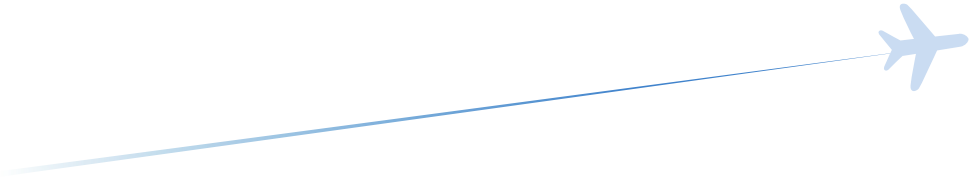

SESAR 2020 DYNCAT - D2.2 - Description of combined data sets

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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

DYNCAT aims at enabling more environmentally friendly and more predictable flight profiles in the TMA, namely on approach, by supporting the pilots in configuration management. A first step is the analysis of the mismatch of aircraft and air traffic control procedures, based on the combination of all relevant data sources (on-board operational data, ATC commands, noise measurement data, surrounding traffic (through radar data), weather information).

Supplementary to an earlier Deliverable which described the noise and weather data, this document contains the description of the operational flight data, which is provided by SWISS, the related radar data and the Air Traffic Control (ATC) recordings. Furthermore, the activity performed in the task "Data Extraction and Matching" is described in detail. In the merging process, all these data are combined to the final data set. To meet the requirements for personal data protection including the pilots' unions' prerequisites, an anonymization of this data set is necessary. The anonymization process and the deleted or anonymized parameters are also described in this document.

This document is intended to help the upcoming tasks to understand the content and structure of the combined data set. The combined data set is the base for the next tasks, which deal with the analysis of the current operation and an initial operational concept. Also the combined data set will be used to prepare realistic scenarios for the real-time simulation.

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1 Introduction[1]

1.1 Background

Part of the Work Package that in overall aims at data and concept analysis, the present activity is one of the starting points for the project. It delivers a comprehensive dataset on which the analysis of the shortcomings of current operations and the subsequent operational concept definition will be based upon. The operational concept will be the final outcome of the Work Package, which gives recommendations to ensure optimised approach operations and it is the basis for following Work Packages.

The objectives of the present WP are:

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

The present Task uses the outcomes of its predecessor, the acoustical measurements and weather data, and combines it with operational flight data, ATC recordings and radar data to create a combined data set. Within the present Deliverable, the authors focus on the description of the data structures themselves (except the acoustic and weather data, which was already done in D2.1 [1]) and the merging and anonymization processes to produce the combined data set.

1.2 Purpose and Structure of the Document

This document is the basis for users of the combined data set in later Tasks of this project. This will be the next Tasks in Work Package 2, which deal with the analysis of current operations and an initial operational concept. In addition, the combined data set will help to prepare realistic scenarios for the real-time simulation of Task 04.01. The document describes the steps performed from the different sources of the processed data to the combined and anonymized data set. The reader will understand how and on which basis the data set was matched and which data were deleted or anonymized to match personal data protection requirements. Furthermore, the reader should understand how the data set is structured in detail and which parameters are part of the data set.

1.3 Changes due to Covid-19

[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.

As already described in detail in D2.1 [1], the original plan to perform a measurement campaign to record noise data was cancelled due to the low air traffic density which is a result of the ongoing Covid-19 pandemic. For this reason, Risk 1 and Risk 5 were activated, and an alternative plan was constructed. Historic noise measurements form September 2019 are now used to provide a data set, which represents an air traffic situation without unwanted effects of the pandemic. Due to the small amount of available noise data (215 flights) these data will be extended by another 300 flights from August to November 2019, which do not contain noise measurements. All 500 flights will be simulated with an aircraft noise simulation tool by the Empa in Task 02.03 to supplement the missing acoustic metrics. For detailed information please refer to D2.1. The chosen alternative data from 2019 are representative of daily operations at Zurich Airport without special influences, e.g. the Covid-19 pandemic. Due to the chosen long period of time in which the data are selected, different seasons are considered within the data, e.g. a holiday season.

