ANIMA

Aviation Noise Impact Management through Novel Approaches

Unofficial D4.3
1st Scenarios Simulation

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[1] Use one of the following codes: R=Document, report (excluding the periodic and final reports)
DEM=Demonstrator, pilot, prototype, plan designs
DEC=Websites, patents filing,press & media actions, videos, etc.
OTHER=Software, technical diagram, etc.
[2] Use one of the following codes: PU=Public, fully open, e.g. web
CO=Confidential, restricted under conditions set out in Model Grant Agreement
CI=Classified, information as referred to in Commission Decision 2001/844/EC.

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Update	**Name**	**Version**
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1 Introduction

ANIMA Task 6.1 is dedicated to the definition and update of a common strategic research roadmap for aviation noise reduction, involving all key aspects related to mitigation solutions, assessment of noise effects on populations and community engagement.

To support the work in this Task, scenarios are to be defined for technologies, operational procedures and noise management actions for the 2035 and 2050 horizons on a number of selected airports. These scenarios will be simulated by the toolkit developed in WP4 and results provided back to T6.1 for assessment.

The objective of this scenario-based approach is to provide a complete overview of the effect of the planned research and its possibilities of achieving the goals set by ACARE from the standpoint of environmental constraints.

The assessment will need to take into consideration criteria such as noise exposure, annoyance and sleep disturbance and noise-emissions interdependencies. The results of the assessment will be used to inform the update process of the common strategic research roadmap.

Two cycles of scenarios are planned to support the updating of the roadmaps in WP6. These scenarios are defined by WP6 through Deliverables D6.2 (Scenario definition V1) and D6.15 (Scenario definition V2) and WP4 will report the results of the calculations through Deliverables D4.3 (1st scenario simulations) and 4.10 (2nd scenario simulations).

It was decided to split the V1 scenarios in 2 parts:

- 1A: to support development of the tool chain
- 1B: the first full set, to support the first update of the roadmap

Deliverable D6.2 was issued with a definition of scenario 1A only. The present version of D4.3 therefore only covers this first scenario, with the aim to test the tool chain.

An update of this document D4.3 will be issued after the definition and simulation of scenario 1B have been finalised.

2 Methodology

The scenarios defined in WP6 will be run through the WP4 tool chain and the results will be returned to WP6, where they will be assessed and used to inform the update of the roadmaps and to define a new set of scenarios for the next round. In addition, the results of the scenario execution will be assessed by WP4, with the aim to identify any improvements that might be implemented in a subsequent version of the tool chain. This process is schematically represented in Figure 1.

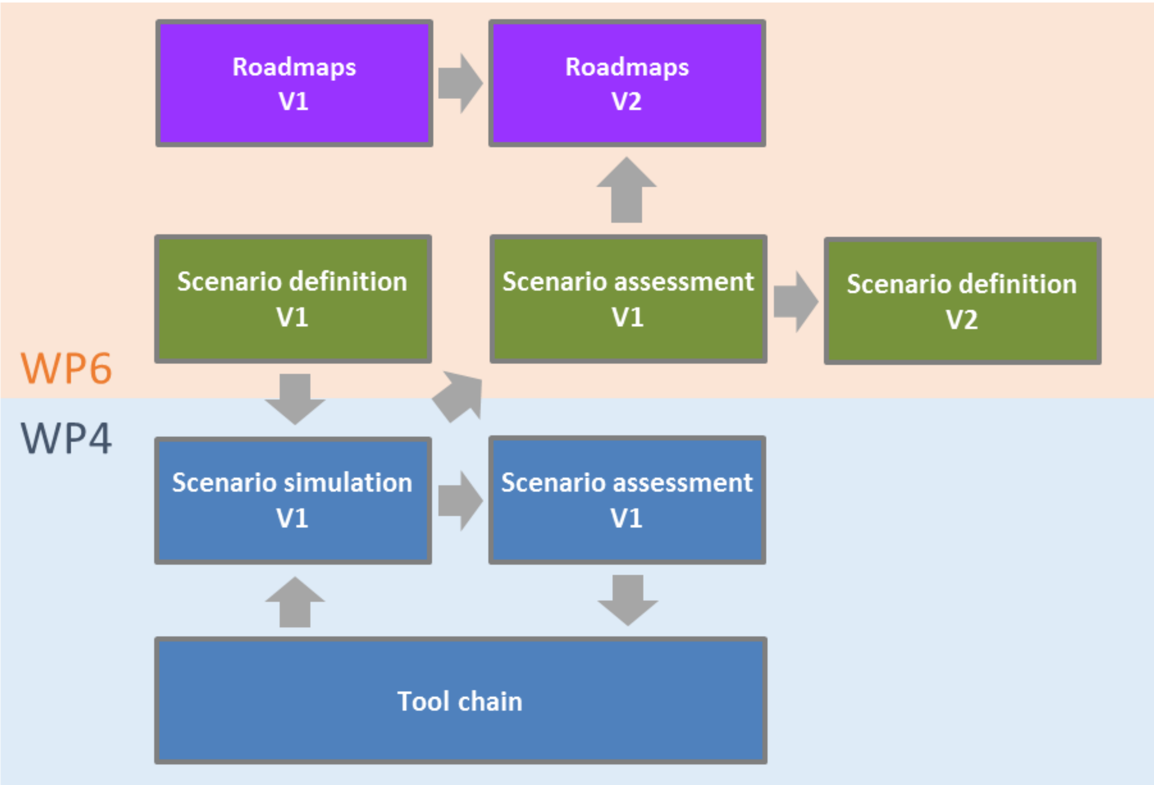


Figure 1 – Scenario process

At the core of the scenario process is the tool chain. To be able to define a scenario to test the various elements of the tool chain, it is necessary to understand the various modules constituting the chain. For the sake of simplification, here two main streams are considered:

- single event branch
- multi event branch

2.1 Tool chain – single event branch

The single event branch (see Figure 2) serves 3 main purposes:

- Create a noise database (Noise-Power-Distance table) for novel concept aircraft and for conventional aircraft with noise reduction technology kits

inserted. This module is based on the FRIDA tool developed by UoR and on the SOPRANO platform developed by Anotec.
- Create a database with single event noise footprints for all aircraft types, tracks and flight profiles considered. The single event noise footprints are calculated by the SONDEO airport noise model, developed by Anotec. This model implements the latest version of ECAC Doc.29. This model is based on the usage of Noise-Power-Distance (NPD) relations, available for each aircraft type to be simulated. For each flight segment of an aircraft operation the corresponding noise level at a point on the ground is calculated by interpolation in the NPD at the corresponding Power and Distance.
- Create a database with single event emissions predictions for all aircraft, tracks and flight profiles considered. These predictions are made by the SONDEO/EM model, developed by Anotec. This model incorporates various methodologies (ICAO LTO, Boeing FF2 method, …). This model will be described in a future deliverable D4.12.

The input required for these models is as follows:
- Fleet composition (aircraft/engine combinations to be considered in the scenarios)
- Ground tracks (based on SIDs and STARs to be considered in the scenarios)
- Flight profiles (mainly based on aircraft performance)
- Engine operating parameters (based on engine deck)
- Airport info (Runway details, elevation, meteorological conditions, etc)
- For novel aircraft:
    - filter to simulate the aircraft/engine configuration relative to a baseline aircraft (for several noise sources like jet, fan and airframe or for a full aircraft/engine combination)
    - aircraft performance
- For noise reduction technology (NRT) insertion:
    - filter to simulate the NRT relative to a baseline aircraft (for several noise sources like jet, fan and airframe or for a full aircraft/engine combination)

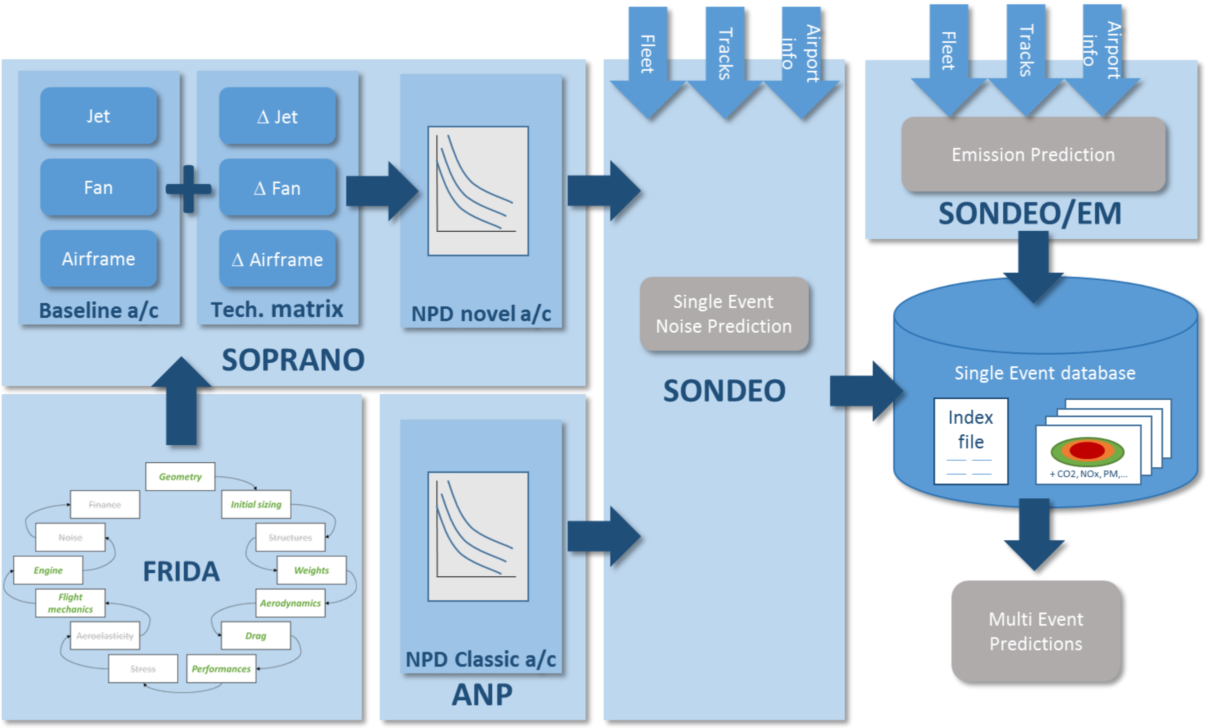


Figure 2 – WP4 Tool chain – Single event branch

2.2 Tool chain – multi event branch

In the former step the noise and emissions data have been calculated for all the aircraft-track-profile combinations that will be considered in the scenarios to be considered. These single event results will then be used to determine the overall result for a given operational scenario. For the purpose of ANIMA, where also the effect of noise management actions should be assessed, a scenario is defined as a specific *operational state* of an airport, combined with a specific state of the areas around the airport, affected by the noise (*receiver state*).

The *operational state* of the airport is mainly defined by the following:

- The number of operations of each aircraft-track-profile combination
- The time of day when these operations take place

The *receiver state* is mainly defined by the following:

- The population distribution around the airport
- The sensitivity to noise of a specific zone around the airport (dose-response relationship)

Figure 3 shows which of the various elements of both states can contribute to the different components of the Balanced Approach. This scheme can be called the Noise Impact Mitigation Matrix, with which scenarios can easily be built. This, combined with the use of pre-processed data (the single events), allows for a fast calculation of each scenario. This facilitates e.g. conducting sensitivity studies, the assessment of combinations of most promising noise mitigation actions or the comparison of different alternatives to achieve the same noise impact reduction.

Whereas the simulation of actions that define the operational state of the airport is more or less straight forward, this Matrix is especially useful when considering actions in the field of Noise Management or Land Use Planning, both main areas of attention in ANIMA. As an example, the effect of house insulation may be simulated by a change in the sensitivity of the population (less response for the same dose) in the area were the insulation is planned to be applied. In a similar manner the result of e.g. stakeholder engagement may also be simulated by adapting the sensitivity accordingly. In this manner various alternatives with the same final objective (reduced impact), may be compared.

