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A NOVEL TOOL TO ESTIMATE THE IMPACT – BEYOND ACOUSTICS – OF AIRCRAFT NOISE ON AIRPORT COMMUNITIES

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ABSTRACT:

In the H2020 project ANIMA, a tool chain is developed, making it possible to predict the noise impact of chosen flight scenarios whilst including new technologies and architectures. The goal is to give end-users, the possibility to calculate noise maps for a full virtual aircraft fleet over a certain amount of time. All that by including annoyance related metrics!

The toolchain itself consists of a so-called Noise Reduction Solutions Simulator and a Virtual Community Tool (VCT). The Simulator is capable of modelling a fleet of current and future aircraft around an airport, creating a noise map with integrated levels (classical acoustic metrics) for given scenarios.

The VCT adds impact and perception related indicators to the conventional noise maps. The awakening factor was chosen as first indicator for implementation that calculates additional awakenings per night when changing scenario configurations.

The VCT represents the interface with the end-user. It's here that it will be able to change, depending on the license type of the tool, the fleet composition, reorganization of flights, local insulation measures etc.

1. INTRODUCTION

The H2020 European Project ANIMA was launched with an objective (among others) to initiate Best Practices on the European level with regard to noise impact management. One way to enhance decision capabilities for local stake

holders is to provide them with a tool making it possible to predict and evaluate the noise and annoyance impact of air traffic scenarios. In that perspective a toolchain consisting of a Noise Reduction Solutions Simulator and a Virtual Community Tool (VCT) are developed.

In this paper, first the single event calculation toolchain is shortly presented. Then a more detailed description of the VCT specifications is given: the User interface, the scenario computation engine, the indicators.

DISCLAIMER: please note that all figures presented in the current paper are generated from fictitious air traffic, flight routes, demography etc. Therefore the reader is asked not to draw any conclusions from them! The sole purpose of them is to demonstrate the capabilities of the tool.

2. GENERATION OF AIRPORT DATABASES

In order for a user to evaluate scenarios around an airport and their impact in terms of noise and annoyance indicators, a lot of data regarding these scenarios are needed. First of all, an airport database needs to be generated. This airport database consists in a collection of footprints and emissions around the airport of all combinations of aircraft types, airport tracks and flight profiles. Each footprint represents the noise of a single flight operation in the airport, also called "single event".

The single event noise footprints are calculated by the SONDEO airport noise model, developed by Anotec. This model implements the latest version of ECAC Doc 29. It is based on the usage of Noise-Power-Distance (NPD) relations, available for each aircraft type to be simulated. For each flight segment of an aircraft operation the

corresponding noise level at a point on the ground is calculated by interpolation in the NPD at the corresponding Power and Distance.

Alongside the noise calculations, pollutant emissions can be predicted. These predictions (for each single event) are done with the SONDEO/EM model, developed by Anotec. This model incorporates various methodologies (ICAO LTO, Boeing FF2 method, etc.).

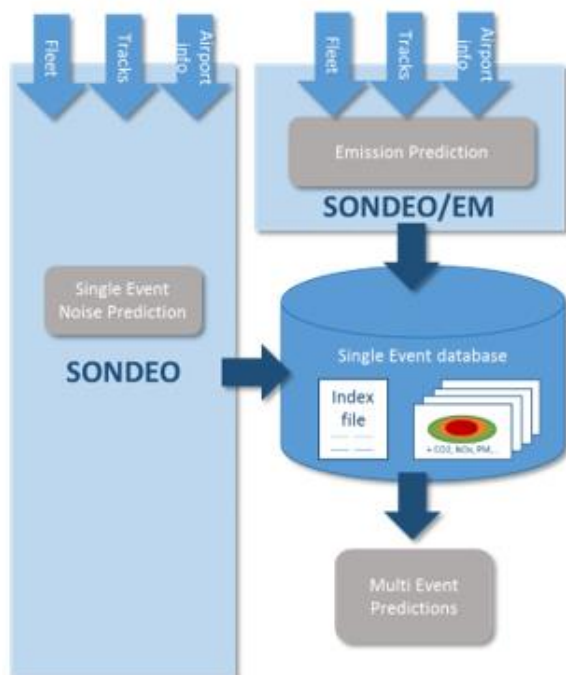


Figure 1. Single event calculation flow chart

The single event calculation toolchain (Figure 1) requires the following input:

- Fleet composition (aircraft/engine combinations to be considered in the scenarios)
- Ground tracks (based on SIDs and STARs to be considered)
- Flight profiles (mainly based on aircraft performance)
- Engine operating parameters (based on engine deck)
- Airport information (Runway details, elevation, meteorological conditions, etc.)

