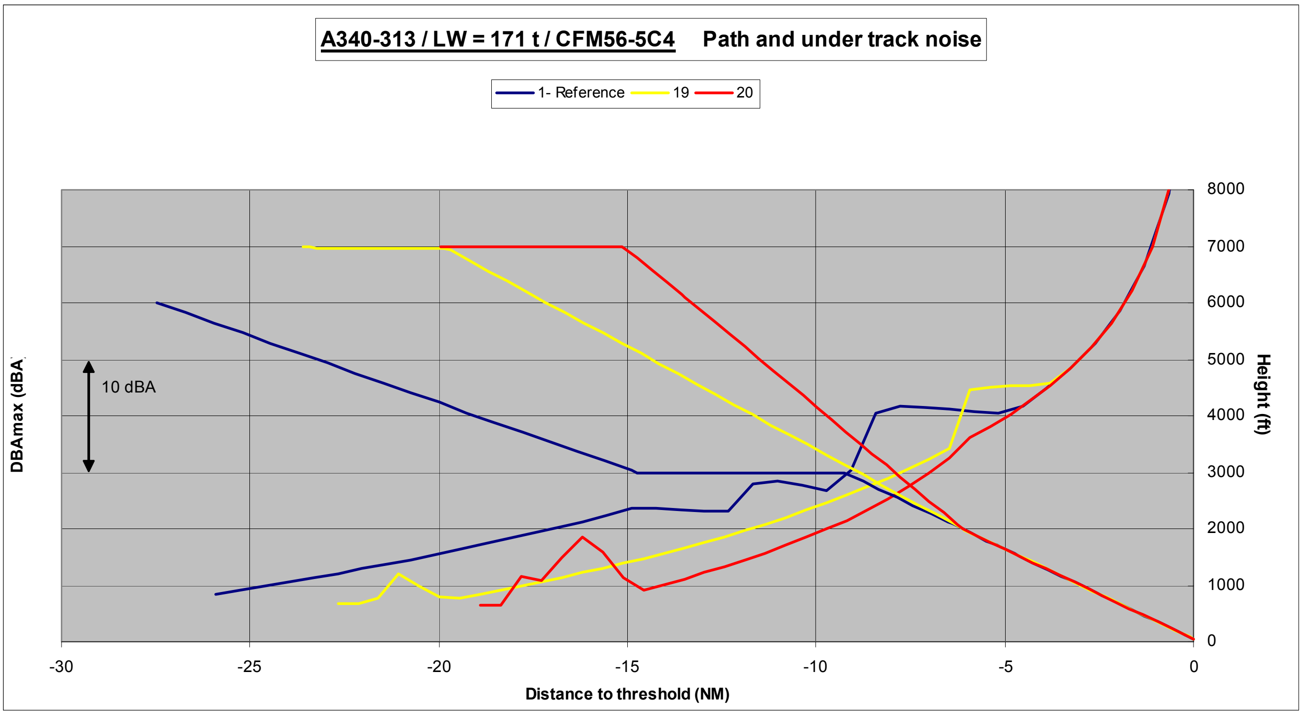

Figure A 6

Procedures 1, 21 and 22 : CAS and DBAmax

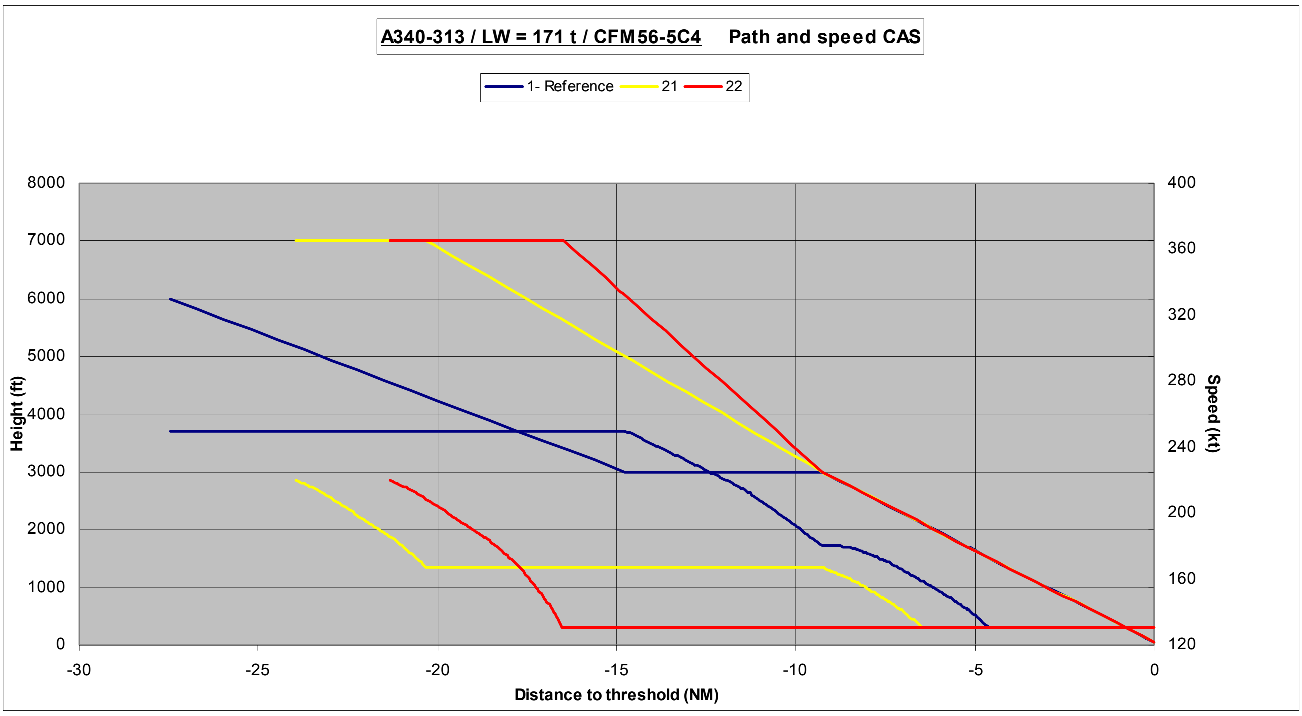

Figure A 7

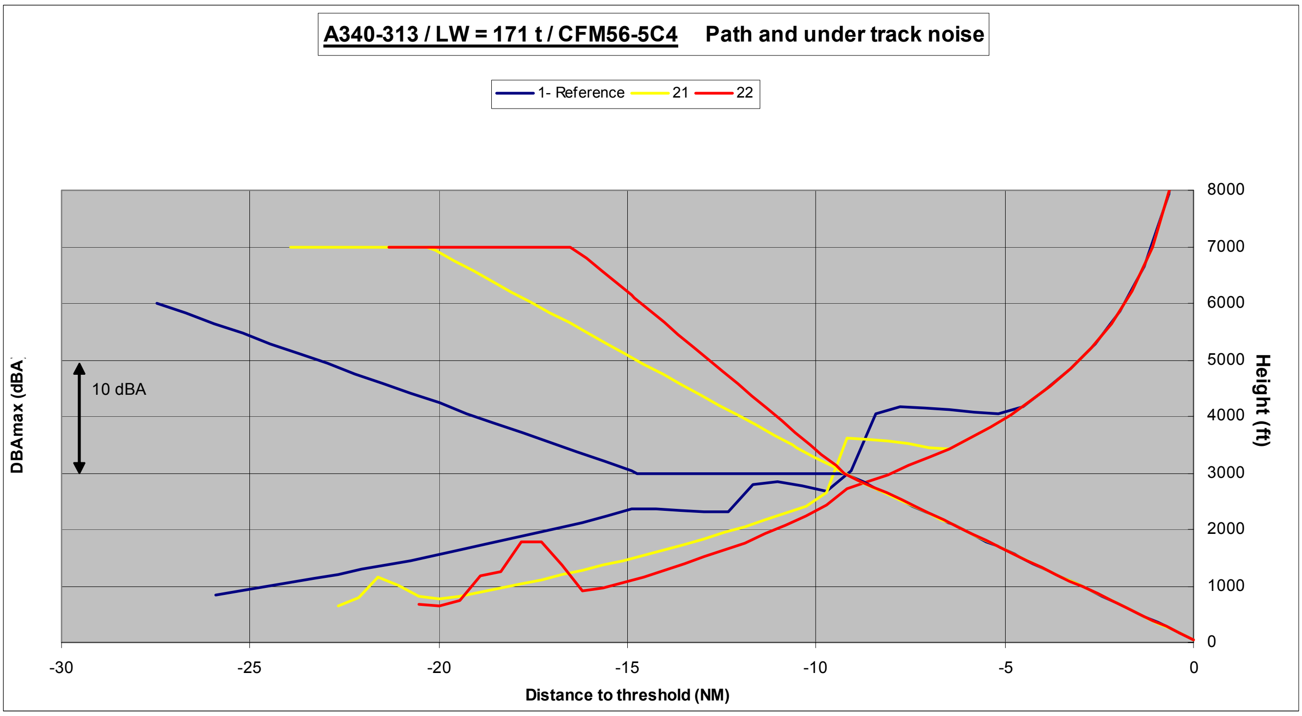

Figure A 8

A.4. Footprints

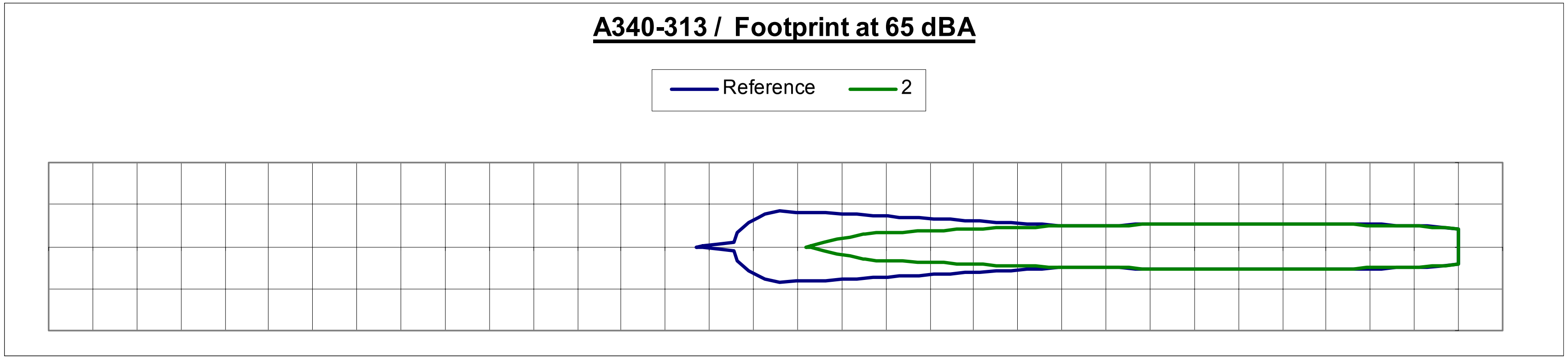

Figure A 9

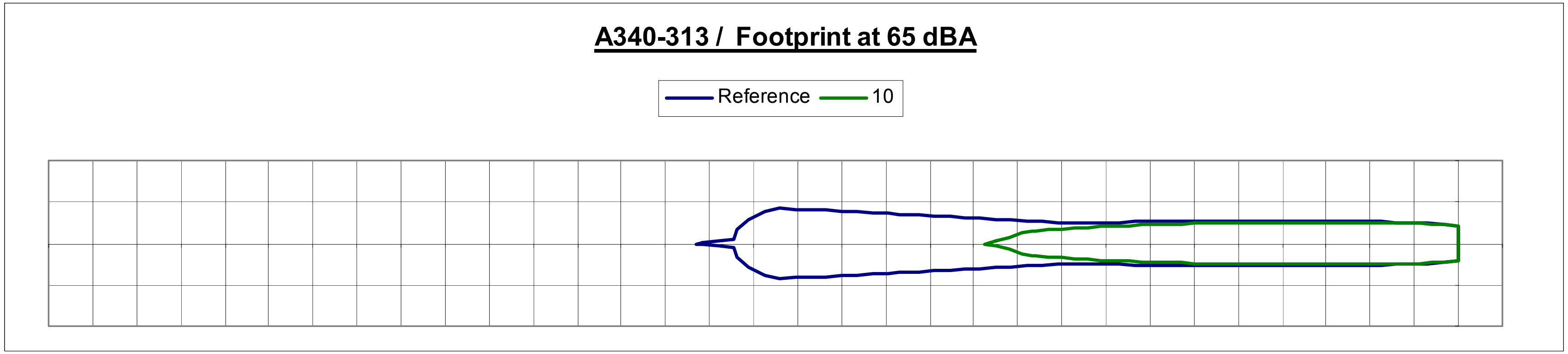

Figure A 10

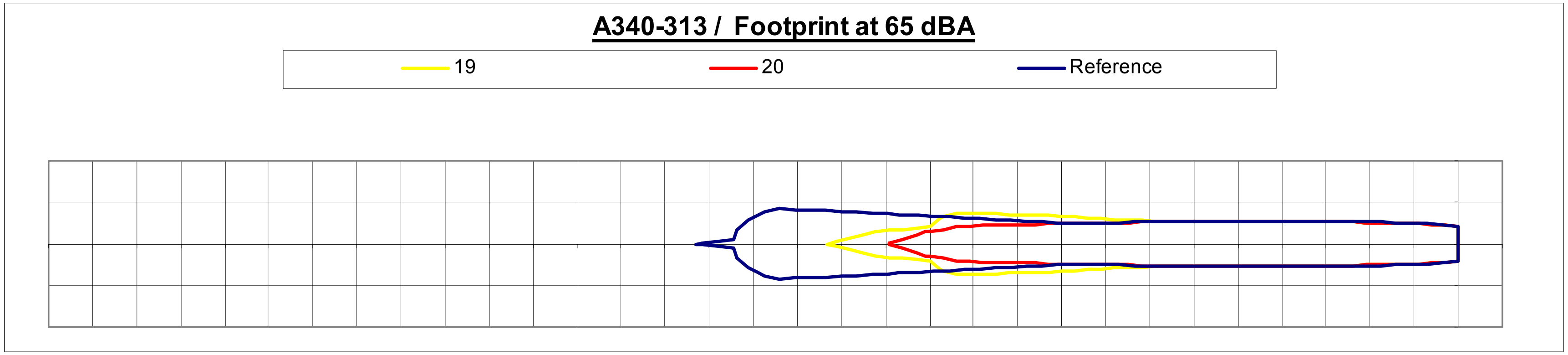

Figure A 11

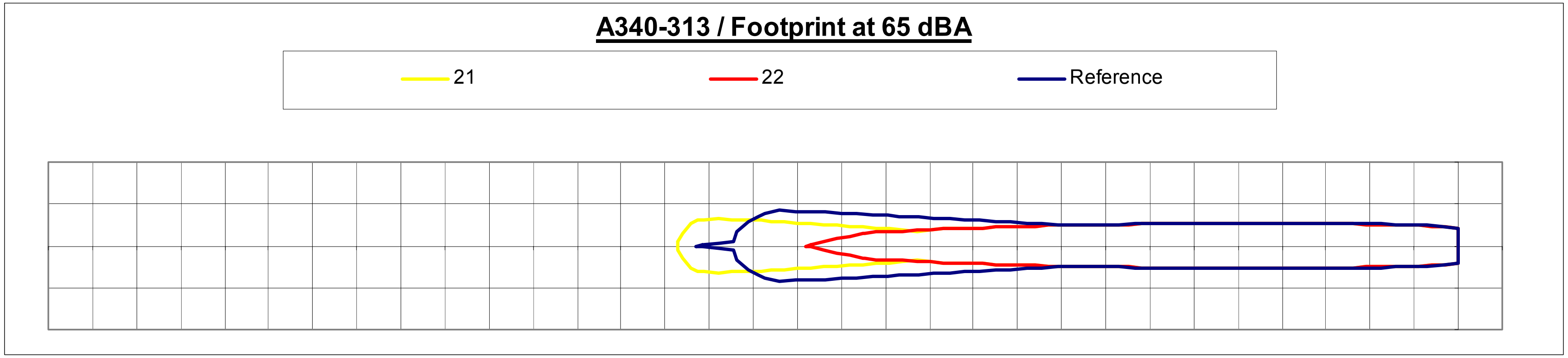

Figure A 12

B. A320 approach procedures

B.1. Standard Glide Slope (3°)

1- Reference
2- CDA early conf. change
4- CDA delayed conf. change

Aircraft type and nomenclature Altitude (ft)	A320-211 **1- Reference**
7000 ft (Fixed height value)	- Initial point: 250kt CAS, Flight Idle, Conf 0, Ldg. Up - Descent constant CAS
3000 ft (Fixed height value)	- Level flight - Flight Idle - Decelerate/change configuration to Conf FULL, Ldg. Down and Vref
3000 ft (Fixed height value)	- Adapted Thrust for descent gradient -5.241% (-3°) - Descent at constant speed to 50 ft

