SAFTu Manual v6.0

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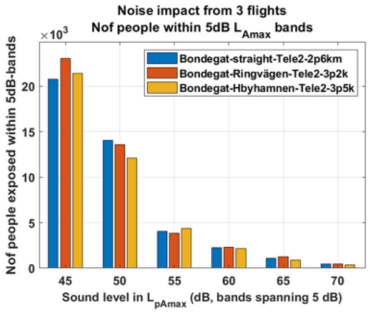

Orientation about SAFTu

SAFTu[1] is a computer program enabling noise-mapping on ground from noise generated by flying UAS (Unmanned Aircraft Systems) or piloted flying vehicles. The typical aim, and output, when running SAFTu are noise contour lines, e.g. dBA_{max}-levels, on a map covering the ground underneath the flight path of a vehicle.

The code is written in and runs from within Matlab. SAFTu is in its current shape to be viewed as a research tool to be further developed and adapted to the needs following with the maturation of the UAS system.

In SAFTu flight trajectories can be created and noise maps produced for *any geographic area on earth. This is enabled using free and open supporting tools and data,* Google Earth for ground track generation and results visualisation, QGIS[2] (+OpenTopography[3]) for elevation data handling, open data from sources such as Copernicus Global DSM 30m[4] and for population data e.g. from OCHA[5]/HDX.

The vehicles are represented by their sound source strength (sound intensity emitted in "all" directions at a radius of 1 m from a point source) along the 3D flightpath modelled. The source models can account for a varying directivity, i.e. source strength/intensity, with propagation angle relative the vehicle.

The flightpath is discretized in timesteps, typically around a second long. At the discretization points, the sound pressure on the ground is computed with ray tracing and the noise history, i.e. sound pressure as a function of time, frequency and position $p(t, f_{thirdoct}, lat, lon)$, is saved in each ground(grid) point.

In the ground grid points, noise histories in L_A are computed and L_{Amax} and/or L_{AE} contour lines are computed. Other noise metrics might rather straight forward be added.

To run SAFTu the user needs to have:

- the source code SAFTu, including vehicle/sound source data
- a Matlab license
- topography/elevation data for the area of concern (available through open sources DEM)
- (to quantify noise mapping with population data – such may be added via open sources)

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[1] SAFTu ("**S**imulering av **A**tmosfär och **F**lygtrafik för en **T**ystare omgivning", u="UAS") , the herein described program, is partly a spin-off and further development of the aircraft noise mapping code SAFT
[2] QGIS an open-source GIS-tool
[3] OpenTopography
[4] Copernicus DEM, DEM = Digital Elevation Model or DSM =Digital Surface Model, is a representation of the bare ground topographic surface of the Earth excluding trees and buildings
[5] OCHA services

SAFTu is filling the gap between standard air traffic noise mapping tools/methods (e.g. INM/AEDT, ECAC Doc.29) on one hand and standard environmental noise estimation tools for static sources and/or road traffic on the other. Software in neither of the two groups is capable of handling general flying drones/UAS.

Content

1. Preparation - installing - dependencies

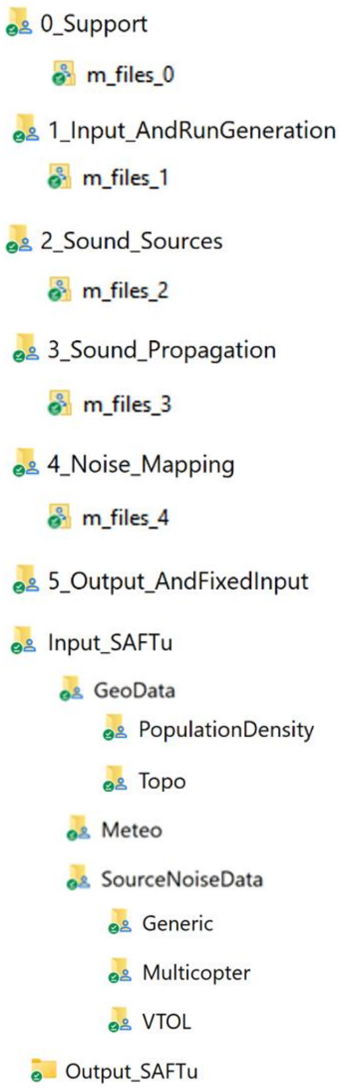
To be able to run SAFTu you need to:

Make sure basic requirements are met

- Get hold of the SAFTu source code (after agreement with the APIS-project)
- Install the Matlab software (or a compiled version of the SAFTu code)
- Install Google Earth Pro (to be used for input handling and results presentations)

Arrange with file directory structure and download source code

- To download the code m-files organised in 4 directories (*as shown here in the right margin)* under your choice of a "[*Main SAFTu*]" directory and then ...
- Into the directories "*0_Support*", ..., to "*4_Noise_Mapping*" you should download the latest Matlab m-files (as already sorted regarding functionality)
- Into the directory "*5_Output_AndFixedInput*" you arrange with the directories shown to the right, "*Input_SAFTu*" (+ sub directories) and "*Output_SAFTu*" (here results will be put when running SAFTu)



Add sound source data

- Sound source data representing different vehicle types are given in matlab.mat-format, typically named *SoundSource.mat*, and are placed in directories under: 5_Output_AndFixedInput/ Input_SAFTu/SourceNoiseData/[UAS-Type]/ SoundSource.mat

Add supporting "static" input data from outside SAFTu

- Add input data of the different types (in *5_Output_AndFixedInput/ Input_SAFTu/...*)

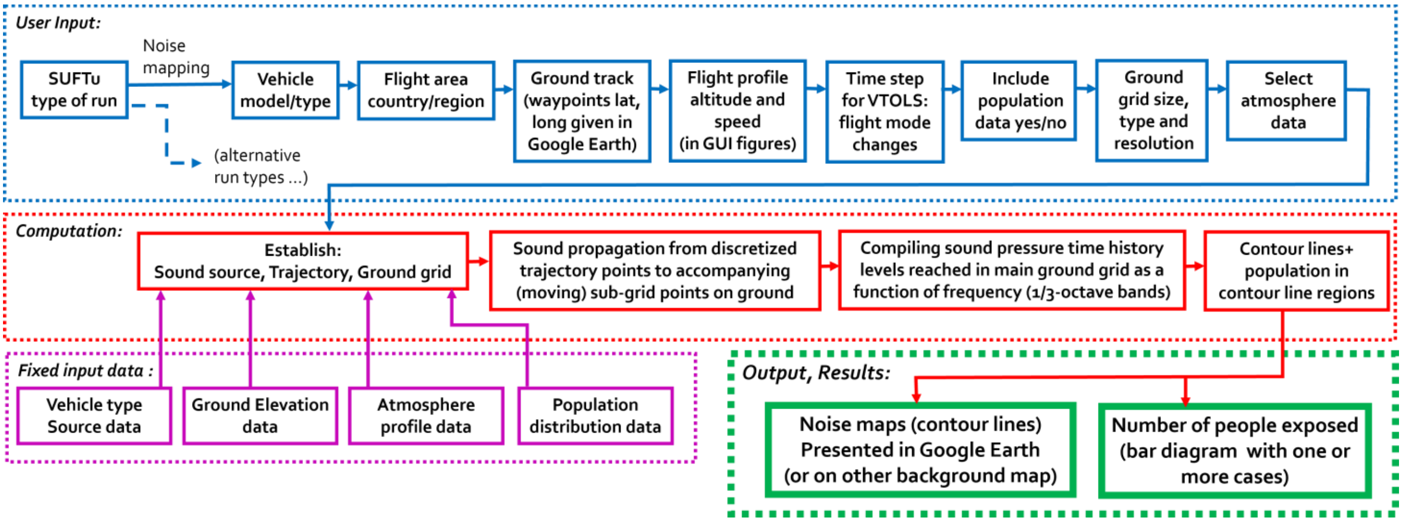
- Geotiff formatted (.tif) ground elevation data for regions of interest, are proposed to place in directories like: .../GeoData/Topo/[subdir name telling region, e.g. Sweden, Stockholm, ...] – NOTE: without any data of this kind covering the noise exposed area SAFTu cannot run at all!
  See Appendix 1 about downloading topography/DEM Digital Elevation Data

- Geotiff formatted population density files for regions of interest, are proposed to be placed in directories like: .../GeoData/PopulationDensity/[subdir name telling region, e.g. Sweden, Stockholm, ...] – NOTE: without any data of this kind covering the noise exposed area SAFTu cannot produce population exposure related results!

(Already prepared data of above types for some regions might also be possible to require from other SAFTu users)

2. Flow chart – SAFTu noise mapping run

Flow chart SAFTu run case noise mapping including population data



As indicated in the flow chart the workflow experienced by the user, as well as the code itself, is serial/sequential.

3. Start running SAFTu

- Start Matlab (after installation of SAFTu as described above)
- In Matlab command window change directory to:

  [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1 by writing:

  cd 'Local_SAFTu_main_dir\1_Input_AndRunGeneration\m_files_1'

  where 'Local_SAFTu_main_dir' denotes the root directory under which you have placed the "first level" directories: 0_Support, ... , to 5_Output_AndFixedInput

- Start the Matlab editor and open SAFTu_v[X].m (where [X] stands for current/latest SAFTu version)
- In this file, SAFTu_v[X].m: change (around line 55) the value of: 'xxxxx' in the line telling:

  Local_SAFTu_main_dir = 'xxxxx' to the directory path name, you have given to your SAFTu root directory

- Save SAFTu_v[X]

Now you are ready to start running SAFTu by writing at the Matlab command window prompt:

>> SAFTu_v[X] and then press return

If some routine/m-function file is missing the run will stop and an error message will inform you about it in the command window

A way to find out which user created m-functions SAFTu_v[X] rely on is to use the command: matlab.codetools.requiredFilesAndProducts, e.g. like this:

(standing in dir: 'Local_SAFTu_main_dir\1_Input_AndRunGeneration\m_files_1')

execute first:

>> [fList, pList] = matlab.codetools.requiredFilesAndProducts('SAFTu_v[X].m');

execute then:

>> for j=1:length(fList); disp(fList(j)); end

... a list of around 150 m-files show up in command window like:

'[Local_SAFTu_main_dir]\0_Support\m_files_0\A_weight_dB.m'

...

'[Local_SAFTu_main_dir]\4_Noise_Mapping\m_files_4\plot_popDens_on_kmlANDopenstreetMap_v2.m'

In order to check if you aremissing any matlab toolboxes write:

>> for j=1:length(pList); disp(pList(j)); end

As of jan 2025 these needed toolboxes should be installed:

'Mapping Toolbox', 'Statistics and Machine Learning Toolbox' and 'Curve Fitting Toolbox'

4. SAFTu main run alternatives (as of Jan.2025 v.33)

When starting SAFTu, i.e. by writing the main-SAFTu file name, like the current version 33 name *SAFTu_V33*, in the command window (or pressing "Run" in the editor when *SAFTu_V33.m* is active), you get some alternative "Main Actions" to choose among. After starting *SAFTu_V33* the command window should look something like (screen dump):

WELCOME, YOU ARE RUNNING SAFTu_v33
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\SAFTu_v33)

MAIN ACTION
1. Choose your wanted kind of SAFTu main action:

----- Preprocessing -----
0. Prepare data to be used in later noise-mapping (e.g. Vehicle Sound Source, Atmosphere-, TL-data, ...)
or
----- Noisemapping -----
1. Define and run a noise mapping case with input given interactively (Default)
[NOTE: a Sound Source representing the vehicle has to be established prior to a noise mapping-run]
or
[NOT YET IMPLEMENTED: 2. Read in and run a previously prepared noise mapping case input file]
or

----- Postprocessing -----

3. Difference between grid field results from two previous runs ("Delta-dB contours")
or
4. Population exposures within dB-bands, bar plot comparison of previous run results

Please give a number, 0, **1**, 3 or 4:

As shown above in the first user input step one has to choose between 3 alternatives:

0. *Preprocessing* (Prepare data to be used in later noise-mapping

1. ***Noise mapping*** – interactive input

3. *Postprocessing A* - Difference between two previous runs noise maps ("Delta-dB contours")

4. *Postprocessing B* - Population exposures within dB-bands, bar plot comparison previous runs

[NOT YET IMPLEMENTED: 2. Noise mapping input from file]

Outline main run alternatives

0. Prepare data to be used ...

When choosing "0" preprocessing as the first input in a SAFTu run one get the following choices in the second input step: NOTE: This step is typically not often needed to apply. If you as a user already have sound source data for the vehicle of concern, you may start directly by running a noise mapping case.

PREPARATION ACTION
2. Please choose your wanted kind of SAFTu data preparation action (1 or 2 or 3), where:
1. Sound source preparation (Default)
2. Create a Groundtrack [NOTE: this might as well be carried out together with a noise mapping run]
3. Create a Trajectory, i.e. Groundtrack + Profile - [NOTE: Specific Vehicle and its Sound Source needed as input!]
4. Download Atmosphere data from met.no OR just Plot Atm-profiles already on disc
5. Create a Transmission Loss (TL) matrix for a selected Atmosphere dataset

[no more alternatives yet]
Please give a number, 1 (Default) 2, 3, 4 or 5:

If then in next step selecting 1 "Sound source preparation", the following choices appear on the screen:

SOUND SOURCE PREPARATION
3. Please choose your wanted kind of sound source origin information (1 or 2), where
1. Sound source preparation starting out from raw-data PSD-spectrum, e.g. digitized* figure data (Default)
   *)NOTE: the digitization of a PSD-curve in found figure is proposed to be done with the free program Engauage Digitizer
   - this since any matlab digitizer giving the same quality has not yet been found
2. Generic simplified UAVs/Soundsources
3. Helicopter - from NPD and supporting data [NOTE: Bell407 the only helicopter choise]
4. Tailored by user - Spectrum, Level and Directivity (one or more conditions/flightmodes)
5. [no more alternatives yet]

Please give a number, 1 (Default) 2 or 3:
1

---- Now you are in function: Establish_UAV_SoundSource_Input_v2.m -----
(at: [Local_SAFTu_main_dir] \2_Sound_Sources\m_files_2\Establish_UAV_SoundSource_Input_v2)

NOTE: implementation of some these paths is not yet finished (e.g. no "3. Helicopter") – neither yet fully documented in this manual. Users are welcome to explore yet missing functionality and propose corrections and adds.

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1. ***Noise mapping*** – interactive input

As indicated above *Noise mapping is the typical and final goal main path through SAFTu*. Here you will produce noise contours overlayed on maps for selected vehicles and tailored flightpaths. Currently only an interactive command window input is possible (a planned input from file is not yet implemented). Most of the interactive inputs regards is accompanied with default values, simply just press return to go on, which makes running SAFTu rather easy and user friendly.

See run-examples further down in this manual to start out running SAFTu and main path: “1” Noise mapping

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[2. Noise mapping input from file - NOT YET IMPLEMENTED]

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3. ***Postprocessing A*** - Difference between two previous runs noise maps ("Delta-dB contours")

When choosing “3 ... Delta-dB contours” as the first input when running SAFTu a difference in sound level between two noise fields previously computed is established. The following is shown on the PC-screen after this selection:

Delta dB CONTOURS BETWEEN TWO FLIGHT CASES

--- A new default output directory has been created ---
[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Output_SAFTu/20250120_1359_Ulf_SAFTu_v33_DeltadB

---- Now you are in function: comp_Delta_dB_from_2NoiseGr_files_u1.m -----
(at C:\Users\Ulf\Min enhet\Jobb\CSA\1_ARBETSMATERIAL\APIS\SAFTu\4_Noise_Mapping\m_files_4\comp_Delta_dB_from_2NoiseGr_files_u1)

You are now going to select two previously computed SAFTu-output files of the type: "NoiseGr*.mat2, containing the noise levels in the noise metrics LAmax or SEL in a ground grid, and from these data create the difference + plot and view the new delta-dB results in Google Earth.

The requirements on the two datasets to be selected are that:
- They have originally been generated on the same ground grid, i.e. same size, resolution and shape, the last implying that the original ground track also is the same.

When these conditions are fullfilled the two datasets may differ in almost any sence, i.e. computational method, vehicle-type, trajectory/procedures, atmospheric profile ("weather") data, ...

This selection and plotting may be carried out in the following way:
1. Decide which two datasets you want to compare
2. Make sure they both are given on the same ground-grid, e.g. same extention and resolution
3. Read the blue input-line no 2 below and the press return
4. In the file-browser window that opens, find and pick the 'NoiseGr*.mat' file containing the 1st dataset
5. Do the same as in 3 and 4 above for the 2nd dataset
   (SAFTu checks that the two grids are the same, if thats the case: continue, else start over the selection - or choose to break the run)
6. Select the wanted fields A and B of the two structs, i.e. 'NoiseGr1.[field A]' and 'NoiseGr2.[field B]' respectively - a list of alternative fields will be shown
7. The Delta-dB defined as: NoiseGr1.[field A] - NoiseGr2.[field B], will be computed, saved in a new output directory, and presented in GE

2. Please browse down in your SAFTu output directory and choose the 1st of the two 'NoiseGr.mat' files from previous runs:
In the file-browser window, which opens after you press RETURN here, open the wanted directory and select your NoiseGr_[-- case 1 identifier extention --].mat file(s)
(You may search for 'NoiseGr*.mat' in the file browser field in the upper right corner)

NOTE: this SAFTu main path, “Delta-dB contours”, is not further described in this manual and new users are recommended to test out the functionality on their own.

