# SESAR 2020 DYNCAT - D2.1 - Description of Acoustical and Weather Data Measurements

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## Copyright Statement

# DYNCAT

## DYNAMIC CONFIGURATION ADJUSTMENT IN THE TMA

This deliverable is part of a project that has received funding from the SESAR Joint Undertaking under grant agreement No 893568 under European Union's Horizon 2020 research and innovation programme.


## Abstract

Deliverable 2.1 represents the first technical report on the timeline of the EU-project DYNCAT and describes the acoustical and weather data measurements. While the planned measurements could not be executed due to the pandemic situation in 2020, secondary data from a specific flight campaign in 2019 are available to the project, which gathered very similar data as needed. Therefore, the flight campaign for approaches on Zurich airport and its measurement setup is described within here. In total, 215 flights of Swiss and Edelweiss airlines were recorded at 7 noise measurement stations. The acoustic metrics and their processing of all recorded events are documented. Preliminary results showed very similar level distributions for both airlines at the majority of the noise measurement stations. Median difference of 1 dB to 1.5 dB on two measurement stations already show the influence of the flight procedure, as those differences can most likely be attributed to the landing gear deployment. Weather data was not measured by the project partners in the past campaign, but obtained from the Swiss weather service.

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# 1 Introduction[1]

The Task 02.01 of work package 2 (WP2), aiming at data and concept analysis, represents the first technical task on the timeline of the EU-project DYNCAT. It is the starting point for the project, as it delivers a comprehensive dataset on which the operational concept definition will be based on. The operational concept will be the final outcome of WP2, which gives recommendations to ensure optimised approach operations, and it is the basis for subsequent work packages.

The objectives of WP2 are:

- Highlight the impact of current ATM operations during approach on environmental pollution, cost effectiveness and safety based on actual flight data.
- Analyse the current situation based partially on available data, complemented with further dedicated measurements (mainly noise).
- Develop an operational concept for on-board configuration management to allow the flight crew to deal with ATC restrictions in a more environmentally friendly way.

The Task 02.01 goes in hand with Task 02.02, the extraction and matching of the data. Within Deliverable 2.1, the authors focus on the description of the measurement and weather data. Those data will be matched and linked to radar data, ATC speech and flight data recordings (FDR) from Swiss International Air Lines in Task 02.02. In addition, the acoustical analysis and preliminary results are described already in the current report, as those are closely related to the acoustic measurements.

In Task 02.03 both the measurement data as well as the weather data are crucial for the analysis of current operations. Firstly, weather has a large influence on the ATC operations as well as on the sound propagation from source to receiver. One or more of the meteorological parameters is expected to correlate with operational changes and thus having an influence on noise or $CO_2$. Secondly, the measured acoustic data will be needed to make a statement on the environmental impact of certain flight procedures or weather conditions.

## 1.1 Task description

Within Task 02.01, acoustic measurements of approach 14 at Zurich airport were planned with up to eight autonomous measurement stations for two weeks. Weather information was planned to be measured in addition and acquired by MeteoSwiss. Finally, such data needs to be processed and documented for the project partners.

## 1.2 Covid-19 situation

[1] The opinions expressed herein reflect the author's view only. Under no circumstances shall the SESAR Joint Undertaking be responsible for any use that may be made of the information contained herein.

With the pandemic situation in 2020, the execution of acoustic measurements were at risk from the beginning of the project. Especially during the preparation phase of the grant agreement in the first half of 2020, many countries throughout Europe were locked down which caused a drastic and still ongoing reduction of air traffic.

Figure 1 depicts the development of approaches on the main approach runway during daytime at Zurich airport. Compared to the previous year, air traffic was drastically reduced by around 90% in April and Mai. As many borders in Europe were reopened again before the summer holidays, the number of movements increased again but stayed at 34% to 40% in July and August compared to the same period in 2019. Including the numbers up to September 14$^{th}$ and extrapolating them linearly, the month of September will remain at this level.