Aircraft type and nomenclature Altitude (ft)	A320-211 **2- CDA early conf. change**
7000 ft (Fixed height value)	- Initial point: 250kt CAS, Flight Idle, Conf 0, Ldg. Up - Fixed descent gradient -3.492% (-2°) - Decelerate/change configuration to **Conf 2** and Ldg. Up
3700 ft (Resulting height value)	- Flight Idle - Fixed descent gradient -5.241% (-3°) - Decelerate/change configuration to Conf FULL, Ldg. Down and Vref
2418 ft (Resulting height value)	- Adapted Thrust for descent gradient -5.241% (-3°) - Descent at constant speed to 50 ft

Aircraft type and nomenclature Altitude (ft)	A320-211 **4- CDA delayed conf. change**
7000 ft (Fixed height value)	- Initial point: 250kt CAS, Flight Idle, Conf 0, Ldg. Up - Descent at -3.492% (-2°) to Conf 2 and Ldg. Up (fixed descent angle)
2784 ft (Resulting height value)	- Flight Idle - Fixed descent gradient -5.241% (-3°) - Decelerate/change configuration to Conf FULL, Ldg. Down and Vref
1708 ft (Resulting height value)	- Adapted Thrust for descent gradient -5.241% (-3°) - Descent at constant speed to 50 ft