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4. ***Postprocessing B*** - Population exposures within dB-bands, bar plot comparison wrt previous runs

In this case it is needed that previous noise mapping cases, at least two cases, including population within bands was included, have been run prior to the current run. After the main path choice “4. ... bar plot comparison” is made the following occure on the screen:

--- A new default output directory has been created ---
[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Output_SAFTu/20250120_1422_Ulf_SAFTu_v33_popComp

---- Now you are in function: select_Population_Within_dBbands_Data_v1.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\select_Population_Within_dBbands_Data_v1)

COMPARISON of POPULATION NOISE-EXPOSURES FOR 2 - 4 previously run flight events shown in bar plots

2. Give the number of previous SAFTu-runs with population noise exposures you want to compare, 2 - 4 flights (Default = 2)
2

Now you are to select the 2 population-noise-exposure files produced within previous SAFTu-runs
3. In the filebrowser that opens: Select the existing SAFTu-output file no 1 of the type: "PopDens_vehicle, place, route, dist, dist straight.mat"
file 1(2):

NOTE: this SAFTu main path, "Population exposures within dB-bands, bar plot comparison", is not further described in this manual but is deemed self-explanatory supported by text given on screen when giving input

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5. Notes - SAFTu as of Jan.2025 (SAFTu_v33.m)

1. **Ground elevation**
   SAFTu relies on topography/elevation data. These data concerns typically 30m*30m raster data on geotiff-format (.tif-files) and can be downloaded from Copernicus DEM (Digital Elevation Data) [ref] and trimmed in GIS-tools such as QGIS.
   The Copernicus 30m*30m DEM geotiff raster data is applied in its standard "geographic", lat, lon, WGS84 format. Within SAFTu transformations to UTM-local zones (and in Sweden also to SWEREF99[6]) and to local ENU (East North Up) cartesian coordinates are carried out. ENU-coordinates are applied for sound propagation (raytracing)

2. **Sound screening**
   Sound screening by natural or built objects is yet only partly implemented. Any buildings or wall constructions (more than one elevation value in single lat, lon positions) are not yet implemented in SAFTu.
   Up to now a simplified approach is applied: a clear line of sight between source-receiver points means that sound reaches the receiver point otherwise no sound is experienced for the given source-path-receiving point combination.
   The current horizontal resolution of elevation is typically 30m which in some cases can be regarded rather coarse. Other finer gridded data can be considered but tend to be non-open and require more memory – these tasks, availability and implementation of finer elevation data is to be considered in coming SAFTu development.
   Models for sound screening ("insertion loss") are rather straight forward to implement with 2D raytracing but the matter of incorporation of vertical objects/buildings in SAFTu is more delicate. The question involves a balance between detail in geometries and possible (city-) area to cover. Building geometry data for Sweden may be found

3. **Weather/atmosphere and sound propagation**
   Sound propagation is dependent on the medium in which the sound waves occur. In our case with sound waves in air, properties typically found in weather prognoses and in the field of meteorology have an impact. We must account for the sound speed, and its slight variation, with static pressure and temperature. The humidity and how absorption of sound depends on this property (strongly frequency dependent but only slightly humidity dependent). With the approach in current SAFTu, altitudes from 10-100 or even some 1000 s meters, flightpaths

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[6] In case of Sweden both 50m*50m from Lantmäteriet given in SWEREF99 and Copernicus 30m*30m in lat lon can be used "directly", i.e. without any coordinate transformation in QGIS or alike

from km's to some hundreds km's we apply a moving source and straight ray model from source to receiver. Here the atmosphere data only comes into the picture through absorption and sound speed, giving that choice of atmospheric data is of minor importance. Though, the user have the possibility to apply either a standard atmosphere profile model (ISA) or apply detailed atmospheric profile models and "real" prognosis data of: temperature, density, RH (Relative Humidity), wind speed and direction as well as turbulent kinetic energy (TKE). These last data can be used to apply refractive raytracing with sound shadow zones and "leakage" of sound energy into these zones.

Methods capable of managing these matters are prepared (partly in previous KTH-CSA projects) and can be implemented/further developed in SAFTu when found needed.

An example of application is the modelling of refraction/sound shadow zones which could be applied to find track path and altitude depending on wind conditions aiming for "smallest noise footprint", could be with regard to annoyance or detection.

4. **Matlab toolboxes**

'Mapping Toolbox', 'Statistics and Machine Learning Toolbox' and 'Curve Fitting Toolbox'

(might be avoided by some extra programming...)

5. **Code version management**

Matlab m-files created within SAFTu are given names ending with: ..._v[X].m, _u[X].m or ..._U[X].m where [X] denotes a version number, such as in SAFTu_v33.m.
The idea that the latest (highest numbered) should be used. (Due to changes within matlab older versions, below a certain number do not work anymore – though the thought is that also previous versions should be able to run as well)
It was decided that no common VCS (Version Control System) GitHub or alike is needed. The simple version numbering and related routines was deemed enough, and less worktime consumed in our case with yet rather few involved developers.

6. **Matlab Versions after 2019b do not present colours of command window text as given in this manual**

(Though: you may choose fonts in matlab through: Home tab, preferences, Fonts)
For the presentation of coloured text in command window SAFTu rely on the matlab file exchange m-file, cprintf.m (Yair Altman, thanks!) found at: https://se.mathworks.com/matlabcentral/fileexchange/24093-cprintf-display-formatted-colored-text-in-command-window For some versions of matlab it is not working.

Template cases to follow

Example run 1: Flight with 40kg eVTOL Krokom- Föllinge ca 40 km Jämtland Sweden
Testcase illustrated with SAFTu user interface screen dumps + explanations
Comments to SAFTu screen dumps workflow highlighted yellow
Comments to Google Earth input/output highlighted green, Info further outlined in Appendices highlighted turquoise

Start SAFTu_v33.m, i.e. current version of main-SAFTu function in Matlab (v33= version 33): Screendump

As you will see most inputs regarding a numeric value are given a *Default alternative* where the user simply presses *Return* if satisfied with the proposed value

>> SAFTu_v33
---- Now you are in function: Init_Global_v1.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\Init_Global_v1)

%%%

WELCOME, YOU ARE RUNNING SAFTu_v33
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\SAFTu_v33)

MAIN ACTION
1. Choose your wanted kind of SAFTu main action:

----- Preprocessing -----
0. Prepare data to be used in later noise-mapping (e.g. Vehicle Sound Source, Atmosphere-, TL-data, ...)
or
----- Noisemapping -----
1. Define and run a noise mapping case with input given interactively (Default)
[NOTE: a Sound Source representing the vehicle has to be established prior to a noise mapping-run]
or
[NOT YET IMPLEMENTED: 2. Read in and run a previously prepared noise mapping case input file]
or

----- Postprocessing -----

3. Difference between grid field results from two previous runs ("Delta-dB contours")
or
4. Population exposures within dB-bands, bar plot comparison of previous run results

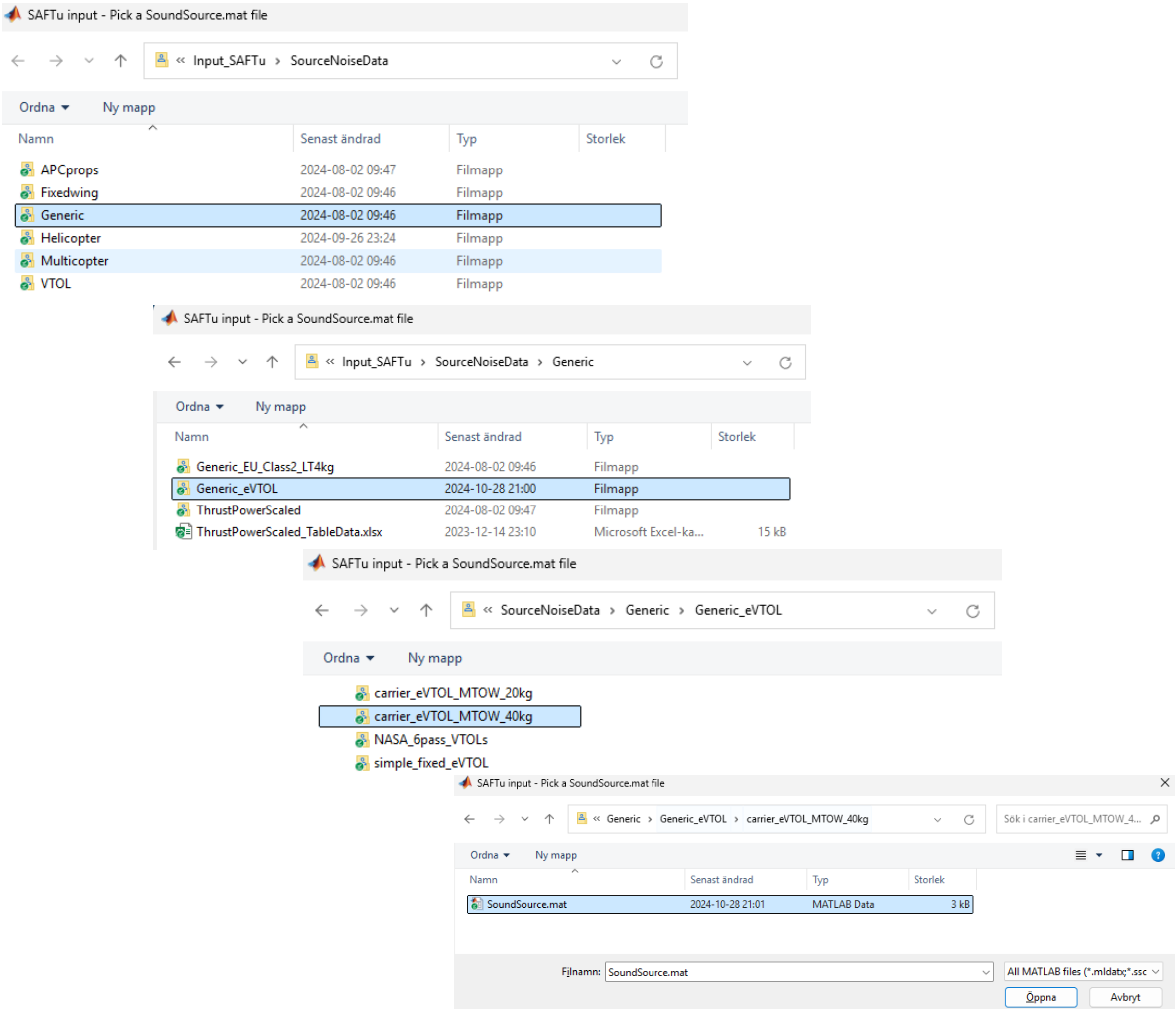
Please give a number, 0, **1**, 3 or 4:
1

--- A new default output directory has been created ---
[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Output_SAFTu/20241121_0835_Ulf_SAFTu_v33_NoiseMap

------- You will now Define and Run a Noise Mapping case with input given interactively -------

You will now tailor a vehicle flight trajectory to be studied with regard to noise reaching ground
In order to enable this you need to know:
- the type of vehicle* to be studied
(i.e. small-/medium multicopter or airtaxi/eVTOL ...)
- where the flight take place
(i.e. geographic region, including start and landing points, profile and waypoints where changes in fundamental flight conditions take place)
[*Vehicle Cathegories and sound sources data NOT YET SETTLED!]

VEHICLE/Sound Source
2. Select a vehicle and its sound source data-file already established and saved on disk
Press return to go on with the selection of such a **SoundSource.mat** file in the filebrowser to be opened ...



Selected SoundSource data outline:
vehicle_type_no: 4
vehicle_type_s: 'Generic'
Generic_Subgroup_s: 'Generic_eVTOL'
source_type_no: 2
modelName: 'carrier_eVTOL_MTOW_40kg'
fullfolderName: [Local_SAFTu_main_dir] ...
\5_Output_AndFixedInput\Input_SAFTu\SourceNoiseData\Generic\Generic_eVTOL\carrier_eVTOL_MTOW_40kg'
fullfileName: [Local_SAFTu_main_dir] ...
\5_Output_AndFixedInput\Input_SAFTu\SourceNoiseData\Generic\Generic_eVTOL\carrier_eVTOL_MTOW_40kg\SoundSource.mat'
DirectivityType_s: 'Omnidirectional'
Dependency: 'None (beside categorical pred.variables)'
NofPredVars: 0
NofFlightModes: 3
ThrustDependency: 0
SpeedDependency: 0
rpmDependency: 0
Flightmode_name_cs: {3×1 cell}
fthOct: [20×1 double]
Sp: [1×3 struct]
--- The selected SoundSource.mat file is: ---
[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Input_SAFTu/...
SourceNoiseData/Generic/Generic_eVTOL/carrier_eVTOL_MTOW_40kg/SoundSource.mat

GROUNDTRACK

3. Do you want to create a completely new groundtrack or apply already existing data?

NOTE: if considering already existing data (at least main waypoints) you need to know where too find these, e.g. in output from a previous run

1. New data input (Default)
2. Copy previously created SAFTu Groundtrack data, stateTraj1.mat or stateTraj2.mat (includes Profile) into this run

Please give 1 (Default) or 2:

1

You will now first create waypoints in Google Earth, continue with interactive saving of these into current SAFTu Output directory,
and then, in a GUI/matlab-figure, tailor the flight path geometric profile, before getting back to this matlab command window.
Here you will get the opportunity to modify the geometric data given + before adding data defining the vehicle states via line inputs.

---- Now you are in function: createUAV_basicGroundtrack_GE_v9.m -----

(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\createUAV_basicGroundtrack_GE_v9)

You will now create waypoints in Google Earth and after that action continue with
interactive saving of these into current SAFTu Output directory, how this is to be carried out will be shown ...

4. Before you start input the geometry of the Groundtrack you need to define a region and area covering the ground track of your flight.

This will be made either:

1. Within Sweden, in a rather straight forward manner, among a set of pre-defined regions (Default)

Note: alt. 2 to 3 below requires that the user already has established topography data (geotiff, tif-format) for the area of concern!

2. Anywhere within the Scandinavian- + Baltic countries (AROME-meteo data from met.no/SMHI available via internet)
3. Anywhere on Earth outside the "Nordic" countries as in alt. 2 above (only "standard atmosphere" data possible)

1

UAV Flight within Sweden

5. You will now select a spot in Sweden close to where your flight take place. You can choose among ca 200 such spots

Depending if you are used to SAFTu you might already have an idea of these possible places to start out from. Anyhow, you can choose either to:

1. Show these selectable places in Google Earth (which will be started) as red placemarks, or ...

0. Go on without the above GE support and just type the name of the place defining the area (to be identified with a red circle in GE)

Please give 1 or 0 (Default):

0

---- Now you are in function: SwedSpots_latlon_U1.m -----

(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\SwedSpots_latlon_U1)

---- Now you are back in : createUAV_basicGroundtrack_GE_v9.m -----

WAYPOINTS

You will now input the waypoints that constitutes a new groundtrack. This is done with support from the Google Earth (GE) GUI-functionality in the following manner:

A. Give a name of a place in Sweden (e.g. name of a city) in the geographic area where you want to postion your flight trajectory
a prepared list of places names are searched to find a match, and if found this region is shown with a red circle in GE
[NOTE: Only Stockholm, Gotland and Dalarna topography data linked to code yet ... ADD MORE ...]
(if the place is not in the list you will be presented the list of ca 200 places and make a new try)

B. Give the approximate extention of the groundtrack you have in mind

C. Google Earth starts with a view centered at the place you have choosen and showing a region related to anticipated track size

D. In GE create and place the first waypoint where you want your groundtrack to begin, (could, but do not need to, be a take-off position)

E. ... repeat D. for the remaining waypoints up to the last (could, but do not need to, be a landing position)

GE will start when you have given the initial geographic position as next input, (= input no 6)

Here we go:

6. A) Give a name of a place in Sweden in the area where you want to position your groundtrack (Default = Visby)

Östersund

7. B) Give the approximate extention (in km) of the groundtrack in you have in mind - will become a radius of a circle shown in GE (Default = 10 km)

10

C) Google Earth should now be running and the view should be centered around the choosen place and show a region related to the anticipated ground track size

Matlab will be paused when you work with the below actions within GE, and continued by you after finalising waypoints input from GE

8. **D) In GE interactively create and position the first waypoint where you want your groundtrack to begin.**

CREATE. This is carried out in a "standard GE fashion", i.e. by ACTIVATING AND SAVING PLACEMARKS as outlined in i) to iii)

i) To the left in the toolbar above the map, click the "Add Placemark" icon - A new input window will open together with a new blinking

ii) Grab the blinking placemark with the mouse/cursor and drag it to the place where you want to put the groundtrack starting point

iii) When placed in wanted position, in the opened Placemark input window, name it: **wp**1and press: "OK"-button in the input window

iv) The placemark will be fixed in the wanted position AND show up as an object named "wp1" in the Sidebar "Place pane" section

v) Then - Do the same as in i)-iv) above for all the remaining waypoints

NOTE: If the start or landing set of wp:s are "close" in lat,lon, which is often the case for an almost vertical take-off or landing, these wp:s should either be set close to a straight line, in the same lat,lon, or the track is to be given a "small" turning radius.

vi) SAVE, either:

Save the waypoint no 1, 2, ... to no [N] placemarks, one by one in individual kml-files, as: wp1.kml, wp2.kml,...

(not as .kmz!), in the current output directory, by:

a) right-clicking on each (in the map or on its name in Places pane), a menu appears ...

b) choose "Save Place As" from the contextual menu that opened, and save it as:

[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Output_SAFTu/20241120_1336_Ulf_SAFTu_v33_NoiseMap/wp1.kml

c) ... when all wp:s, like: **wp2, wp3, ..., wp[N]** are saved like this, press return

... or (faster), instead, after all wp:s are created/positioned in GE:

a) mark all ALL N waypoints in the Places pane, then in the menu window that opens, right-click and select "multigeometry"

b) they are then combined into one "geometry" with the name: "wp1" (where all waypoints now gets the individual name **wp1** in GE/on screen

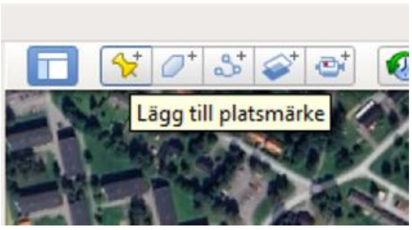
c) save them all as one kml file in the current SAFTu Output-dir by right clicking on any of them on GE-map (or on wp1 in the Places pane), in this case the filename should be: **wp1to[N].kml** where N is the number of the last waypoint, 1, 2, ..., N :

[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Output_SAFTu/20241121_0835_Ulf_SAFTu_v33_NoiseMap/wp1to[N].kml

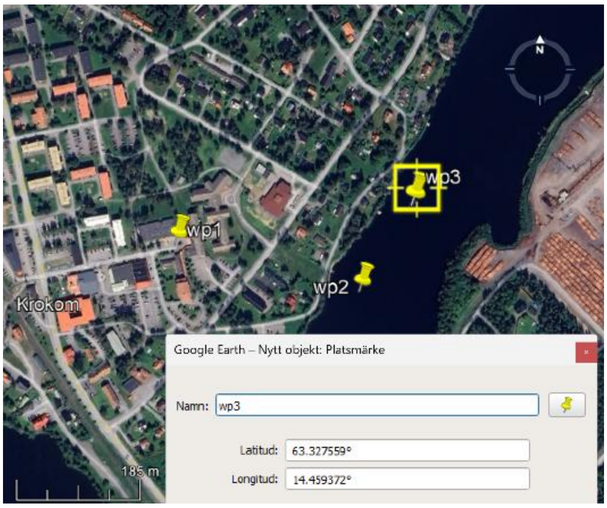
Google Earth (GE) starts and for the input choice of place (in Sweden) shows a red circle with radius of 10 km (or with radius given by user)

When the last waypoint/placemark is INTERACTIVELY saved from the GE-window into current output-dir, enter this matlab window again and press RETURN to proceed the paused matlab execution...