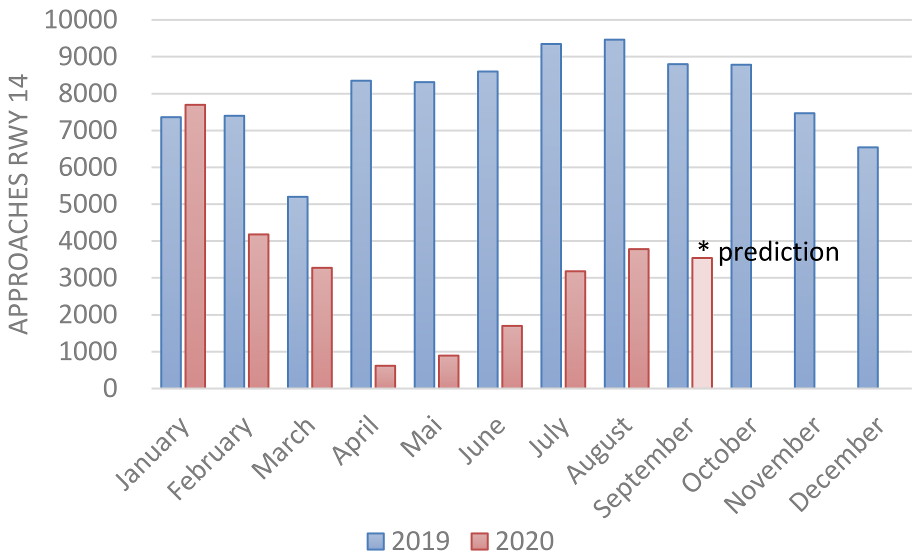


**Figure 1: Development of approaches on runway 14 at Zurich airport during the Covid-19 pandemic. Source: Zurich Airport [1]**

## 1.3 Changes due to Covid-19

Due to low air traffic and the closed border to Germany, where two of the measurement stations were planned, the whole project was shifted to start two month later in July. After air traffic stabilized partly, the preparations for the measurement campaign started in August 2020. To compensate for the low number of airplane movements, it was planned to double the length of the measurement period. It was planned to record all approaches in October, which also includes a holiday period in Switzerland.

These plans were soon changed, for two reasons raised by the main operator and flight data deliverer Swiss International Air Lines, one of the project members of DYNCAT. First, even with the number of operations having partly recovered since June, modern aircraft types such as the Bombardier C-Series or the A320 neo are currently the preferred types due to a change in passenger volume and for efficiency reasons. Therefore, the aircraft type A320-214, which is the main focus of this project, will be used less frequently than Figure 1 might suggest. Second, many countries experience a second rise in infection numbers and travel warnings with mandatory quarantine for

Spain, France and even parts of Switzerland are active again, which might further reduce air traffic. As a consequence, the number of measurable A320-214 flights would be too low for this project, even with the increased measurement period. In sum, these effects lead to an air traffic situation which is not representative for pre-pandemic times and might result in misleading project outputs. Therefore, the project members decided to cancel the planned measurements and to activate the following risks of work package 2:

- Risk 1: *Measurement data cannot be obtained in planned quality and / or quantity*
- Risk 5: *COVID-19 outbreak – long-time continuation of suspension of free movement, cessation of air traffic (at least to a large extent)*

Furthermore, it was decided to use an alternative dataset from the past, which consist of two subsets. The alternative dataset with acoustic measurements stems from the project called "Optimization of approach procedures to reduce noise at Zurich Airport with the DLR Low Noise Augmentation System (LNAS)" (BAZL BV87 project 2017-040, [2]). Within this project, approaches of a specific test aircraft were recorded during a five day period from September 9$^{th}$ to September 13$^{th}$, 2019. As the regular air traffic during this period was recorded by the measurement stations as well, this data set can be used as proxy. In addition, the runway as well as the positions of the planned measurement were based on the experiences of the alternative dataset used now, therefore the available dataset is representative for the planed measurement campaign. Only one additional measurement station was planned where no measurements are available now.

Another drawback of the alternative dataset is the short measurement period of 5 days, thus measurements from only 215 flights of the A320-214 are available. Therefore, data of another 300 flights from August to November 2019 will be gathered in WP2 as the second data subset. All 500 flights will then be simulated with the aircraft noise simulation tool sonAIR [3] to supplement the missing acoustic metrics. Based on a validation using the 215 measured flights, a robust statement on the uncertainty of such simulation method can be formulated. Based on a validation of the sonAIR model [4], the uncertainty of the acoustic metrics with simulated flights are expected to be 0.5 dB to 1 dB higher than the uncertainty of the measurements with typically 0.5 dB.