The effect on Task 02.02 is that not all data sets will contain noise *measurement* data, compared to the original plan. The consortium believes that the quality of the noise simulation is such that the quality of the outcomes of this project will not be appreciably affected. There will be additional effort but no changes in the time plan, nor will future project work be affected

1.4 Acronyms

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

Acronym	Meaning
ASTERIX	All Purpose Structured Eurocontrol Surveillance Information Exchange
ATANOMS	Airport Track And Noise Monitoring System
ATC	Air Traffic Control
ATM	Air Traffic Management
COVID-19	Coronavirus Disease 2019
CSV	Comma-separated values
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)
ENG	Engine
ER	Exploratory Research
EU	European Union
FLCH	Flight level change
FZAG	Flughafen Zürich Aktiengesellschaft (Zurich Airport company)
GA	Go-Around
GMT	Greenwich Mean Time Zone

Acronym	Meaning
GND	Ground
GPS	Global Positioning System
H2020	Horizon 2020
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
LNAV	Lateral navigation
LOC	Localizer
MCP	Mode control panel
MP3	Moving Picture Experts Group Audio Layer III
MS	Milestone
POPD	Protection of Personal Data
Q<code>	ICAO Q-Code, e.g. QNH
RADAR	Radio Detection and Ranging
SESAR	Single European Sky ATM Research
SJU	SESAR Joint Undertaking
SRS	Speed Reference System
SSR	Secondary Surveillance RADAR
TMA	Terminal Manoeuvring Area
TOGA	Take-Off/Go-Around
VHF	Very High Frequency
VNAV	Vertical Navigation
UTC	Coordinated Universal Time
WP	Work Package

Table 1: Acronyms used in this report

2 Data Structure

A description of existing data in the combined data set and its distribution to the different files is given here. The overview of the file and directory structure can be found in Appendix A.1

2.1 Acoustical and Weather Data

A detailed description of the acoustical and weather data is already the main content of D2.1 [1]. However, a short description of the data structure is repeated to provide the understanding of data merging and anonymizing.

As mentioned in chapter 1.3, there are acoustical data available only for 215 of 500 flights. Weather data, on the other hand are available for every flight of the complete data set.

First of all, an event list is provided which contains an entry for every noise measurement at every measurement station (up to 7 entries per flight). This list contains basic acoustical data, basic weather data and metadata on the related flight like aircraft registration, touchdown time or flight number. For flights without available acoustical data, the related data fields are empty in this file. In the complete data set, the file name is *"NoiseBaseData.csv"*. For a detailed description of this list, please refer to D2.1, appendix A.1.

For every flight with available acoustical data, there is also a directory provided which contains detailed acoustical measurement data in several MATLAB and audio files containing a recording of each event itself. The related file names are linked in the event list entries. For a detailed description of this data, please refer to D2.1, appendix A.2.

Beside the basic weather information for flights with available acoustical measurements in the event list mentioned above, the combined data set contains a file named "*Meteo.csv*". This file provides detailed weather data from the two measurement stations '*Kaiserstuhl*' and '*Kloten*', whereas for *Kaiserstuhl* only precipitation information is available. The data are available in the period from 10 minutes before the operational flight data recording starts until touchdown. In this period, a data point is available every 10 minutes. For a detailed description of this data, please refer to D2.1, appendix A.3.

2.2 Operational Flight Data

The operational flight data are recorded aboard every Swiss aircraft and contain many parameters from the different aircraft systems. Within this project, the data for the corresponding flights were extracted from a database with historical recordings to CSV files by SWISS. The scope of parameters and period of time in which the data are provided were agreed among the project participants. The main objective was to provide sufficient data to perform an analysis of current operation and to create an operational concept which is part of the upcoming Tasks 02.03 and 02.04. Also, the preparation of the real-time simulation in Task 04.01 provided requirements for provision of sufficient data to create representative simulator scenarios.

The data for every flight have been recorded at a frequency of 0.5 Hz. The period in which the data are extracted is chosen based on multiple criteria which lead to approximately 30 minutes of data until the

aircraft crosses the runway threshold. The filename in the combined data set is *"AircraftData.csv"*. A detailed list of provided parameters is available in appendix A.2.

2.3 Radar Data

The radar data contain not only the investigated flights in this project, but also the air traffic around the airport. The data provide the recorded radar path for every flight itself and metadata, e.g. registration, callsign, origin/destination and touchdown time. The related surrounding data are filtered by the following criteria for every investigated flight:

- All arriving flights at the airport from 10 minutes before the start of the operational flight data recording until touchdown of the investigated flight.
- All departing flights at the airport from 30 minutes before the touchdown until the touchdown of the investigated flight.