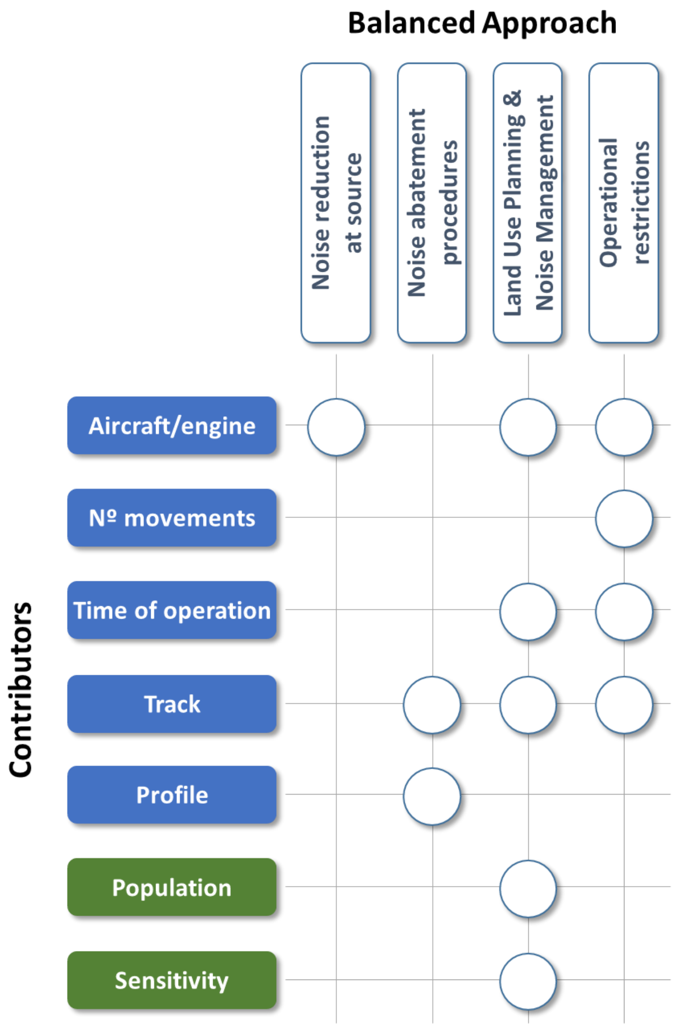


Figure 3 – Noise Impact Mitigation Matrix

Figure 4 gives a schematic overview of the multi-event branch, implementing the Noise Impact Mitigation Matrix to define the scenario(s) to be calculated. As a starting point a baseline scenario is defined, which constitutes the reference case on which the different scenarios are based. Based on the user-defined scenario a Scenario Generator will create the required input files to the various tools of the multi-event branch. The Event Merger mainly applies the appropriate weighting factor to each single event and calculates the total noise on a grid and the total emissions generated, corresponding to the operational state of the airport. The Virtual Resident maps this noise on a population map and applies specific weightings depending on the receiver state.

Note: At present the Virtual Resident is still under development and a detailed description is not yet available. It is noted that at present there is no agreed and robust metric available to express annoyance. ANIMA is striving to find metrics which can be related to the description of annoyance and can be accepted by both the scientific as well as the decision making community. One such metric is for instance the awakening indicator, which describes the probability for awakening caused by noise events. In this document the terminology annoyance will be used collectively for any kind of such metrics.

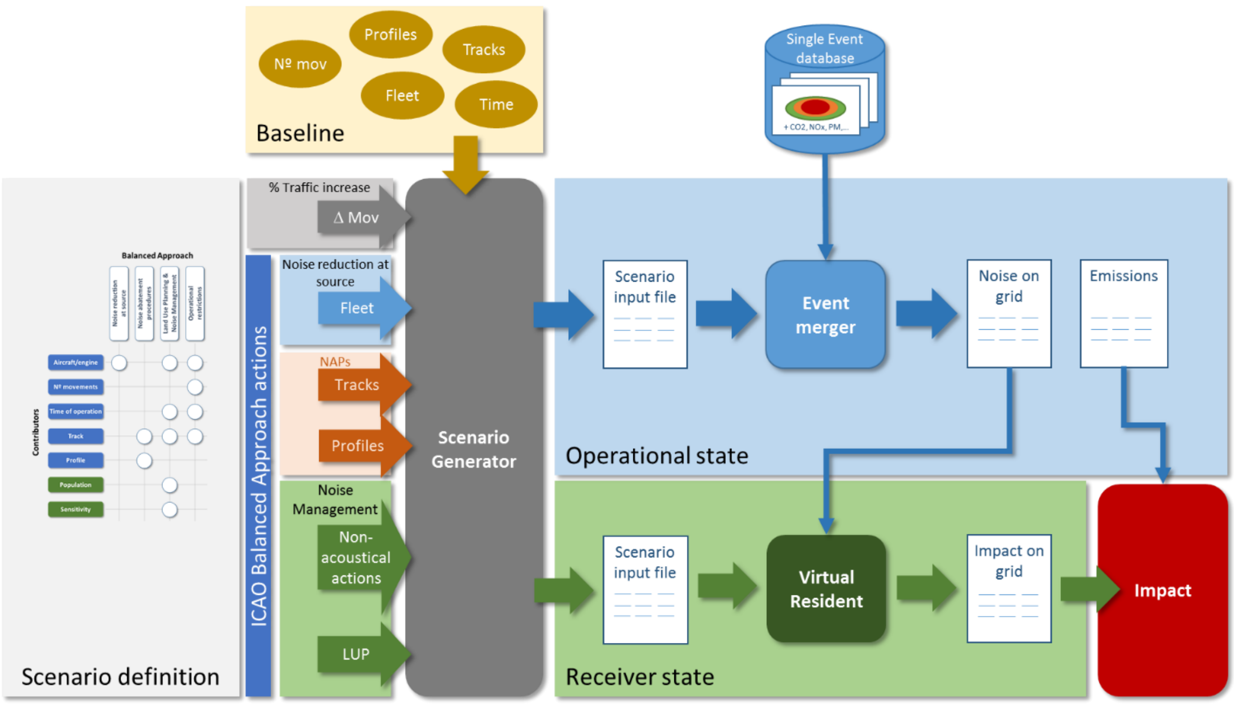


Figure 4 – WP4 Tool chain – Multi-event branch

Table 1 provides some examples of actions that can be simulated.

Table 1 – Examples of actions based on the Noise Impact Mitigation Matrix

	Noise reduction at source	Noise abatement procedures	LUP & noise management	Operational restrictions
Aircraft/engine	Noise reduction technology		Economic incentives for quiet aircraft	Ban on noisy aircraft
Nº movements				Cap on nº operations
Time of operation			Respite (together with track) Interval between movements	Night ban
Track		Avoid overflight of population	Respite (together with time)	Closure of runway at night
Profile		CDA low noise take-off procedures		
Population			Reallocation Zoning Population growth	
Sensitivity			House insulation Communication Consultation	

With the aim to support the development of the common research roadmap for the various noise reduction technologies that are being considered, a variety of scenarios are defined by WP6, based on a basic Technology Matrix, as depicted in Figure 5.

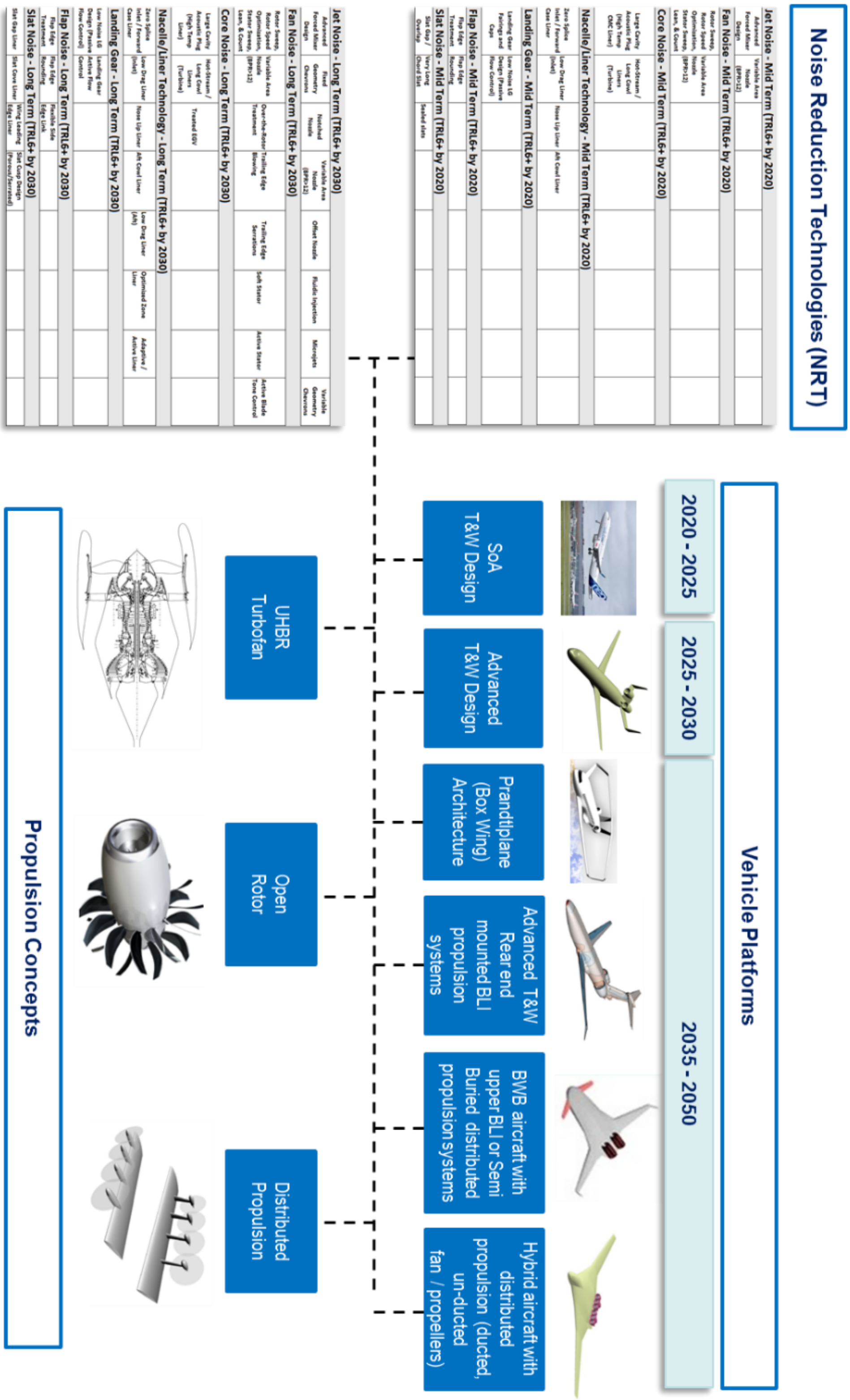


Figure 5 – Basic ANIMA Technology Matrix

3 Scenarios

Two cycles of scenarios are planned to support the updating of the roadmaps in WP6. These scenarios are defined by WP6 through Deliverables D6.2 (Scenario definition V1) and D6.15 (Scenario definition V2) and WP4 will report the results of the calculations through Deliverables D4.3 (1st scenario simulations) and 4.10 (2nd scenario simulations).

3.1 Scope of the Scenarios

A total of 3 scenarios are defined:

- 1A: to support development of the tool chain
- 1B: the first full set, to support the first update of the roadmap
- 2: the second full set, to support the elaboration of the final roadmap, extending the scope to several airports and to new aircraft concepts that will become available through e.g. the ARTEM project.

Figure 6 gives an overview of the scope of these scenarios.

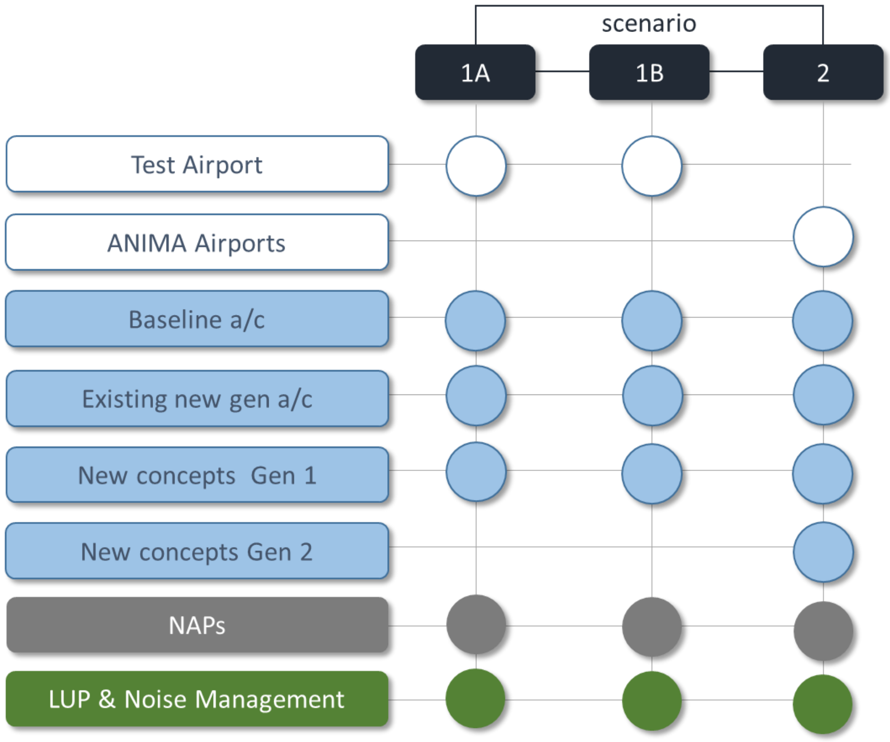


Figure 6 – Overview of the scope of the scenarios considered in ANIMA WP6

Although the scope of 1A and 1B is apparently the same, it is noted that in 1A only a small number of cases will be defined, with the only aim to test the various components of the tool chain.

Note: The definition of scenario 1A is covered by the current version of D6.2. A detailed description of scenario 1B will be provided in an update of D6.2, whereas the definition of *scenario 2 will be provided in due time through D6.15. The current version of the present document D4.3 only covers the simulations made for scenario 1A. The results for scenario 1B will be included in an update of this document. The following section comes from D6.2 and is included here to facilitate reading.*

3.2 Selection of the dataset for scenario 1A

To support the development of the tool chain in WP4, a dataset for a single airport was considered sufficient.