Procedures 1, 2, and 4: CAS and DBAmax

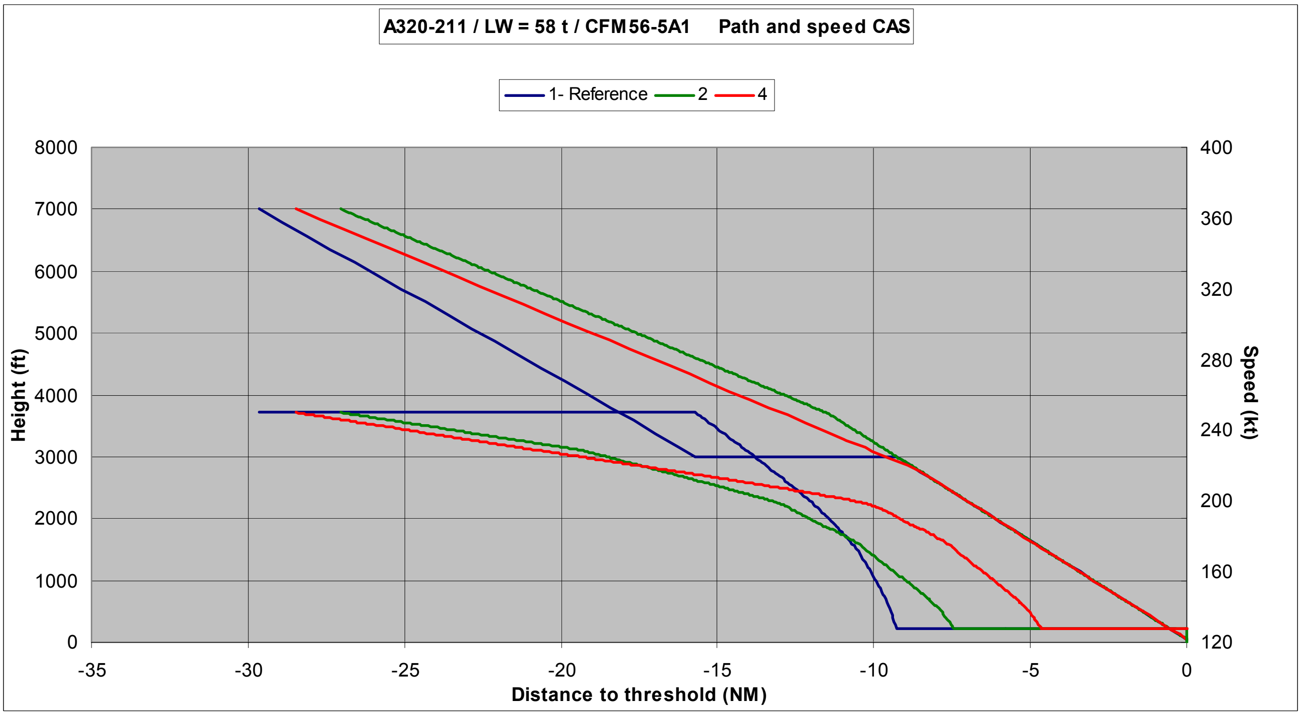

Figure B 1

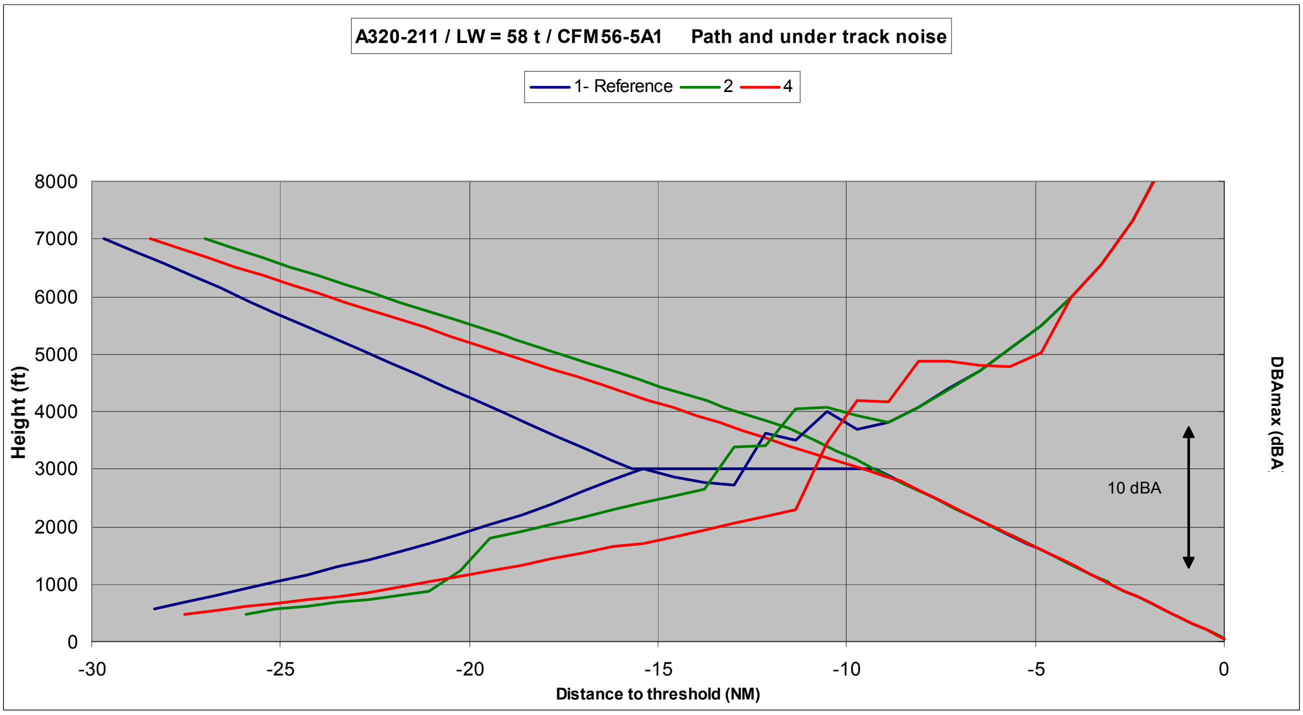

Figure B 2

B.2. Increased Glide Slope (4°)

1- Reference
7- CDA 4° glide slope

Aircraft type and nomenclature Altitude (ft)	A320-211 **1- Reference**
7000 ft (Fixed height value)	- Initial point: 250kt CAS, Flight Idle, Conf 0, Ldg. Up - Descent constant CAS (resulting descent angle -2.7°)
3000 ft (Fixed height value)	- Level flight - Flight Idle - Decelerate/configuration change to Conf FULL, Ldg. Down and Vref
3000 ft (Fixed height value)	- Adapted Thrust for descent gradient -5.241% (-3°) - Descent at constant speed to 50 ft

Aircraft type and nomenclature Altitude (ft)	A320-211 **7- CDA 4° glide slope**
7000 ft (Fixed height value)	- Initial point: 230kt CAS, Flight Idle, Conf 0, Ldg. Up - Fixed descent angle -3.492% (-2°) - Decelerate/change configuration to Conf FULL, Ldg. Down and Vref
3188 ft (Resulting height value)	- Adapted Thrust for descent gradient -6.993% (-4°) - Descent at constant speed to 50 ft