By providing the surrounding traffic of every investigated flight, the analysis of current operation in dependency on the air traffic situation and possible improvements should be possible. The filename in the combined data set is *"Radar.csv"*. A detailed list of provided parameters is available in appendix A.3.

The origin of the radar data is the Swiss air navigation service provider 'Skyguide'. They are provided in the ASTERIX (All Purpose Structured Eurocontrol Surveillance Information Exchange) format and include SSR (Secondary Surveillance Radar) as information source. Subsequently, the data were bundled and connected with flight plan data in the ATANOMS (Airport Track And Noise Monitoring System) software by FZAG (Zurich Airport AG) before delivery to the project. For use in DYNCAT, the data format was only changed slightly to make it more readable for humans. In detail, date formats were translated into a readable format and the data fields were separated by semicolons to provide a CSV data format. No data content was changed or deleted except during the anonymization process as described in section 4.

2.4 ATC Recording Data

For every investigated flight an ATC file named "ATC.csv" is available in the combined data set. The data were extracted from the original, unprocessed recorded ATC radio frequencies of 'Approach East' and 'Approach West' of Zurich Airport by listening to the commands as spoken by the ATC controller and transcribing them with time references. The historical recordings from 23rd Aug. 2019 until 10th Nov. 2019 data was purchased from the 'LiveATC.net LCC' company which provide VHF records from many airports worldwide. The original data are available in MP3 audio files separated in 30 minutes each. The transcription of the MP3 recordings for the evaluation has been done by pilots at DLR. A detailed list of provided parameters is available in appendix A.4.

3 Merging

The merging process converts the different raw data sets into a single data set for every investigated flight (as described in chapter 2). The data contain only the related data of this flight, e.g. only an extract from the raw radar data set. The merged data are called 'combined data set'.

The algorithm for merging and anonymizing is implemented in Java programming language. It enables easy access to text-based data like the CSV file format and is usable independent from special hardware or operating systems. The merging process starts with the identification of the individual flights from the event list by an explicit set of metadata. For every flight an output directory is created and the related rows are copied to the "*NoiseBaseData.csv*"-file as described in chapter 2.1. Also, the detailed acoustical information is copied into this directory. Now the basic information about this certain flight is available to find all other related data. The following parameters are used as explicit data set to find and select the operational flight data, radar data, meteorological data and ATC data to this flight as described in chapter 2:

- Registration/Tail Sign
- Flight Number
- Touchdown Time

The merging and anonymization process in visualized in Figure 1.