3.2.1 Airport

For the purpose of supporting the development of the tool chain, in principal a dataset for any airport would be acceptable. A first idea was to use the case study at Schiphol, used in the OpenAir and Clean Sky projects. Unfortunately, the corresponding dataset could not be traced. However, Schiphol Airport agreed to provide, through NLR, an alternative dataset for the current task, under the condition that the information provided would not be available to any partner except UoR.

3.2.2 Contents and format

The dataset was received by UoR from NLR on the 19 April 19 2019, and consists of 266 operations, from 6 AM to 10 AM of 2018-04-15, organised in a single file.

Within the dataset, each operation consists in a header (containing the relevant information), followed by the coordinates in Dutch National Grid (RDNAP) sampled every 4 seconds. The information of each operation is as follows:

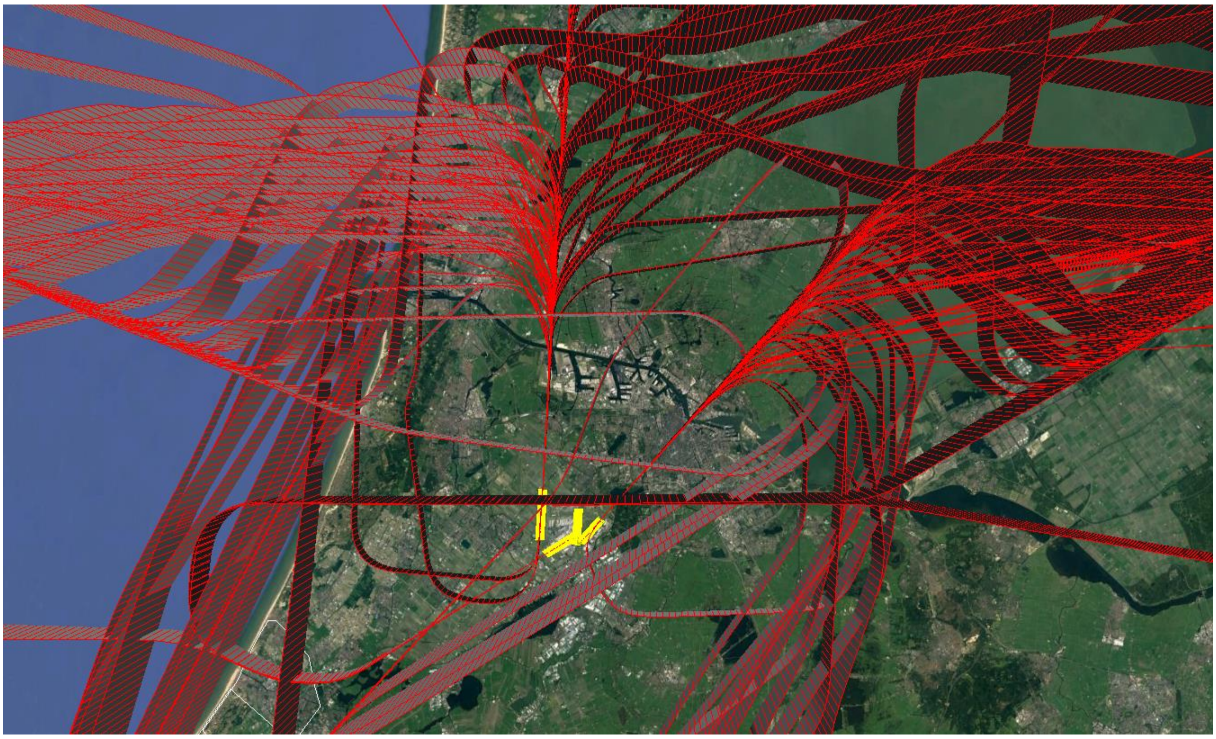
- Identification code of the flight
- Date and Time
- Type of operation: departure (D) or arrival (A)
- Identification of the route
- Airport of departure or arrival
- ICAO aircraft type designator code
- Track start time
- X [m], Y [m] and Z [ft] (RDNAP)

A snippet of the data provided is given in Figure 7.

```
FlightId-24396369
Time-2018-04-15 07-31-24
OperationType-D
Route-LOP2S
PeerAirport-LSZH
AircraftType-A320
TrackStartTime-2018-04-15 07-30-26
TrackPoint-113417 479799 7
TrackPoint-113414 479797 7
TrackPoint-113391 479782 7
 ...
 ...
 ...
TrackPoint-139195 415421 20525
TrackPoint-139471 414710 20659
TrackPoint-139757 413999 20791
```

Figure 7 - Schiphol data format

Figure 8 gives a graphical impression of the flight trajectories contained in the dataset.



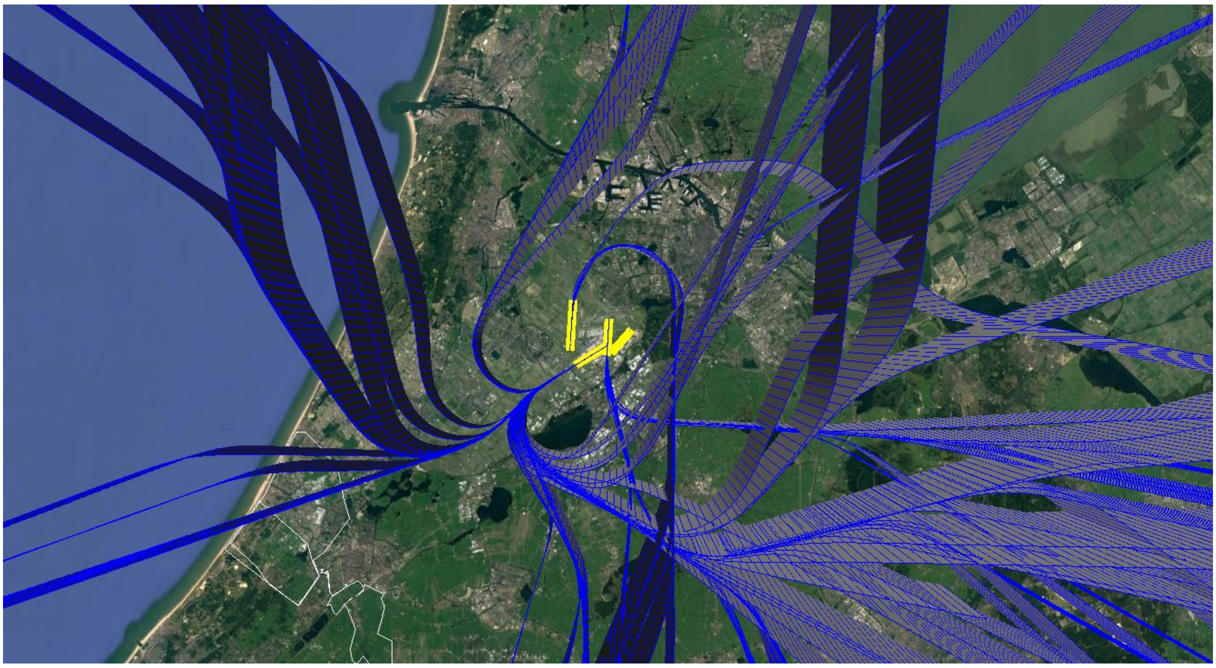


Figure 8 – Flight trajectories in the Schiphol dataset (Top: Arrivals; Bottom: Departures)

Table 2 presents the fleet composition of the dataset.

Table 2– Fleet composition in the Schiphol dataset

	Number of operations		
Aircraft ID	**Departures**	**Arrivals**	**Total**
A319	6	3	9
A320	11	8	19
A321	4	6	10
A332	0	6	6
A333	1	11	12
A359	1	1	2
B733	0	2	2
B735	0	1	1
B737	18	14	32
B738	35	24	59
B739	2	2	4
B744	1	6	7
B748	1	2	3
B763	0	6	6
B764	0	1	1
B772	0	3	3
B77L	0	4	4
B77W	0	7	7
B788	0	1	1
B789	0	5	5
E170	14	13	27
E190	24	21	45
E195	1	0	1
Total	**119**	**147**	**266**

3.2.3 Additional information

For the purpose of this first test scenario, a flat surface is assumed for the whole study area. For the case of Schiphol this is a reasonable approximation.

For the population count, the GHS population database hosted by the JRC is used.

3.3 Definition of the cases to be considered in scenario 1A

The cases to be considered in the calculations have been defined such that the main components and interfaces of the tool chain can be tested and further developed, if needed. The following Table 3 provides the information required for each scenario to be calculated. The first 5 cases are used to generate a complete single-event database. Cases 6 and 7 are used to establish a baseline case, against which the rest of the cases are to be compared. Cases 8 to 13 are simulations of actions taken within the Balanced Approach as indicated in Figure 6. As noted earlier, at present there is no agreed and robust method available to express annoyance related impact. Therefore the current scenario does not include any case to simulate actions in the field of Noise Management targeting reduction of annoyance.

In the following table and in the rest of the document, the baseline aircraft (BLA) is representative for short-medium range twin-aircraft like the A320 and B737, whereas existing re-engined aircraft like the A320-NEO and B737MAX are called "existing new generation aircraft" (ENGA).

Table 3– Cases to be studied in Scenario 1A

<table>
<tr><th>Case</th><th>Description</th><th>Function tested</th><th>Scope*</th></tr>
<tr><td>1A-1</td><td>Single-event prediction for each aircraft in Schiphol dataset, using ANP database</td><td>Generation of single event database of classic aircraft</td><td>N + E</td></tr>
<tr><td>1A-2</td><td>Single-event prediction for A320, using actual average profile and FRIDA performance and applying source breakdown. Result is used as the baseline aircraft (BLA)</td><td>Generation of single event database for baseline aircraft based on FRIDA + SOPRANO.</td><td>N + E</td></tr>
<tr><td>1A-3</td><td>Single-event prediction for ENGA, using adjusted ANP database (ΔNPD method); same profile and performance as 1A-2</td><td>Generation of single event database of existing new generation aircraft</td><td>N + E</td></tr>
<tr><td>1A-4</td><td>Single-event prediction for BLA, using generic noise reduction technology:
<table>
<tr><th>Case</th><th>Δfan* (dB)</th><th>Δjet* (dB)</th></tr>
<tr><td>1A-4a</td><td>0</td><td>-3</td></tr>
<tr><td>1A-4b</td><td>-3</td><td>0</td></tr>
<tr><td>1A-4c</td><td>-3</td><td>-3</td></tr>
</table>
*indicated ΔdB applied to all frequencies
same profile and performance as 1A-2</td><td>Generation of single event database for noise reduction technology insertion</td><td>N</td></tr>
<tr><td>1A-5</td><td>Single-event prediction for generic novel aircraft concept; same profile and performance as 1A-2</td><td>Application of filter + generation of single event database of novel concept aircraft</td><td>N</td></tr>
<tr><td>1A-6</td><td>Baseline prediction for full Schiphol dataset, using ANP database</td><td>Scenario generator, Event-merger and Virtual Resident</td><td>N + E</td></tr>
<tr><td>1A-7</td><td>Baseline prediction with equivalent number of operations with BLA (from 1A-2), obtaining similar footprint as in 1A-6</td><td>Fleet composition builder, Event-merger and Virtual Resident</td><td>N + E</td></tr>
<tr><td>1A-8</td><td>Insertion of current new generation aircraft. Replace BLA by ENGA (8a:25%, 8b:50%, 8c:75%, 8d:100%)</td><td>Simulation of Noise Reduction at Source (insertion of new generation aircraft)</td><td>N+E</td></tr>
<tr><td>1A-9</td><td>Insertion of noise reduction technology. Replace BLA by BLA with NRT packages:
<table>
<tr><th>Case</th><th>Δfan* (dB)</th><th>Δjet* (dB)</th><th>%</th></tr>
<tr><td>1A-9a/b</td><td>0</td><td>-3</td><td>50/100</td></tr>
<tr><td>1A-9c/d</td><td>-3</td><td>0</td><td>50/100</td></tr>
<tr><td>1A-9e/f</td><td>-3</td><td>-3</td><td>50/100</td></tr>
</table></td><td>Simulation of Noise Reduction at Source (NRT insertion)</td><td>N</td></tr>
<tr><td>1A-10</td><td>Insertion of novel concept aircraft. Replace BLA by generic novel concept (10a:25%, 10b:50%, 10c:75%,</td><td>Simulation of Noise Reduction at Source (insertion of novel concept aircraft)</td><td>N</td></tr>
</table>

	10d:100%)		
1A-11	Noise Abatement Procedure: change of profile (Steep approach)	Simulation of effect of change in profile (NAP)	N+E
1A-12	Noise Abatement Procedure: change of track	Simulation of effect of change in track (NAP)	N+E
1A-13	Land Use Planning: Effect of limit on population growth (building permits). Reduce population in some of the most affected villages	Simulation of effect of LUP	N

**N = noise; E=emissions*

4 Scenario 1A simulation results

The Cases defined in Table 3 can be distributed in several groups:

1. Generation of single-event database (Cases 1A-1 to 1A-5)
2. Simulations of Noise Reduction at Source (Cases 1A-6 to 1A-10)
3. Simulations of Noise Abatement Procedures (Cases 1A-11 to 1A-12)
4. Simulations of Land Use Planning (Case 1A-13)

Figure 9 shows the calculation steps required for the generation of the single-event database. As an intermediate step in each of these Cases, an NPD (Noise-Power-Distance) database is generated, that will be used by SONDEO to generate the single-events for the corresponding aircraft type.