Procedures 1 and 7: N1 and DBAmax

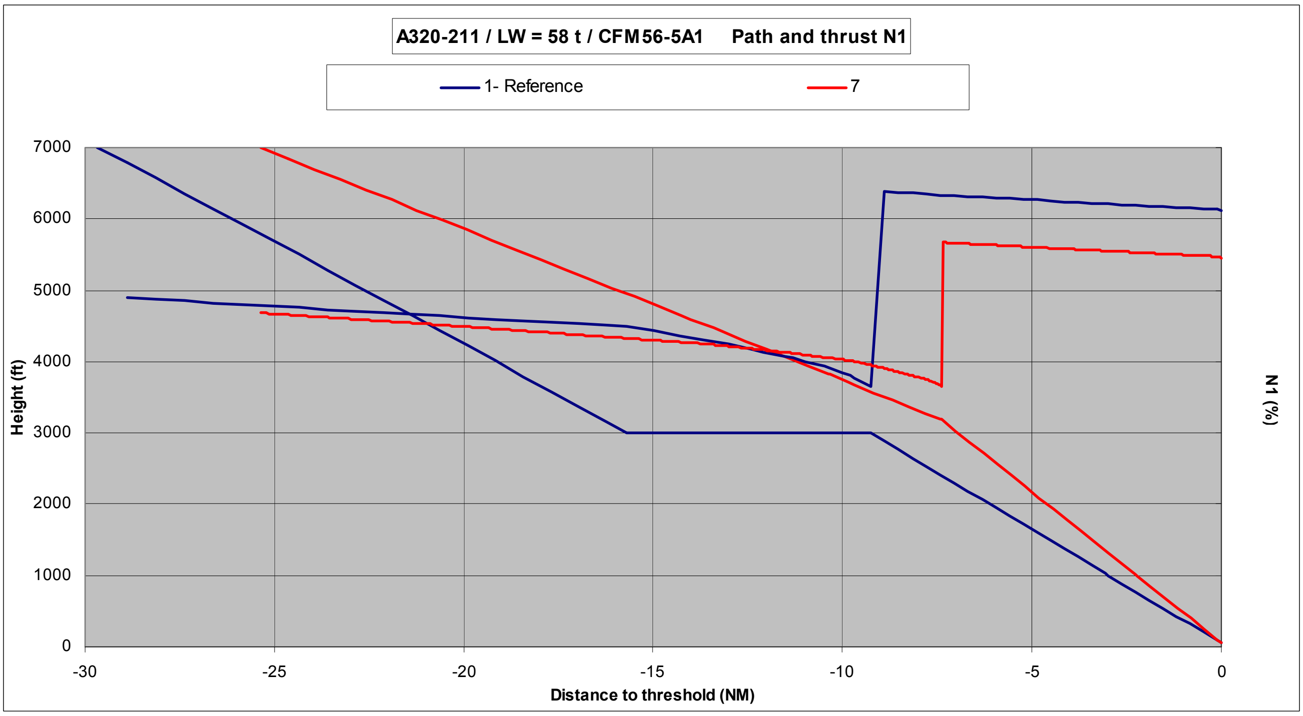

Figure B 3

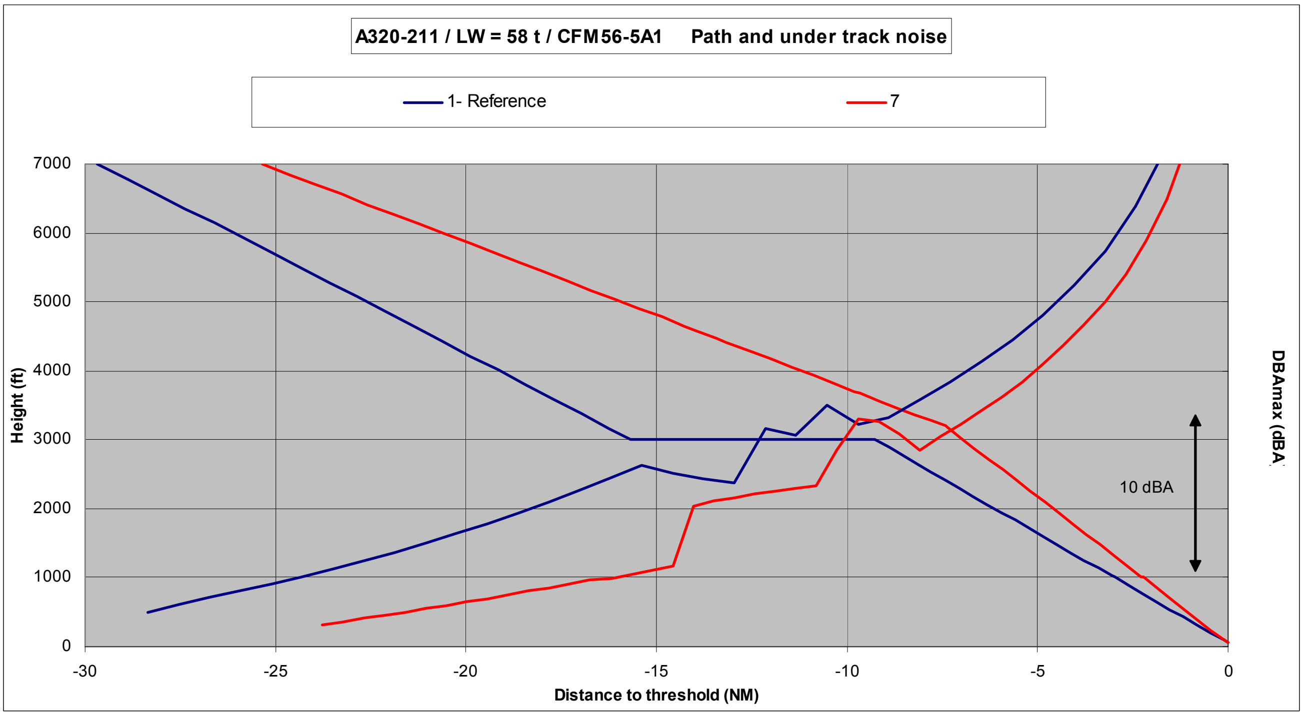

Figure B 4

B.3. CDA Adapted to A340 procedures

1- Reference
10- CDA 4° glide slope
20- Variable path segment at Conf FULL L/G down and Flight Idle, HS 2000ft
21- Variable path segment at Conf2 L/G up and Flight Idle, HS 3000ft

Aircraft type and nomenclature Altitude (ft)	A320-211 **1- Reference**
7000 ft (Fixed height value)	- Initial point: 250kt CAS, Flight Idle, Conf 0, Ldg. Up - Descent constant CAS
3000 ft (Fixed height value)	- Level flight - Flight Idle - Decelerate/configuration change to Conf FULL, Ldg. Down and Vref
3000 ft (Fixed height value)	- Adapted Thrust for descent gradient -5.241% (-3°) - Descent at constant speed to 50 ft

Aircraft type and nomenclature Altitude (ft)	A320-211 **10 -** CDA 4° glide slope
6000 ft (Fixed height value)	- Initial point: 220kt CAS, Flight Idle, Conf 0, Ldg Up - Fixed descent gradient -3.492% (-2°) - Decelerate/change configuration to Conf FULL, Ldg Down and Vref
3723 ft (Resulting height value)	- Adapted Thrust - Fixed descent angle -3.492% (-2°) - Descent at constant speed to 3000 ft
3000 ft (Fixed height value)	- Adapted Thrust for descent gradient -6.993% (-4°) - Descent at constant speed to 50 ft

Aircraft type and nomenclature Altitude (ft)	A320 - 211 **20 -** Variable path segment at Conf FULL L/G down and Flight Idle, HS 2000ft
7000 ft (Fixed height value)	- Initial point: 220kt CAS, Flight Idle, Conf 0, Ldg Up - Level flight - Decelerate/change configuration to Conf FULL, Ldg Down and Vref
	- Flight Idle - Descent at constant speed to 2000 ft
2000 ft (Fixed height value)	- Adapted Thrust for descent gradient -5.241% (-3) - Descent at constant speed to 50 ft

Aircraft type and nomenclature Altitude (ft)	A320 - 211 21- Variable path segment at Conf2 L/G up and Flight Idle, HS 3000ft
7000 ft (Fixed height value)	- Initial point: 220kt CAS, Flight Idle, Conf 0, Ldg Up - Level flight - Decelerate/change configuration to Conf 2, Ldg Up
	- Flight Idle - Descent at constant speed to 3000 ft
3000 ft (Fixed height value)	- Flight Idle - Fixed descent gradient -5.241% (-3°) - Decelerate/change configuration to Conf FULL, Ldg Down and Vref
1999 ft (Resulting height value)	- Adapted Thrust for descent gradient -5.241% (-3) - Descent at constant speed to 50 ft