The activated risk and the alternated dataset are representative with the amount of the data and minor shortcomings in quality. The first subset with measured data will be of the same quality as planned. The second subset with simulated acoustic metrics extends the first subset by 300 additional flights, with a slightly lower quality expected (larger uncertainty). A simulation of the flights measured from the first subset allows the project team to validate the simulations and to report the uncertainty of the simulation within Task 02.03. It is expected to achieve a similar level of quality. The time that was planned to execute the measurements will be used for the additional work mentioned. Thus, the changes within Deliverable 2.1 will not affect future project work with regard to the timely continuation of the project.

Similarly to the original project plan, the new dataset of 500 flights will be complemented with weather data, radar data, flight deck recordings from Swiss and Edelweiss as well as ATC speech recordings. This will be done in Task 02.02; the present Deliverable 2.1 focuses on the description of the measurement, preliminary results and weather data.

## 1.4 Acronyms

The following table contains a list of acronyms used in this report.

| Acronym | Meaning |
|---|---|
| ATC | Air Traffic Control |
| ATM | Air Traffic Management |
| ATRA | Advanced Technologly Research Aircraft |
| BAZL | Bundesamt für Zivilluftfahrt (Federal Office of Civil Aviation) |
| CDA | Continuous Descent Approach |
| COVID-19 | Coronavirus Disease 2019 |
| D<no.> | Deliverable <no.> |
| DLR | Deutsches Zentrum für Luft- und Raumfahrt e.V. (German Aerospace Center) |
| DYNCAT | Dynamic Configuration Adjustment in the TMA |
| Empa | Eidgenössische Materialprüfungs- und Forschungsanstalt (Swiss Federal Laboratories for Material Science and Technology) |
| ER | Exploratory Research |
| EU | European Union |
| FDR | Flight Data Recorder |
| GPS | Global Positioning System |
| H2020 | Horizon 2020 |
| ICAO | International Civil Aviation Organization |
| LNAS | Low Noise Augmentation System |
| Q<code> | ICAO Q-Code, e.g. QNH |
| SESAR | Single European Sky ATM Research |
| SJU | SESAR Joint Undertaking |
| SYNOP | Surface synoptic observation |
| TMA | Terminal Manoeuvring Area |
| UTC | Coordinated Universal Time |
| WMO | World Meteorological Organization |
| WP | Work Package |

**Table 1: Acronyms used in this report**

# 2 Acoustical measurement and analysis

## 2.1 LNAS flight campaign at Zurich Airport

The Low Noise Augmentation System (LNAS) is a pilot assistance system developed by the German Aerospace Center (DLR) to support airline pilots in performing energy-optimized approaches and thus reducing noise and fuel consumption. In a recent project, which ran from September 2018 until March 2020, this system was further developed in collaboration with the non-profit Skylab Foundation, the German Aerospace Center and Empa [2]. The scope of the project was to extend LNAS by various types of approaches such as the Continuous Descent Approach (CDA), taking into account the specific environment of Zurich Airport (terrain, airspace restrictions, etc.). In addition, air traffic control information about the distance to the runway was used to optimize the vertical flight profile.

In a one-week flight campaign, the system was tested onboard the DLR Airbus A320 ATRA (Advanced Technology Research Aircraft). The test flights were piloted by regular airline pilots in the vicinity of Zurich Airport with the goal of demonstrating the potential of noise reduction through optimized approach profiles and aircraft configuration changes. To this end, the ATRA flew a total of 91 approaches to Zurich Airport's runway 14, each one ending with a go-around initiated at an altitude of 800 feet above ground.

Since the acoustical measurement stations were running continuously during the test week, all regular approaches on runway 14 were also recorded. These additional measurements could then be filtered to extract all flights by A320 aircraft operated by Swiss and Edelweiss airlines. This additional dataset and the measurement setup are described below.

## 2.2 Measurement setup

During the week-long flight campaign from September 9th to 13th, 2019, the approaches of the ATRA as well as the regular air traffic were acoustically measured by Empa's Laboratory for Acoustics/Noise Control. Seven measurement stations were installed along the approach path. The stations consisted of a ½'' Class 1 measurement microphone M2230 including WP30 weather protection, which was installed on a mast four meters above ground, and a sound level meter NTi XL2, which recorded the signal in the form of a continuous 24-bit MONO audio signal in 48 kHz and generated a characteristic value log. A GPS receiver was used to record a highly accurate GPS time stamp in parallel, which allowed an exact correlation of the measurements with the flight path data during evaluation.