In (GE) – to establish a groundtrack for the flight - add waypoints/placemarks along the flightpath.- see the yellow needle in the GE menu bar in the first figure to the right:



In this case, with a take-off in Krokom, you will start with one waypoint at the thought position wp1 in the next GE-figure to the right: This successive waypoint generation in GE is continued until we reach the landing position



In the first GE map to the right we have manually created all 14 waypoints from start to landing position.

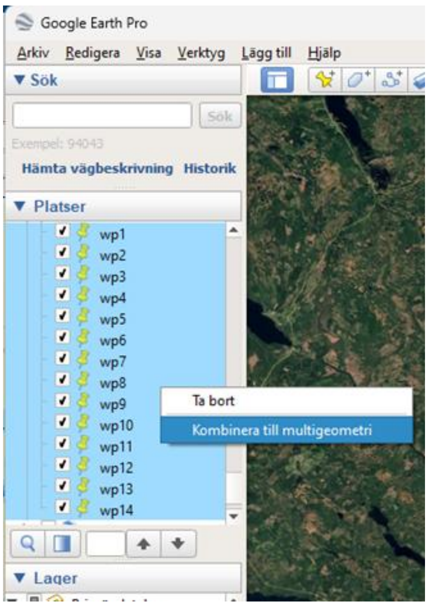
The number of waypoints must be considered before starting a run, here the number of turns, occurring speed changes and ascents/descents are decisive

① The waypoints must be given the names:
wp1, wp2, ...(up to the last) wp14 in the shown case – see first figure to the right:

② The next step in GE is to gather the waypoints/placemarks into one "multigeometry"(as of GE vocabulary), see

①

②



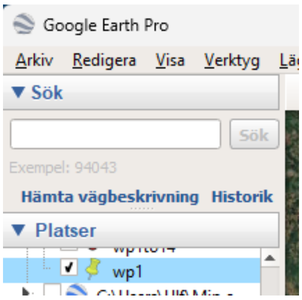
the second picture column here to the right on how to achieve that

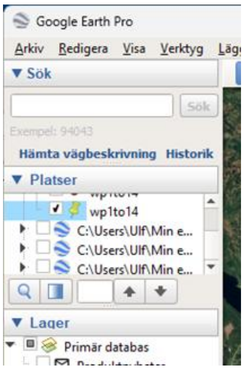
③ The "multigeometry" containing all waypoints will automatically get the name wp1 (as of the first incorporated geometric entity).

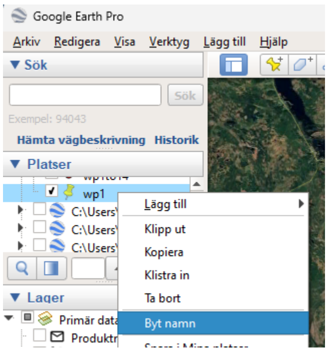
④,⑤
Now, change the name to: wp1to14 and...

⑥ save it in current SAFTu output directory as: wp1to14.kml

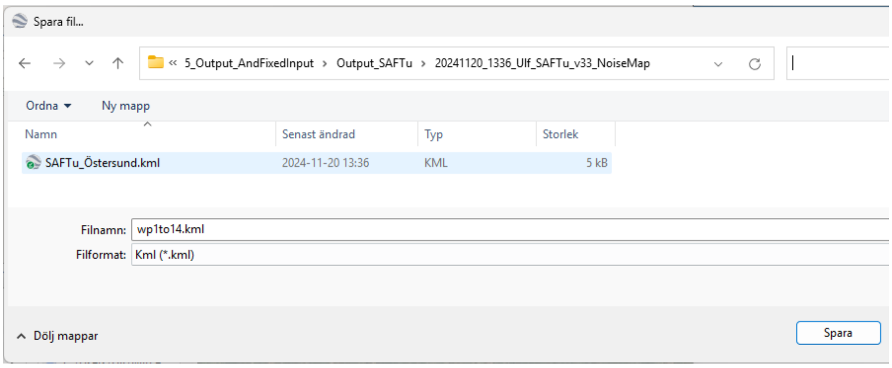
It can be noted that currently one out of four general kind of flight cases can be addressed in SAFTu:
1. "complete flight", start-level - landing
2. "take off" - start + any number of wpts
3. A pass-by flight
4. An approach/landing only

③


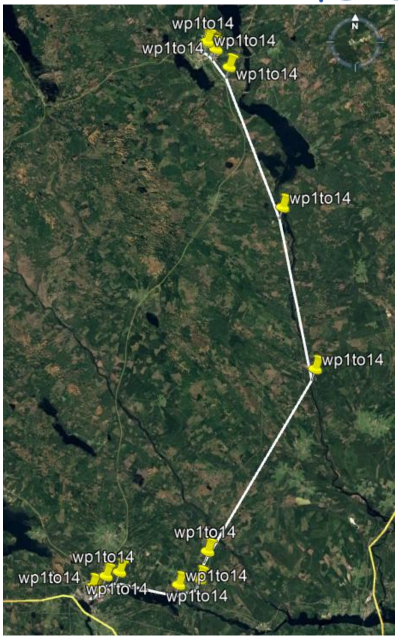
⑤


④


NOTE: the waypoints (and other GE/SAFTu geospatial entities) are saved and can be reused in later SAFTu runs

⑥


In the right GE view: straight lines groundtrack between waypoints from start in Krokom and landing in Föllinge



Below view: Take-off in Krokom and first ca 5 km of flight

Now the straight segments of the current groundtrack will be trimmed with curved flight in "corners"

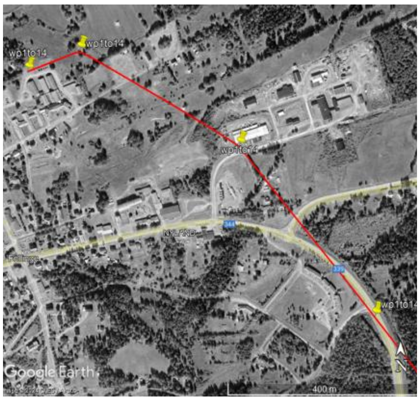
When the change of heading in a waypoint is regarded big enough a curved circular groundtrack segment is replacing the corner
9. Please give the limit in heading change/yaw angle (deg's) you want in this case (Default = 1 deg):1

10. Please give the turning radius you want to apply in these cases
(NOTE: larger turning radius may create problems when wp:s are placed close and "curvy" (Default = 10 m):25

Info: The difference in flight distance between original straight legs groundtrack and the trimmed, curved turns, one, is: 10 m
Flown horisontal distance, s: 50 km (original) 50 km (curved turns)

Step1 stateTraj, containing initial info and Groundtrack saved on disc in file stateTraj1.mat
in current out-dir:
[Local_SAFTu_main_dir]
/5_Output_AndFixedInput/Output_SAFTu/20241121_0835_Ulf_SAFTu_v33_NoiseMap

In the right GE view: approach and landing section of groundtrack, now with curved sections around waypoints



---- Now you are in function: AddInfoAndFileNameTo_stateTraj1_v4.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\AddInfoAndFileNameTo_stateTraj1_v4)

ADD Groundtrack Info and Name
The Groundtrack, just saved as a stateTraj1.mat-file in the "standard OutDir", i.e. in:
[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Output_SAFTu/20241121_0835_Ulf_SAFTu_v33_NoiseMap/stateTraj1.mat
will also be saved in a sub-directory in the directory for input flight trajectories, "TrajAndGroundTracks"-dir:
[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Input_SAFTu/TrajAndGroundTracks/Sweden/Jämtland/ ["user given subdir name"] /stTr1_50km
from where it later may be picked as a input Groundtrack in coming SAFTu noisemapping runs

11. Input of the ["user given subdir name"] where the Groundtrack, i.e. stateTraj1 struct-variable, will be saved
It is recommended that the name is put together like: **[start pos name]_Via[passing]_[end pos name]** in case of a "full" path, takeoff-transport-landing
e.g. like in: "Kappellskär_ViaNorrtälje_Uppsala"
For a "non-complete" flight, i.e. takeoff-transport or transport-landing, or just takeoff or landing, more simple two or one word ID-strings may do
Please give the wanted sub-directory name:
Krokom_AspånäsetSO_Föllinge

The Groundtrack (stateTraj1) will be saved in:
[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Input_SAFTu/TrajAndGroundTracks/Sweden/Jämtland/Krokom_AspånäsetSO_Föllinge/stTr1_5

The struct-variable stateTraj1.[fields] field .SoundSource_ID is given the same value as SoundSource.modelName, i.e: carrier_eVTOL_MTOW_40kg

ADD info fields to Groundtrack-struct stateTraj1
Now you have the possibility to add further information about the intention of the trajectory and vehicle. This is made in 3 steps:
1. IntendedVehicle - Which kind of vehicle(s) are thought to be flown the track? (e.g. eVTOLs, multicopters < 100, >50kg, ...)
2. IntendedPurpose - Which kind of purpose could a flight represent? (e.g. air-taxi, delivery, reconnaissance, ...)
3. OtherInfo - Other information needed or supporting the understanding of the track

12. Please give a short text that hints about for which kind of vehicles the track is intended (field: IntendedVehicleTypes)
(Default = Generic_Generic_eVTOL_carrier_eVTOL_MTOW_40kg)
eVTOL_MTOW_40kg

13. Please give a short text that hints about the purpose of a flight along the track (field: IntendedPurpose)
testcase

14. Please input text that may be valuable for the further use of the Groundtrack (field: OtherInfo)

---- Now you are in function: SetProfilePtsAndData_onBasicGroundTrack_v14.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\SetProfilePtsAndData_onBasicGroundTrack_v14)

You will now, in a matlab figure to be opened ("Input waypoint altitudes GUI-figure"), interactively give with the mouse/cursor(crosshair):

Step 1. At begin- and end-points the default case is that these take place at ground altitude + 5 m
(but this this may be changed in cases like a simple pass-by flight or a take-off or approach/landing case is to be studied)

Step 2. At each of the SHOWN PRIMARY WAYPOINTS*, except at begin- and end-points(see above and figure legend), you have to give the altitudes
(*"MAIN WAYPOINTS" considers here the ones in between the original straight groundtrack legs, secondary waypts are automatically added at curved turning sections)

Step 3. If needed, ADDING more WAYPOINTS, including altitude!, this is the case where you want to add some major change in flight conditions** that take place
at OTHER POSITIONS than the already SHOWN PRIMARY WAYPOINTS (**"flight conditions" could here regard speed, descent angle, ... but not yaw/heading which is already set)

After this figure-based input follows standard command-window based input of:

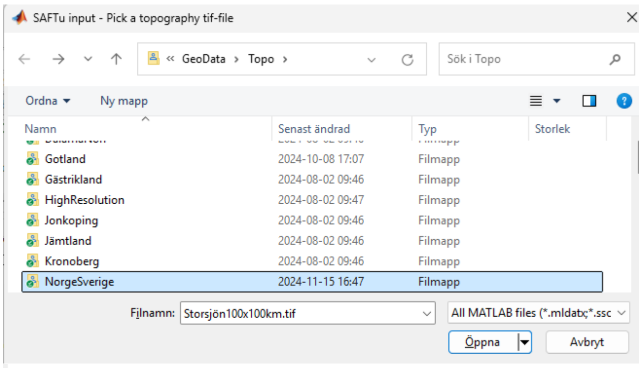
Step 4. If needed, correct/trim the above given waypoint altitudes

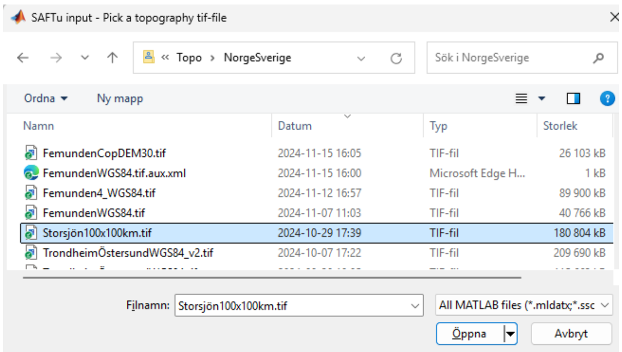
Step 5. The remaining state-conditions along the trajectory linked with the NEEDS OF VEHICLE TYPE AND SOUND SOURCE DEFINITION - to be developed...!!!

15. Do the flight to be studied consider:
1. A complete trajectory, i.e. from take-off to landing ? (Default)
2. A take-off only?
3. A pass-by flight only?
4. An approach/landing only?
Please give 1, 2, 3, or 4:
1

In SAFTu noise propagation computations ground elevation is accounted for. The data sources and proposed handling of the topography/elevation is outlined in Appendix 1 of this manual

SELECTION OF ALREADY USER PREPARED TOPOGRAPHY DATA FILE
16. Now you have to select a previously established topo-/geotiff-file which you know covers the already prepared trajectory waypoints
Press return to go on with selection of the geotiff-file in the filebrowser that will open





The topography file: Storsjön100x100km.tif in directory: [Local_SAFTu_main_dir] \5_Output_AndFixedInput\Input_SAFTu\GeoData\Topo\NorgeSverige\ was read in utm-zone: 33
... and used for ground elevation interpolation at groundtrack waypoints

The 2D profile s(km), z(m)-points, i.e. horisontal distance flown and altitude will be given interactively by mouse/cursor input in a GUI-figure screen graph.
For the profile to be adjusted in a the coming GUI-figure you can give a template altitude for the en-route phase (i.e. all pts except possible start/landing)

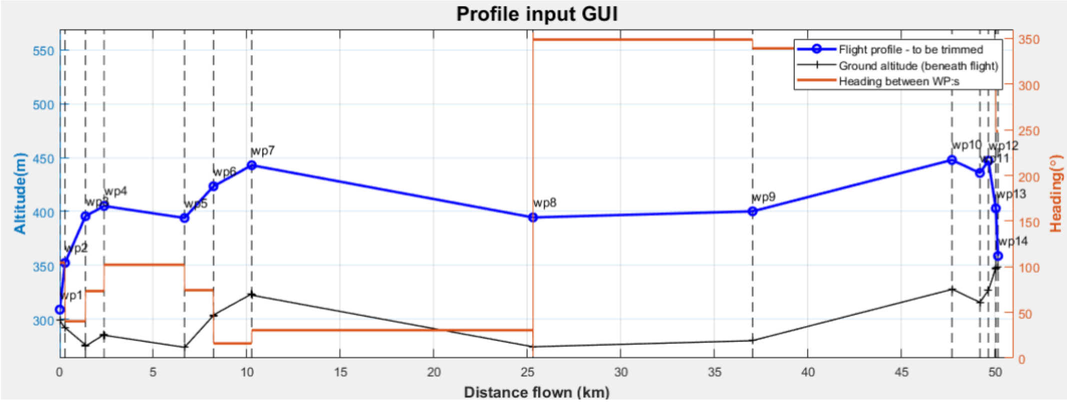
17. Please give the typical en-route height above ground in meters for the profile to be designed (Default = 300)
120

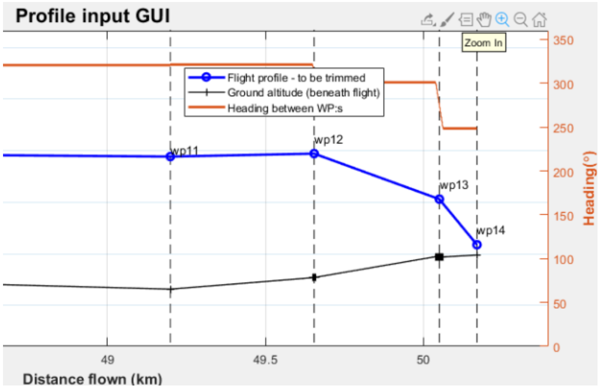
Interactive profile input via matlab GUI-figure
Now you are ready to adjust the altitude of preset waypoints in the Profile input GUI figure, shown as blue circles on top the template blue profile curve
18. Simply use the mouse, click/drag on the waypoints (circles) that you want to move to higher/lower altitude, you will get the possibility to trim them more exact later

When satisfied with the profile - press RETURN to continue the paused run ...