Procedure 10, 20, 21: DBAmax

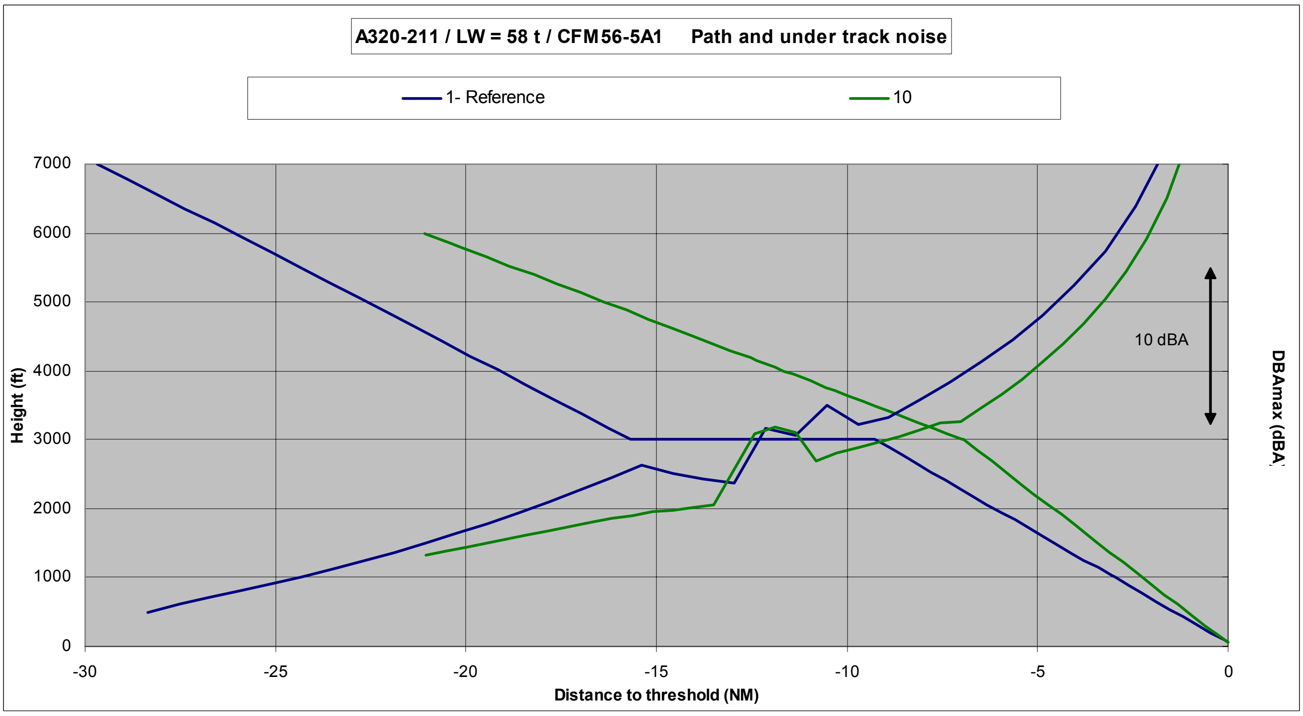

Figure B 5

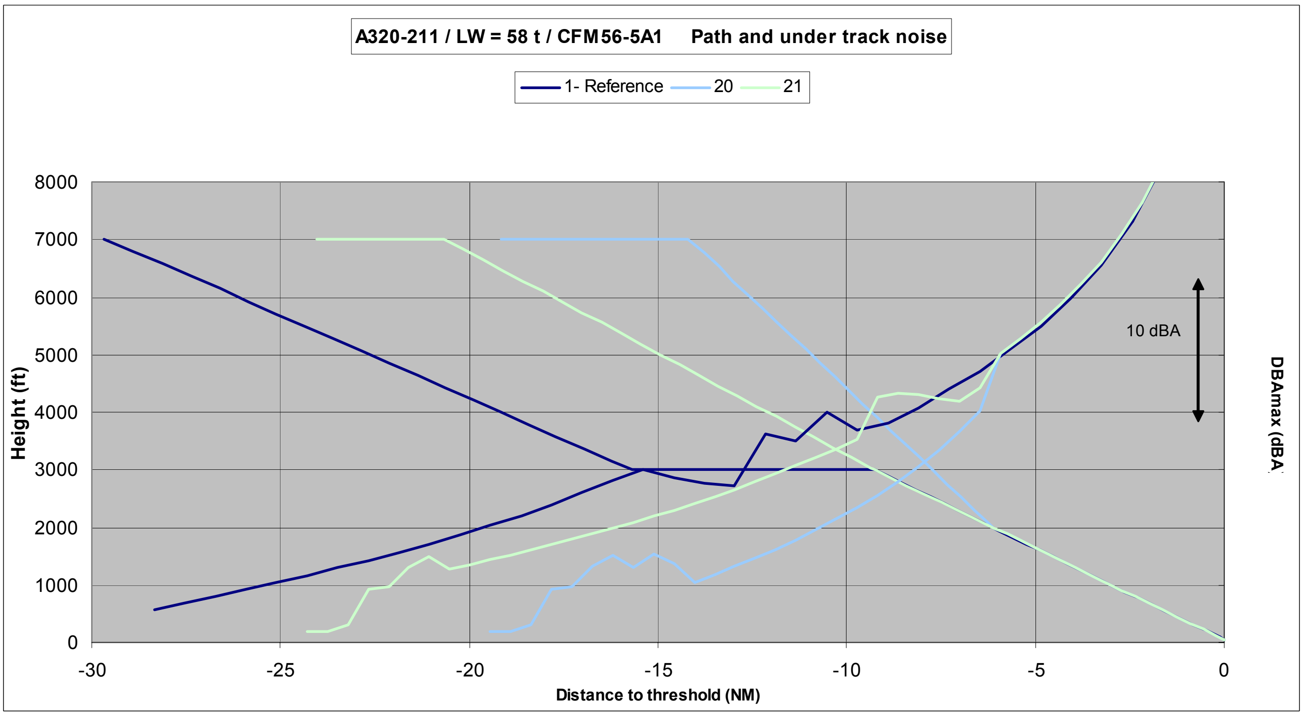

Figure B 6

B.4. Footprints

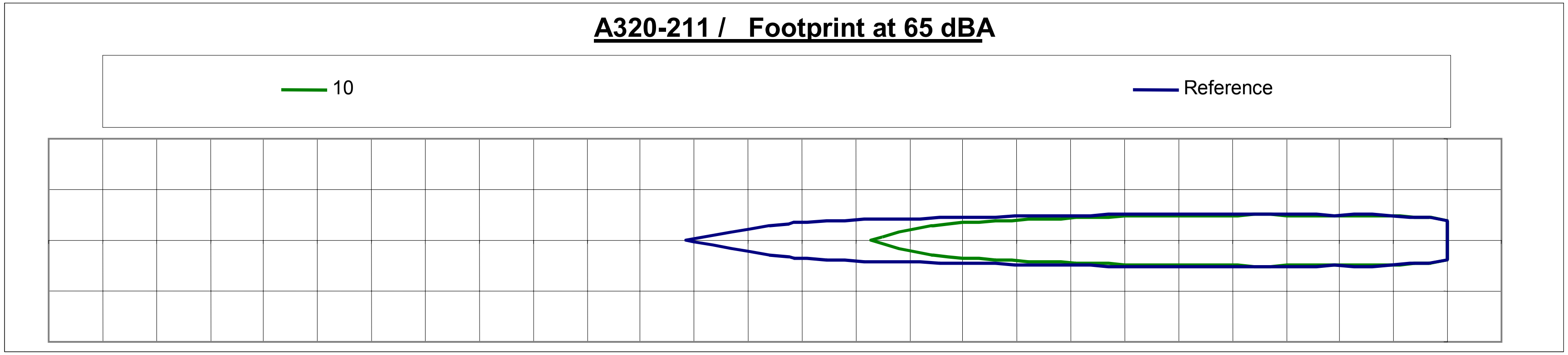

Figure B 7

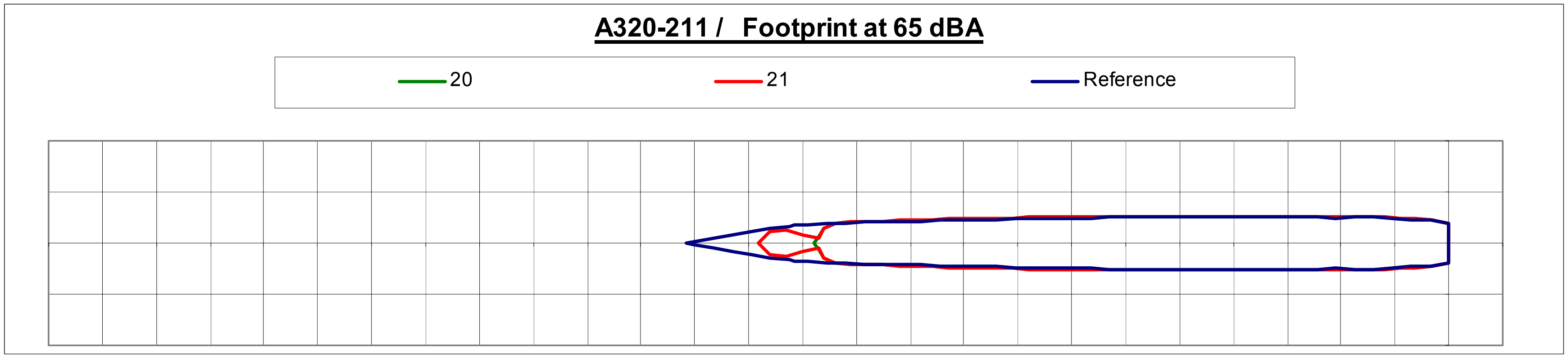

Figure B 8

C. A340 departure procedures

1- Reference ICAO A
2- NADP 1
3- NADP 2
4- SOURDINE Optimised Close-In
5- SOURDINE Optimised Distant
6- NADP2, Adapted Thrust under 3000 ft
7- NADP1, Adapted Thrust under 3000 ft

Aircraft type and nomenclature Altitude (ft)	A340-313 **1- Reference ICAO A**
0 ft	- TOGA (Take-Off Go Around) Thrust - Conf 1+F - Climb out at V2 + 10 kt
1500 ft	- Reduce to Climb Thrust - Maintain V2 + 10 kt
3000 ft	- Acceleration to 250 kt, retracting flaps/slats on schedule - Climb to 15000 ft

Aircraft type and nomenclature Altitude (ft)	A340-313 **2- NADP1**
0 ft	- TOGA (Take-Off Go Around) Thrust - Conf 1+F - Climb out at V2 + 10 kt
800 ft	- Reduce to Climb Thrust - Maintain V2 + 10 kt
3000 ft	- Acceleration to 250 kt, retracting flaps/slats on schedule - Climb to 15000 ft

Aircraft type and nomenclature Altitude (ft)	A340-313 **3- NADP2**
0 ft	- TOGA (Take-Off Go Around) Thrust - Conf 1+F - Climb out at V2 + 10 kt
800 ft	- Acceleration to Vzf and flaps/slats retraction - Reduce to Max Climb Thrust
3000 ft	- Acceleration to 250 kt - Climb to 15000 ft

Altitude (ft) / Aircraft type and nomenclature	A340-313 **4- SOURDINE Optimised Close-In**
0 ft	- TOGA (Take-Off Go Around) Thrust - Conf 1+F - Climb out at V2 + 10 kt
1000 ft	- Reduce thrust to 1.7% OEI climb gradient - Maintain V2 + 10 kt
5000 ft	- Gradual increase in thrust to Climb thrust - Maintain V2 + 10 kt
7500 ft	- Acceleration to 250 kt, retracting flaps/slats on schedule - Climb to 15000 ft

Altitude (ft) / Aircraft type and nomenclature	A340-313 **5- SOURDINE Optimised Distant**
0 ft	- TOGA (Take-Off Go Around) Thrust - Conf 1+F - Climb out at V2 + 10 kt
1000 ft	- Acceleration to Vzf, retracting flaps/slats to Conf 1
	- Reduce thrust to 1.7% OEI climb gradient - Retracting flaps/slats to Conf 0 - Maintain speed
5000 ft	- Start gradual thrust increase - Acceleration to 250 kt
	- Continue gradual thrust increase to Climb thrust - Maintain speed
9000 ft	- Increase in thrust to Max Climb - Maintain speed - Climb to 15000 ft

Altitude (ft) / Aircraft type and nomenclature	A340-313 **6- NADP2, Adapted Thrust under 3000ft**
0 ft	- TOGA (Take-Off Go Around) Thrust - Conf 1+F - Climb out at V2 + 10 kt
800 ft	- Acceleration to Vzf, retracting flaps/slats to Conf 1
	- Reduce thrust to 1.7% OEI climb gradient - Retracting flaps/slats to Conf 0 - Maintain speed
3000 ft	- Increase thrust to Climb Thrust - Acceleration to 250 kt - Climb to 15000 ft

Altitude (ft) / Aircraft type and nomenclature	A340-313 **7- NADP1, Adapted Thrust under 3000ft**
0 ft	- TOGA (Take-Off Go Around) Thrust - Conf 1+F - Climb out at V2 + 10 kt
800 ft	- Reduce to Climb Thrust 1.7% OEI climb gradient - Maintain V2 + 10 kt
3000 ft	- Increase thrust to Climb Thrust - Acceleration to 250 kt, retracting flaps/slats on schedule - Climb to 15000 ft