The measurement devices were housed in weatherproof cabinets or cases (see Figure 2) and could be operated autonomously for the entire measurement week by using a solar panel and a storage battery. Due to a connection to the mobile phone network, the stations could be controlled remotely and the data could be downloaded continuously. On-site support of the measuring stations was therefore not necessary.

**Figure 2: Example of a mobile measurement station consisting of microphone, solar panel and measurement cabinet.**

Five measurement stations were located on Swiss territory, two more in Germany (see Figure 3). The exact measurement positions are listed in table 1.

| No | Name | Country | Latitude [°] | Longitude [°] | Height MSL [m] | Distance to runway [NM] |
|---|---|---|---|---|---|---|
| 3 | Hasle | DE | 47.59983 | 8.37207 | 643.4 | 9.7 |
| 4 | Steinruette | DE | 47.59294 | 8.38948 | 640.6 | 8.9 |
| 6 | Kaiserstuhl | CH | 47.56646 | 8.42229 | 366.8 | 6.9 |
| 5 | Weiach | CH | 47.54988 | 8.44289 | 447.3 | 5.6 |
| 7 | Stadel | CH | 47.52883 | 8.47205 | 427.4 | 3.8 |
| 8 | Stadlersee | CH | 47.52321 | 8.47939 | 417.9 | 3.4 |
| 9 | Hoeri | CH | 47.51009 | 8.49764 | 428.1 | 2.3 |

**Table 2: Coordinates of the seven measurement points**

The measurement devices were operated daily from 07:45 - 12:00 and from 13:00 - 19:30 during the measurement week. In addition to the ATRA flights, all regular approaches to runway 14 were also recorded during these periods. Those regular approaches, restricted to flights of the A320-214 by Swiss and Edelweiss Airlines, are used to build up the measurement dataset for DYNCAT. The ATRA flights will not be included, as the ATRA is equipped with a different engine type and as it did not fly regular approaches during the tests.