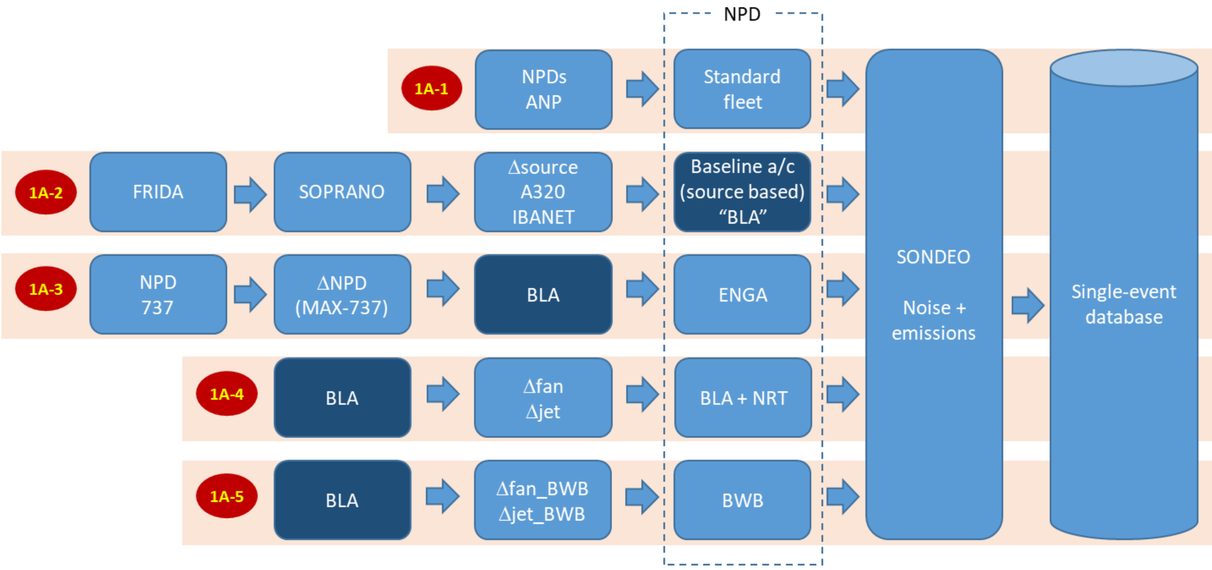


Figure 9 – Process for generation of single-event database

This single-event database is then used for the calculation of the various cases, which simulates actions that can be taken in the frame of the Balanced Approach. For this, a certain combination of the single-events is used to simulate the desired fleet distribution and runway/track use.

In the following the methodology used and the results obtained for each case are described.

4.1 Case 1A-1

1A-1	Single-event prediction for each aircraft in Schiphol dataset, using ANP database	Generation of single event database of classic aircraft	N + E

This case uses SONDEO to generate a database of single event grids in SEL and LAMAX for the whole fleet present in the Schiphol dataset (table 2).

Radar tracks using a given route are plotted separately of the rest to see the dispersion of the route and select one operation as representative of the route (Figure 10).

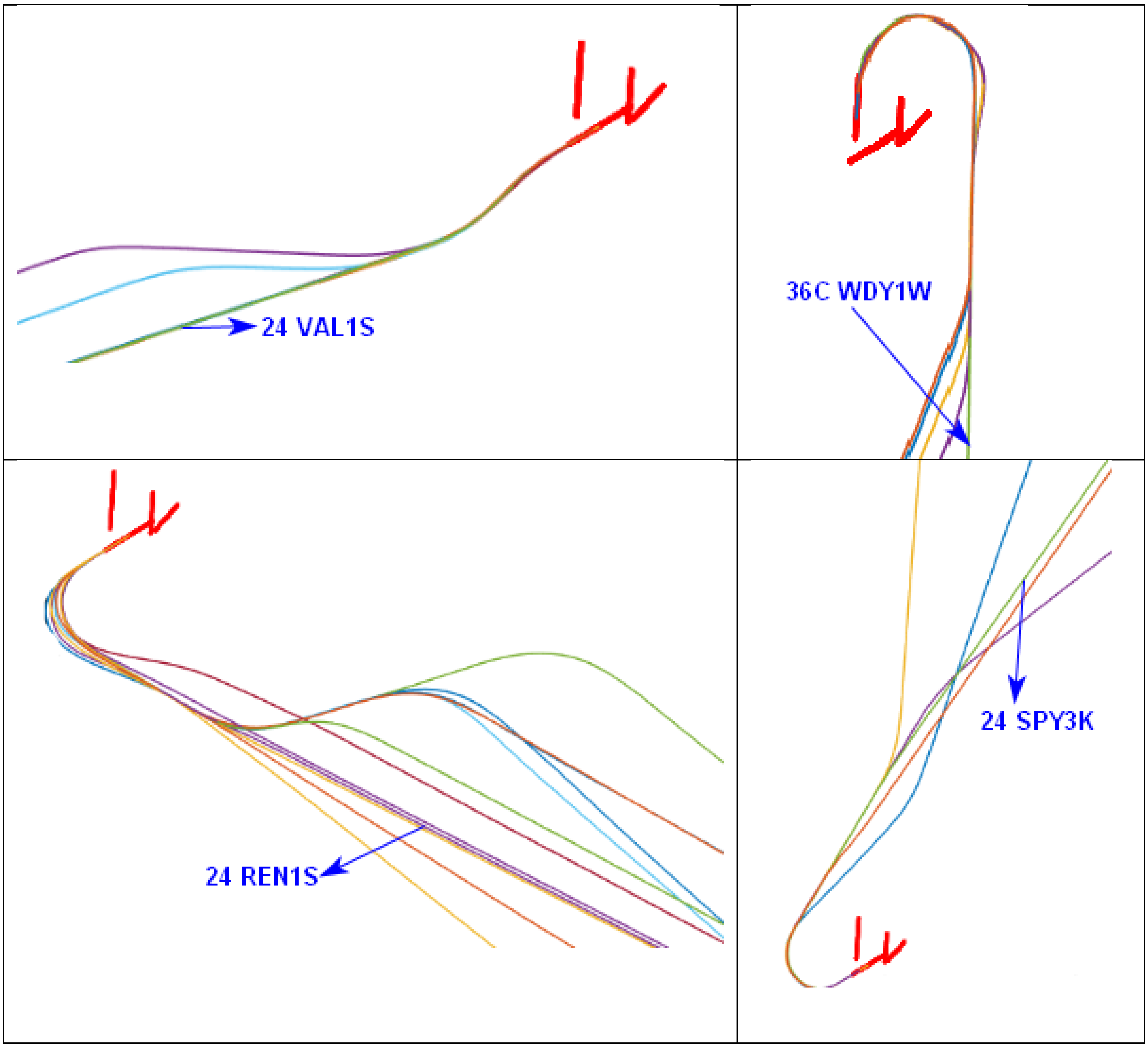


Figure 10 – Representative tracks selected among the operations of each route

For each operation, the stage length (used in SONDEO to estimate the take-off weight) is estimated based on the peer airport and the rate of climb observed in the profile.

A single event grid is then available for each aircraft type - stage length – route combination (see example in Figure 11).

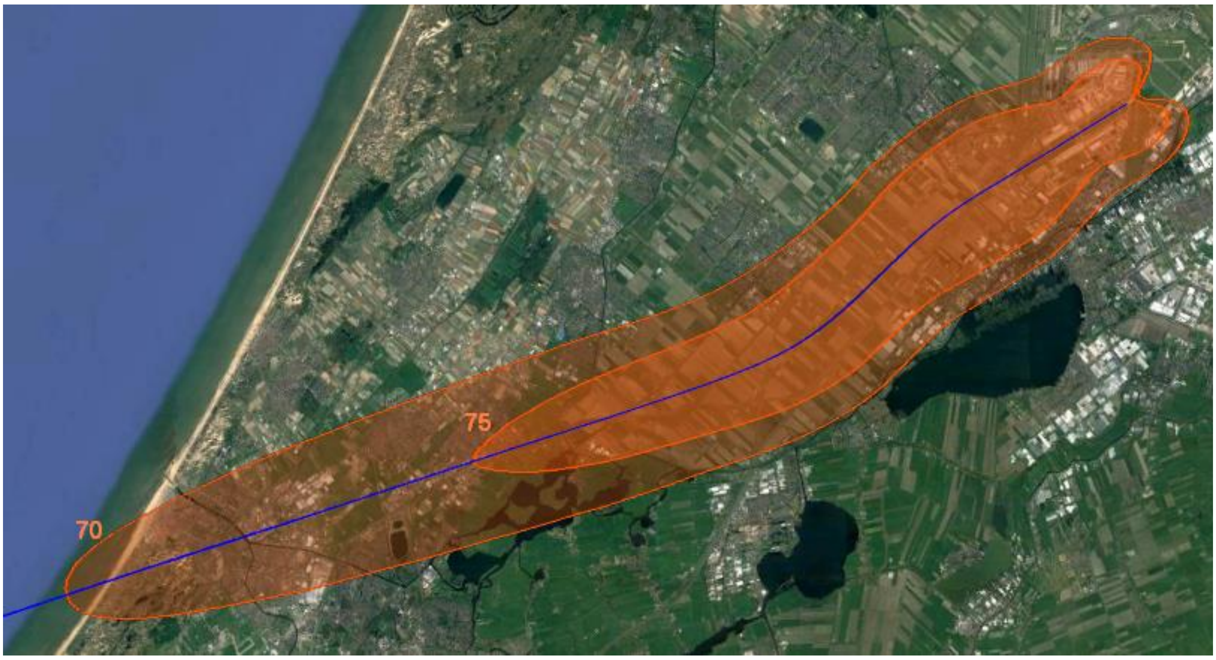
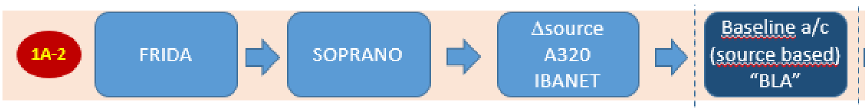


Figure 11 – Example of a single-event SEL footprint for an A320 departing from RWY 24 and following Route VAL1S

4.2 Case 1A-2

1A-2	Single-event prediction for A320, using actual average profile and FRIDA performance and applying source breakdown. Result is used as the baseline aircraft (BLA)	Generation of single event database for baseline aircraft based on FRIDA + SOPRANO.	N + E



The A320 was selected as the basis for the baseline aircraft (BLA). This aircraft can be considered representative for the A320 and B737 families, which constitute over 50% of the operations in the Amsterdam Schiphol dataset. An important consideration to take the A320 is also that a detailed model of this aircraft is already available in FRIDA, and a comprehensive noise database has been established from installations of the noise monitoring system IBANET developed and operated by Anotec.

To simplify the dispersion in vertical profiles, a representative profile is chosen among the available A320 departures (average profile), see Figure 12.

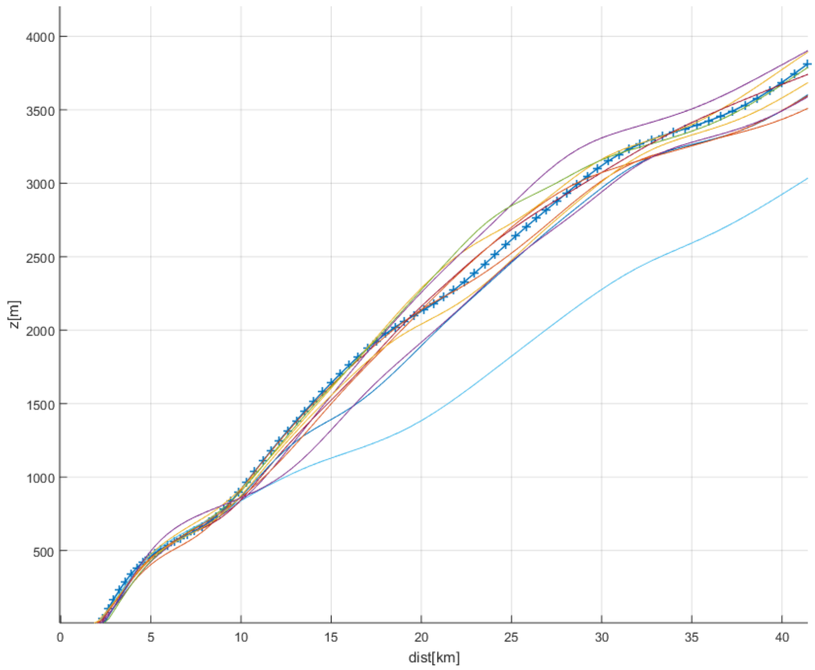


Figure 12 – Selection of average profile among the available A320 departures

For this profile, the aircraft performance needed in SOPRANO was calculated by FRIDA (see Table 4).