Procedures 1, 2, 4 and 7: CAS and DBAmax

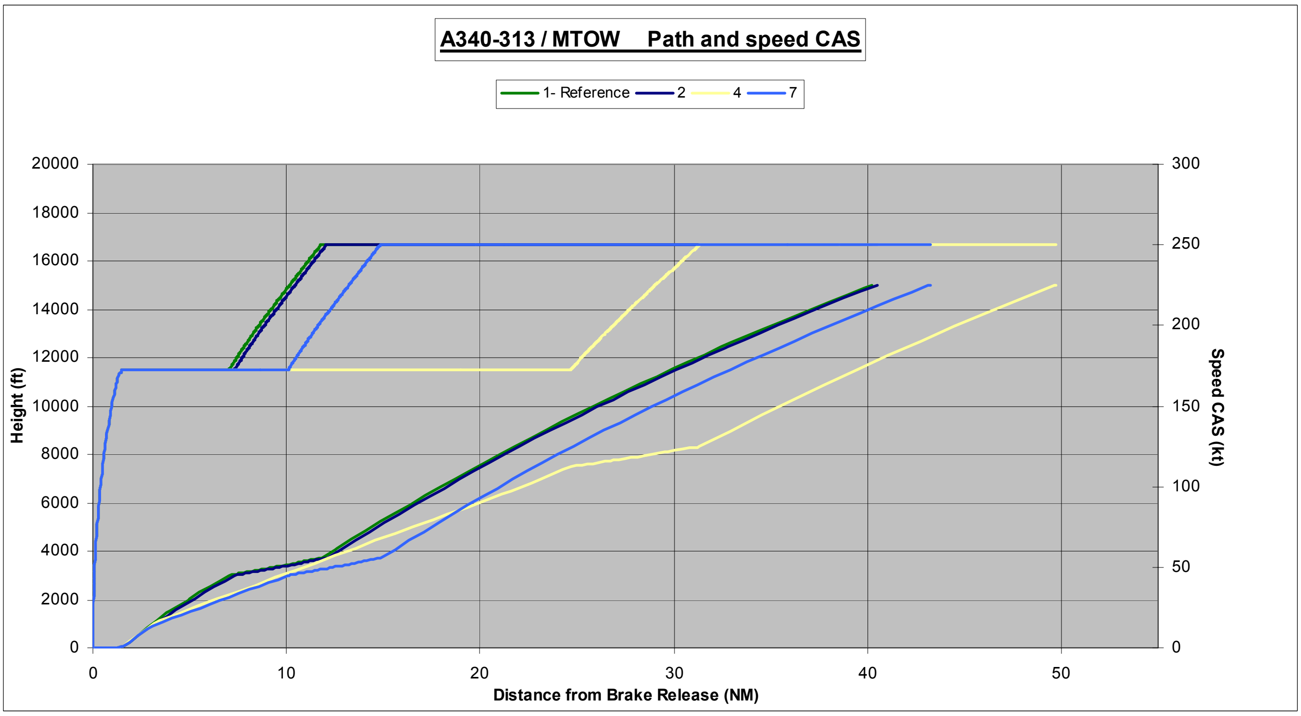

Figure C 1

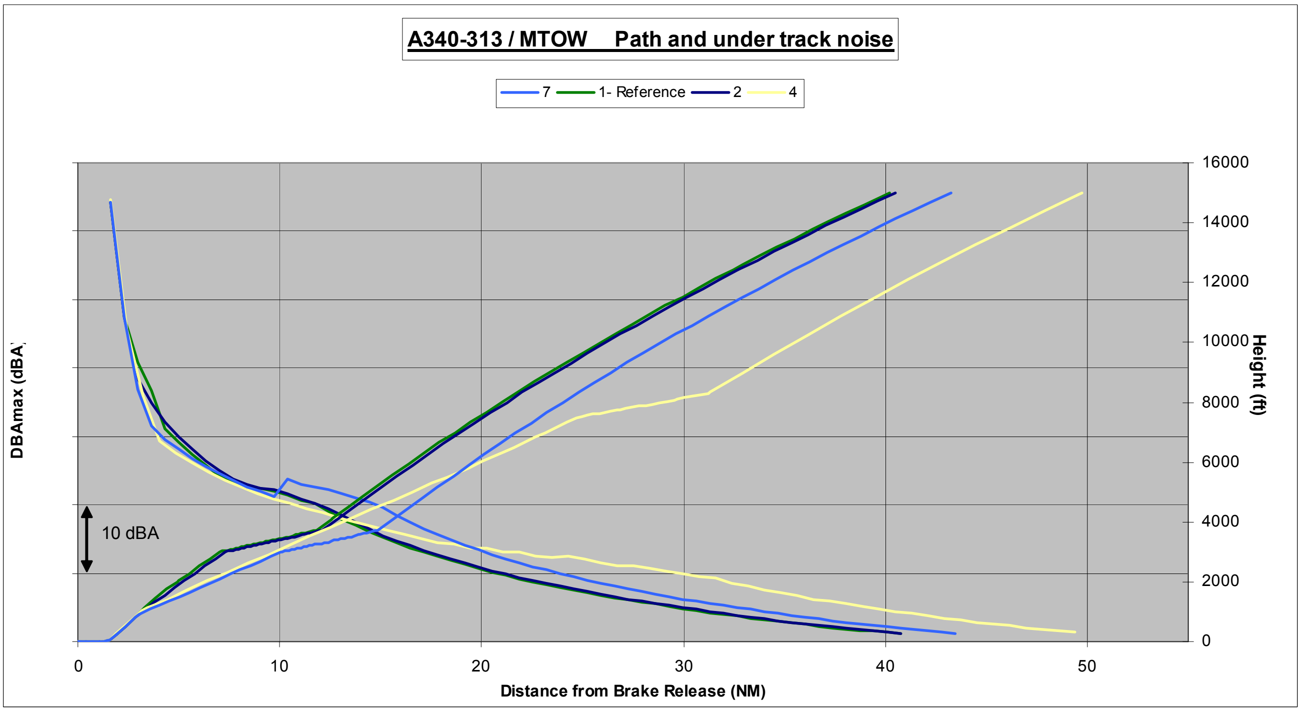

Figure C 2

Procedures 1, 2, 4 and 7: SEL

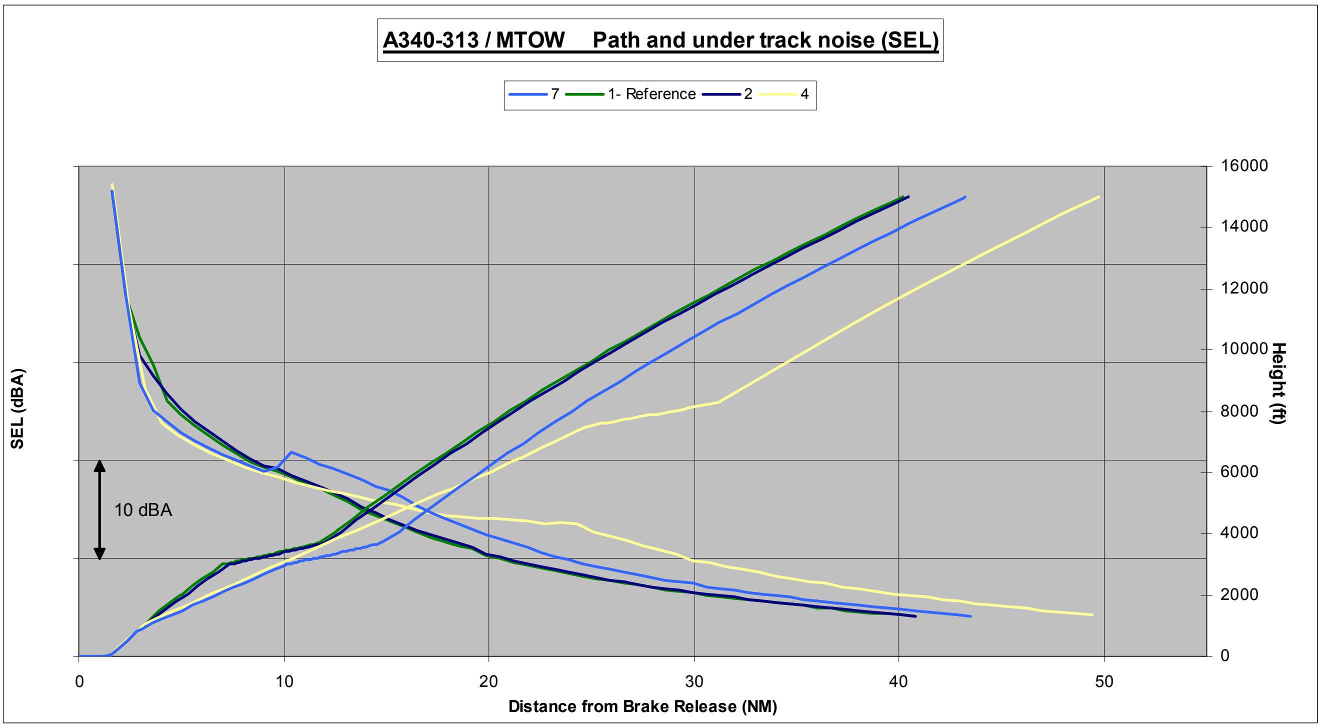

Figure C 3

Procedures 1, 3, 5 and 6: CAS and DBAmax

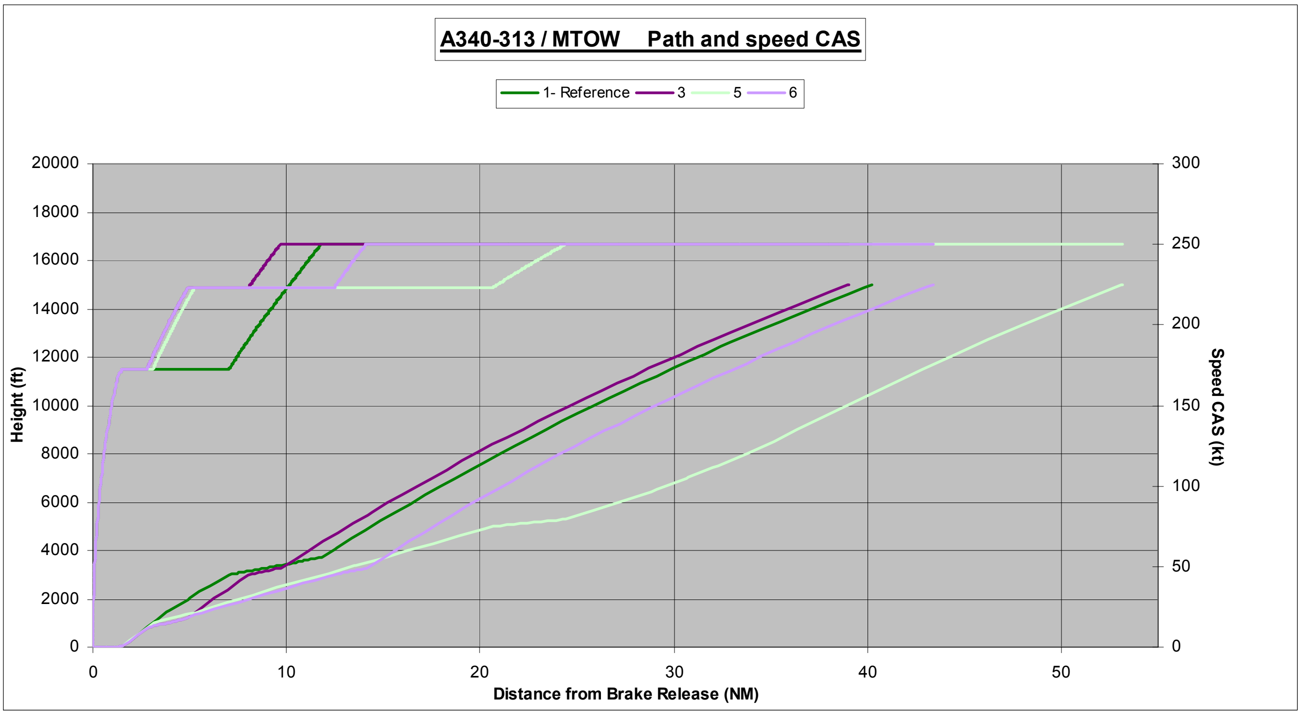

Figure C 4