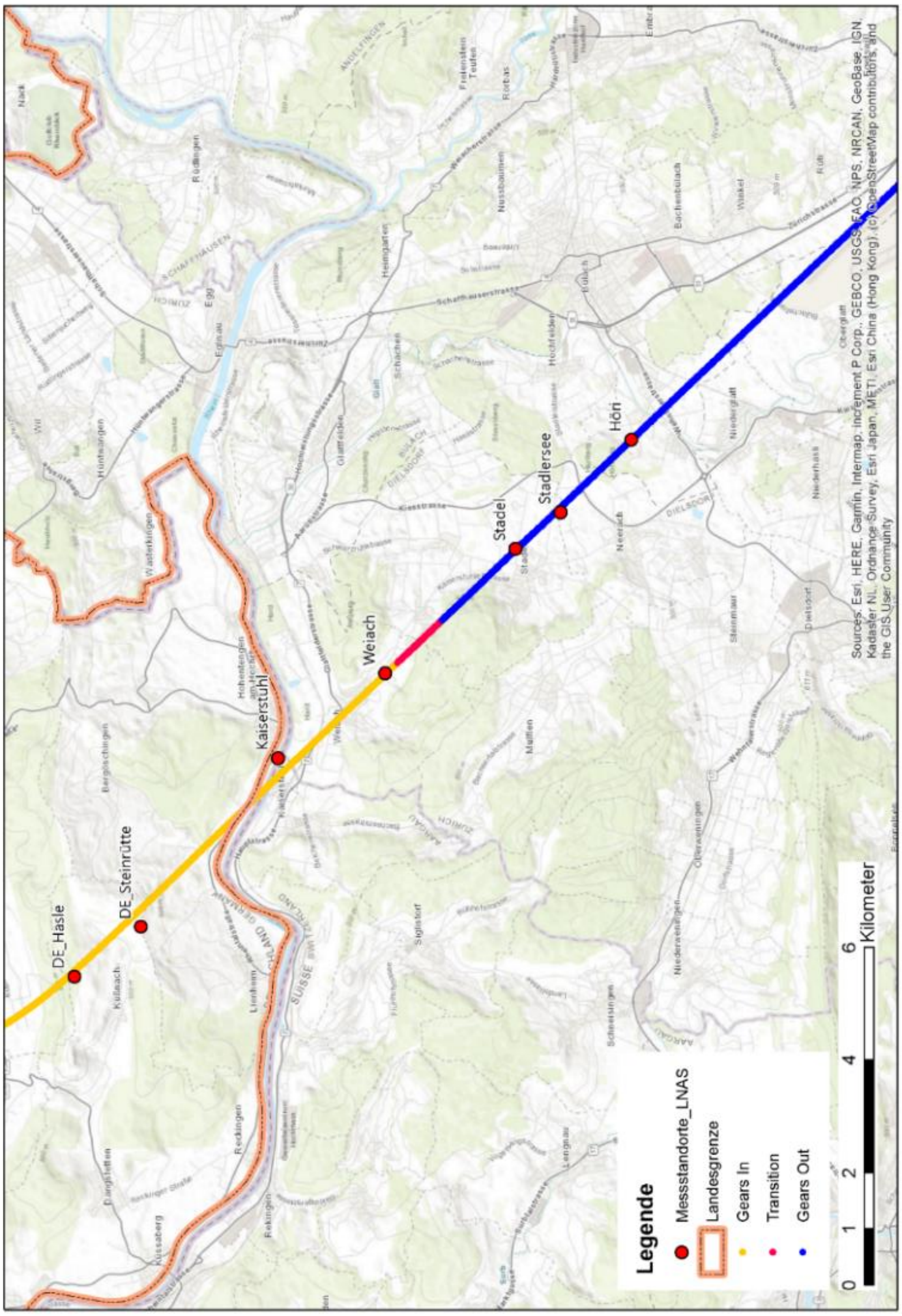


**Figure 3: Measurement chain along the approach path on runway 14 of Zurich Airport.**

## 2.3 Acoustic metrics

The sound pressure signal of each measurement point was recorded as a 48 kHz audio signal. This allowed full acoustical evaluation during post processing with all spectral and time information still being available. In addition, each event can be listened to in order to discriminate unwanted noise from aircraft noise events.

The A-weighted sound exposure level $L_{AE}$ is the central acoustic parameter. The sound exposure level describes the sound intensity of a flyover integrated at a measuring point over time, i.e. the acoustic dose. Based on the event level $L_{AE}$ the equivalent continuous sound level $L_{Aeq}$ can be calculated, which is used to compare the noise exposure at a location with noise limits. For the comparison of simulations to measurements, the $L_{AE}$ based on the t10-down time is often used and therefore also evaluated. The t10-downtime is defined by the time interval where the sound pressure level is within 10dB below its maximum value.

In addition, A-weighted maximum levels $L_{AS,max}$ are also calculated. Here the time signal of the A-weighted sound pressure level is smoothed with a time constant of 1 s and the maximum value is recorded. Although the maximum level is not included in the noise assessment of large aircraft according to the Swiss Noise Abatement Ordinance Annex 5 [5], it is often used for the calculation of noise-induced wake-up reactions and is thus used, for example, for the Zurich Aircraft Noise Index [6].

## 2.4 Recorded events and data processing

During the test week from September 9th to 13th, 2019, 215 approaches of the A320-214 of SWISS and Edelweiss airlines were measured. All events at all measurements point were processed and verified within this project. The verification consists of an automated and a manual part. The automated analysis clips 120s of each overfly event, calculates the time-level history of the $L_{AS}$ and checks for the following occurrences:

- Background noise lies above 50 dB
- Span between maximum level and background noise is smaller than 12 dB
- Difference between the $L_{AS,min}$ before and after the $L_{AS,max}$ is larger than 10 dB (indicates the presence of unwanted noise)
- Length of audio file insufficient (<120 s)

If any of those occurrences are detected, the corresponding noise event is marked as invalid and excluded from further analysis.

In addition, an expert runs through all 1484 events to visually check the level-time histories. If indicated, the expert further listens to the sound file and excludes recordings which contain unwanted noise such as cars, trains, other aircraft, human voice and so on. In total, 112 events were declared as unusable, leaving a dataset with 1372 measured events.

The expert also checked the sound files for two very prominent cavity tones, which are generated by the fuel overpressure ports underneath the wing of the A320. Several airlines such as Swiss installed a retrofit called airflow deflector, which generates a vortex and prevents the generation of those tones. The event list can therefore be filtered for aircraft types with and without cavity tones. For

Swiss, all aircraft types were set to "no cavity tone". For Edelweiss, only one flight was found and marked as "with cavity tone".

## 2.5 Preliminary results

Figure 4 depicts a statistical representation of the measured flights, grouped by airline and measurement point. No further grouping such as different sub engine types, anti-ice activation or equipment (e.g. sharklets) was carried out. This is part to the other tasks of WP2.