SONDEO is capable of inserting any kind of future aircraft type including for instance flying wings by generating new NPDs using a source based aircraft noise prediction program called SOPRANO also developed by Anotec. More about the prediction of new generation aircraft in ANIMA will be published in the future.

Finally, footprints are generated for a user defined grid around the runways, storing relevant information such as SEL and $L_{A,MAX}$. From these data the Noise Reduction Solutions Simulator (developed in the framework of ANIMA) is able to derive exposure maps (L_{Aeq} , L_{den} , ...) for a given scenario by using a so-called “Event Merger”, which mainly applies the appropriate weighting factor to each single event and calculates the total noise on the grid and the total emissions generated, corresponding to the operational state of the airport.

3. USER INTERFACE AND BASICS OF THE VIRTUAL COMMUNITY SOFTWARE

The calculated airport data is input to the Virtual Community Tool (VCT), which serves as the interface with the end-user. A first mock-up version (Matlab), was developed. It consists of two kinds of windows, each serving different purposes.

In the Main Window of the software (Figure 2) the airport’s flight schedules can be loaded and computational parameters can be set. The schedules may contain the flight traffic data of any time span (from a few days until a whole year for example). This allows to study short as well as long term effects of air traffic (a typical week, a critical renovation time period, a summer season, etc.). Through additional tabs in the Main Window, modifications can be made in a very simple and straightforward way to alter the original scenario. This allows to easily study new situations without the necessity from the user to create new flight schedules manually (e.g. with more flights or without certain aircraft types, etc.) Internally, the tool modifies the original flight schedule in a sophisticated way to match the modifications. All this is done with the originally calculated airport data. No new noise calculations are done.

Flight schedule lists, which enumerate aircraft with their type, take-off/landing time, used runway and star/sid, can be imported from Excel files. They and their modified counterparts can be saved into a proprietary file format (Matlab files) and can later be loaded back.

After loading one or more flight schedules (i.e. original scenarios) a separate Results Display Window (Figure 3) can be opened to each of the loaded scenarios to visualise various indicators (i.e. the awakening-indicator, L_{Aeq} , L_{den} , L_{night} , etc.) of the given scenario. The effect of the modifications in the Main Window on the actually visualised indicator can automatically be reflected in the Results Window.