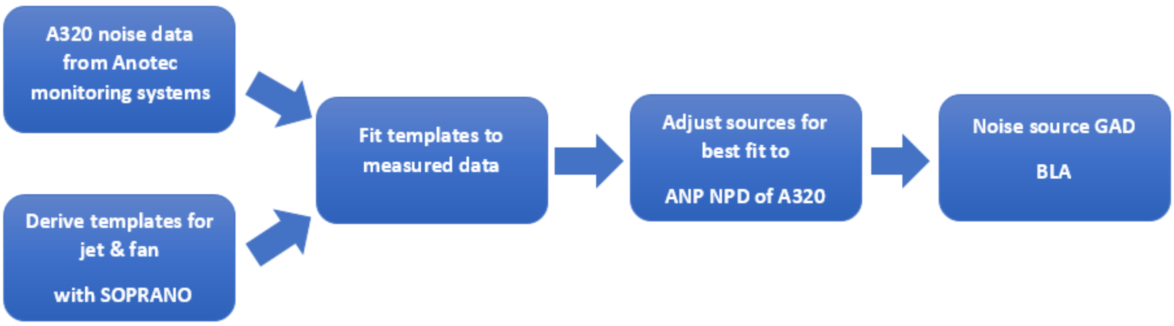
Table 4– Aircraft performance for the average profile as calculated by FRIDA

dist[m]	time [s]	x [m]	y [m]	z [m]	v [m/s]	a [m/s^2]	slope [deg]	AoA [deg]	AoB [deg]	flaps [deg]	slats [0/1]	LG [0/1]	thrust [kN]	N1 [rpm]	N2 [rpm]
0.0	0	113479	479836	0	13	0	0	0	0	10	0	1	222.4	4843.9209	11444.6414
51.6	4	113435	479809	0	13	0	0	0	0	10	0	1	221.0892	4835.7465	11425.951
103.2	8	113391	479782	0	13	0.3644	0	0	0	10	0	1	219.7784	4827.5374	11407.1812
154.9	12	113347	479755	0	16	1.1362	0	0	0	10	0	1	218.4675	4829.1702	11410.9146
229.8	16	113283	479716	0	22	1.5303	0	0	0	10	0	1	217.1567	4841.7553	11439.6899
330.8	20	113197	479663	0	28	1.5222	0	0	0	10	0	1	215.8459	4853.8634	11467.3747
454.3	24	113092	479598	0	34	1.5273	0	0	0	10	0	1	214.5351	4865.9832	11495.0862
604.2	28	112964	479520	0	40	1.4955	0	0	0	10	0	1	213.2242	4877.9635	11522.479
776.6	32	112817	479430	0	46	1.4393	0	0	0	10	0	1	211.9134	4888.9466	11547.5914
973.3	36	112650	479326	0	52	1.4577	0	0	0	10	0	1	210.6026	4899.1222	11570.8576
1191.0	40	112464	479213	0	58	1.5999	0	0	0	10	0	1	209.2918	4910.274	11596.3559
1435.7	44	112256	479084	0	65	1.6613	0	0	0	10	0	1	207.9809	4923.8537	11627.4054
1707.7	48	112024	478942	0	71	1.3757	0	0	0	10	0	1	206.6701	4936.2148	11655.6689
2004.4	52	111771	478787	0	76	0.9444	0	0	0	10	0	1	205.3593	4941.9188	11668.7108
2310.6	56	111510	478627	35	79	0.4653	9.3279	11.0639	0	10	0	1	204.0485	4972.05	11737.6049
2624.5	60	111244	478460	102	79	0.3724	9.6267	10.7784	-0.0086	10	0	0	194.997	4914.1063	11605.1183
2939.2	64	110978	478292	168	80	0.294	9.7631	10.5023	-0.0055	10	0	0	190.4476	4887.0011	11543.143
3255.4	68	110710	478124	231	81	0.2474	9.5485	10.2356	0.0373	10	0	0	183.981	4844.4881	11445.9385
3573.3	72	110440	477956	288	81	0.2337	8.9999	9.9605	0.1612	10	0	0	175.8723	4787.481	11315.5934
3892.9	76	110169	477787	339	82	0.2468	8.2273	9.6499	0.4286	10	0	0	166.9886	4721.6961	11165.1781
4214.4	80	109896	477617	383	83	0.2778	7.3617	9.2821	0.92	10	0	0	158.2829	4654.4628	11011.4513

It should be noted here that for the purpose of this scenario V1A, a single-event prediction is made for the departure case only. For Approach, Airframe Noise should be included as an additional source but at this stage no sufficient information is available to determine this noise source with acceptable quality.

From the Anotec noise monitoring system (IBANET), an A320 measured noise database is available.

Using the flight data and engine performance of the average profile, SOPRANO can predict the main noise sources jet and fan. This source breakdown is used as a template for the noise source, which is then adjusted by applying ΔdBs, so as to fit with the measured data (see Figure 13).



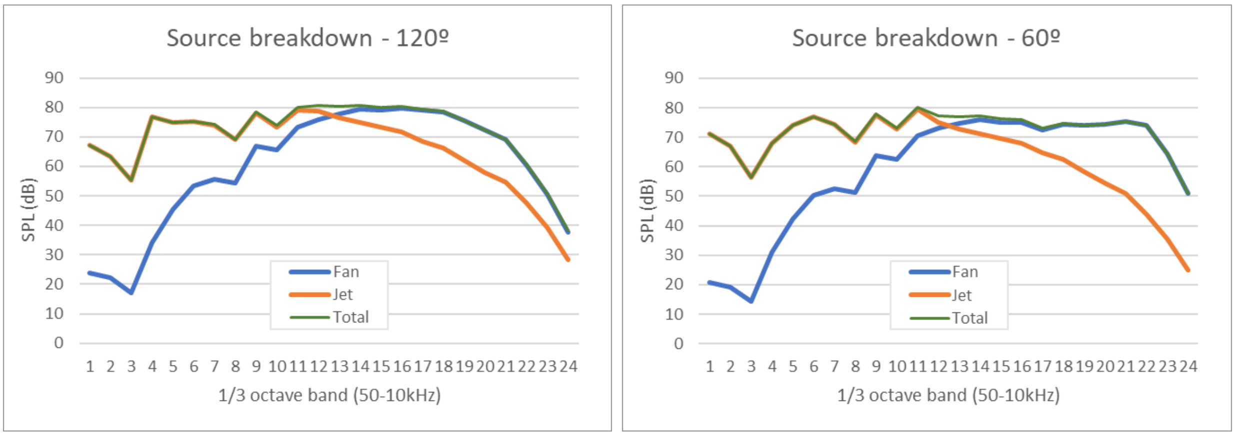


Figure 13 – Source breakdown process and example results

With adjusted templates SOPRANO generates a Noise Power Distance (NPD) for the baseline aircraft (BLA) that can be compared with the A320 ANP database (Figure 14).

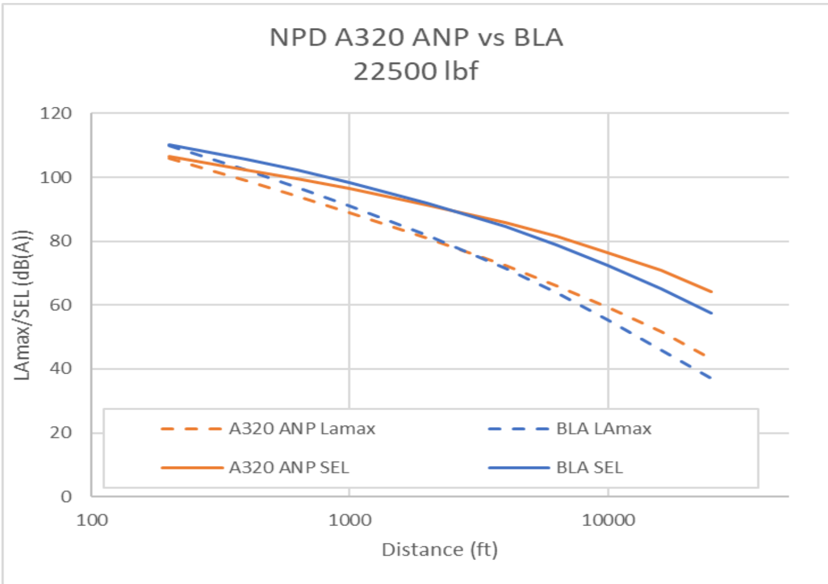


Figure 14 – Comparison of BLA with A320 NPD

A reasonable fit over the relevant distance range is obtained. It is noted that a calibration of the templates by Original Equipment Manufacturers (OEMs) may improve the results.

To see the effect of using these different NPDs on a SONDEO footprint, a comparison between single events A320 ANP vs. BLA is presented here (Figure 15):

1. Based on A320 NPD from ANP (case 1A-1)
2. Based on BLA NPD, with average actual profile (case 1A-2)

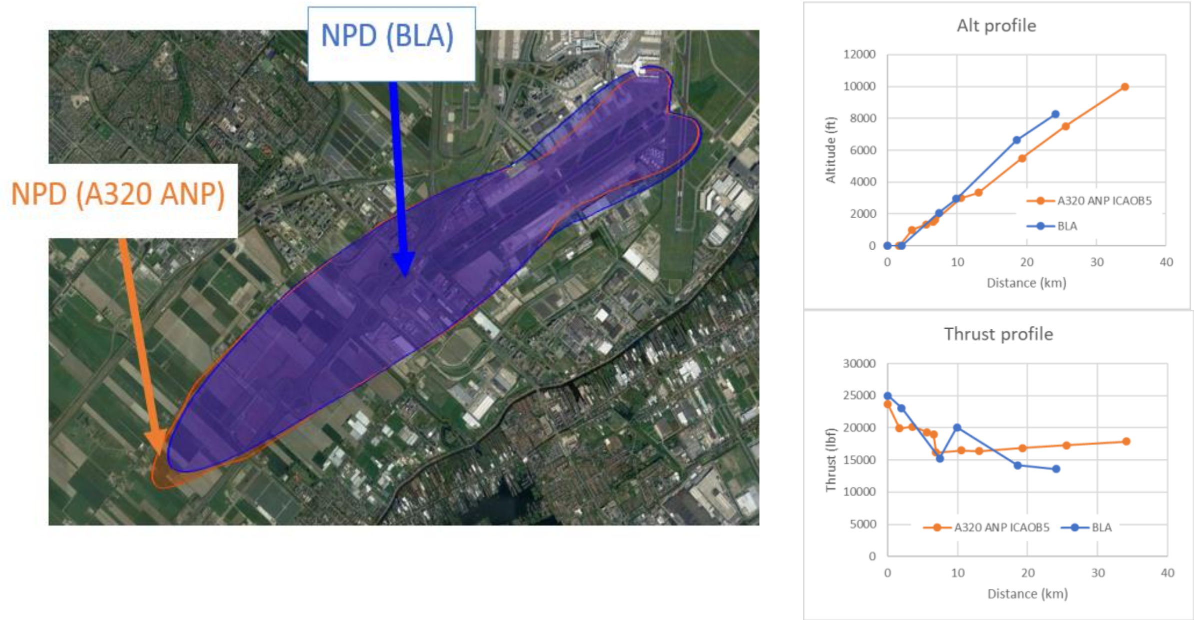


Figure 15 – Comparison between A320 and BLA single-event footprint

4.3 Case 1A-3: ENGA

1A-3	Single-event prediction for ENGA, using adjusted ANP database (ΔNPD method); same profile and performance as 1A-2	Generation of single event database of existing new generation aircraft	N + E

This case tests the generation of a single event database of an existing new generation aircraft (ENGA), representative for the A320neo and 737MAX families. For this purpose, the ΔNPD method is used, this is to adjust the BLA NPD by adding the ΔdBs from B737-800 to MAX (Figure 16).

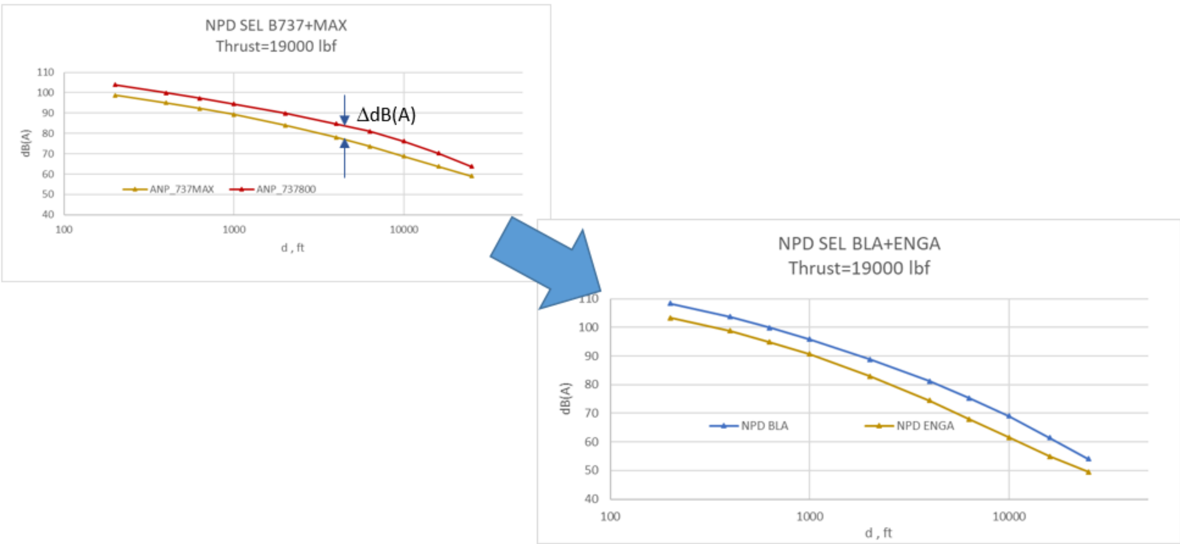


Figure 16 – Generation of ENGA NPD and comparison with BLA NPD

4.4 CASE 1A-4: NRT

1A-4	Single-event prediction for BLA, using generic noise reduction technology: **Case** | **Δfan* (dB)** | **Δjet* (dB)** 1A-4a | 0 | -3 1A-4b | -3 | 0 1A-4c | -3 | -3 *indicated ΔdB applied to all frequencies same profile and performance as 1A-2	Generation of single event database for noise reduction technology insertion	N

This case tests the insertion of NRT to the baseline aircraft generating NPDs for different noise reduction packages.