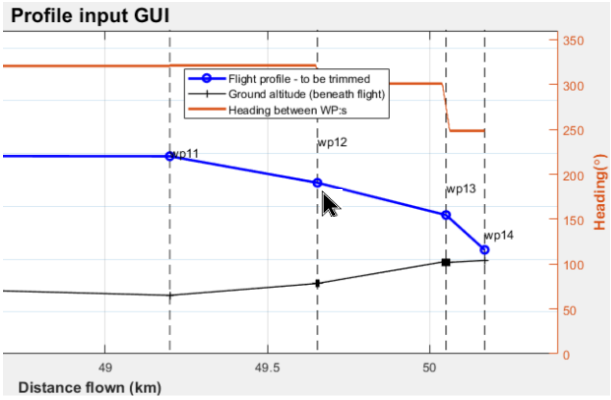
An input GUI figure opened in Matlab
Here you can click with cursor and move the waypoints up and down. When satisfied, press Return

In this case we selected 120 m above ground as the input and want to trim it slightly …

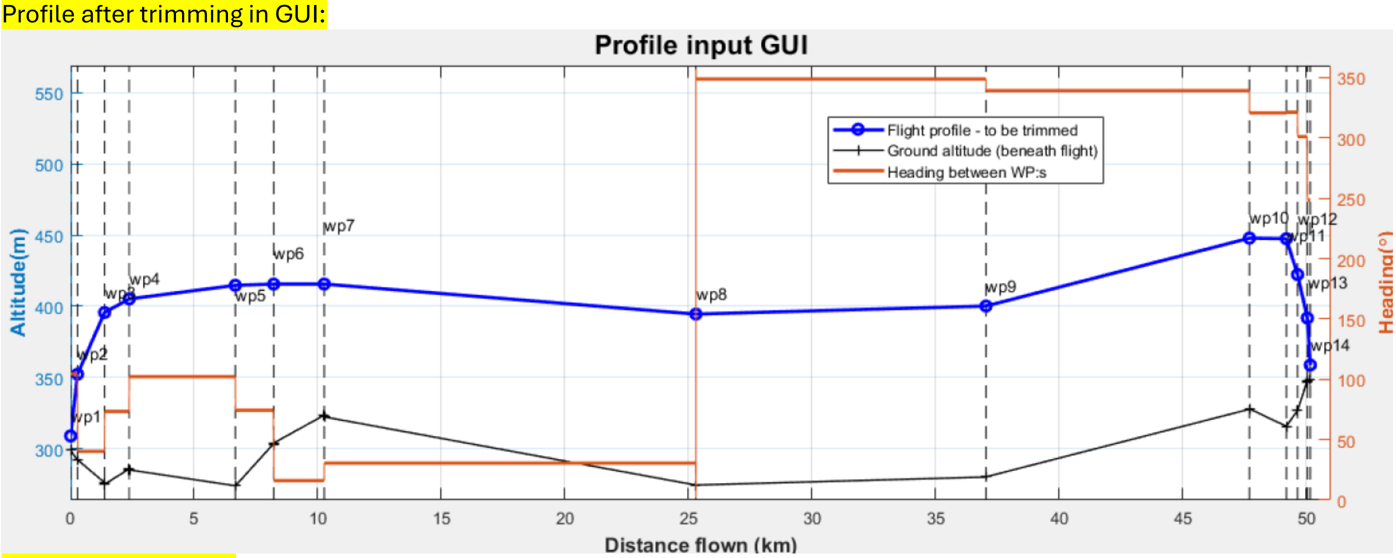




A slight trimming of wp12 and wp13 altitudes (and at 5-10 km, not shown)



Profile after trimming in GUI:



(...Return pressed...)

Now your 1st step of the profile input is carried out, altitude tailoring step 1, and you can continue with the final altitude trimming if found needed. Watch the table below and input eventual MAIN WAYPOINTS you want to trim further wrt velocity

wp no	s(wp)km	alt(wp)m	height over ground(wp) m	ascent_deg

1	0	309	10	9
2	0.279	352	60	2
3	1.374	396	120	1
4	2.369	405	120	0
5	6.666	415	141	0
6	8.216	416	112	0
7	10.262	416	93	0
8	25.303	395	120	0
9	37.046	400	120	0
10	47.705	448	120	0
11	49.199	447	132	-3
12	49.654	422	95	-4
13	50.051	392	45	-15
14	50.17	359	10	0

Here one may select waypoints and change the altitude manually by input of a new value - this possibility was not used in this case, but could have been applied e.g. to change the wp5 altitude from 141 m to 120 m

19. Please provide a number between 1 and 14 for which you want to change its altitude. Or, choose NO more trimming: 0 (Default)

0

NO more trimming

Now you are to input the speed in the MAIN WAYPOINTS, one by one. From these data the time and speed along the complete trajectory will be computed assuming a linear acceleration along the 3D trajectory

20. Please give the unit in which you want to treat the speed, knots, km/h or m/s

1. knots (Default)
2. km/h
3. m/s

Input 1,2 or 3:

take-off and landing speed set to 0 knots

21. Please give the speed (knots) in MAIN WAYPOINT number 2 (Default = 10):25

22. Please give the speed (knots) in MAIN WAYPOINT number 3 (Default = 25, i.e. as in previous WP) :

54

23. Please give the speed (knots) in MAIN WAYPOINT number 4 (Default = 54, i.e. as in previous WP) :

81

24. Please give the speed (knots) in MAIN WAYPOINT number 5 (Default = 81, i.e. as in previous WP) :

25. Please give the speed (knots) in MAIN WAYPOINT number 6 (Default = 81, i.e. as in previous WP) :

26. Please give the speed (knots) in MAIN WAYPOINT number 7 (Default = 81, i.e. as in previous WP) :

27. Please give the speed (knots) in MAIN WAYPOINT number 8 (Default = 81, i.e. as in previous WP) :

28. Please give the speed (knots) in MAIN WAYPOINT number 9 (Default = 81, i.e. as in previous WP) :

29. Please give the speed (knots) in MAIN WAYPOINT number 10 (Default = 81, i.e. as in previous WP) :

30. Please give the speed (knots) in MAIN WAYPOINT number 11 (Default = 81, i.e. as in previous WP) :

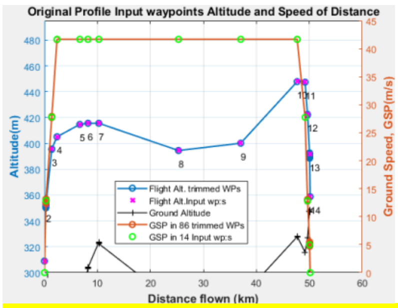
54

31. Please give the speed (knots) in MAIN WAYPOINT number 12 (Default = 54, i.e. as in previous WP) :

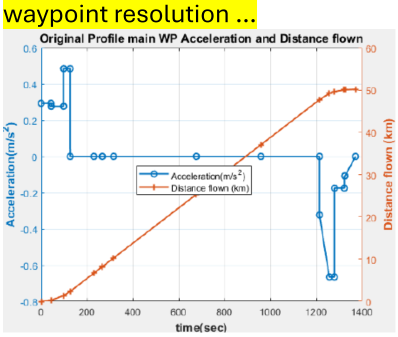
25

32. Please give the speed (knots) in MAIN WAYPOINT number 13 (Default = 25, i.e. as in previous WP) :

10



After input of waypoints speed some trajectory feedback is given in plots, first for original waypoint resolution ...



For noise source model "carrier_eVTOL_MTOW_20kg", no predictor variables applied, though 2 different flight modes/spectra, Hover and Cruise

Geometry, times, speeds and accelerations has now been established for the trajectory WPs

Up to now the trajectory might be rather sparsly dicretisized along its straight legs. In order to achieve a more dense and even distribution of data points along the studied flight path, interpolation of data in between MAIN WP:s sections will be carried out.

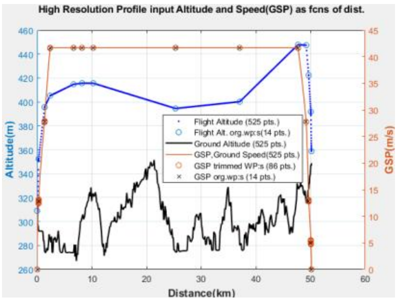
The duration of the studied flight will be around: 00:22:52 hours:minutes:seconds

33. Please give the time step, i.e. an increment in seconds to be applied for the 1372 seconds long flight trajectory discretisation
(NOTE: the time increment will not become exactly the same for each step since original WP:s will be kept)
(Default = 7 sec) :
3
NOTE: starting point (ORIGO) taken as reference position primary reference ground altitude wrt sealevel
traj-kml file no 3 written: trajectory_HR_21Nov2024_Ulf_no3.kml
Step2 stateTraj2, containing HR (High-Resolution) trajectory geometry, speeds and accelerations saved on disc in file stateTraj2.mat
in current out-dir: [Local_SAFTu_main_dir] \5_Output_AndFixedInput\Output_SAFTu\20241121_0835_Ulf_SAFTu_v33_NoiseMap

---- Now you are back in function: Inputs_for_SAFTu_Run_v33.m -----

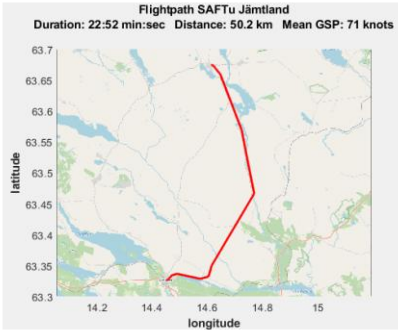
---- Now you are in function: SouStrengthOfFlightMode_carrier_eVTOL_MTOW_40kg_v3.m -----
(at: [Local_SAFTu_main_dir] \2_Sound_Sources\m_files_2\SouStrengthOfFlightMode_carrier_eVTOL_MTOW_40kg_v3)

...and after the time step is set by user, the profile is plotted in the final discretisation representation:



You should now set the SoundSource cathegory along the flightpath, i.e.
vertical("copter") mode, transition(both) or level(fixed wing) mode
This might be done by: 1. criteria in horisontal speed and flight angle or 2. changes in fixed positions
34. Do you want to decide flightmode through:
1. Horisontal speed + Ascent(>0) and Descent angles (<0) (Default)
2. Fixed positions along the Groundtrack (interactve in GUI-figure)
2
Vknots_StartTransVertAsc2Forw set to: 20 knots
AscentAngle_StartTransVertAsc2Forw set to: 5 deg
Vknots_StartPureForw set to: 15 knots
AscentAngle_StartPureForw set to: 2 deg
Vknots_StartTransForw2VertDesc set to: 10 knots
DescentAngle_StartTransForw2VertDesc set to: -5 deg
Vknots_StartPureDescent set to: 5 knots
DescentAngle_StartPureDescent set to: -20 deg

Groundtrack plot on Openstreetmap background:

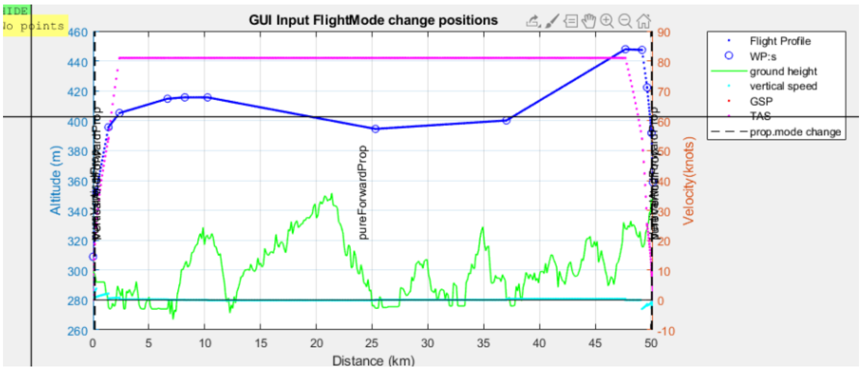


36. In the figure 8, "GUI Input FlightMode change positions', set the distance (x-axis) for flight mode change no. 1 to 4
by manual input (crosshair-cursor will show up) by clicking on the flight profile at the max 4 wanted x,y-(dist.,alt.-) positions
NOTE: if one or more (consequtive) flightmode-shifts do not take place in current flight, mark a position outside the current x-limits!
Please start the profile-change-flightmode-position by moving cursor over picture and click at wanted positions (y-value doesn't matter)...

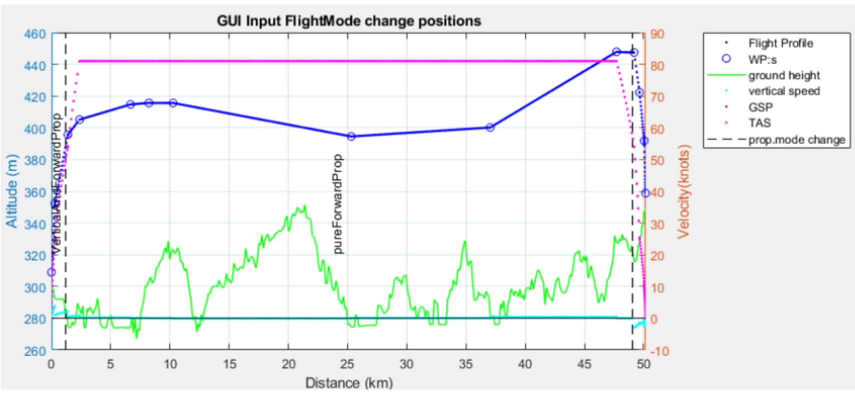
In this example run we have chosen alt. 2 "Fixed positions …(interactive in GUI-figure)"in input 34 [fix: input no. 35 left out in code by mistake]. Below a view of how this GUI-figure comes out on screen initially.
As seen a crosshair is shown, with this crosshair the user marks x-positions where the flight mode changes.
For the selected 40 kg eVTOL we have 10 rotors for vertical flight and 2 for forward/vertical flight (different propeller types)
And transitions between: A. copter(vertical) → B. copter + fixed wing(horizontal) → C. fixed wing → B. copter + fixed wing(horizontal) → A. copter(vertical).
To simplify the input we stick to only: B. copter + fixed wing(horizontal) → C. fixed wing → B. copter + fixed wing(horizontal).
Since noise from the 10 "vertical" rotors clearly dominates over the 2 "horisontal" rotors generation its deemed not signifficant if we include these two or not.

1. So, to start out from mode B: we mark the postion for change of A to B allready to the left of x = 0.
2. Then we make the assumption that the change from B to C take place at a speed of 100 km/h = 54 knots. This makes us move the crosshair to x ≈ 1.25 km, where v ≈ 54 knots, and press left mousebutton to mark the second change. (NOTE: that the y-position of the crosshair do not matter, only the x-position)
3. Then where v = 54 knots in approach we make the next marking, for flight mode change from C to B.
4. Due to how the code is written for this input we need to mark also the last mode change, from B to A somewhere, in this is done after the last x-position (outside the x-span where x > 50 km). Whith this follows that no mode A, "copter only", takes place during the simulation of this flight.

NOTE: for the (SAFTu-)type of vehicle applied in this example SAFTu currently allows only for the above mentioned sequence of flightmodes(with related soundsource characteristics)



left:
original default change flightmode positions



left:
finally set change flightmode positions

Step2 stateTraj2, containing HR (High-Resolution) trajectory geometry, speeds and accelerations saved on disc in file stateTraj2.mat
in current out-dir: [Local_SAFTu_main_dir] \5_Output_AndFixedInput\Output_SAFTu\20241121_0835_Ulf_SAFTu_v33_NoiseMap

---- Now you are back in function: Inputs_for_SAFTu_Run_v33.m -----

37. You may now choose to include population data or not (nof people living within different noise contour dB-spans)
0. No population data to be involved in computations (Default)
1. Include population data in computation - NOTE: This need a population raster file to be prepared!
Please give 0 (Default) or 1
0

CREATE A GROUND GRID

Along with the Grid to be established some computationally demanding figures may be established.

38. Do you want to plot these or supress in order save time/avoid crashes in case of large Grids (~>30km) ?
0. No extra detail Grid data plotting (Default)
1. Yes, plot extra details related to Grid/topography/nof sound-ray hits/sub-grid borders in main Grid
0

---- Now you are in function: create_GroundGrid_aroundGroundTrack_v13.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\create_GroundGrid_aroundGroundTrack_v13)

NOTE: starting point (ORIGO) taken as reference position primary reference ground altitude wrt sealevel

In SAFTu ground grids for sound receiving points on ground are applied. This is handled by two different grid levels. The upper level with a rectangular *Maingrid* covering the entire groundtrack + extra distances at the ends(corners). Then the lower level with smaller local moving *Subgrids* stepwise following discretised trajectory. The two grid levels coincide such that the Subgrids points constitute a subset of the Maingrid. The grid size is set by the user (supported by default/recommended size) outgoing from vehicle sound source strength and wanted resulting minimum noise levels to show on map.
Here the user also must make a choice whether different Subgrid sizes should be applied along the flightpath or not. A larger Subgrid extension is typically motivated at take-off and approach/landing regions where higher noise levels (stretching further) is found than during higher altitudes at level flight. This situation is further emphasised when simulating VTOLs flight and changes between hover and fixed-wing mode.

39. Do you want to apply more then one sub-grid size ? E.g. with larger size closser to take-off and/or landing areas?
(the current sub-grid half-width value is: 600 m)
Please input 0/1 (Default = 0, No - one sub-grid size is enough, alt. 1 Yes - more than one sub-grid size)
1
3 sub-grid regions, larger grid span at take-off and landing

Now you will give the positions along the groundtrack for where the sub-grid size changes
It is recomended to watch one of the latest figures, e.g. "Input flightmode change positions" to get an idea of distances selection
40. Give the distance in km:s where you want a change in sub-grid size for change position 1(2):
2
41. Give the distance in km:s where you want a change in sub-grid size for change position 2(2):
48
1. Change in sub-grid size after: 2 km
2. Change in sub-grid size after: 48 km

41. Are you satisfied with the distances? (1 = Yes, Default / 0 = No, I want to change the above given input)
1
First, you are now to give the sub-grid extention in meters for the region with the smaller sub-grid size
Then, you are to give an integer factor, which is used to multiply the smaller extention to get the bigger sub-grid size
42. For the region with a smaller grid width, typically underneath trajectory sections spanning level-flight conditions, give the sub-grid extention you think will cover noise levels of concern
If you are OK with the current value: 600 m (Default) just press Return

"Small-sized" sub-grid extention, max ground grid width for noise contours, set to: 600 m

43. For the region(s) with a need for larger sub-grid size, typically trajectory spans closer to ground during take-off and approach/landing give an even integer factor, 2, 4, 6, ... which the smaller sized sub-grid extention will be be multiplied with in order to cover noise levels of concer
(Default = 4):
6

"Big-sized" sub-grid extention, max ground grid width for noise contours set to: 3600 m

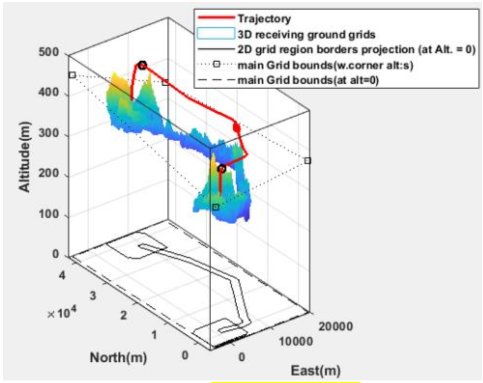
44. Please give the Grid resolution, the same size for all sub-grid regions, in meters: (Default = 60 m, i.e. 1/10 of sub-grid extension)

60

Nof sub-grid regions is: 3

---- Now you are in function: create_multipleSubGridSets_v5.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\create_multipleSubGridSets_v5)

NOTE: starting point (ORIGO) taken as reference position primary reference ground altitude wrt sealevel
maxDist_GrWishedCorner_ExactGridPt1 = 42 m
maxDist_GrWishedCorner_ExactGridPt2 = 41 m
maxDist_GrWishedCorner_ExactGridPt3 = 40 m
Elapsed time is 5.742101 seconds.
Elapsed time is 46.357109 seconds.
Elapsed time is 8.174103 seconds.
Elapsed time is 0.740007 seconds.