Here, preliminary results of all 215 approaches are shown for the $L_{AE}$ (Figure 4 left) and $L_{AS,max}$ (Figure 4 right). As 161 fights were conducted by Swiss and only 54 flights by Edelweiss, the variation of Swiss flights is slightly higher.

The median levels and the level distribution is very similar for the measurement points Hasle and Steinrütte far away from the threshold as well as for the points close to the runway (Stadel, Stadlersee and Höri). The flight procedures thus seem to be similar for both airlines at these distances. At Kaiserstuhl, 6.9 NM from the threshold, the flights performed by Edelweiss show an increased median value by 1.5 dB. Similarly, the median value at Weiach (5.6 NM before threshold) is increased by about 1 dB. Those differences can be most likely be attributed to the landings gears, which seem to be deployed earlier for the Edelweiss flights. This assumption can be verified by analysing flight data recordings, which will be added to the dataset within task 2.2.

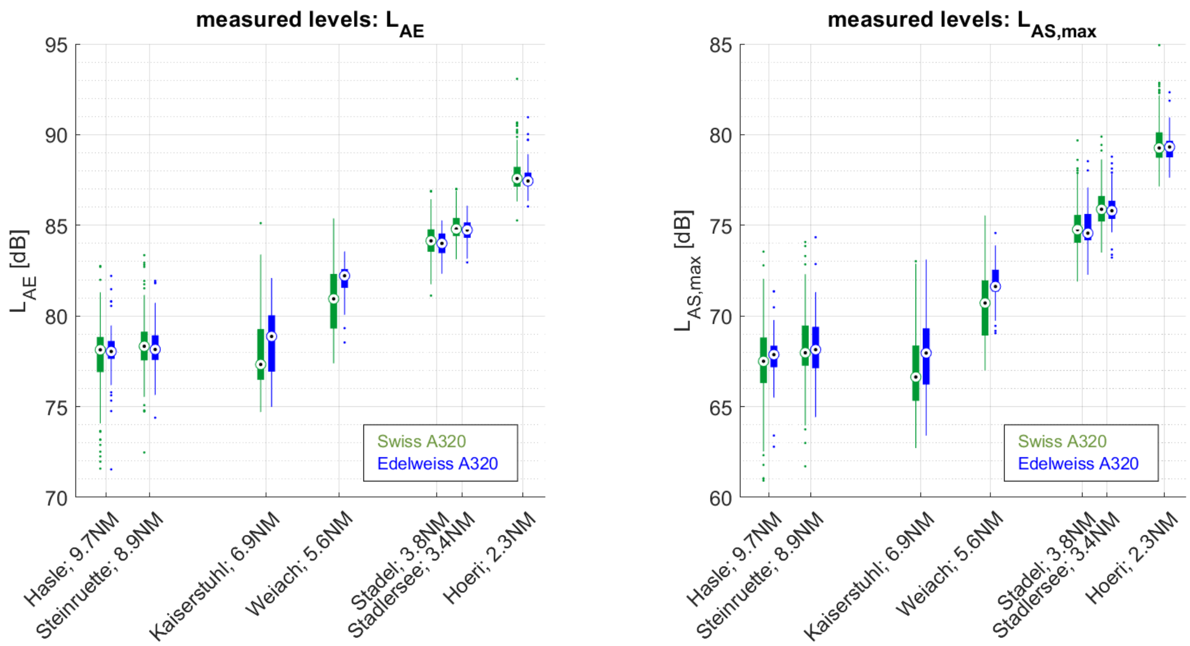


**Figure 4: Box whisker plots of the measured sound levels of A320 approaches by Swiss and Edelweiss between September 9th and 13th, 2019**

# 3 Weather data

No measurements of weather data were executed by Empa itself during the measurement of the LNAS flight campaign. However, the Swiss weather service MeteoSwiss runs a permanent weather station located at Zurich airport. These ground based measurements at the station "Kloten (KLO)" were provided by MeteoSwiss in a high time resolution of 10 minutes for several parameters. For the whole list and further description on the data format see Appendix 0.

During the 215 flights of the LNAS flight campaign, the following range of the main weather parameters were recorded:

- Temperature at 2 m: 9°C to 26°C, mean value of 18.5°C
- Pressure QFE: 965 to 985 hPa, mean value of 974 hPa
- Relative air humidity: 36% to 97% , mean value of 59%
- Wind speeds at 6 m: 0.3 to 4.8 m/s, mean value of 2 m/s
- No precipitation

As the most distant measurement point was located 10 NM away from the weather station, data from a second weather station at "Kaiserstuhl (KAI)" close to the German border with precipitation measurement only was provided too. This station did not record any precipitation during the test week, either.