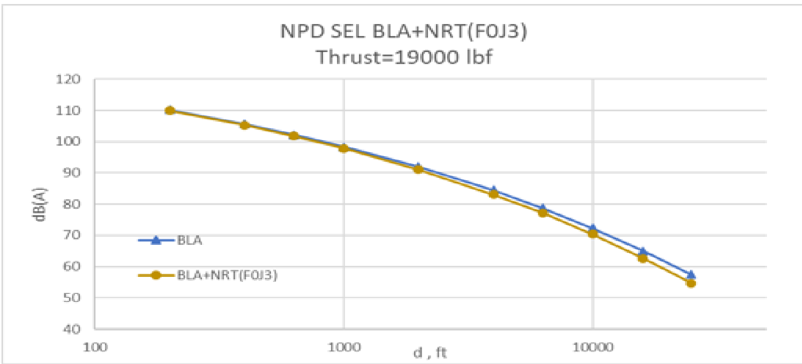
Using SOPRANO, a generic ΔdB is applied to BLA to all frequencies of each source (Jet and/or Fan) according to the following table 5. Performance is maintained from case 1A-2.

Table 5– Subcases for NRT insertion in BLA

Case	**Δfan* (dB)**	**Δjet* (dB)**
1A-4a	0	-3
1A-4b	-3	0
1A-4c	-3	-3

*indicated ΔdB applied to all frequencies

For each subcase, an NPD is obtained (see Figure 17). An example of a spectrum (case 1A-4b) is also provided.



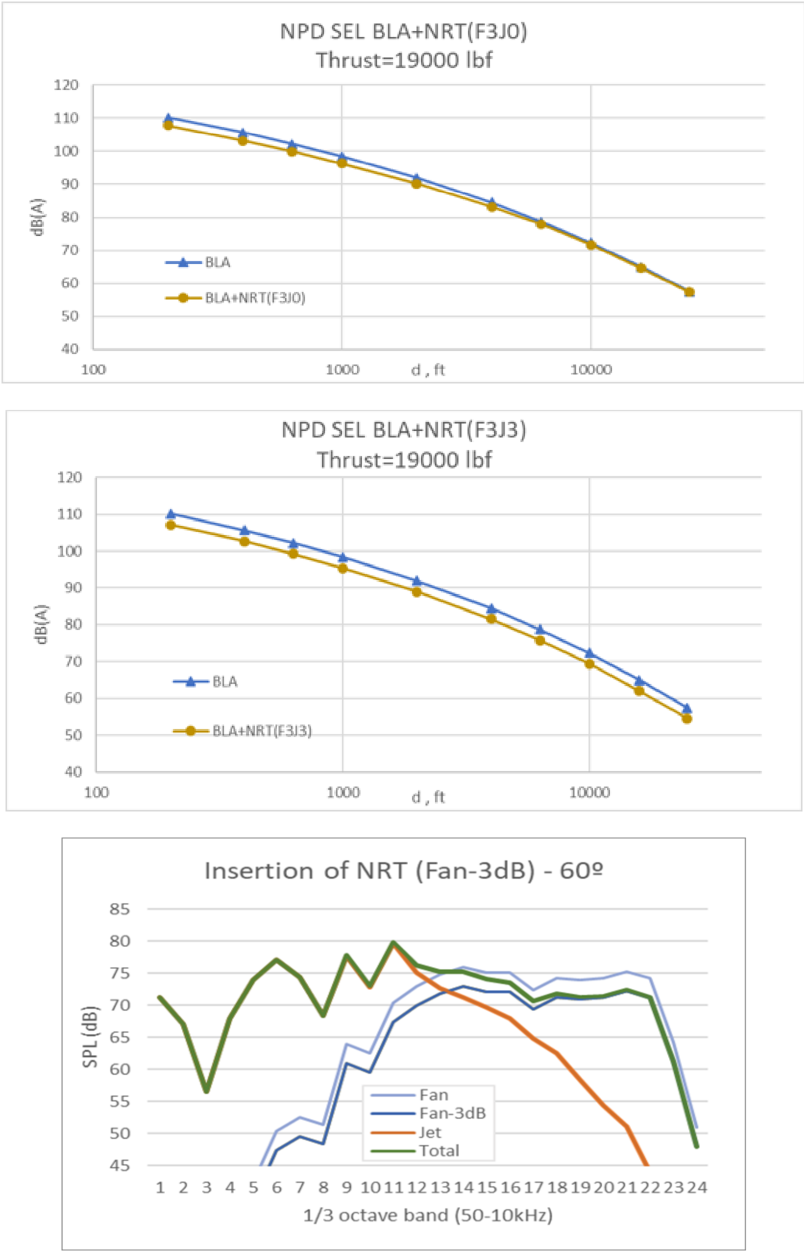
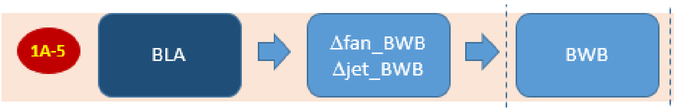


Figure 17 – Generation of NRT NPDs and comparison with BLA NPD

4.5 CASE 1A-5: Novel aircraft concepts

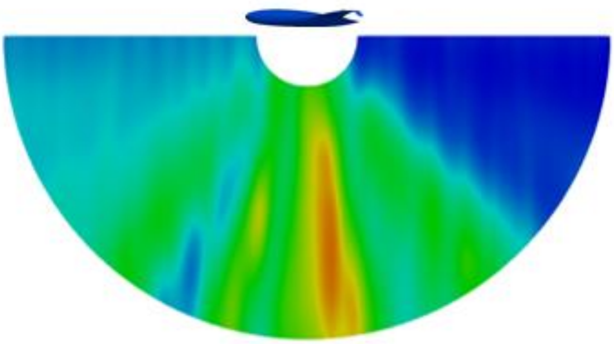
1A-5	Single-event prediction for generic novel aircraft concept; same profile and performance as 1A-2	Application of filter + generation of single event database of novel concept aircraft	N



This case tests the generation of NPDs for novel aircraft concepts by inserting a filter representing the installation effects of a Blended Wide Body aircraft (BWB).

Using SOPRANO, the REBEL/BOLT filter provided by UR3 is applied to the full aircraft spectra of BLA obtained in case 1A-2. An NPD is then generated using the same performance as in 1A-2

Figure 18 presents the filter in the aircraft symmetry plane and the resulting NPD. As can be seen, the effect on the NPD is still limited due to the low maximum frequency up to which the current filter is calculated (500Hz). UR3 is still working on this and will increase this maximum frequency in next releases and the effect will be more noticeable especially at larger distances.



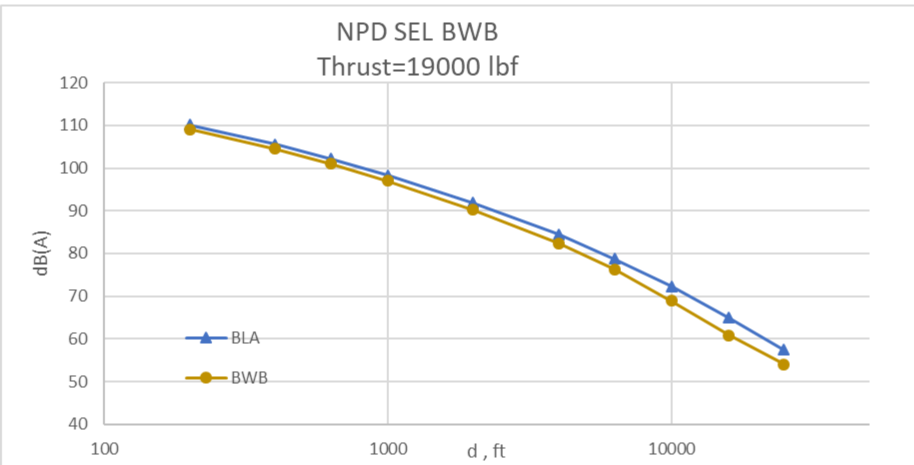


Figure 18 – Comparison of NPD for BWB with BLA NPD

4.6 CASE 1A-6+7: All operations

1A-6	Baseline prediction for full Schiphol dataset, using ANP database	Scenario generator, Event-merger and Virtual Resident	N + E
1A-7	Baseline prediction with equivalent number of operations with BLA (from 1A-2), obtaining similar footprint as in 1A-6	Fleet composition builder, Event-merger and Virtual Resident	N + E

In previous cases, a single event database of current, novel aircraft and other generic noise reduction technologies has been generated. Next cases will test the use of this database by the scenario generator and the event merger that sums the single events.

Case 1A-6 contains all aircraft and operations for full Schiphol dataset and it is calculated using the ANP NPDs and ANP profiles best matching the actual profiles.

Since the actual fleet contains many aircraft types and profiles, for scenario calculations it is convenient to create an equivalent BLA fleet using single events from 1A-2, adjusting the number of BLA operations such that a similar noise footprint as in 1A-6 is obtained. This equivalent BLA fleet will then be used as a reference for the following cases in V1A.

As can be seen in Figure 19, the equivalent BLA fleet footprint does not fully resembles that of the actual real fleet. This is mainly due to the fact that a significant part of the traffic was in reality operated by long-range aircraft, which are not well represented by the short-medium range single-aisle BLA. This is considered acceptable here, since the main purpose of the V1A scenario simulation is to test the tool chain and mainly relative results are considered in the following cases.