Above figure: the three Subgrids projection on z=0 plane (black solid lineand Maingrid dashed black)

Now you are back in function: create_GroundGrid_aroundGroundTrack_v13.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\create_GroundGrid_aroundGroundTrack_v13)

Grid, containing MainGrid and SubGrids saved on disc in file Grid.mat
in current out-dir: [Local_SAFTu_main_dir] \5_Output_AndFixedInput\Output_SAFTu\20241121_0835_Ulf_SAFTu_v33_NoiseMap

---- Now you are back in function: Inputs_for_SAFTu_Run_v33.m -----

[fix: input no. 45 left out in code by mistake]

46. Do you want to:

0. Apply a standard Atmosphere (ISA) dataset (Default)
1. Download AROME-atmosphere profile(s) data from met.no
2. Apply AROME atmos-profile data already existing on local disc

0

---- Now all input is given (function: Inputs_for_SAFTu_Run_v33.m is finished) -----

---- Back in main: SAFTu_v33.m -----
---- Now you are in function: initAtmosProfile_U1.m -----

(at: [Local_SAFTu_main_dir] \3_Sound_Propagation\m_files_3\initAtmosProfile_U1)

---- Now you are in function: set_ISAprofileData_v2.m -----
(at: [Local_SAFTu_main_dir] \3_Sound_Propagation\m_files_3\set_ISAprofileData_v2)

Atmosphere data use o noise popagation modelling involves atmospheric data profiles, i.e. selected atmospheric properties as functions of altitude from ground upto above flight altitude. The specfic variables of interest depend on sound propagation model and at least of temperature and humidity. Current SAFTu version apply a facile straight ray approach involve only these two atmospheric variables for estimation of absorption along the propagation path. Though, more sophisticated ray-tracing models accounting for wind and turbulent kinetic energy are prepared and ready to implement when deemed necessary.

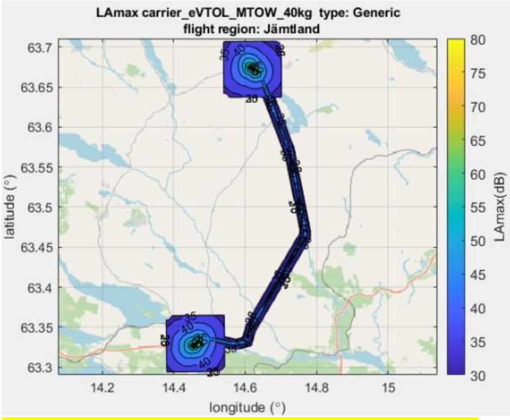
Atmospheric data to use may either be a standard (ISA) atmoshere or prognosis data from met.no. See Appendix 2 for more information about atmospheric data and noise propagation modelling

COMPUTATION OF NOISE -PROPAGATION AND -MAPPING

---- Now you are in function: SoundPropagation_Traj2Grid_v18.m -----
at:
[Local_SAFTu_main_dir]\3_Sound_Propagation\m_files_3\SoundPropagation_Traj2Grid_v18

---- Now you are in function: SoundProp_Traj2moreGrids_v4.m -----
at:
[Local_SAFTu_main_dir]\3_Sound_Propagation\m_files_3\SoundProp_Traj2moreGrids_v4

NOTE: Generic_eVTOL regards a simplified source with constant sound source strength along the trajectory -without effects of thrust, flightmode, ... etc.



above: outline resulting L_{Amax} contourlines

SoundSource.DirectivityType_s :Omnidirectional

---- Now you are in function: lat_lon_proportions_ulf1.m -----
(at:
[Local_SAFTu_main_dir]\0_Support\m_files_0\lat_lon_proportions_ulf1)

GE-plotting

---- Now you are in function: contours2kml_ulf_v3.m -----
(at:
[Local_SAFTu_main_dir]\4_Noise_Mapping\m_files_4\contours2kml_ulf_v3
)

NOTE: a fixed min dBA level to be shown in GE is set to 40
(can later be trimmed to wanted levels within GE)

KML-fil skapad:
...\5_Output_AndFixedInput\Output_SAFTu\20241121_0835_Ulf_SAFTu_v3
3_NoiseMap\...
LAmax_Contours_labels.kml

kmlfilename_labels = 'LAmax_Contours_labels'
file LAmax_Contours.kml saved on disk
file LAmax_Contours.kml saved on disk

---- Back in main: SAFTu_v33.m -----

Size of original NoiseGr-struct: 1557 MB

size to be reduced ...

Size of reduced-size and saved NoiseGr-struct: 72 MB

Results in struct NoiseGr.[fields] and NoiseGridInfo.[fields] saved on disc

---- SAFTu-run noise_contours -> noise mapping finalised -----

RESULTS OUTPUT Example 1:

Figure to the right: LpA level in point near starting position over time – note step in level, related to change of flight/propulsion mode from hover(+level) to only level/fixed wing mode

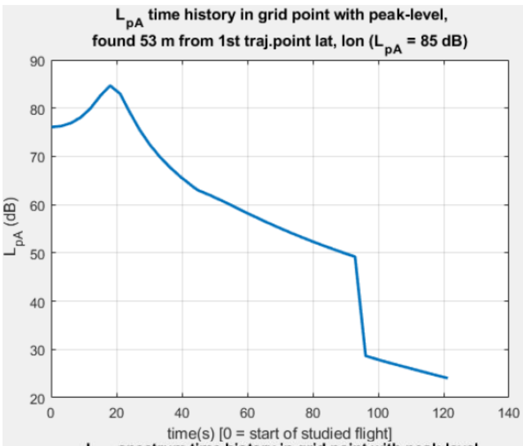
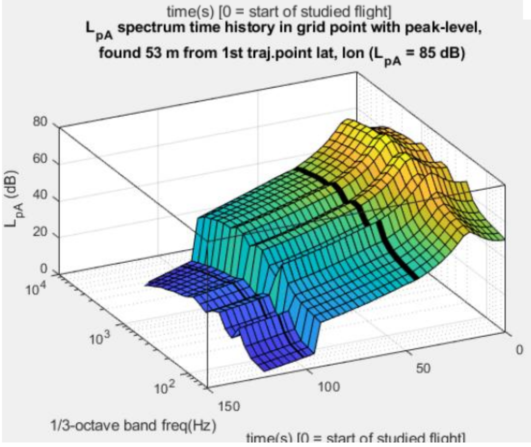
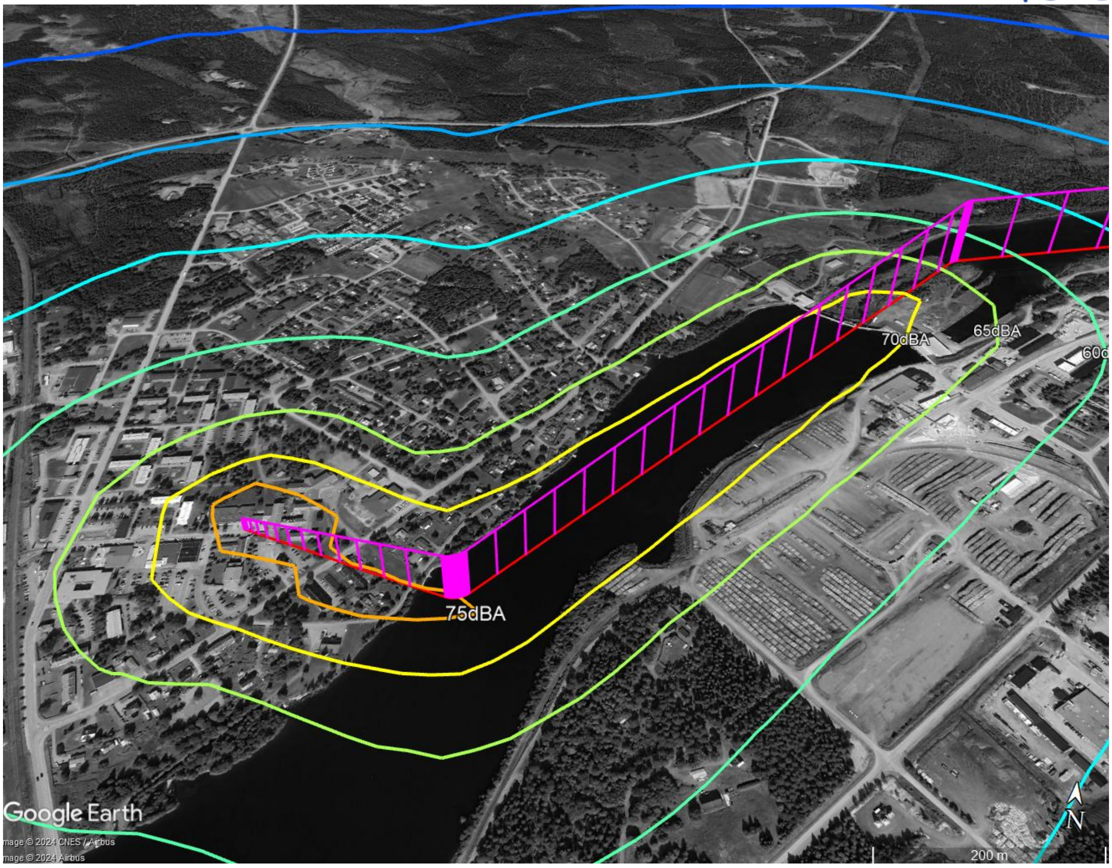


Figure to the right: LpA 1/3 octave spectrum level in point near starting position over time – note step in level, related to change of flight/propulsion mode from copter(+level) to only level/fixed wing mode



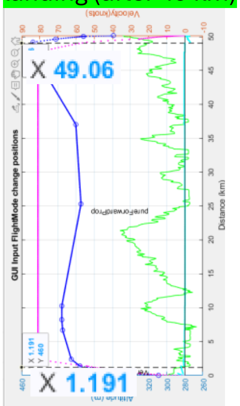
In the GE view to the right L_{Amax} contours are shown for the take-off in Krokom

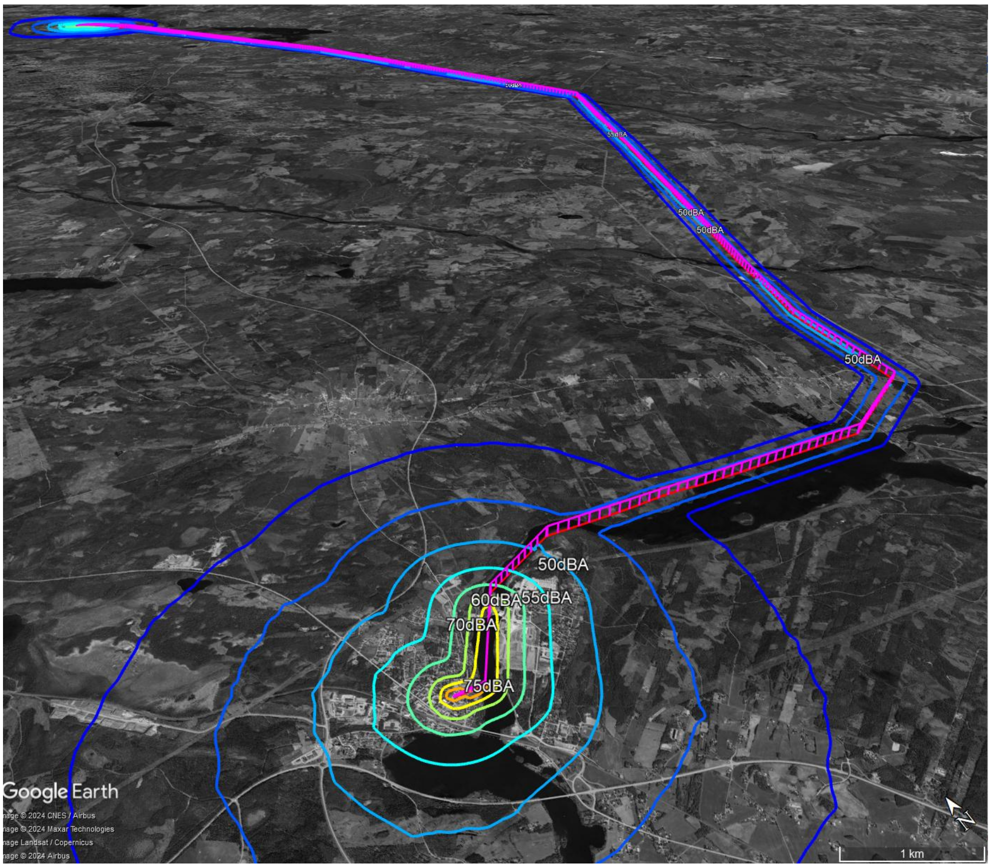
The red line shows groundtrack while the magenta-coloured 3D profile is the modelled trajectory. The upper end of the vertical lines denotes the discrete points from which the sound is emitted in the simulation. The dens sections of such are related to shorter time-steps in the turns.

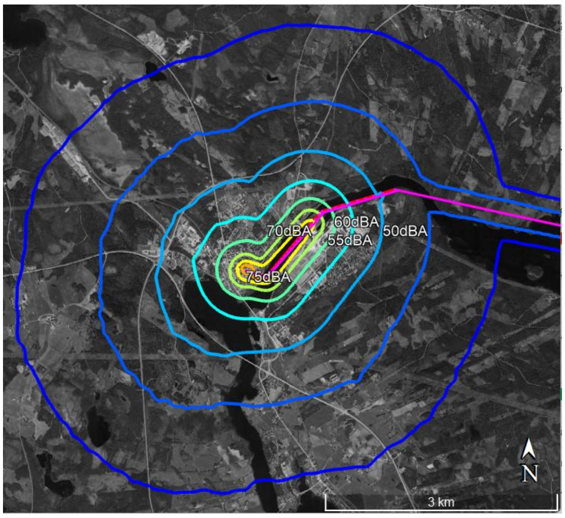


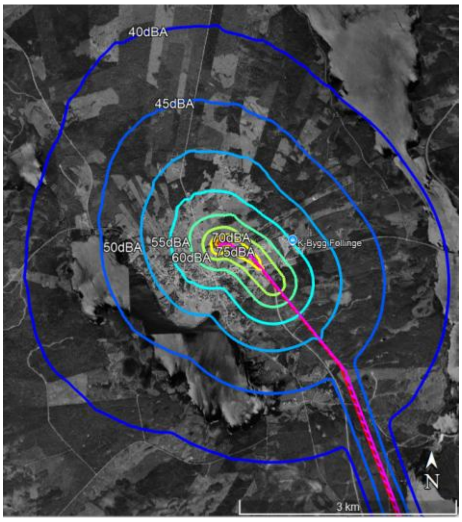
In this GE view to the right L_{Amax} we look at the take-off +the full flight from a higher position.

The change from copter to fixed wing mode is taking place ca 1.2 km after take-off and back to copter ca 1.2 km before landing (after 49 km)

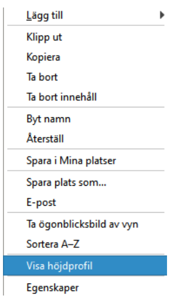


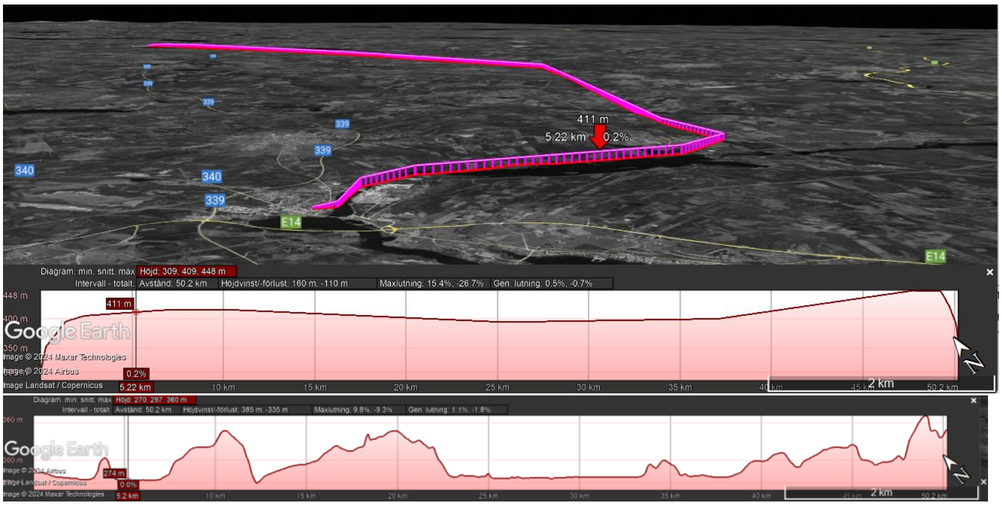






The altitude profiles from both groundtrack and flight trajectory can also be displayed in GE by right-clicking on the geometric entities: .../trajectory_HR_[DayYear]_[user]_no3.kml (upper right) and curvedTrack.kml (right) (lower right)





Example run 2: Flight with 40kg eVTOL Östersund: Göviken-Orrviken 15 km Jämtland Sweden
Testcase illustrated with SAFTu user interface screen dumps + explanations
Comments to SAFTu screen dumps workflow highlighted yellow
Comments to Google Earth input/output highlighted green, Info further outlined in Appendices highlighted turquoise

Start SAFTu_v33.m, i.e. current version of main-SAFTu function in Matlab (v33= version 33): Screendump

>> SAFTu_v33
---- Now you are in function: Init_Global_v1.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\Init_Global_v1)

%%%

WELCOME, YOU ARE RUNNING SAFTu_v33
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\SAFTu_v33)

MAIN ACTION
1. Choose your wanted kind of SAFTu main action:

----- Preprocessing -----
0. Prepare data to be used in later noise-mapping (e.g. Vehicle Sound Source, Atmosphere-, TL-data, ...)
or
----- Noisemapping -----
1. Define and run a noise mapping case with input given interactively (Default)
[NOTE: a Sound Source representing the vehicle has to be established prior to a noise mapping-run]
or
[NOT YET IMPLEMENTED: 2. Read in and run a previously prepared noise mapping case input file]
or

----- Postprocessing -----

3. Difference between grid field results from two previous runs ("Delta-dB contours")
or
4. Population exposures within dB-bands, bar plot comparison of previous run results

Please give a number, 0, **1**, 3 or 4:
1

--- A new default output directory has been created ---
[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Output_SAFTu/20241125_1114_Ulf_SAFTu_v33_NoiseMap

------- You will now Define and Run a Noise Mapping case with input given interactively -------

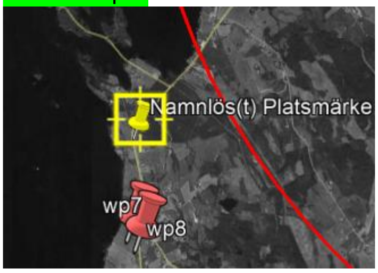
You will now tailor a vehicle flight trajectory to be studied with regard to noise reaching ground
In order to enable this you need to know:
- the type of vehicle* to be studied
(i.e. small-/medium multicopter or airtaxi/eVTOL ...)
- where the flight take place
(i.e. geographic region, including start and landing points, profile and waypoints where changes in fundamental flight conditions take place)
[*Vehicle Cathegories and sound sources data NOT YET SETTLED!]