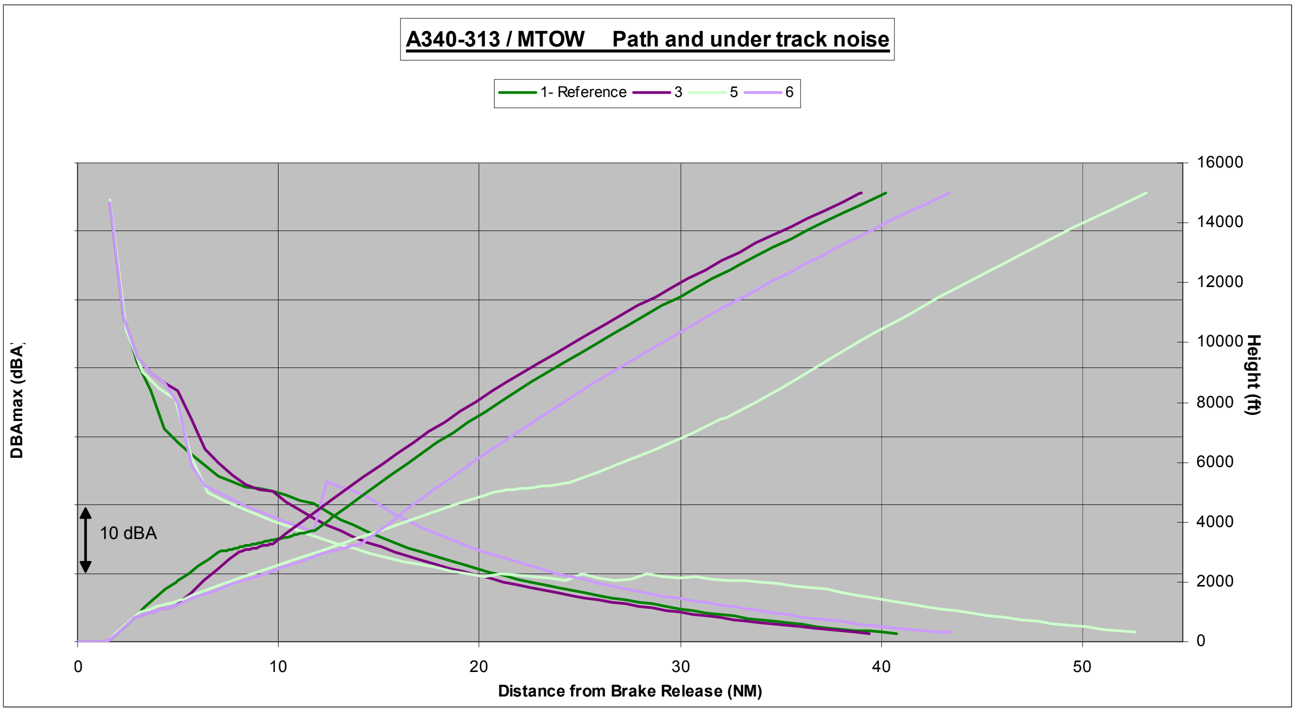

Figure C 5

Procedures 1, 3, 5 and 6: SEL

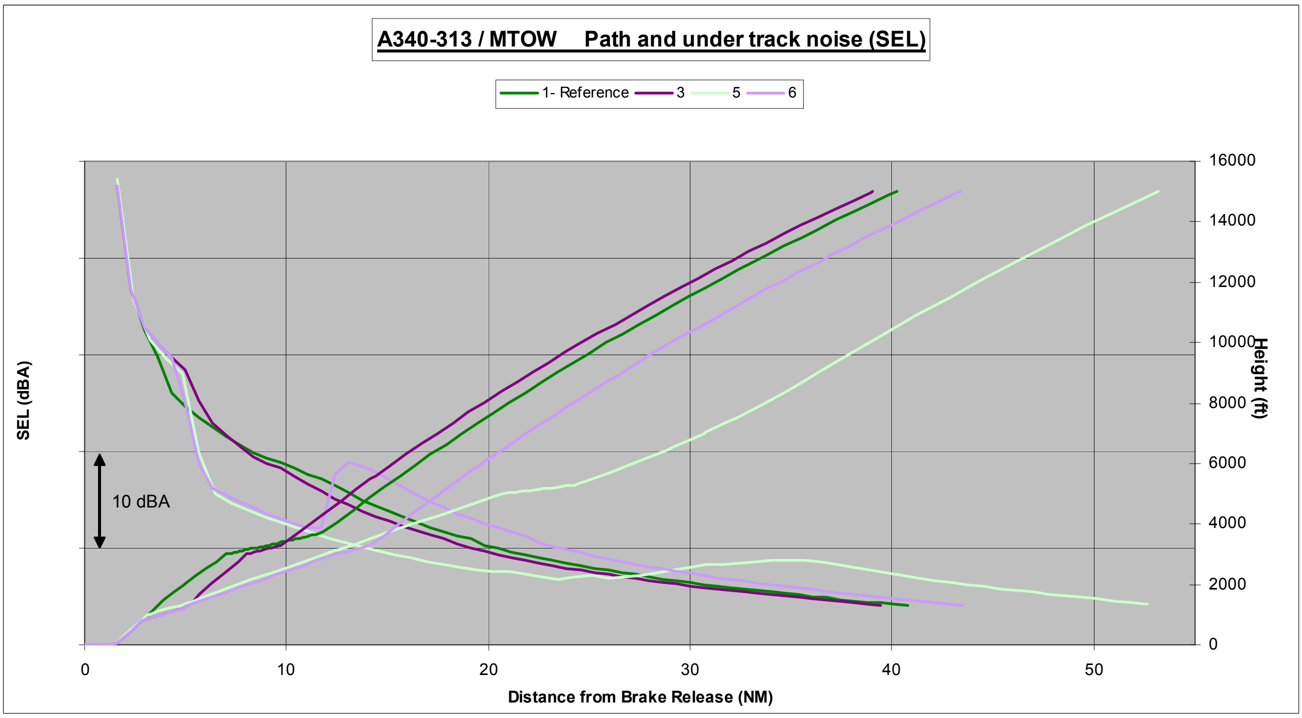

Figure C 6

Procedures 1 and 4 DBAmax footprints:

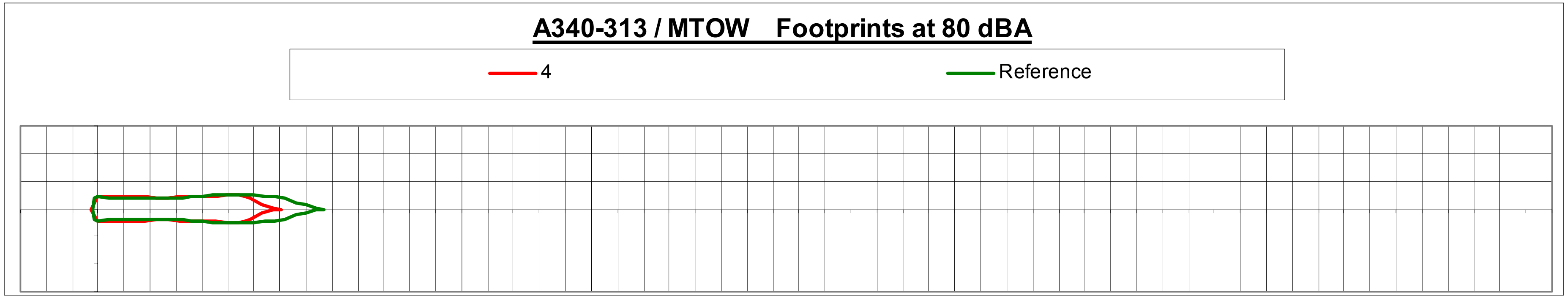

Figure C 7

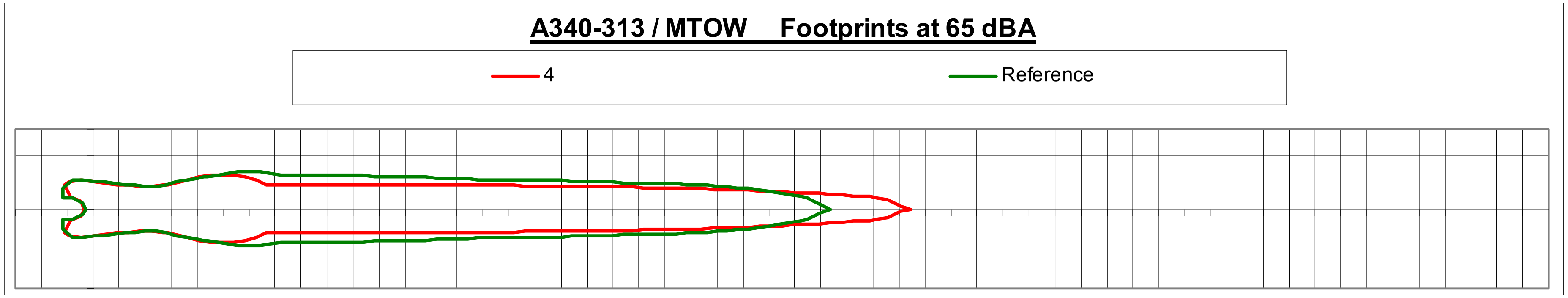

Figure C 8

Procedures 1 and 5 DBAmax footprints:

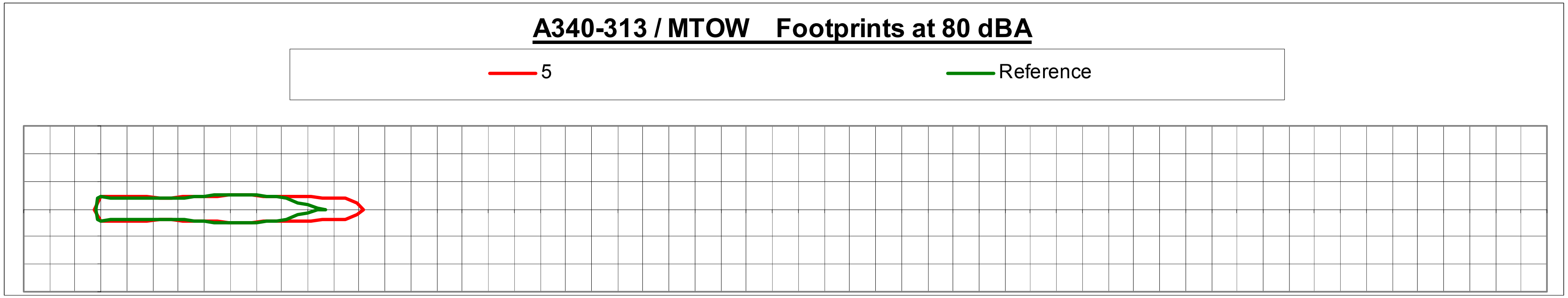

Figure C 9

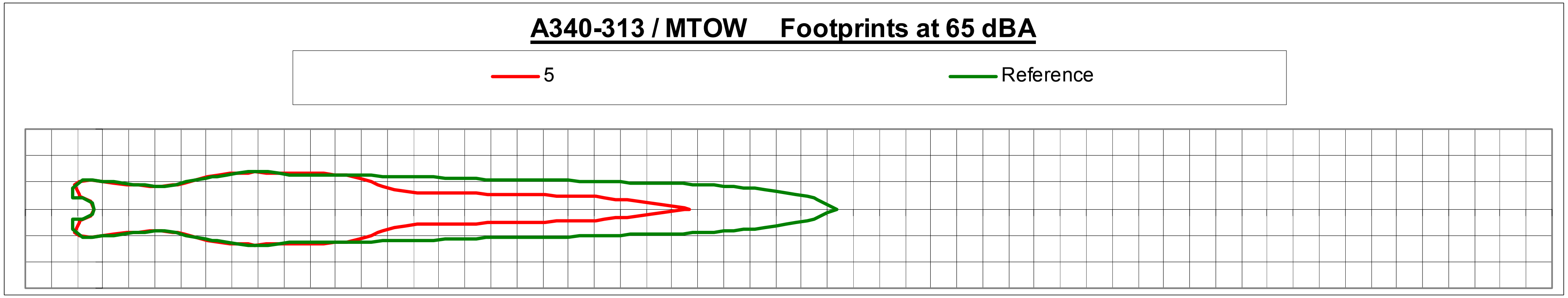

Figure C 10

D. A320 departure procedures

1- Reference ICAO A
3- NADP2 800ft
19- NADP2 1000 ft
20- NADP2 1500 ft

Aircraft type and nomenclature Altitude (ft)	A320-211 **1- Reference ICAO A**
0 ft	- TOGA (Take-Off Go Around) Thrust - Conf 1+F - Climb out at V2 + 10 kt
1500 ft	- Reduce to Climb Thrust - Maintain V2 + 10 kt
3000 ft	- Acceleration to 250 kt, retracting flaps/slats on schedule - Climb to 10000 ft

Aircraft type and nomenclature Altitude (ft)	A320-211 **3- NADP2 800ft, 19- NADP2 1000ft, 20- NADP2 1500ft**
0 ft	- TOGA (Take-Off Go Around) Thrust - Conf 1+F - Climb out at V2 + 10 kt
800, 1000, 1500 ft	- Acceleration and flaps/slats retraction to Vzf - Reduce to Max Climb Thrust
3000 ft	- Acceleration to 250 kt - Climb to 10000 ft

Procedures 1, 3, 19 and 20: CAS and DBAmax

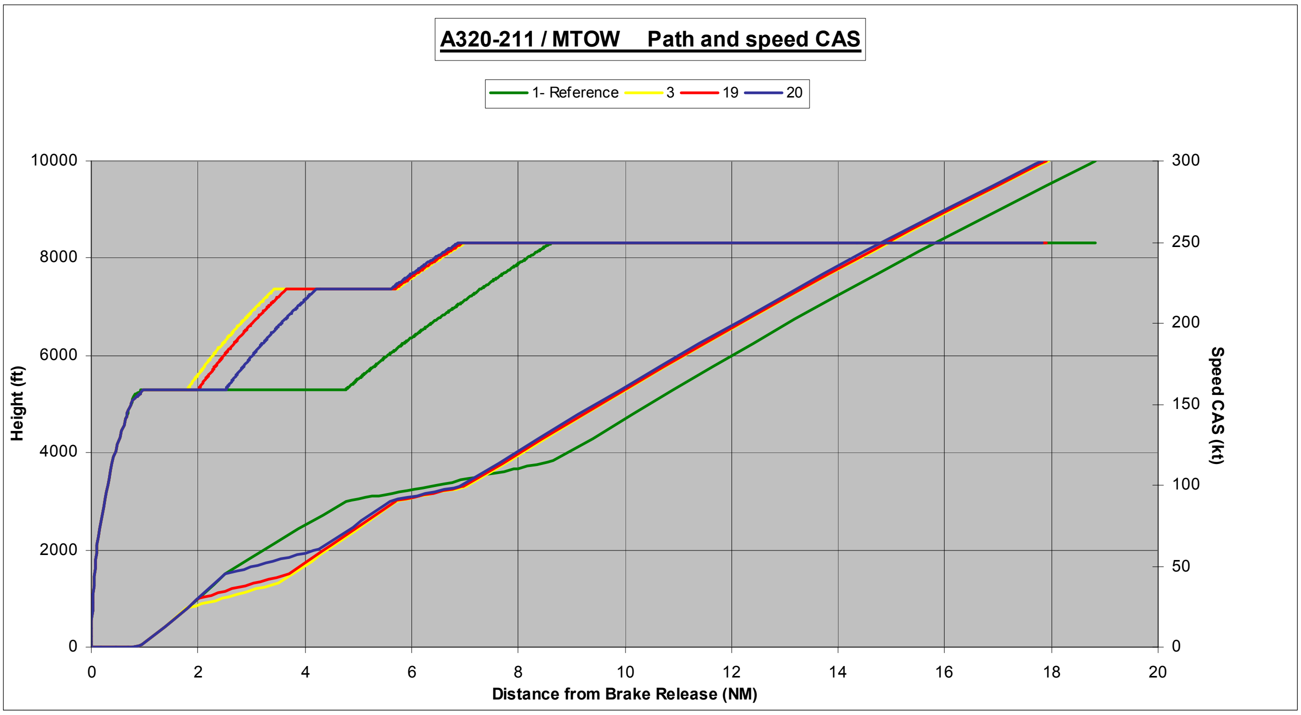

Figure D 1

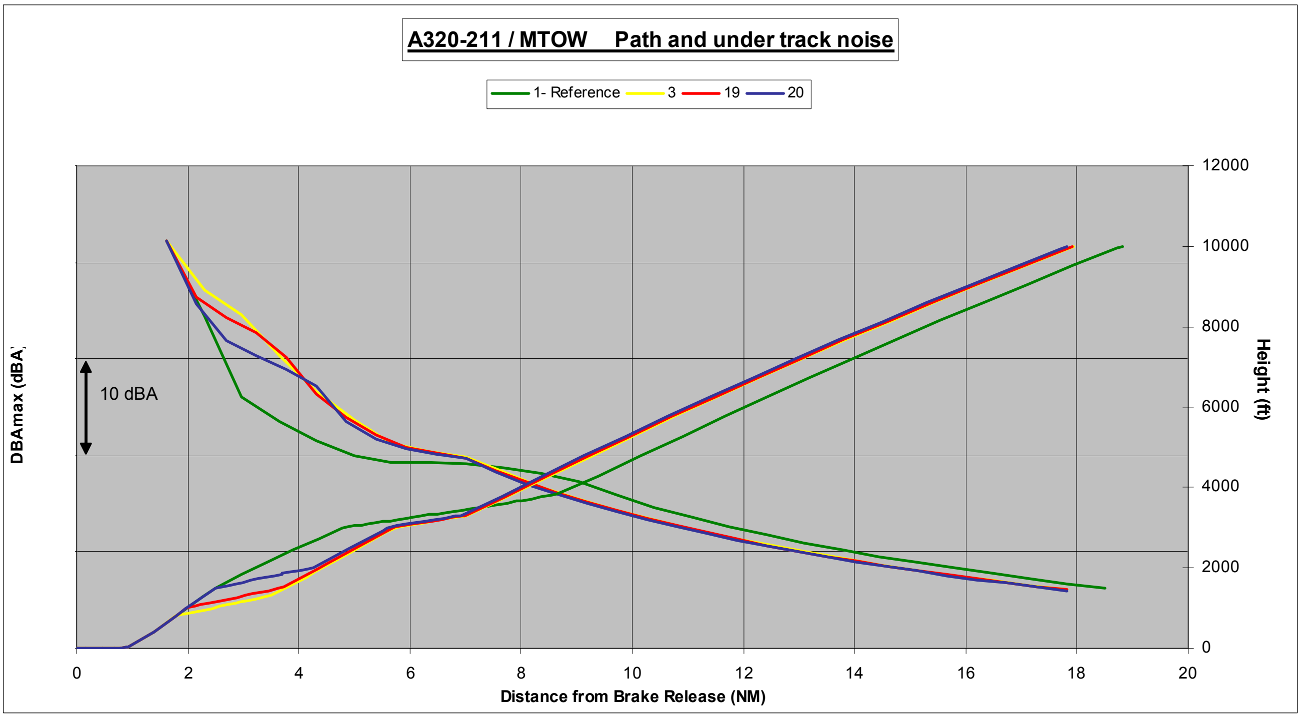

Figure D 2