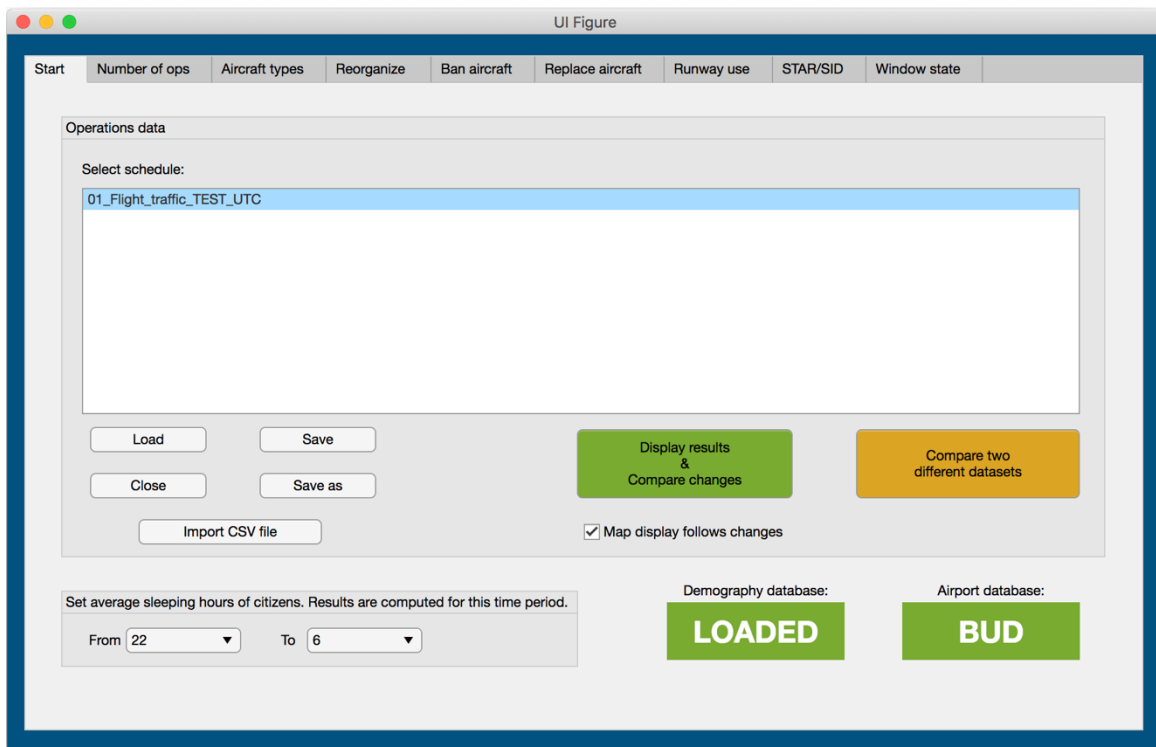


Figure 2 : Main Window

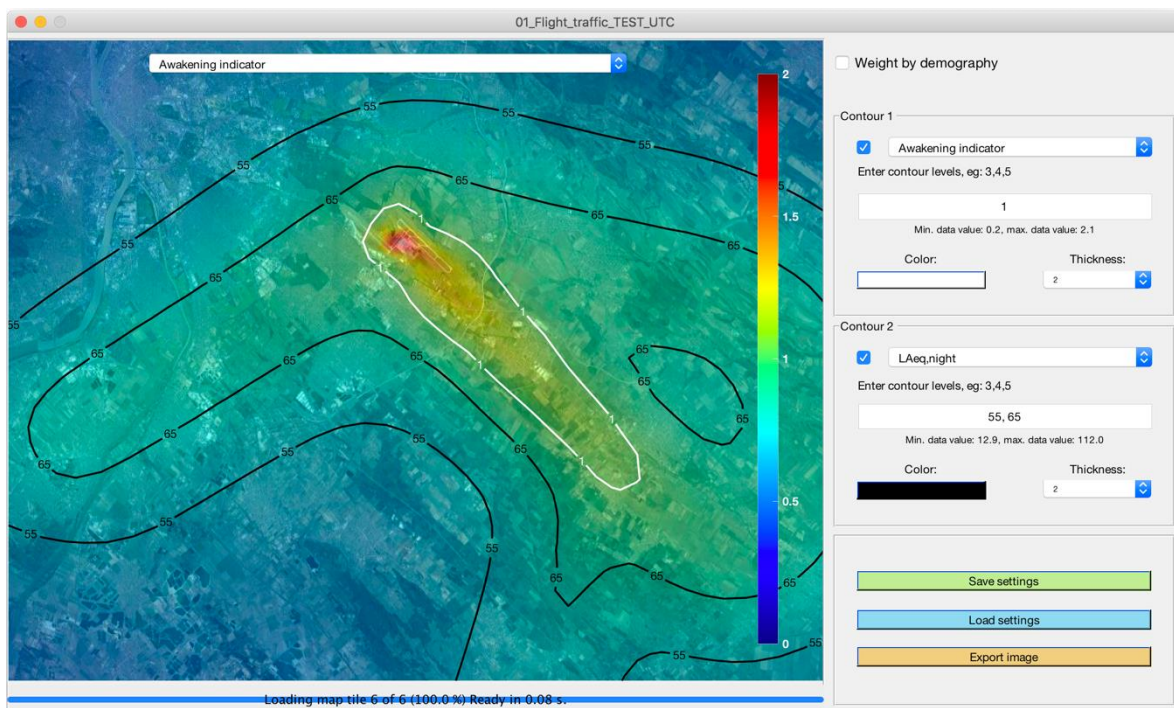


Figure 3 : Results Display Window

To be able to compare two e.g. significantly different scenarios, it is also possible to compare directly two loaded scenarios.

Presently two indicators and their demography-weighted versions are computed for the results display: the $L_{Aeq,night}$ equivalent sound pressure level, and the **awakening indicator**. The latter is a statistical sleep disturbance indicator and shows the probable number of additional awakenings per night caused by aircraft noise. The demography-weighted version of the above indicators is obtained by multiplying them with the number of people locally sleeping.