# 4 References

[1] Zurich Airport, «Flight movements at Flughafen Zürich,» [Online]. Available: https://www.zurich-airport.com/the-company/noise-policy-and-the-environment/flight-movements/flow-statistics. [Zugriff am 14 September 2020].

[2] Skylab, DLR, Empa, «Optimierung von Anflugverfahren zur Lärmminderung am Flughafen Zürich mit dem DLR Pilotenassistenzsystem LNAS und Bewertung durch Flugversuche, Feldmessungen und Lärmsimulation,» 2020.

[3] J. M. Wunderli, C. Zellmann, M. Köpfli, M. Habermacher, O. Schwab, F. Schlatter und B. Schäffer, «sonAIR - a GIS-Integrated Spectral Aircraft Noise Simulation Tool for Single Flight Prediction and Noise Mapping,» *Acta Acustica United with Acustica,* Nr. 104, pp. 440-451, May-Jun 2018.

[4] D. Jäger, C. Zellmann, F. Schlatter und J. Wunderli, «Validation of the sonAIR aircraft noise simulation model,» *Noise Mapping,* 2020.

[5] Swiss Federal Council, «Noise Abatement Ordinance (NAO) from 15 December 1986 (Effective 7 May 2019),» 1986.

[6] B. Schäffer, M. Brink, G. Thomann, P. Huber, S. Plüss und R. Hofmann, «Zurich Aircraft Noise Index ZFI – basics, application, and special aspects,» in *Proceedings of Forum Acusticum 2011*, Aalborg, Denmark, 2011.

# Appendix A Detailed dataset description

## A.1 Event list description

| Name | Unit | Description |
|---|---|---|
| EventID | | Unique event ID consisting of ID_<datetime>_<Type>_<Messung> |
| DirName | | Event folder name |
| WAVName | | Audio file name (wav-File) |
| PfadAudio | | Local path to raw audio file at Empa |
| Datzeit | Datetime | Timestamp when the aicraft passed by the microphone (local time) |
| TDAB | Datetime | Timestamp at TouchDown (TouchDown/AirBorne Time) in local time. Such string can be found in the radar data to merge both data sources |
| BID | | Flight ID from processed movement list |
| AREG | | Aircraft Registration / Call Sign from processed movement list |
| Flugzeugtyp | | ICAO type of the aircraft |
| Typ_FZAG | | Complete aircraft type designation from processed movement list |
| Destination | | Destination airport of the flight |
| TW_AREG | | Complete engine type designation from processed movement list |
| Typ_Engine | | Empa-type of the engine (sonAIR grouping) |
| Flugnr_ICAO | | ICAO flight number |
| Airline_Code | | ICAO airline code |
| ATOW | Kg | Actual take-off weight (empty for approach) |
| MTOW | Kg | Maximum take-off weight |
| Emissionsmodell | | Noise emisison model sonAIR |
| TrajektorieFDR | | ID of FDR data |
| TrajektorieRDR | | ID of radar data |
| Messung | | Approach/Departure and runway name, e.g. A14 |
| Kampagne | | Name of the measurement campaign |
| Route | | Route name |
| Subroute | | Subroute, e.g. Standard Instrument Depature |
| Gate | | Gate used to determin "Datzeit" |
| Messpunkt | | Name of measurement point |
| IndexMP | | Number of measurement point |
| Netbox | | Netbox-designation of the measurement station |
| MeteoSchweizTsurface | °C | Air temperature at surface; current value (MeteoSwiss) |