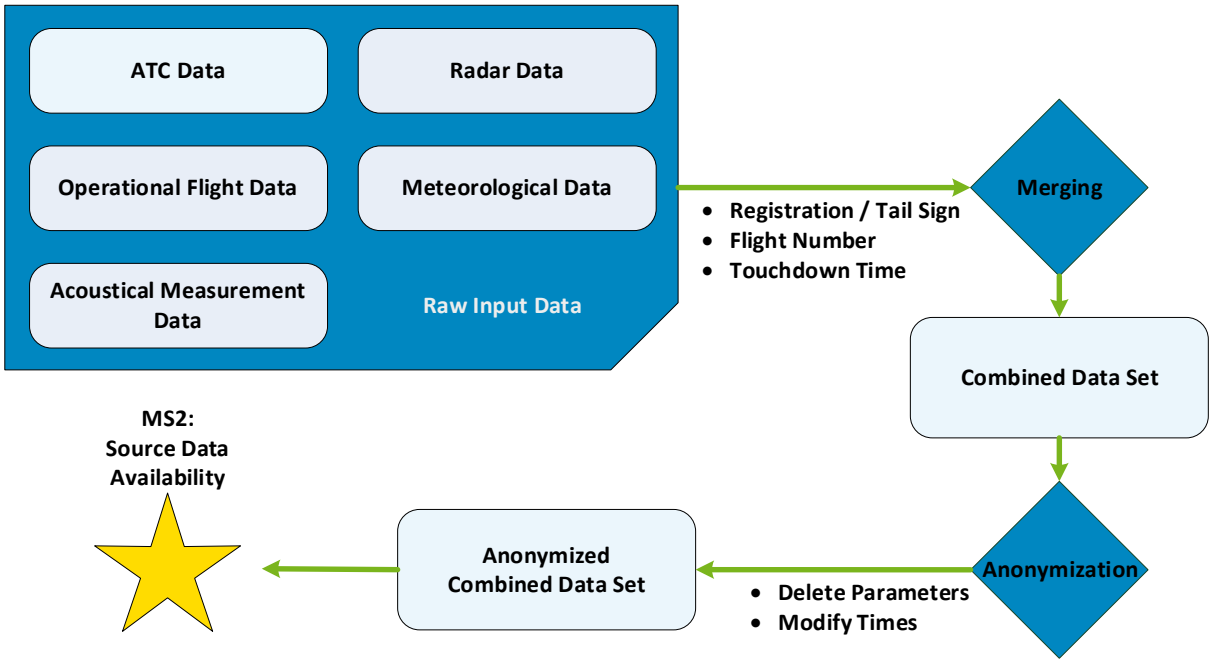

Figure 1: Dataflow from raw data to the anonymized combined data set with merging and anonymization.

4 Anonymization

To comply with applicable privacy standards [2], including the pilots' union's prerequisites for consent to a data release to Task 02.02, it must not be possible to identify a certain flight in the combined data set. For this reason, several parameters were deleted or manipulated in an appropriate way. This was performed for all individual flight related information in e.g. the radar data. A detailed list of anonymized parameters is available in Appendix B. The anonymization software is implemented in the Java programming language as already mentioned in chapter 3. The merging and anonymization process is visualized in Figure 1 above.

4.1 Date and Time

The date and time in the data set can identify a certain flight explicitly (e.g. the touchdown time). On the other hand, to allow a proper analysis in the next tasks of this project, a chronological connection between the different data sets of one flight must be given. For example, it must be possible to associate the change in wind direction to certain resulting pilot actions. To meet both requirements, all dates (year, month and day) will be deleted and the remaining times will be converted to UTC time. The remaining times does not allow to identify an individual flight, but a chronological connection along the different datasets is retained. Also changes over the day can be detected later on.

4.2 Deleted parameters

Other parameters, which can provide an identification of a certain flight, are simply not needed in further project steps. These parameters are for example the flight number or origin of the flight. For this reason, these parameters become replaced by the expression "XXXX" to identify them as deleted in the anonymization process. A detailed list of these parameters is available in Appendix B.

5 References

[1] D2.1, “Description of acoustical and weather data measurements”, 17th November 2020, Edition 00.02.00

[2] N.N., “Ethics Summary Report” on proposal number 893568 entitled “DYNCAT”, 23rd January 2020

Appendix A Detailed dataset description

A.1 Combined data set structure

A flight and all its related data are collected in one directory. The name of this directory is a random number. The directory contains files and directories as shown in the following table.

Name	Type	Description
AicraftData.csv	File	Operational flight data
ATC.csv	File	Commands given by Air Traffic Control
Meteo.csv	File	Detailed weather data
NoiseBaseData.csv	File	Event list with basic data
Radar.csv	File	Radar data of this flight and surrounding traffic
NoiseEvent	Directory	Detailed acoustical measurement data

Table 2: Combined data set structure

A.2 Operational flight data description

The data are provided in the comma-separated values (CSV) format. The separation character is the semicolon. The filename is “AicraftData.csv”. The file starts with a header row which contains the parameter names. Each following row contains the values described in the header for a certain recording time. The order of the parameters represents the order of data columns in the file itself.

Parameter Name	Unit	Description
Flight Record	Counter	Swiss internal recording number
GMT	Time	Recording time of related row
Longitude	deg	Aircraft position longitude
Latitude	deg	Aircraft position latitude
GPS Altitude	ft	Aircraft altitude by GPS
Baro Corr Altitude CAP	ft	Corrected barometric altitude on the captain’s side
QNH Setting CAP	mBar	QNH setting on the captain’s side
True Heading	deg	
Pressure Altitude	ft	Altitude pressure / barometric altitude (ref 1013 mBar)
True Track	deg	
FPA	deg	Flight path angle
Bank angle	deg	
Pitch angle	deg	
Corr AoA	deg	Corrected angle of attack
Indicated AoA	deg	Indicated angle of attack