VEHICLE/Sound Source
2. Select a vehicle and its sound source data-file already established and saved on disk
Press return to go on with the selection of such a **SoundSource.mat** file in the filebrowser to be opened ...
(same source choosen as in ex.1 above: 'carrier_eVTOL_MTOW_40kg')
...
(input 3-7 as in ex. 1 above)
...
8. ...
When the last waypoint/placemark is INTERACTIVELY saved from the GE-window into current output-dir, enter this matlab window again and press RETURN to proceed the paused matlab execution...

In this example we have read in a list of way points from an external source, in sweref99 (coordinates) and produced kml-files with input waypoints ...

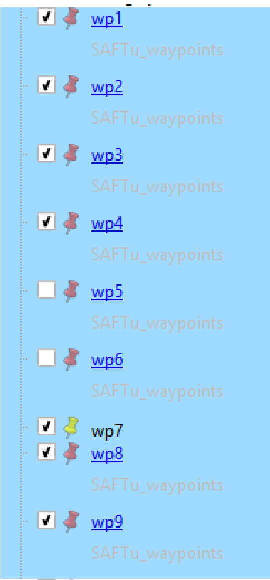
In this example we have read in a list of way points from an external source, in sweref99 (coordinates), and produced kml-files with 8 input waypoints given in lat, lon. NOTE: such support for programatic input generation (kml-format or else), e.g. matlab functions, are not yet integrated with SAFTu (but could rather easily be made)

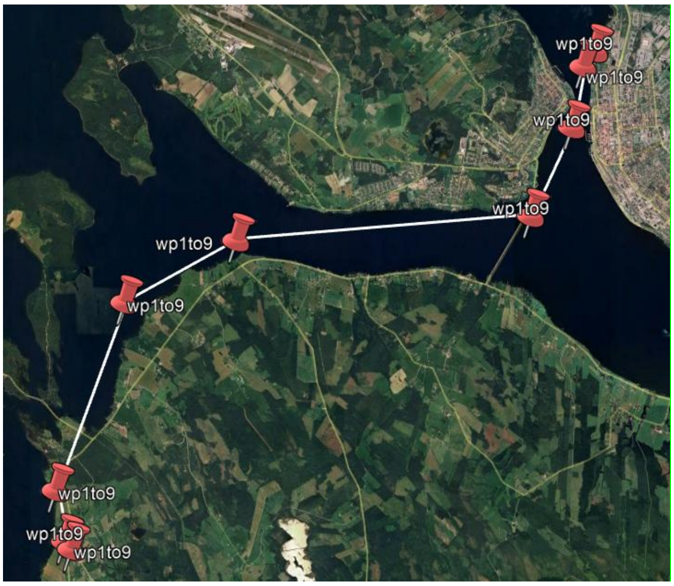
So, in this case the first 8 waypoints were inatially given (shown as red push pins in map figure to the right) , i.e. a list of 8 sweref99 coordinates transformed to lat long in kml-format and read in in GE. (the red circle with 10 km radius and center in Östersund is support in kml from DAFTu to find approximate region of concern).
To treat the approach towards the last waypoint, wp8, with more varying decellerations we want to add one more way point before and close to current wp7.



We call this wp7 and then changes previous (red) wp:s 7 and 8 names to wp8 qnd wp 9 respectively (right click on waypoint and mark change name)

Now, as in Ex.1 we re-name the sequence of waypoints to: wp1to9 before saving them in current SAFTu output directory





Now the straight segments of the current groundtrack will be trimmed with curved flight in "corners"

When the change of heading in a waypoint is regarded big enough a curved circular groundtrack segment is replacing the corner
9. Please give the limit in heading change/yaw angle (deg's) you want in this case (Default = 1 deg):

10. Please give the turning radius you want to apply in these cases
(NOTE: larger turning radius may create problems when wp:s are placed close and "curvy" (Default = 10 m):25

Info: The difference in flight distance between original straight legs groundtrack and the trimmed, curved turns, one, is: 5 m
Flown horisontal distance, s: 16 km (original) 16 km (curved turns)

Step1 stateTraj, containing initial info and Groundtrack saved on disc in file stateTraj1.mat
in current out-dir: **[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Output_SAFTu/20241125_1145_Ulf_SAFTu_v33_NoiseMap**

---- Now you are in function: AddInfoAndFileNameTo_stateTraj1_v4.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\AddInfoAndFileNameTo_stateTraj1_v4)

ADD Groundtrack Info and Name

The Groundtrack, just saved as a stateTraj1.mat-file in the "standard OutDir", i.e. in:
[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Output_SAFTu/20241125_1145_Ulf_SAFTu_v33_NoiseMap/stateTraj1.mat
will also be saved in a sub-directory in the directory for input flight trajectories, "TrajAndGroundTracks"-dir:
[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Input_SAFTu/TrajAndGroundTracks/Sweden/Jämtland/ ["user given subdir name"] /stTr1_16km
from where it later may be picked as a input Groundtrack in coming SAFTu noisemapping runs

11. Input of the ["user given subdir name"] where the Groundtrack, i.e. stateTraj1 struct-variable, will be saved
It is recommended that the name is put together like: **[start pos name]_Via[passing]_[end pos name]** in case of a "full" path, takeoff-transport-landing
e.g. like in: "Kappellskär_ViaNorrtälje_Uppsala"
For a "non-complete" flight, i.e. takeoff-transport or transport-landing, or just takeoff or landing, more simple two or one word ID-strings may do
Please give the wanted sub-directory name:
Göviken_Digernäs_Orrviken

The Groundtrack (stateTraj1) will be saved in:
[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Input_SAFTu/TrajAndGroundTracks/Sweden/Jämtland/Göviken_Digernäs_Orrviken/stTr1_16km

The struct-variable stateTraj1.[fields] field .SoundSource_ID is given the same value as SoundSource.modelName, i.e: carrier_eVTOL_MTOW_40kg

ADD info fields to Groundtrack-struct stateTraj1
Now you have the possibility to add further information about the intention of the trajectory and vehicle. This is made in 3 steps:
1. IntendedVehicle - Which kind of vehicle(s) are thought to be flown the track? (e.g. eVTOLs, multicopters < 100, >50kg, ...)
2. IntendedPurpose - Which kind of purpose could a flight represent? (e.g. air-taxi, delivery, reconnaissance, ...)
3. OtherInfo - Other information needed or supporting the understanding of the track

12. Please give a short text that hints about for which kind of vehicles the track is intended (field: IntendedVehicleTypes)
(Default = Generic_Generic_eVTOL_carrier_eVTOL_MTOW_40kg)
eVTOL_MTOW_40kg

13. Please give a short text that hints about the purpose of a flight along the track (field: IntendedPurpose)
testGreenFlyways

14. Please input text that may be valuable for the further use of the Groundtrack (field: OtherInfo)

15. Do the flight to be studied consider:

1. A complete trajectory, i.e. from take-off to landing ? (Default)
2. A take-off only?
3. A pass-by flight only?
4. An approach/landing only?

Please give 1, 2, 3, or 4:
1

SELECTION OF ALREADY USER PREPARED TOPOGRAPHY DATA FILE

16. Now you have to select a previously established topo-/geotiff-file which you know covers the already prepared trajectory waypoints

Press return to go on with selection of the geotiff-file in the filebrowser that will open

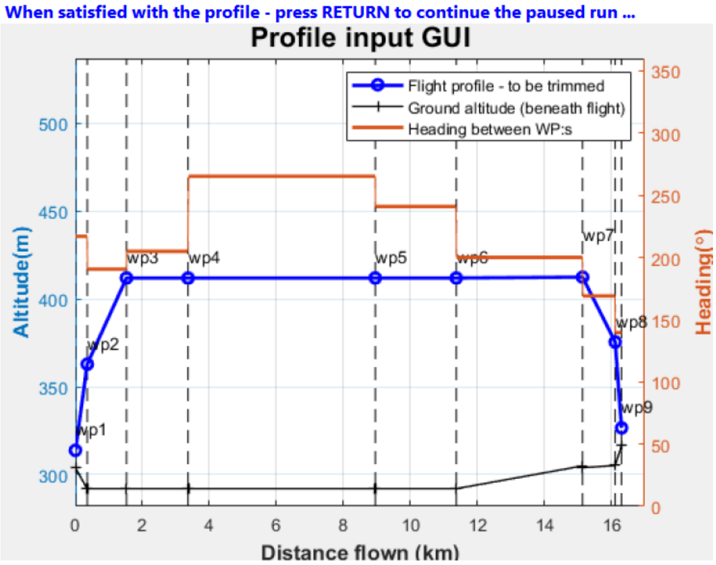
The topography file: Storsjön100x100km.tif in directory: [Local_SAFTu_main_dir] \5_Output_AndFixedInput\Input_SAFTu\GeoData\Topo\NorgeSverige\ was read in utm-zone: 33
... and used for ground elevation interpolation at groundtrack waypoints

The 2D profile s(km), z(m)-points, i.e. horisontal distance flown and altitude will be given interactively by mouse/cursor input in a GUI-figure screen graph.
For the profile to be adjusted in a the coming GUI-figure you can give a template altitude for the en-route phase (i.e. all pts except possible start/landing)

17. Please give the typical en-route height above ground in meters for the profile to be designed (Default = 120)
120

Interactive profile input via matlab GUI-figure
Now you are ready to adjust the altitude of preset waypoints in the Profile input GUI figure, shown as blue circles on top the template blue profile curve
18. Simply use the mouse, click/drag on the waypoints (circles) that you want to move to higher/lower altitude, you will get the possibility to trim them more exact later

When satisfied with the profile - press RETURN to continue the paused run ...



wp no	s(wp)km	alt(wp)m	height over ground(wp) m	ascent_deg
1	0	314	10	8
2	0.353	363	71	2
3	1.525	412	120	0
4	3.364	412	120	0
5	8.956	412	120	0
6	11.374	412	120	0
7	15.147	412	108	-2
8	16.121	376	70	-14
9	16.31	327	10	0

19. Please provide a number between 1 and 9 for which you want to change its altitude. Or, choose NO more trimming: 0 (Default)

NO more trimming

Now you are to input the speed in the MAIN WAYPOINTS, one by one. From these data the time and speed along the complete trajectory will be computed assuming a linear acceleration along the 3D trajectory

20. Please give the unit in which you want to treat the speed, knots, km/h or m/s
1. knots (Default)
2. km/h
3. m/s

Input 1,2 or 3:

take-off and landing speed set to 0 knots

21. Please give the speed (knots) in MAIN WAYPOINT number 2 (Default = 10):54
22. Please give the speed (knots) in MAIN WAYPOINT number 3 (Default = 54, i.e. as in previous WP) :
81
23. Please give the speed (knots) in MAIN WAYPOINT number 4 (Default = 81, i.e. as in previous WP) :

24. Please give the speed (knots) in MAIN WAYPOINT number 5 (Default = 81, i.e. as in previous WP) :

25. Please give the speed (knots) in MAIN WAYPOINT number 6 (Default = 81, i.e. as in previous WP) :

26. Please give the speed (knots) in MAIN WAYPOINT number 7 (Default = 81, i.e. as in previous WP) :

27. Please give the speed (knots) in MAIN WAYPOINT number 8 (Default = 81, i.e. as in previous WP) :
54
For noise source model "carrier_eVTOL_MTOW_20kg", no predictor variables applied, though 2 different flight modes/spectra, Hover and Cruise

Geometry, times, speeds and accelerations has now been established for the trajectory WPs

As in SAFTu run Example 1 we are looking at a 40 kg eVTOL with a typical flight mode change – copter to fixed wing – at 54 knots and a cruise speed 81 knots, which we apply at main* way points as seen in screen dump to the left, input 20-27.

*) With main wp:s we consider the user's waypoints input in GE. When the final curved ground track is generated algorithmically within in matlab a second set of way point accounts for a discretised curvature

around this first set of way points.

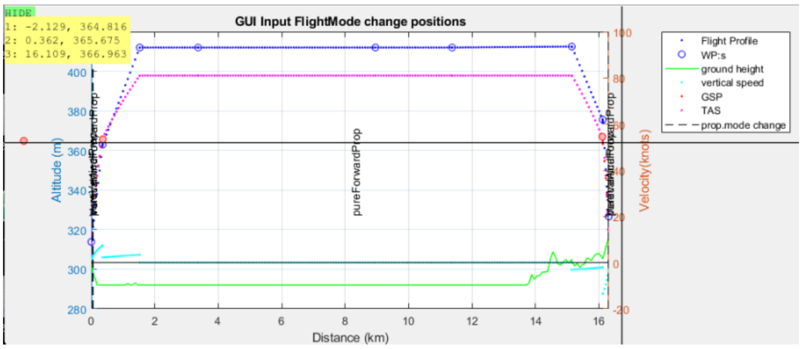
28. Please give the time step, i.e. an increment in seconds to be applied for the 429 seconds long flight trajectory discretisation
(NOTE: the time increment will not become exactly the same for each step since original WP:s will be kept)
(Default = 2 sec) :

NOTE: starting point (ORIGO) taken as reference position primary reference ground altitude wrt sealevel
traj-kml file no 3 written: trajectory_HR_25Nov2024_Ulf_no3.kml
Step2 stateTraj2, containing HR (High-Resolution) trajectory geometry, speeds and accelerations saved on disc in file stateTraj2.mat
in current out-dir: [Local_SAFTu_main_dir] \5_Output_AndFixedInput\Output_SAFTu\20241125_1145_Ulf_SAFTu_v33_NoiseMap

---- Now you are back in function: Inputs_for_SAFTu_Run_v33.m -----

---- Now you are in function: SouStrengthOfFlightMode_carrier_eVTOL_MTOW_40kg_v3.m -----
(at: [Local_SAFTu_main_dir] \2_Sound_Sources\m_files_2\SouStrengthOfFlightMode_carrier_eVTOL_MTOW_40kg_v3)

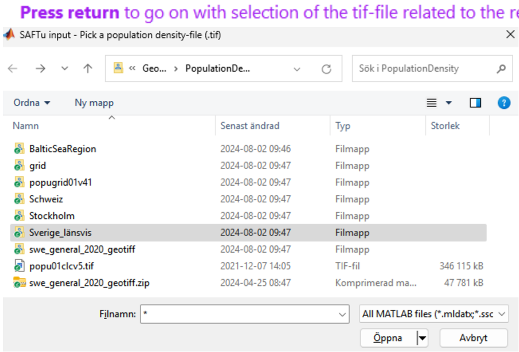
You should now set the SoundSource cathegory along the flightpath, i.e. vertical("copter") mode, transition(both) or level(fixed wing) mode
This might be done by: 1. criteria in horisontal speed and flight angle or
2. changes in fixed positions
You should now set the SoundSource cathegory along the flightpath, i.e. vertical("copter") mode, transition(both) or level(fixed wing) mode
This might be done by: 1. criteria in horisontal speed and flight angle or
29. Do you want to decide flightmode through:
1. Horisontal speed + Ascent(>0) and Descent angles (<0) (Default)
2. Fixed positions along the Groundtrack (interactve in GUI-figure)
2

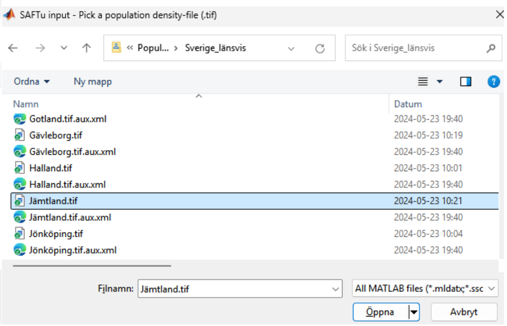


31. In the figure 8, "GUI Input FlightMode change positions', set the distance (x-axis) for flight mode change no. 1 to 4 by manual input (crosshair-cursor will show up) by clicking on the flight profile at the max 4 wanted x,y-(dist.,alt.-) positions
NOTE: if one or more (consequtive) flightmode-shifts do not take place in current flight, mark a position outside the current x-limits!
Please start the profile-change-flightmode-position by moving cursor over picture and click at wanted positions (y-value doesn't matter)...
Step2 stateTraj2, containing HR (High-Resolution) trajectory geometry, speeds and accelerations saved on disc in file stateTraj2.mat
in current out-dir: [Local_SAFTu_main_dir] \5_Output_AndFixedInput\Output_SAFTu\20241125_1145_Ulf_SAFTu_v33_NoiseMap
---- Now you are back in function: Inputs_for_SAFTu_Run_v33.m -----

In figure above it is seen that change pos 1 is placed before x=0, with which follows that its non-active, i.e. the flight start with hover+forward props running. (see Example 1) the second change – to solely forward props is as seen placed at 0.362 km and the third at 16.109 km. and the last no 4, is to be put outside end of x-axis, i.e. both sets of props active up to end of studied trajectory.
[fix: input no. 30 left out in code by mistake].