| Name | Unit | Description |
|---|---|---|
| MeteoSchweizT5cm | °C | Air temperature at 5 cm above grass; current value (MeteoSwiss) |
| MeteoSchweizT2m | °C | Air temperature 2 m above ground; current value (MeteoSwiss) |
| QFF | hPa | Pressure reduced to sea level (QFF); current value (MeteoSwiss) |
| QFE | hPa | Pressure at station level (QFE); current value (MeteoSwiss) |
| RelHum | % | Relative air humidity 2 m above ground; current value (MeteoSwiss) |
| WindSpeed | m/s | Wind speed scalar; ten minutes mean (MeteoSwiss) |
| WindDir | ° | wind direction; ten minutes mean (MeteoSwiss) |
| Precip_30min | Mm | Niederschlag der letzten 30 min (MeteoSwiss) |
| SnowHeight | - | Snow height (MeteoSwiss) |
| GlobRad | W/m^2 | global radiation; ten minutes mean (MeteoSwiss) |
| LASmax | dB(A) | Maximum A-weighted level of the event (time constant Slow=1s) |
| LAE | dB(A) | Measured sound exposure level of the event |
| LAEt10 | dB(A) | Measured sound exposure level during 10 dB-downtime |
| LengthMainEvent | S | Time of the event without any unwanted noise |
| usable | Boolean | Marker if the measured event is usable or not (due to missing soundfile, unwanted noise etc.) |
| gut | Boolean | Additional marker, not used so far |
| Grund | | Reason for events with usable=0 |
| Cavity_tone | Boolean | Marker if the cavity tone at the lower side of the wings, generated at the fuel overpressure ports, was found in the acoustic spectrogram or not. (Swiss aircraft were automatically set to 0, as all aircraft were equipped with the airflow deflector retrofit) |

**Table 3: Event list description**

## A.2 Acoustic data description

| Name | Unit | Description |
|---|---|---|
| Lpspec | dB | Short-term $L_{eq}$ time histories with 50 ms interval for each of the 26 one-third octave bands in f (unweighted) |
| Lpsmooth | dB | Smoothed $L_{eq}$ time histories with a moving average of 1s, which was used to determine individual time intervals of levels above background noise (unweighted) |
| Name | | Name of the measurement point |
| Ereignis | | Unique name of the event |
| Mic | | Number of the measurement point |
| f | Hz | Mid-frequencies of the used one-third octave bands |
| LAS | dB(A) | A-weighted level-time-history LAS with time constant Slow=1s |
| t50 | s | Relative time of Lpspec |
| tabs50 | datetime | Absolute time of Lpspec |
| int | s | Time interval of each one-third octave band, in which the level is 6 dB above the background noise. In addition, a level variation higher than 6 dB would have been identified as unwanted noise, which shortens the interval.<br>-Not used- |
| ind | | Index of time interval int<br>-Not used- |

**Table 4: Acoustic data description**

## A.3 Meteo data format and parameters

Format:

stn yyyyMMddHHmm

stn Station abbreviation
y Year
M Month
d Day
H Hour
m Minute

Times in UTC: 0040 UTC = 02:40 Summer time = 01:40 Winter time

Observation interval for hourly values, unless otherwise indicated in the parameter description: HH = (HH-1):01 - HH:00

Example: 13 = observation period 12:01 to 13:00

Missing values are marked with '-'

Quality information: The key to quality information can be found under: https://gate.meteoswiss.ch/idaweb/text/datenqualitaet_legende_de.pdf

| Name | Unit | Description |
|---|---|---|
| nsh000s0 | octas | amount of all cloud of type CICm (WMO2700) |
| gre000z0 | W/m² | Global radiation; ten minutes mean |
| chh000s0 | Code | Height above station of the base of the lowest clouds |
| ch2000s0 | Code | Height over station of the middle cloud base |
| ch3000s0 | Code | Height over station of the top cloud base |
| ch1000s0 | Code | Height over station of the lowest cloud base |
| ch4000s0 | Code | Height above station of the most important (4) cloud layer |
| prestas0 | hPa | Pressure at station level (QFE); current value |
| pp0qffs0 | hPa | Pressure reduced to sea level (QFF); current value |
| pp0qnhs0 | hPa | Pressure reduced to sea level according to standard atmosphere (QNH); current value |
| tre200s0 | °C | Air temperature 2 m above ground; current value |
| tre005s0 | °C | Air temperature at 5 cm above grass; current value |
| tresurs0 | °C | Air temperature at surface; current value |
| rre150z0 | mm | Precipitation; ten minutes total |
| ure200s0 | % | Relative air humidity 2 m above ground; current value |

| Name | Unit | Description |
|---|---|---|
| vhoauts0 | m | visibility; automatic measurement |
| sre000z0 | min | Sunshine duration; ten minutes total |
| nto000sw | octas | SYNOP: total cloud cover (WMO 2700) |
| tde200s0 | °C | Dew point 2 m above ground; current value |
| fkl010z0 | m/s | Wind speed scalar; ten minutes mean |
| dkl010z0 | ° | wind direction; ten minutes mean |

**Table 5: Meteo data parameter**

**Contact of data owner**

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