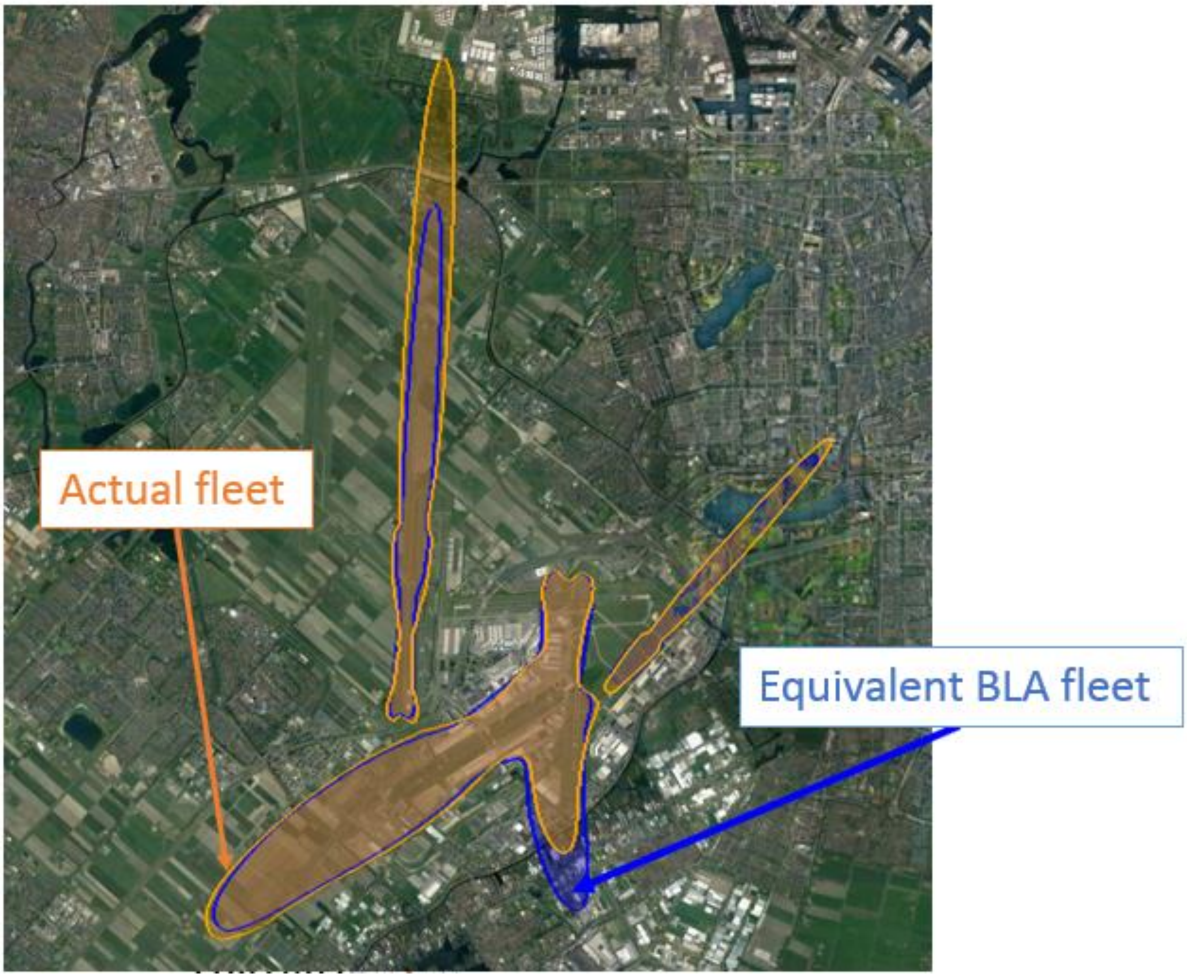


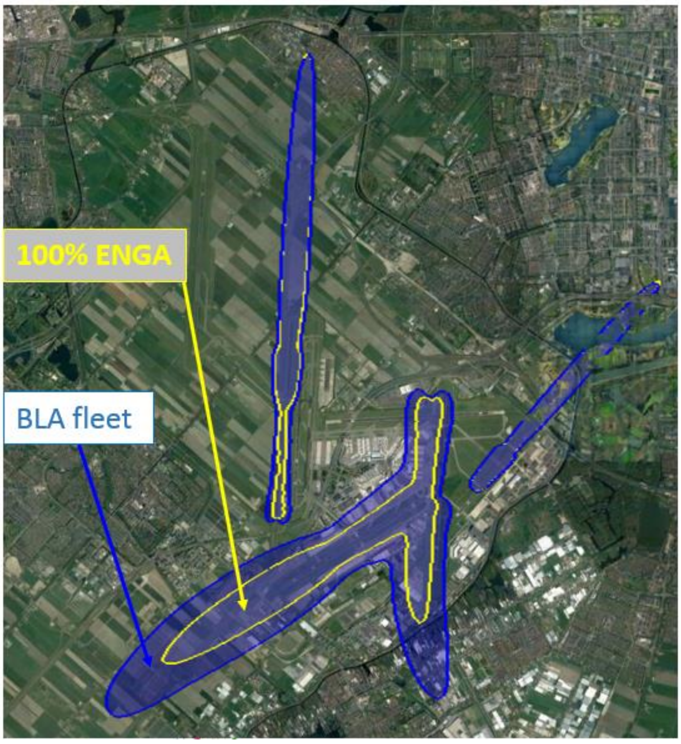
Figure 19 – Comparison of footprints of actual fleet and equivalent BLA fleet

4.7 CASE 1A-8: Insertion of ENGA

1A-8	Insertion of current new generation aircraft. Replace BLA by ENGA (8a:25%, 8b:50%, 8c:75%, 8d:100%)	Simulation of Noise Reduction at Source (insertion of new generation aircraft)	N+E

Using the scenario generator to replace x% of BLAs in the equivalent fleet by ENGA aircraft, the event merger sums the corresponding single events and generates contours.

The effect can be evaluated by comparing contour area reduction with respect to the BLA equivalent fleet (case 1A-7) (Figure 20).



		Contour area reduction		
Case	Descr	Δ55dB	Δ60dB	Δ65dB
1A-8a	25% ENGA	-11%	-12%	-14%
1A-8b	50%ENGA	-22%	-26%	-28%
1A-8c	75% ENGA	-32%	-39%	-42%
1A-8d	100% ENGA	-44%	-53%	-58%

Case	Descr	ΔNOx	ΔCO2	ΔHC	ΔCO
1A-8a	25% ENGA	-4%	-3%	-24%	-22%
1A-8b	50%ENGA	-8%	-5%	-47%	-44%
1A-8c	75% ENGA	-11%	-8%	-71%	-66%
1A-8d	100% ENGA	-15%	-10%	-94%	-88%

Figure 20 – Effect on footprint and emissions when x% of BLA fleet is replaced by ENGA aircraft

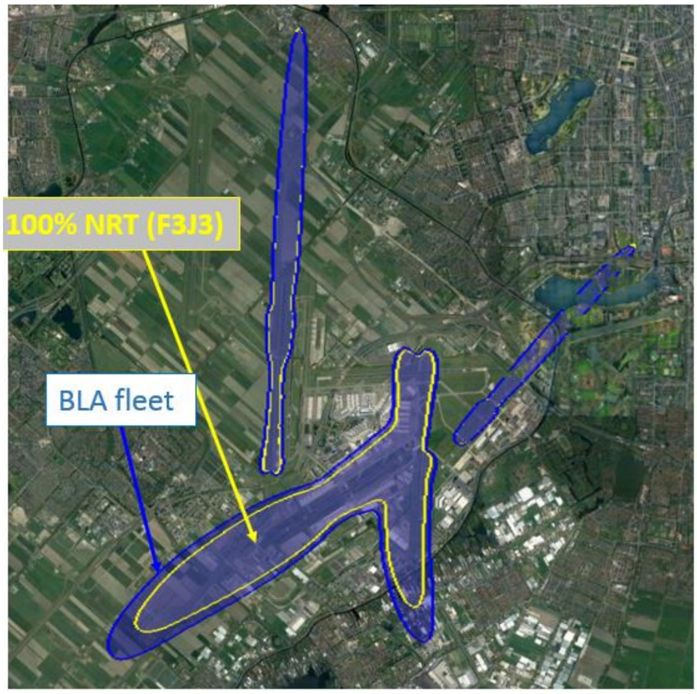
4.8 CASE 1A-9: Insertion of NRT

<table>
<tr>
<td>1A-9</td>
<td>Insertion of noise reduction technology. Replace BLA by BLA with NRT packages:
<table>
<tr><th>Case</th><th>Δfan* (dB)</th><th>Δjet* (dB)</th><th>%</th></tr>
<tr><td>1A-9a/b</td><td>0</td><td>-3</td><td>50/100</td></tr>
<tr><td>1A-9c/d</td><td>-3</td><td>0</td><td>50/100</td></tr>
<tr><td>1A-9e/f</td><td>-3</td><td>-3</td><td>50/100</td></tr>
</table>
</td>
<td>Simulation of Noise Reduction at Source (NRT insertion)</td>
<td>N</td>
</tr>
</table>

This case tests the simulation of Noise Reduction Technologies at Source (NRT insertion) at fleet level.

Using the scenario generator to replace x% of BLAs in the equivalent fleet by BLA with one or more NRT packages, the event merger sums single events and generates contours.

The effect can be evaluated by comparing contour area reduction with respect to the BLA equivalent fleet (case 1A-7) (Figure 21).



			Contour area reduction		
Case	NRT	insert NRT	Δ55dB	Δ60dB	Δ65dB
1A-9a	F / J-3	50%	-7%	-9%	-11%
1A-9b	F / J-3	100%	-14%	-19%	-24%
1A-9c	F-3 / J	50%	-6%	-7%	-8%
1A-9d	F-3 / J	100%	-13%	-15%	-17%
1A-9e	F-3 / J-3	50%	-11%	-13%	-15%
1A-9f	F-3 / J-3	100%	-22%	-26%	-31%

Figure 21 – Effect on footprint when 100% of NRT is inserted in BLA fleet (most favourable case: 1A-9f)

4.9 CASE 1A-10: Insertion of novel concept aircraft

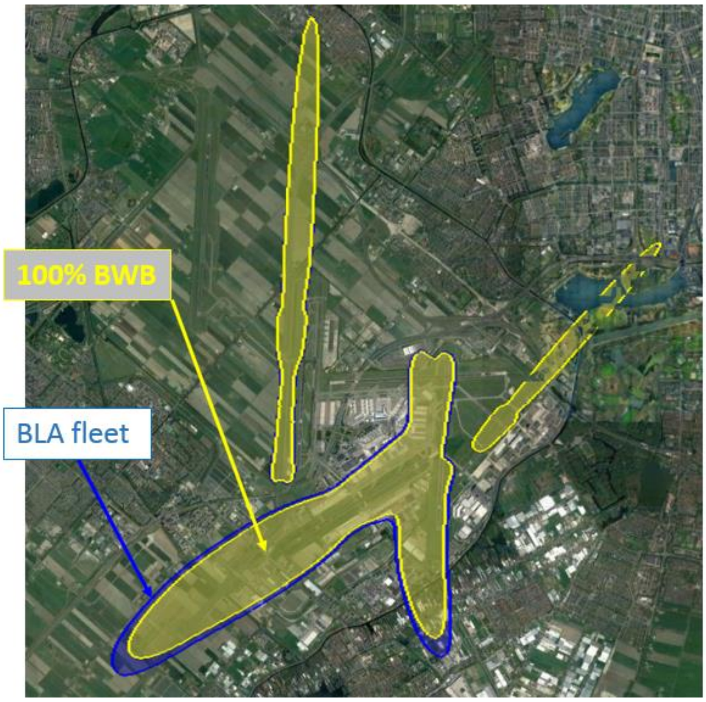
1A-10	Insertion of novel concept aircraft. Replace BLA by generic novel concept (10a:25%, 10b:50%, 10c:75%, 10d:100%)	Simulation of Noise Reduction at Source (insertion of novel concept aircraft)	N

This case tests the simulation of the insertion of novel concept aircraft in the fleet.

Using the scenario generator to replace x% of BLAs in the equivalent fleet by Novel Concept (BWB) aircraft, the event merger sums single events and generates contours.

The effect can be evaluated by comparing contour area reduction with respect to the BLA equivalent fleet (case 1A-7) (Figure 22).

Although the effect of the insertion of the BWB aircraft doesn't seem significant, it is recalled that the filter used for the current test case is limited up to 500Hz only (see Case 1A-5 above). Once this filter is extended to higher frequencies, the effect will be more pronounced. It is also noted that the main objective here is to demonstrate the capability of the tool chain to simulate this kind of aircraft, rather than to estimate the benefit of such solution.



		Contour area reduction		
Case	Descr	Δ55dB	Δ60dB	Δ65dB
1A-10a	25% BWB	-3%	-2%	-4%
1A-10b	50% BWB	-6%	-6%	-7%
1A-10c	75% BWB	-9%	-10%	-11%
1A-10d	100% BWB	-13%	-14%	-15%

Figure 22 – Effect on footprint when x% of BWB is inserted in BLA fleet

4.10 CASE 1A-11: NAP – Steep Approach

1A-11	Noise Abatement Procedure: change of profile (Steep approach)	Simulation of effect of change in profile (NAP)	N+E

This case tests the ability to simulate the effect of changing the vertical profile used in noise abatement procedures (NAP), in this case steep approaches. Flight conditions for 3º, 4.5º and 6º glideslopes were calculated with FRIDA by UR3 for the A320. In figure 23, the different phases of the approach are plotted, e.g. High Lift Devices are deployed at certain speeds followed by an increase of thrust, landing gears are deployed at 2000ft (609m)

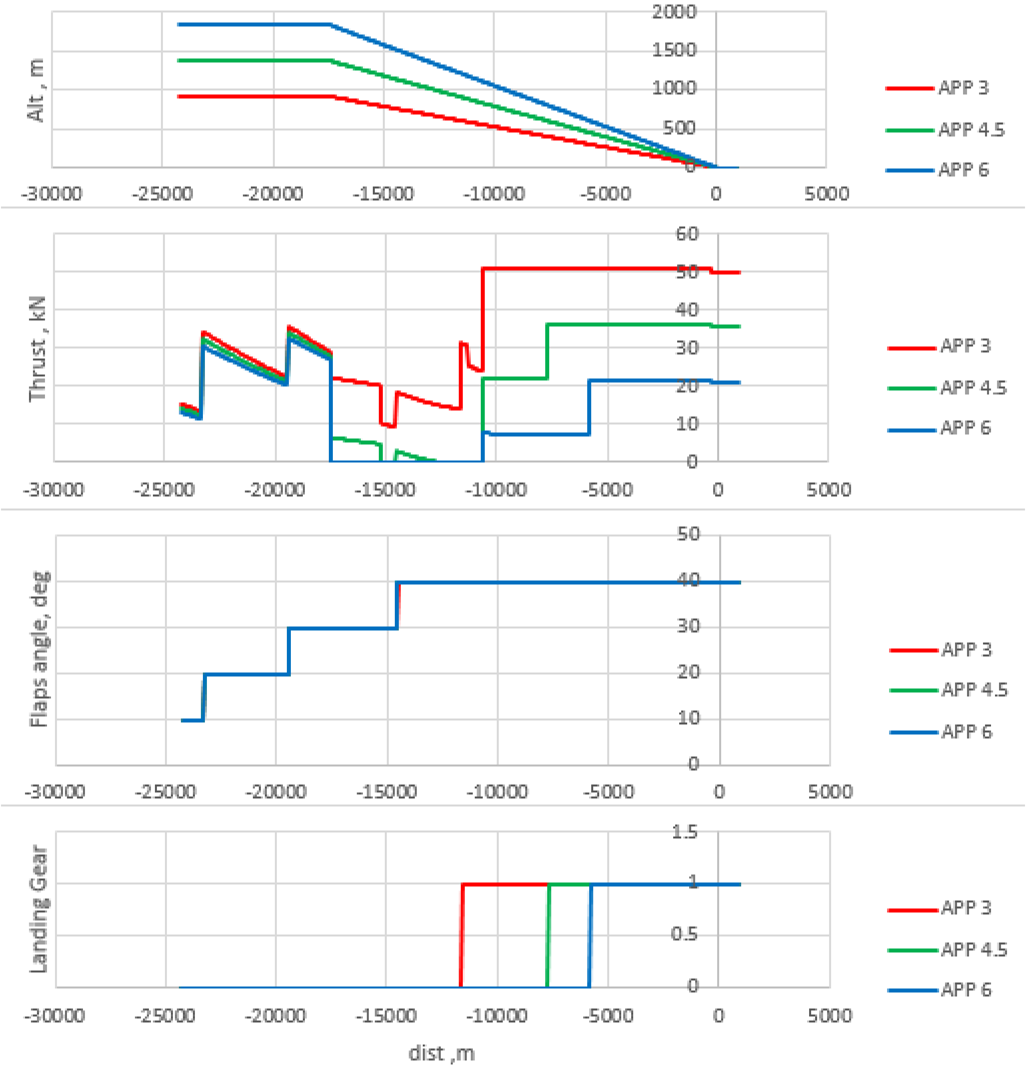


Figure 23 – Standard approach (3º) and steep approaches (4.5º, 6º) generated with FRIDA

Airframe noise is an important (if not dominant) noise source in steep approaches, but is not considered as such in the standard NPDs, available in the ANP database. A NPD should therefore be constructed taking into account at least jet, fan and airframe noise. However, at this stage no sufficient measured data is available to adjust predictions. Therefore, as a first approximation, single events are simulated using SONDEO and the ANP NPD. In a next scenario cycle airframe noise should be taken into account to generate the NPD with SOPRANO, once validated with measured data. Support from OEMs will be sought for this.