32. You may now choose to include population data or not (nof people living within different noise contour dB-spans)
0. No population data to be involved in computations (Default)
1. Include population data in computation - NOTE: This need a population raster file to be prepared!
Please give 0 (Default) or 1
1
33. Now you have to select an existing population density-file (.tif) covering the supposed noise impact area around groundtrack
Press return to go on with selection of the tif-file related to the region of concern in the filebrowser that will open





Selected population density .tiff-file:
...\5_Output_AndFixedInput\Input_SAFTu\GeoData\PopulationDensity\Sverige_länsvis\Jämtland.tif
NOTE: the population data in SAFTu has to be extracted from the Meta site for High Resolution Population Density
E.g. in the case of data over Sweden:
https://data.humdata.org/organization/meta?res_format=GeoTIFF&q=population+density&ext_page_size=25&page=2#datasets-section
Such data, with a resolution of ca 30 m (< 30 circumferentially/long-wise), becomes, depending on country size, soon rather big.
One way to make these files, in geotiff (.tif) format, manageable in terms of size, is to process them in a GIS-program like QGIS.
Could be by tiling them along country borders - using open vector data, from Lantmäteriet in case of Sweden,
e.g. the file admindelning_sverige.gkpg (zipped) and apply QGIS plugin: "Easy Raster Splitter"

CREATE A GROUND GRID

Along with the Grid to be established some computationally demanding figures may be established.

34. Do you want to plot these or supress in order save time/avoid crashes in case of large Grids (~>30km) ?

0. No extra detail Grid data plotting (Default)
1. Yes, plot extra details related to Grid/topography/nof sound-ray hits/sub-grid borders in main Grid

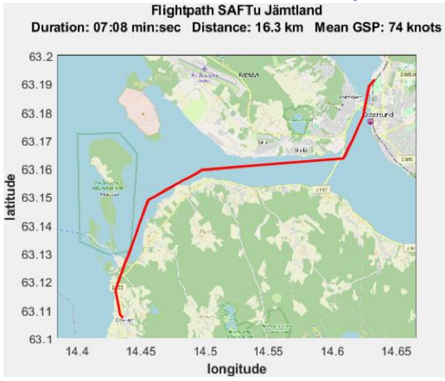
1

---- Now you are in function: create_GroundGrid_aroundGroundTrack_v13.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\create_GroundGrid_aroundGroundTrack_v13)

NOTE: starting point (ORIGO) taken as reference position primary reference ground altitude wrt sealevel

35. Do you want to apply more then one sub-grid size ? E.g. with larger size closer to take-off and/or landing areas?
(the current sub-grid half-width value is: 600 m)
Please input 0/1 (Default = 0, No - one sub-grid size is enough, alt. 1 Yes - more than one sub-grid size)

1



Now you will give the positions along the groundtrack for where the sub-grid size changes
It is recomended to watch one of the latest figures, e.g. "Input flightmode change positions" to get an idea of distances selection
36. Give the distance in km:s where you want a change in sub-grid size for change position 1(2):
1
37. Give the distance in km:s where you want a change in sub-grid size for change position 2(2):
15
1. Change in sub-grid size after: 1 km
2. Change in sub-grid size after: 15 km

37. Are you satisfied with the distances? (1 = Yes, Default / 0 = No, I want to change the above given input)

1

The use of subgrid regions with different extention is usful when dealing with different altitudes and/or noise source strength – typically when a modelling a VTOL-flight, changing from copter to fixed wing flight mode

First, you are now to give the sub-grid extention in meters for the region with the smaller sub-grid size
Then, you are to give an integer factor, which is used to multiply the smaller extention to get the bigger sub-grid size
38. For the region with a smaller grid width, typically underneath trajectory sections spanning level-flight conditions, give the sub-grid extention you think will cover noise levels of concern
If you are OK with the current value: 600 m (Default) just press Return

"Small-sized" sub-grid extention, max ground grid width for noise contours, set to: 600 m

Below: every 10th subgrid along groundtrack plotted. Subregion2 (small width along level flight in black)

39. For the region(s) with a need for larger sub-grid size, typically trajectory spans closer to ground during take-off and approach/landing give an even integer factor, 2, 4, 6, ... which the smaller sized sub-grid extention will be be multiplied with in order to cover noise levels of concern
(Default =4):

6
"Big-sized" sub-grid extention, max ground grid width for noise contours set to: 3600 m

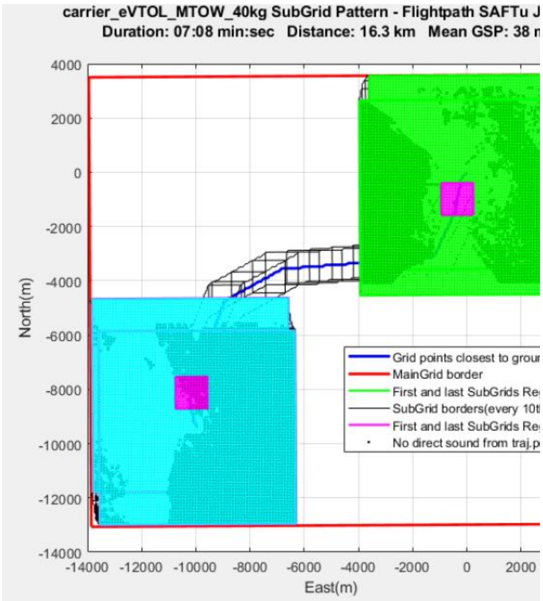
40. Please give the Grid resolution, the same size for all sub-grid regions, in meters:
Nof sub-grid regions is: 3

---- Now you are in function: create_multipleSubGridSets_v5.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\create_multipleSubGridSets_v5)

NOTE: starting point (ORIGO) taken as reference position primary reference ground altitude wrt sealevel
maxDist_GrWishedCorner_ExactGridPt1 = 38 m
maxDist_GrWishedCorner_ExactGridPt2 = 41 m
maxDist_GrWishedCorner_ExactGridPt3 = 40 m

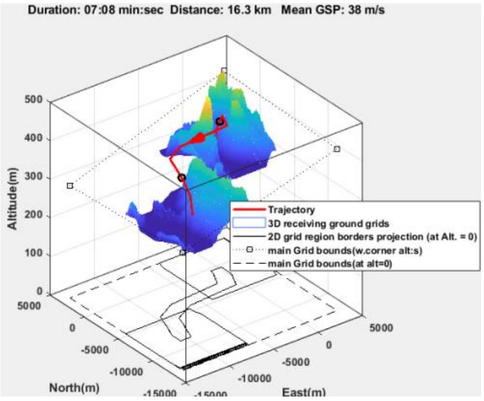
---- Now you are in function: Sonified_GridPts_MultipleSubgridRegions_v2.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\Sonified_GridPts_MultipleSubgridRegions_v2)

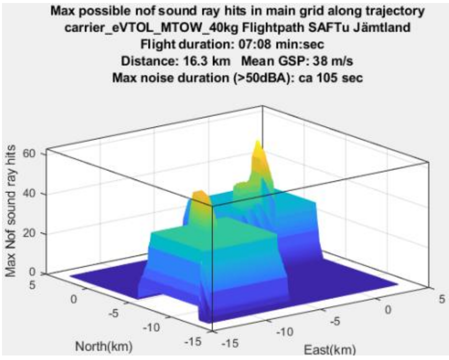
comp_IL =
0
Elapsed time is 2.638295 seconds.
Elapsed time is 2.756246 seconds.
Elapsed time is 3.100510 seconds.
Elapsed time is 0.367451 seconds.
Elapsed time is 1.977134 seconds.
Elapsed time is 1.559113 seconds.
Elapsed time is 511.504448 seconds.

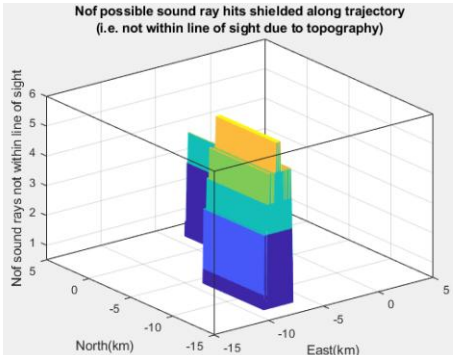


Now you are back in function: create_GroundGrid_aroundGroundTrack_v13.m -----
(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\create_GroundGrid_aroundGroundTrack_v13)

NOTE: The multiple subgrid regions implementation must be corrected in that it always should create mathching grids in transition zones and not lead to crashes (has happened)







Grid, containing MainGrid and SubGrids saved on disc in file Grid.mat
in current out-dir: [Local_SAFTu_main_dir]
\5_Output_AndFixedInput\Output_SAFTu\20241125_1145_Ulf_SAFTu_v33_NoiseMap

---- Now you are in function: plot_popDens_on_kmlANDopenstreetMap_v2.m -----
(at: [Local_SAFTu_main_dir]
\4_Noise_Mapping\m_files_4\plot_popDens_on_kmlANDopenstreetMap_v2)
You may here choose between ISA- standard atm or either of an already existing atmosphere file or to download a new one
41. Do you want to:

0. Apply a standard Atmosphere (ISA) dataset (Default)
1. Download AROME-atmosphere profile(s) data from met.no
2. Apply AROME atmos-profile data already existing on local disc

0

---- Now all input is given (function: Inputs_for_SAFTu_Run_v33.m is finished) -----

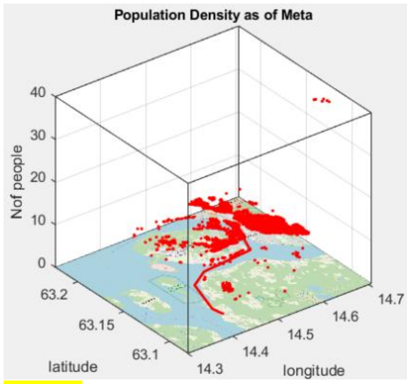
---- Back in main: SAFTu_v33.m -----

---- Now you are in function: initAtmosProfile_U1.m -----
(at: [Local_SAFTu_main_dir] \3_Sound_Propagation\m_files_3\initAtmosProfile_U1)

---- Now you are in function: set_ISAprofileData_v2.m -----
(at: [Local_SAFTu_main_dir] \3_Sound_Propagation\m_files_3\set_ISAprofileData_v2)

---- Now you are in function: Establish_AtmosProfile_struct_u2.m -----
(at C:\Users\Ulf\Min enhet\Jobb\CSA\1_ARBETSMATERIAL\APIS\SAFTu\3_Sound_Propagation\m_files_3\Establish_AtmosProfile_struct_u2)

---- Now you are in function: absorption_of_alt_u1.m -----
(at: [Local_SAFTu_main_dir] \3_Sound_Propagation\m_files_3\absorption_of_alt_u1)



Above:
When including population data in a run a plot may be made indicating population distribution in the area (z=est. nof people living) [corr: change groundtrack color from red to other col.]

COMPUTATION OF NOISE -PROPAGATION AND -MAPPING

---- Now you are in function: SoundPropagation_Traj2Grid_v18.m -----
(at: [Local_SAFTu_main_dir] \3_Sound_Propagation\m_files_3\SoundPropagation_Traj2Grid

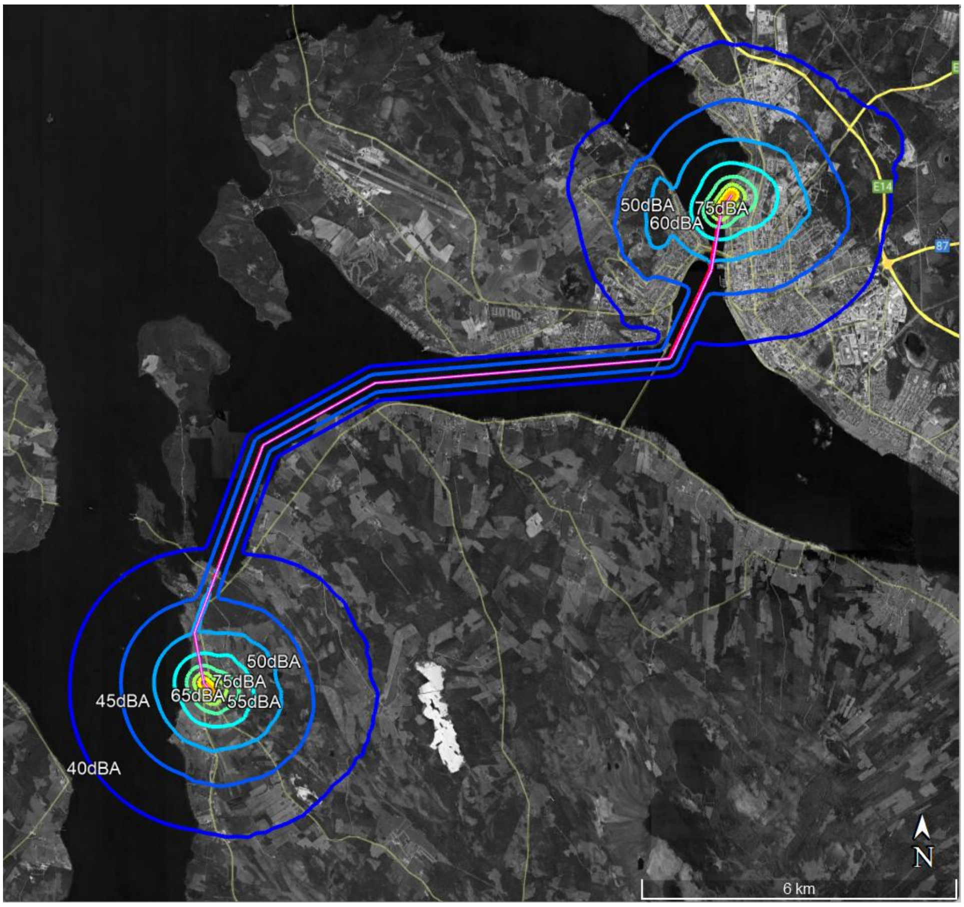
---- Now you are in function: SoundProp_Traj2moreGrids_v4.m -----
(at: [Local_SAFTu_main_dir] \3_Sound_Propagation\m_files_3\SoundProp_Traj2moreGrids_

NOTE: Generic_eVTOL regards a simplified source with constant sound source strength along the trajectory -without effects of thrust, flightmode, ... etc.
SoundSource.DirectivityType_s :Omnidirectional

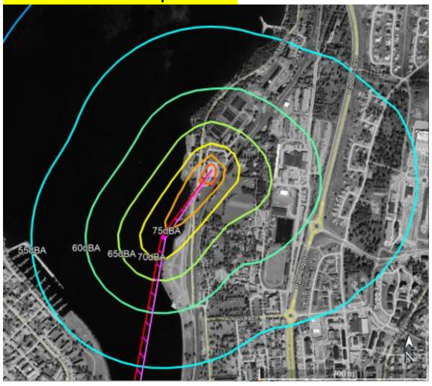
The computation of population within noise level intervals is based on open data from:
Sweden: High Resolution Population Density Maps (swe_general_2020_geotiff.zip), OCHA

The data and method has to be further validated but initial comparison with EU-data over Stockholm tend to give equal results. A crude check in this example compare total inhabitans in central Östersund, ca 31 000 (2023) ca 28 000 within 40 dB. If this is an overestimation or not is to early to say.

Exposed to levels > 40 dBA: ca 28100 inhabitants (as of 5dB-bands data)

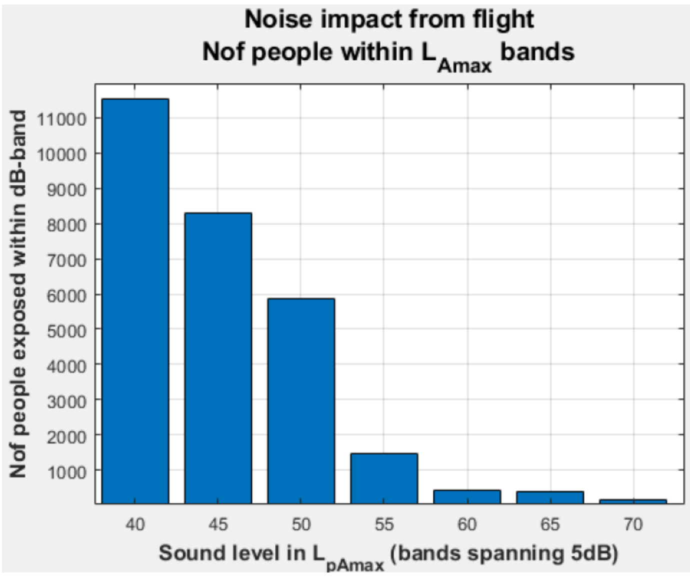


To the left: L_{Amax} contours 40 dBA to 80 dBA in 5 dB steps.
It should be noted that the 80 dBA regions are small (~50 m length) and that Such levels are comparable or less than a starting motorbike at 10 m (ca 80-90 dBA). A starting car 10 m away can typically be in the region 60-70 dBA.
40 dBA_{max}, the outermost darker blue curve, can, regarding level, be considered similar to silent environments like libraries, countryside with some wind or rain. Though, the character of the noise and pass-by event can have impact on human response.