Parameter Name	Unit	Description
Selected Altitude	ft	
Selected HDG	deg	Selected heading
Selected SPD	kts	Selected speed
Selected Vertical Speed	ft/min	
IAS	kts	Indicated air speed
TAS	kts	True air speed
Mach		Mach number
Ground speed	kts	
Ground speed GPS	kts	
Vertical Speed (inertial)	ft/min	
Approach speed	kts	Approach speed from flight management system
VLS	kts	Lowest selectable airspeed
S Speed	kts	Flaps 2 theoretical (backward) retraction speed
F Speed	kts	Flaps 3 and 4 theoretical (backward) retraction speed
Flap Speed Limit	kts	Next Flaps Maximum Speed (Vfen)
Gross Weight	kg	
N1	%	Combined fan speed of both engines (average)
Flap Handle Position		[0-4]: 0 = retracted; 1 = Flaps1; 2 = Flaps2; 3 = Flaps3; 4 = Flaps Full
Gear Lever		[0-1]: 0 = up; 1 = down
Landing Gear Nose		[0;1]: 0 = up; 1 = down
Landing Gear Right		[0;1]: 0 = up; 1 = down
Landing Gear Left		[0;1]: 0 = up; 1 = down
Spoiler	deg	Spoiler / Air Brakes
Glideslope Deviation	dots	
Localizer Deviation	dots	
Static Air Temperature	°C	
Wind Speed	kts	
Wind Direction	deg	
Static Pressure	mBar	Corrected average static pressure
Air Density	kg/m³	
AP1		Autopilot 1; [0,1]: 0 = deactivated; 1 = activated
AP2		Autopilot 2; [0,1]: 0 = deactivated; 1 = activated

Parameter Name	Unit	Description
ATHR		Autothrottle; [0,1]: 0 = deactivated; 1 = activated
Nav Hold Mode		[0,1]: 0 = deactivated; 1 = activated
Open Descent Mode		[0,1]: 0 = deactivated; 1 = activated
Glideslope Hold		[0,1]: 0 = deactivated; 1 = activated
Glideslope Capture		[0,1]: 0 = deactivated; 1 = activated
Localizer Hold		[0,1]: 0 = deactivated; 1 = activated
Localizer Capture		[0,1]: 0 = deactivated; 1 = activated
Altitude Hold		[0,1]: 0 = deactivated; 1 = activated
Altitude Capture		[0,1]: 0 = deactivated; 1 = activated
FPA Mode		[0,1]: 0 = deactivated; 1 = activated
Vertical Speed Mode		[0,1]: 0 = deactivated; 1 = activated
Managed Speed		[0,1]: 0 = deactivated; 1 = activated
Engine Anti-Ice		[0,1]: 0 = deactivated; 1 = activated
Wing Anti-Ice		[0,1]: 0 = deactivated; 1 = activated
QNH selected on EFIS (CAPT)		QNH selected on captains' side; [0,1]: 0 = deactivated; 1 = activated
QNH selected on EFIS (FO)		QNH selected on first officers' side; [0,1]: 0 = deactivated; 1 = activated
Fuel Flow Left	kg/hr	Fuel flow left engine
Fuel Flow Right	kg/hr	Fuel flow right engine
Flap Angle	deg	
Spoiler Position 1 Left	deg	
Spoiler Position 2 Left	deg	
Spoiler Position 3 Left	deg	
Spoiler Position 4 Left	deg	
Spoiler Position 5 Left	deg	
Spoiler Position 1 Right	deg	
Spoiler Position 2 Right	deg	
Spoiler Position 3 Right	deg	
Spoiler Position 4 Right	deg	
Spoiler Position 5 Right	deg	
Flight Phase		[0-10]: 0: Unknown 1: GND: POWER ON

Parameter Name	Unit	Description
		2: GND: TAXI OUT 3: GND: TAKE OFF ROLL1 4: GND: TAKE OFF ROLL2 5: AIR: TAKE OFF CLIMB 6: AIR: CLIMB/CRUISE/DESCENT 7: AIR: FINAL APPR. 8: GND: LANDG. ROLL 9: GND: TAXI IN 10: GND: ENG. SHUTDOWN
Vman	kts	Manoeuvring speed
Vmax operational	kts	Maximum operation speed
V alpha prot	kts	Speed alpha protection
V alpha max	kts	Speed alpha limit
Gross Weight	metric tons	
Side Slip	deg	
Drift Angle	deg	
Acceleration longitudinal	g	
Acceleration lateral	g	
Acceleration normal	g	
Corrected MSL altitude	ft	
Speed Brake Deployed		[0-1]: 0 = retracted; 1 = deployed
Landing Gear Position		[0-2]: 0 = up; 1 = in transit; 2 = down
Active Lateral Mode		[0-10]: 0: Unknown 1: GA Track 2: Heading 3: LNAV 4: LOC Hold 5: ROLL Hold 6: ROLLOUT 7: Runway 8: Runway Track 9: Selected Track 10: Track Hold
Active Vertical Mode		[0-19]: 0: Unknown 1: Altitude Hold