The positive effect of the steep approach is clearly perceived in the footprint and its area (Table 6 and Figure 24).

Table 6– Effect on the footprint area SELA 75dBA

Profile	Area [km²]
APP 6º	13.89
APP 4.5º	16.01
APP 3º	17.25

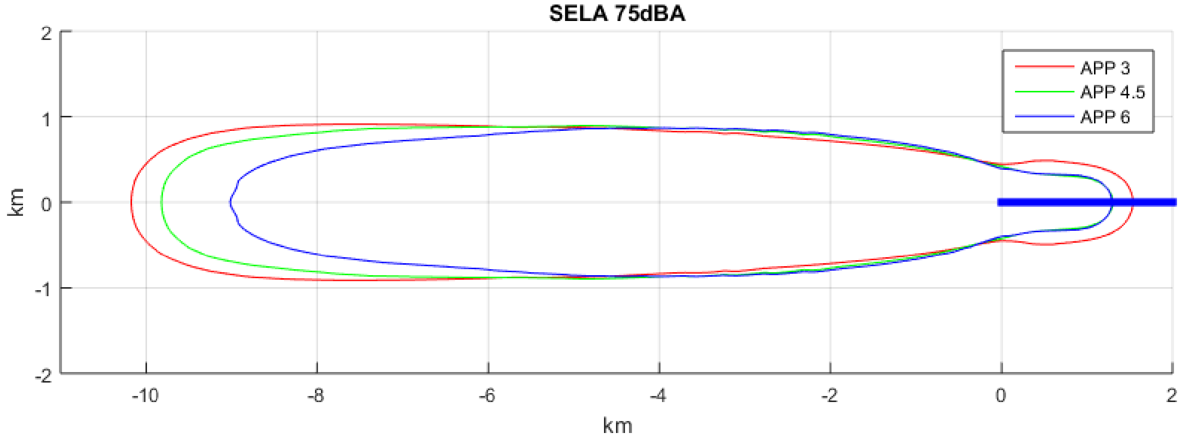


Figure 24 – Effect on footprint 75dBA SELA for 3 different approach angles

4.11 CASE 1A-12: NAP – Change of Track

1A-12	Noise Abatement Procedure: change of track	Simulation of effect of change in track (NAP)	N+E

This case tests the population affected when creating a new airport track (or change its percentage of use) to e.g. avoid a certain residential area.

For the purpose of this test case two existing Schiphol tracks were used, and two scenarios were created by redistributing the traffic of both tracks into only one of them (Figure 23).

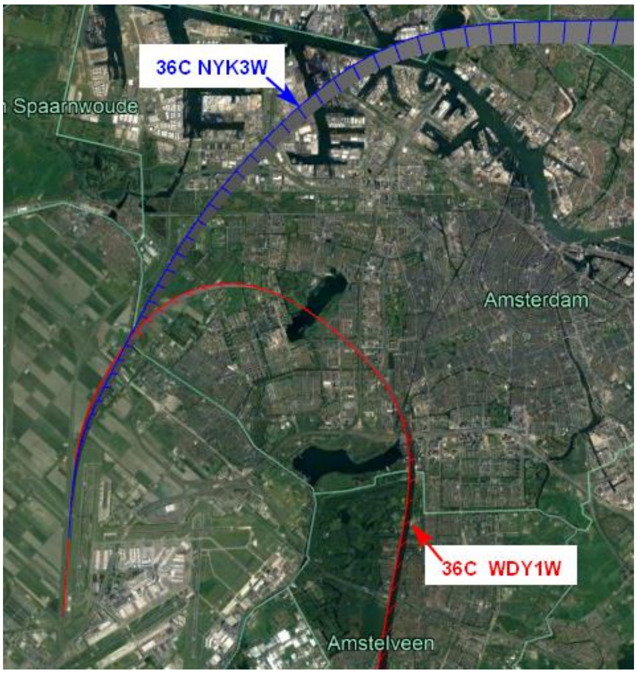


Figure 25 – Tracks used for the NAP test case

Since the original dataset only contains data for day-time, the traffic was extrapolated to a full day in order to be able to calculate the Lden contours (see Tables 6 and 7).

Table 7– Original traffic 6am -10am

Scenario	Aircraft	Rwy - Track	Ops Day	Ops Eve	Ops Night
1A-1	737-800	36C - NYK3W	1	0	0
		36C - WDY1W	5	0	0

Table 8– Redistributed traffic, extrapolating to 0-24 hours

Scenario	Aircraft	Rwy - Track	Ops Day	Ops Eve	Ops Night
1A-12a	737-800	36C - NYK3W	18	6	12
		36C - WDY1W	0	0	0
1A-12b	737-800	36C - NYK3W	0	0	0
		36C - WDY1W	18	6	12

Although the contour area will not change significantly between both cases (Figure 26), the population affected can change drastically due to the different population distribution in the areas affected by the two tracks.

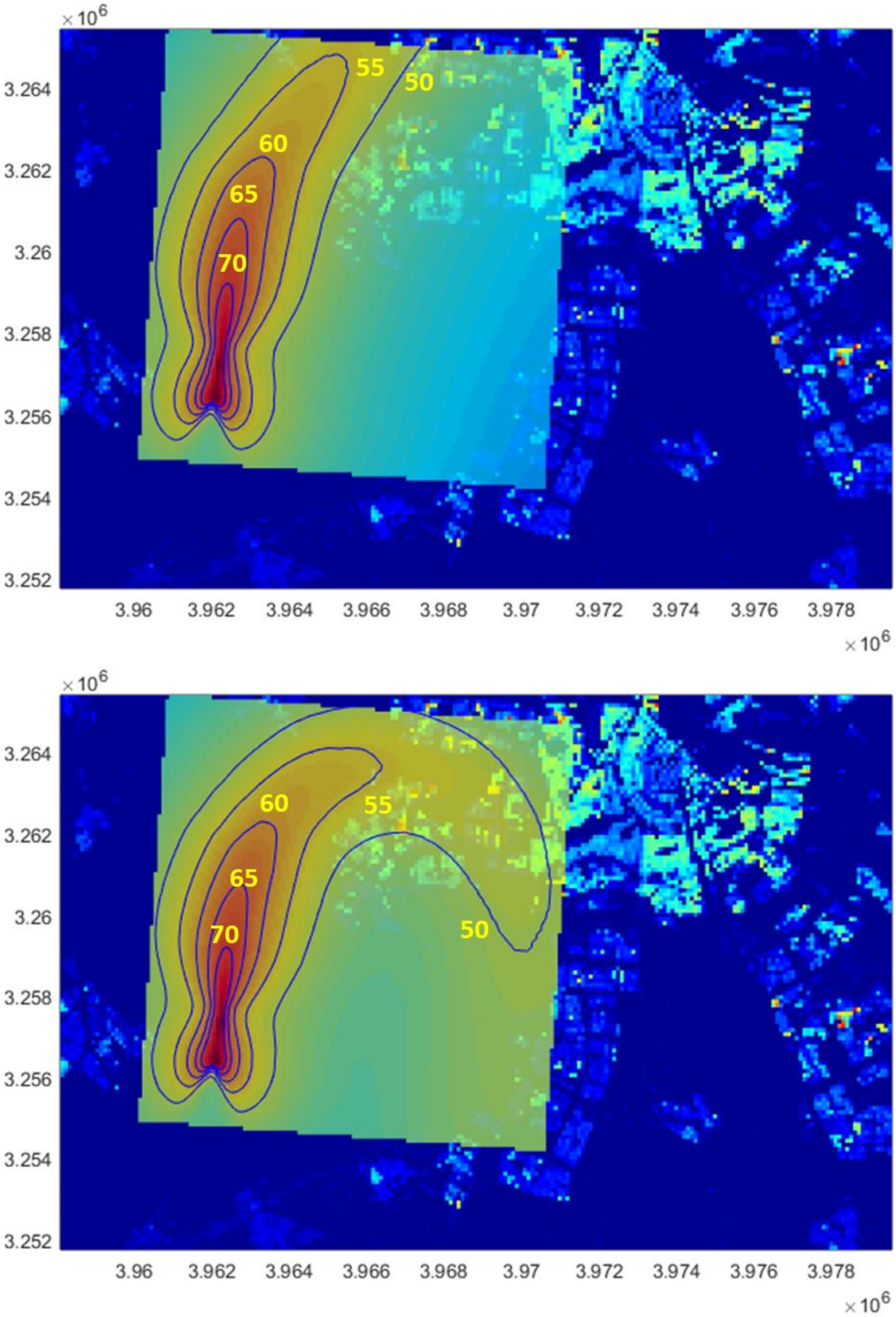


Figure 26 – Noise contours for case 1A-12a (top) and 1A-12b (bottom) on population background

Population has been taken from the GHS population grid, derived from EUROSTAT census data (regular 100x100m cells GeoTiff) https://data.jrc.ec.europa.eu/dataset/jrc-ghsl-ghs_pop_eurostat_europe_r2016a

SONDEO calculates the noise levels in the center of each cell. As a first approximation, for each threshold level, the population of each cell with a noise level attributed to that cell is added to the corresponding Lden band. In a second approximation, if cells are crossed by a threshold level, the cell population is split accordingly. Table 9 provides the results for both test cases.

Table 9– Number of persons for bands of Lden level for 2 different Departure procedures

	Nº of persons for case	
Lden	**1A-12a**	**1A-12b**
50-55	9899	97431
55-60	831	1505
60-65	120	131
>65	23	23

Clearly, as housing is prevented close to the airport, the low noise levels which are encompassing the widest populations are the most affected by track changes.

4.12 CASE 1A-13: LUP – Limit on population growth

1A-13	Land Use Planning: Effect of limit on population growth (building permits). Reduce population in some of the most affected villages	Simulation of effect of LUP	N

This case simulates the effect of Land Use Planning (LUP).

Using test case 1A-12b (worst scenario) as the starting point, the following plan leading to case 1A-13 will be simulated:

Areas above 60 dBA will have to reduce their population by 5%

Areas between 55 to 60 dBA Lden will not be allowed to grow

Areas below 55dBA may increase up to 10% their population

In order to estimate if the improvement obtained by the LUP action in the worst case (1A-12b) will have a positive or negative impact in the other case (1A-12a), , this scenario 1A-12a will also be recalculated to see its effect in affected population.

The results of this exercise are presented in Table 10.

Table 10– Number of persons for bands of Lden level when implementing LUP

	Nº of persons for case			
Lden	**1A-12b**	**1A-13**	**1A-12a**	**1A-13**
50-55	97431	107174	9899	10796
55-60	1505	1505	831	855
60-65	131	124	120	114
>65	23	22	23	22
	9735		914	

It can be seen that Scenario 1A-12a with LUP has increased marginally the number of people in the 55-60 zone (+24 persons), reduced by 7 persons above 60dBA and increased by 897 persons between 50-55dBA

5 Conclusions

A first set of scenarios (V1A) has been defined in Deliverable D6.2, with the main objective to provide test cases with which all the relevant components of the Noise Management Tool Chain can be verified. In the current document the results of the simulations of these test cases have been presented.

It has been demonstrated that the current version of the Noise Management Tool Chain, developed in WP4, is capable of simulating a range of actions that can be taken in any of the pillars of the Balanced Approach.

In the next step (scenario V1B) a new set of cases will be defined, with the objective to support the first update of the roadmaps in WP6. The main improvements needed for this are:

- Extension of the Baseline Fleet with a Baseline representing long-range aircraft, in a similar manner as the BLA aircraft for short-medium range, used in scenario V1A
- Inclusion of Airframe Noise in the Approach NPDs for both Baseline Aircraft
- Improved filter for BWB