RESULTS OUTPUT Example 2:

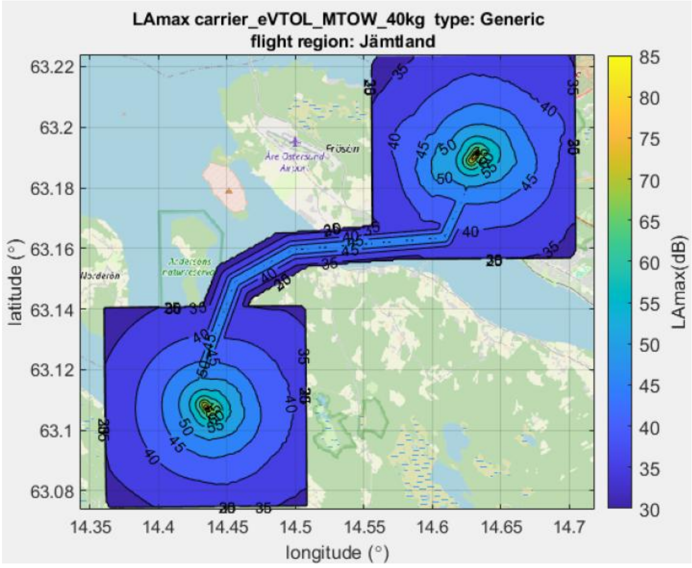
Upper right figure:
When including population data in a run the main result is a plot of the type to the right. In this case the current flightpath started near central Östersund which means that the bars content is strongly dominated by noise from the take-off and initial hover-mode flight phase in this case This kind of “nof people exposed”-data can be postprocessed and compared between different cases (see Example 3)

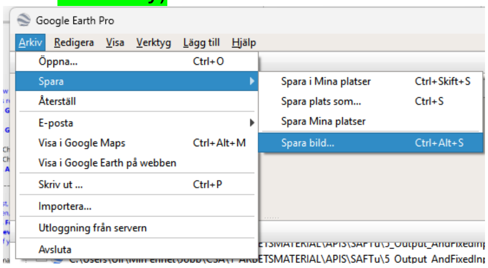


Middle right figure:
When running noise mapping plots noise contour result on top of a openstreetmap, are produced. These purpose of these is mainly to check that the run (and input) was OK, in order to get a better view the user is supposed to consider the kml-file data sets to be applied and observed in GE

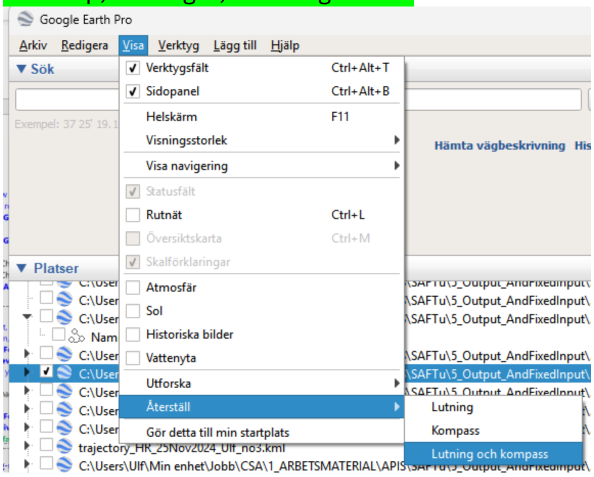
Lower right figure:
Within Google Earth the results may be observed on top of:

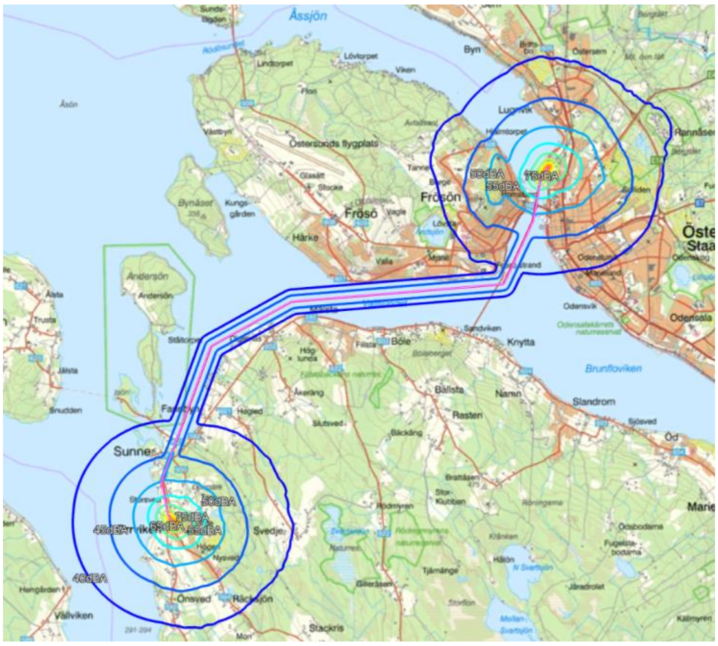
1. the usual sattelite photo background
2. the sattlite photo background but in "print mode" where you can select grayscale background to make coloured contours and else to show better (see first fig below)
3. any backround picture read in and overlayed to GE, like the map from Lantmäteriet seen here (here one need to scale/rotate th map/figure until positioned correctly)





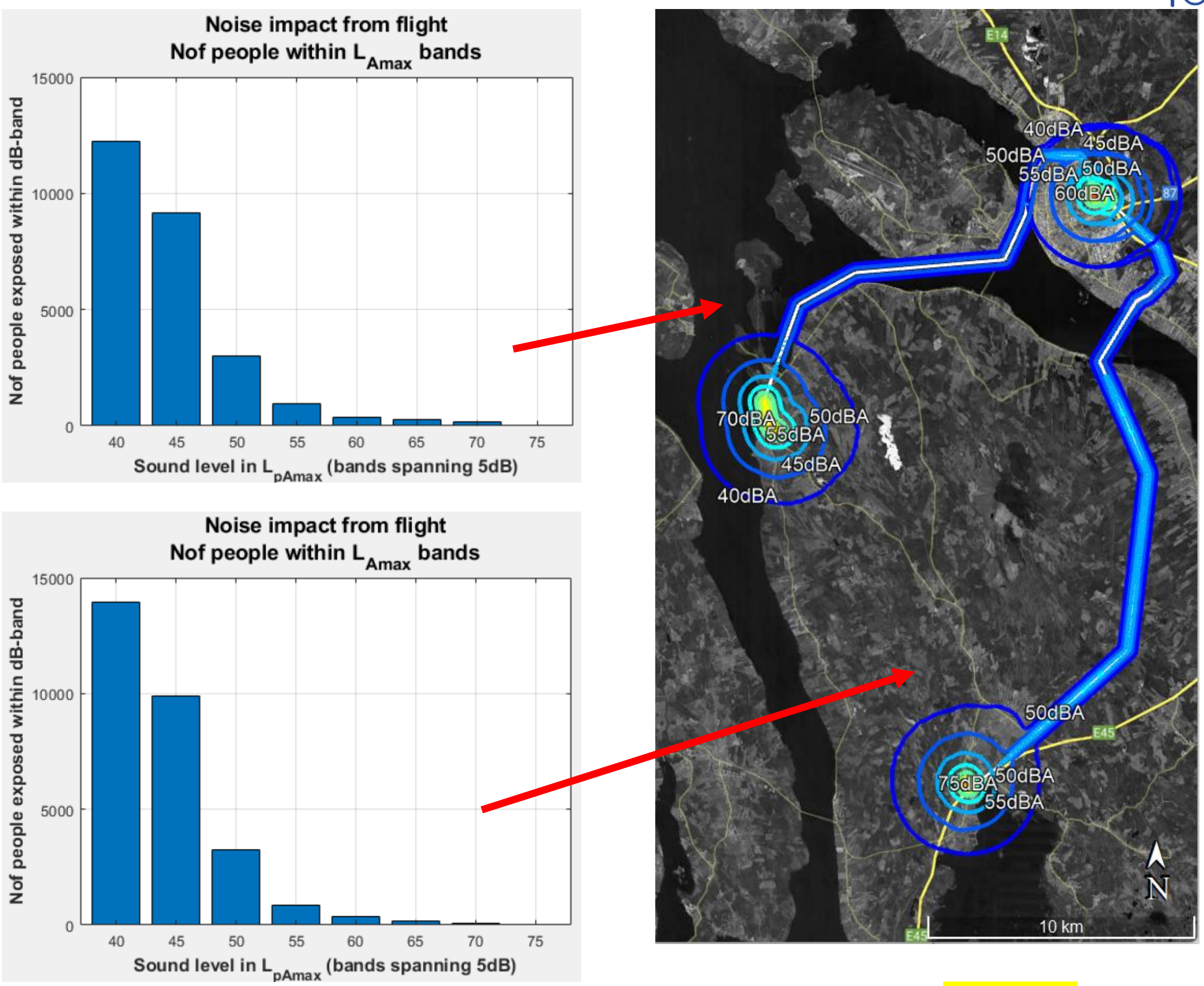
Note that the GE view can be altered in 3D, and back to 2D, north up, east right, like in fig below:





Example run 3: Comparing two flights regarding nof people exposed to diverse levels of noise – same vehicle in both cases, 40kg eVTOL two different paths and profiles:
Solliden-Orrviken 20 km vs Solliden-Fåker 27.5 km
Östersund, Jämtland Sweden
Testcase illustrated with SAFTu user interface screen dumps + explanations
Comments to SAFTu screen dumps workflow highlighted yellow
Comments to Google Earth input/output highlighted green, Info further outlined in Appendices highlighted turquoise

Input data from the two previous runs, noise contours from these:



Start SAFTu_v33.m, i.e. current version of main-SAFTu function in Matlab (v33= version 33): Screendump

>> SAFTu_v33
%%
%%%

WELCOME, YOU ARE RUNNING SAFTu_v33

(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\SAFTu_v33)

(where: [Local_SAFTu_main_dir] denotes C:\Users\Ulf\Min enhet\Jobb\CSA\1_ARBETSMATERIAL\APIS\SAFTu\ as set by user)

MAIN ACTION

1. Choose your wanted kind of SAFTu main action:

----- Preprocessing -----

0. Prepare data to be used in later noise-mapping (e.g. Vehicle Sound Source, Atmosphere-, TL-data, ...)

or

----- Noisemapping -----

1. Define and run a noise mapping case with input given interactively (Default)

[NOTE: a Sound Source representing the vehicle has to be established prior to a noise mapping-run] or

[NOT YET IMPLEMENTED: 2. Read in and run a previously prepared noise mapping case input file]

or

----- Postprocessing -----

3. Difference between grid field results from two previous runs ("Delta-dB contours")

or

4. Population exposures within dB-bands, bar plot comparison of previous run results

Please give a number, 0, **1**, 3 or 4:

4

--- A new default output directory has been created ---

[Local_SAFTu_main_dir] /5_Output_AndFixedInput/Output_SAFTu/20241126_1333_Ulf_SAFTu_v33_popComp

---- Now you are in function: select_Population_Within_dBbands_Data_v1.m -----

(at: [Local_SAFTu_main_dir] \1_Input_AndRunGeneration\m_files_1\select_Population_Within_dBbands_Data_v1)

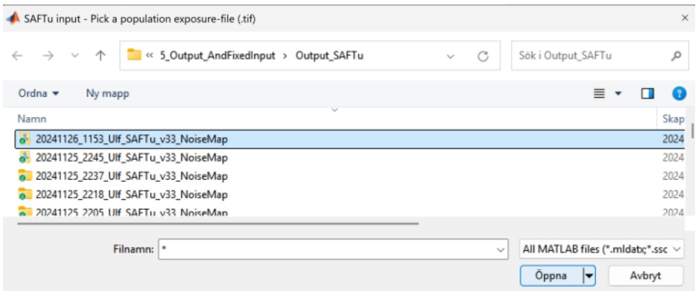
COMPARISON of POPULATION NOISE-EXPOSURES FOR 2 - 4 previously run flight events shown in bar plots

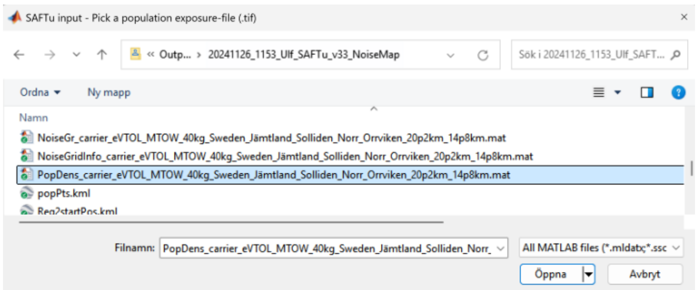
2. Give the number of previous SAFTu-runs with population noise exposures you want to compare, 2 - 4 flights (Default = 2)

2

Now you are to select the 2 population-noise-exposure files produced within previous SAFTu-runs

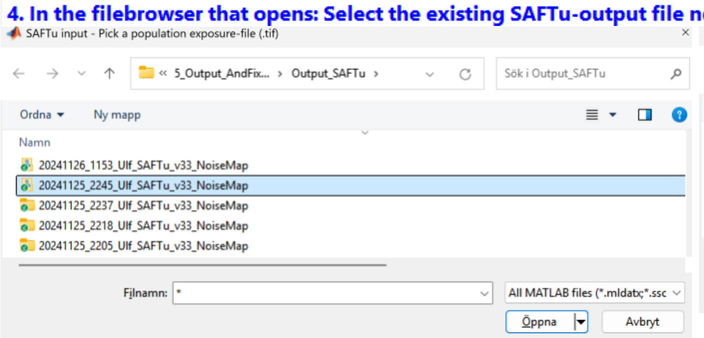
3. In the filebrowser that opens: Select the existing SAFTu-output file no 1 of the type: "PopDens_vehicle, place, route, dist, dist straight.mat"

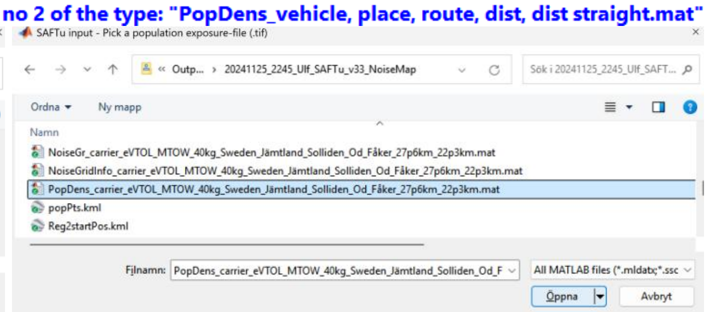




file 1(2): PopDens_carrier_eVTOL_MTOW_40kg_Sweden_Jämtland_Solliden_Norr_Orrviken_20p2km_14p8km.mat

4. In the filebrowser that opens: Select the existing SAFTu-output file no 2 of the type: "PopDens_vehicle, place, route, dist, dist straight.mat"





file 2(2): PopDens_carrier_eVTOL_MTOW_40kg_Sweden_Jämtland_Solliden_Od_Fåker_27p6km_22p3km.mat

The 2 Flight cases to be compared with regard to noise exposure (nof people) will by default be identified in plots with the below texts

1. Solliden_Norr_Orrviken_20p2km
2. Solliden_Od_Fåker_27p6km

5. Do you want to keep these legend texts or change any of them? 0 = keep (Default) or 1 = change texts

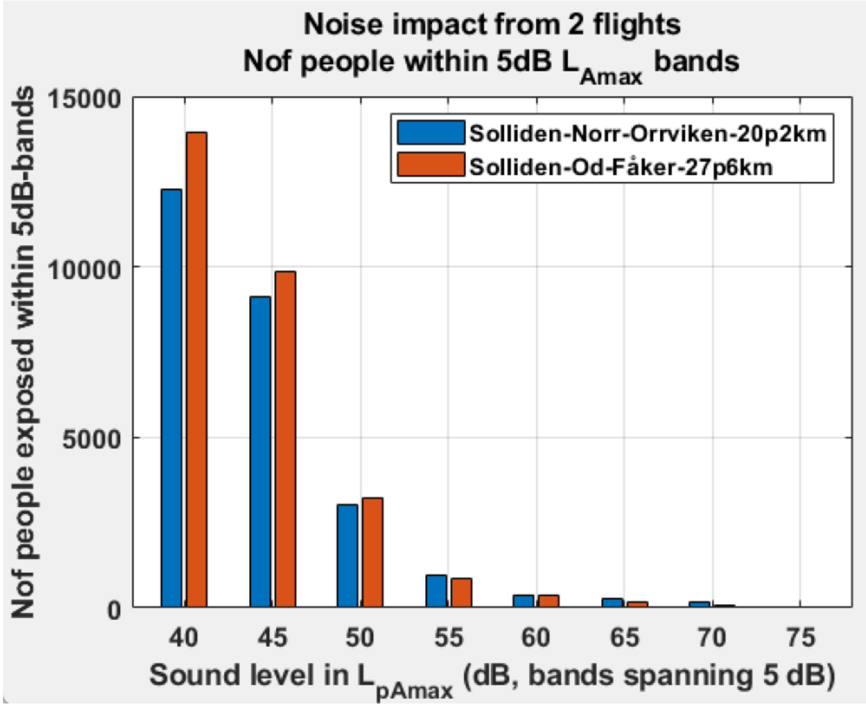
0

The selected data containing nof noise exposed people are:
'PopDens_carrier_eVTOL_MTOW_40kg_Sweden_Jämtland_...
Solliden_Norr_Orrviken_20p2km_14p8km.mat'
Solliden_Od_Fåker_27p6km_22p3km.mat'

---- Now all input is given (function: ... Inputs_for_SAFTu_Run_v33.m is finished) -----

---- Back in main: SAFTu_v33.m -----

RESULTS OUTPUT Example 3:



Appendix 1

Ground Elevation Data in SAFTu

Ground elevation level information is needed to run SAFTu noise computations. Different datasets with varying resolution, both sideways, from 1m to some tens of meters, with a very high resultion in height (~1dm to 1m) .See Lanmäteriet (link).

In current SAFTu we have used open data from lantmäteriet, N-,E-resolution 50m in SWEREF99 for Sweden and for Europe, including Sweden, Copernicus DEM, 30m, in WGS84 coordinates, both on geotiff-format.

There are different ways to get hold of this kind of open data and to enable them within SAFTu applications. One way we have applied within the APIS project has been to use the open-source GIS-program QGIS and plugins for downloading (see links on page 1). Basically, this involves:

Via QGIS and therein installed plugin: OpenTopography DEM Downloader

- In QGIS after plugin + authorisation key (get help in video)
- In QGIS: a toolbar button "OpenTopography DEM Downloader" should appear
- Show open streetmap XYZ-tiles in QGIS, save section as of OpenTopography DEM Downloader
- Define extent shown map window or draw selection whitin map, Save to file (WGS84, lat,lon)

Appendix 2

Atmospheric data in SAFTu

(TO BE ADDED)

Appendix 3

Population data in SAFTu

Population data, i.e. an estimate of population distribution per land area. Could be daytime (most people at work) or evening+night, most people in their homes.

Irrespective of inherent accuracy of the data the metric of “people within noise bands” it s seen as a useful tool to quantify and compare dfferent cases, flights, route, vehicle etc. in SAFTu.

For use within SAFTu data can be extracted from the HDE/Meta site for High Resolution Population Density. These data are in approx. 30mx30m resolution and in geotiff format and directly readable from SAFTu, but due to the large area covered (e.g. complete Sweden) typically best managed by a subdivision into regions within QGIS.

Could be by tiling them along country (or other region) borders - using open vector data, from Lantmäteriet in case of Sweden, e.g. the file admindelning_sverige.gkpg (zipped) and apply QGIS plugin: "Easy Raster Splitter".