Parameter Name	Unit	Description
		2: Altitude Capture 3: Climb 4: Descend 5: Expedite 6: Flare 7: FLCH 8: Flight Path Angle Hold 9: Glideslope Hold 10: Open Climb 11: Open Descend 12: Pitch Roll 13: SRS 14: TOGA 15: Vertical Speed Hold 16: VNAV ALT 17: VNAV PATH 18: VNAV SPEED 19: VNAV
Approach Speed Target	kts	
Selected Speed MCP	kts	
Phase of Flight		[0-10]: Same as 'Flight Phase' above
Great-Circle Distance to Threshold	NM	

Table 3: Operational flight data description

A.3 Radar data description

The radar data file is provided in comma-separated values (CSV) format. The filename is "Radar.csv". The separation character is the semicolon. The file starts with a header row which contains the parameter names. The first data row represents the investigated flight itself. All following rows represent flights in the air traffic around the investigated flight as described in chapter 2.3. The order of the parameters represents the order of data columns in the file itself.

Parameter Name	Unit	Description
IATA Call Sign	Text	Callsign in IATA standard
TDAB	Datetime	Touchdown or airborne time
ICAO Call Sign	Text	Callsign in ICAO standard
Registration	Text	Tail Number / Registration of the aircraft
Origin/Destination	Text	
Operation	[A,D]	Arrival or departure

Parameter Name	Unit	Description
Rwy	Text	Arrival or departure runway
SID	Text	Standard instrument departure route
Stufengruppe		
Track length	sec	
MTOW	t	Maximum take-off weight
X	m	X-Coordinate in Swiss coordinate system (CH1903 LV03)
Y	m	Y-Coordinate in Swiss coordinate system (CH1903 LV03)
Z	m	Z-Coordinate in Swiss coordinate system (CH1903 LV03). Reference altitude 423m. Measurement source altitude 4m.
t		Data point time
X,Y,Z,t…		Repeating for all recorded radar points

Table 4: Radar data description

A.4 ATC data description

The ATC data file is provided in comma-separated values (CSV) format. The filename is "*ATC.csv*". The separation character is the semicolon. The file starts with a header row which contains the parameter names. The order of the parameters represents the order of data columns in the file itself.

Parameter Name	Unit	Description
Filename	Text	Original audio filename of ATC radio recording
Time	Datetime	Timestamp of the related command
Callsign	Text	Callsign in ICAO standard
ATC command	Text	Transcribed information from ATC
Comment	Text	Optional comment

Table 5: ATC data description

Appendix B Anonymized parameters

B.1 NoiseBaseData.csv

Parameter Name	Action
Airline_Code	deleted
BID	deleted
Datzeit	anonymized
Destination	deleted
EventID	anonymized
Flugnr_ICAO	deleted
PfadAudio	deleted
TDAB	anonymized
WAVName	anonymized

Table 6: Anonymized parameters - NoiseBaseData.csv

B.2 AircraftData.csv

Parameter Name	Action
Flight Date	deleted
Flight Number	deleted
Flight Number String	deleted
Flight Record	deleted
GMT	anonymized

Table 7: Anonymized parameters - AircraftData.csv

B.3 ATC.csv

Parameter Name	Action
ATC command (only the callsign if existing)	deleted
callsign	deleted
filename	deleted
time	anonymized

Table 8: Anonymized parameters - ATC.csv

B.4 Meteo.csv

Parameter Name	Action
Time	anonymized

Table 9: Anonymized parameters - Meteo.csv

B.5 Radar.csv

Parameter Name	Action
IATA Call Sign	deleted
ICAO Call Sign	deleted
Origin/Destination	deleted
TDAB	anonymized

Table 10: Anonymized parameters - Radar.csv

B.6 NoiseEvent directory

Parameter Name	Action
Timestamps in filenames	anonymized

Table 11: Anonymized parameters - NoiseEvent directory

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