A key point for the awakening indicator is the indoor sound level caused by aircraft noise. To be able to translate outdoor levels provided in the airport database to indoor levels, at current stage of the development, 3 levels of building insulation quality can be specified for the airport area in a specific file. In the absence of this, the tool assumes medium sound insulation quality over the whole area. By means of this feature, areas, where noise insulation has been paid, can be realistically taken into account. Another use of this feature is to take into account area-dependent building quality (e.g. poorer or richer areas).

At the current stage, the development of the tool is focused on the awakening indicator and thus on night traffic. However it is intended to enrich the tool to cover also day-related features of the air traffic, but certainly not such indicators, which are already well elaborated in commercially available software, like INM.

An interesting feature is also the ability to take into account typical window state of residents (closed / open / tilted) at various seasons. (see Figure 4). Among others, this feature also gives airport residents the possibility to visualise what to expect, when their newly replaced sound insulating windows are most of the time open or tilted.

Back to the Results Display Window itself, it provides a number of tools for comparing the effects of modifications or comparing various scenarios. The results of the computations are overlaid as a transparent colour-coded layer over a satellite map centred around the selected airport. The data/indicator to be shown over the map can be selected in the popup menu near the top. A colorbar corresponding to the displayed values is shown on the right side. Naturally the map together with the overlaid data can be zoomed in/out as well

as be panned. Likewise, it is also possible to switch on two different kinds of contours, for example one for L_{night} and one for the awakening indicator. Color and line-width can be selected freely for the contours. Each contour marks the area(s) of a given indicator at specified levels. The user can enter as many levels as he wishes.

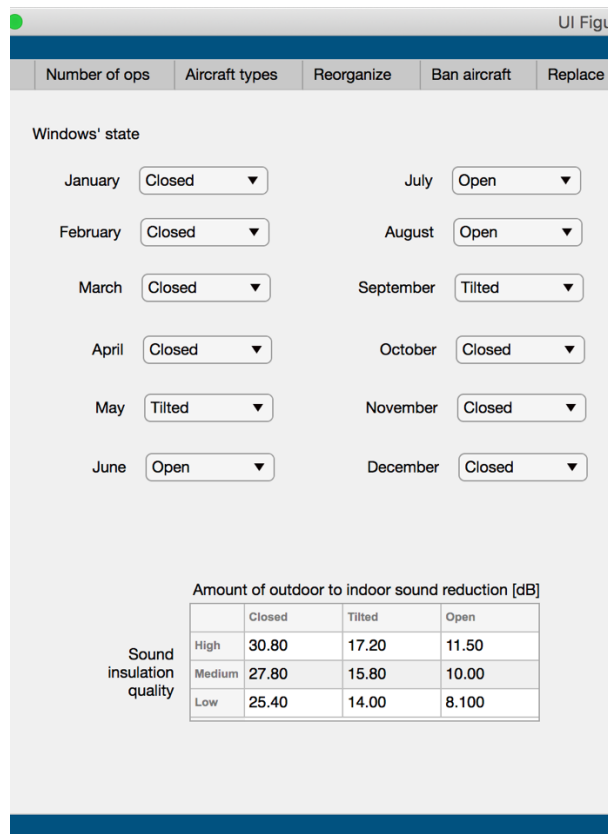


Figure 4: The Window state tab

4. SCENARIO-CHANGING FEATURES

The current mock-up version of the tool incorporates (or will soon incorporate) the following features making it possible to modify an original scenario:

- change the number of operations
- modify the percentage of aircraft types
- reorganise the hourly distribution of the flight traffic
- completely ban aircraft types
- replace aircraft types by other ones
- modify the hourly usage's percentage of runways
- redistribute traffic among STARs/SIDs

4.1. Change the number of operations

The number of operations is the most obvious parameter of an airport, which changes over time. With the aid of this tool, the user can easily

estimate how a situation will change e.g. when the number of operations will increase in the future.

Not only the total amount of operations can be changed, but also their distribution over the night hours can be set (see Figure 5).

4.2. Modify the percentage of aircraft types

With the appearing of a new airline at an airport for instance, the distribution/balance of aircraft types can significantly change. (For economic reasons, most operators prefer to use similar aircraft from the same vendor. E.g. Wizzair, one of the strongest airlines in Hungary, operates only Airbus A320s and A321s, all together 110 of them. They represent a heavy part of Budapest Airport's total operations.)

The tool lists all aircraft types and their share in the current flight-schedule list, and the user has the possibility to adjust their percentage (see Figure 6).

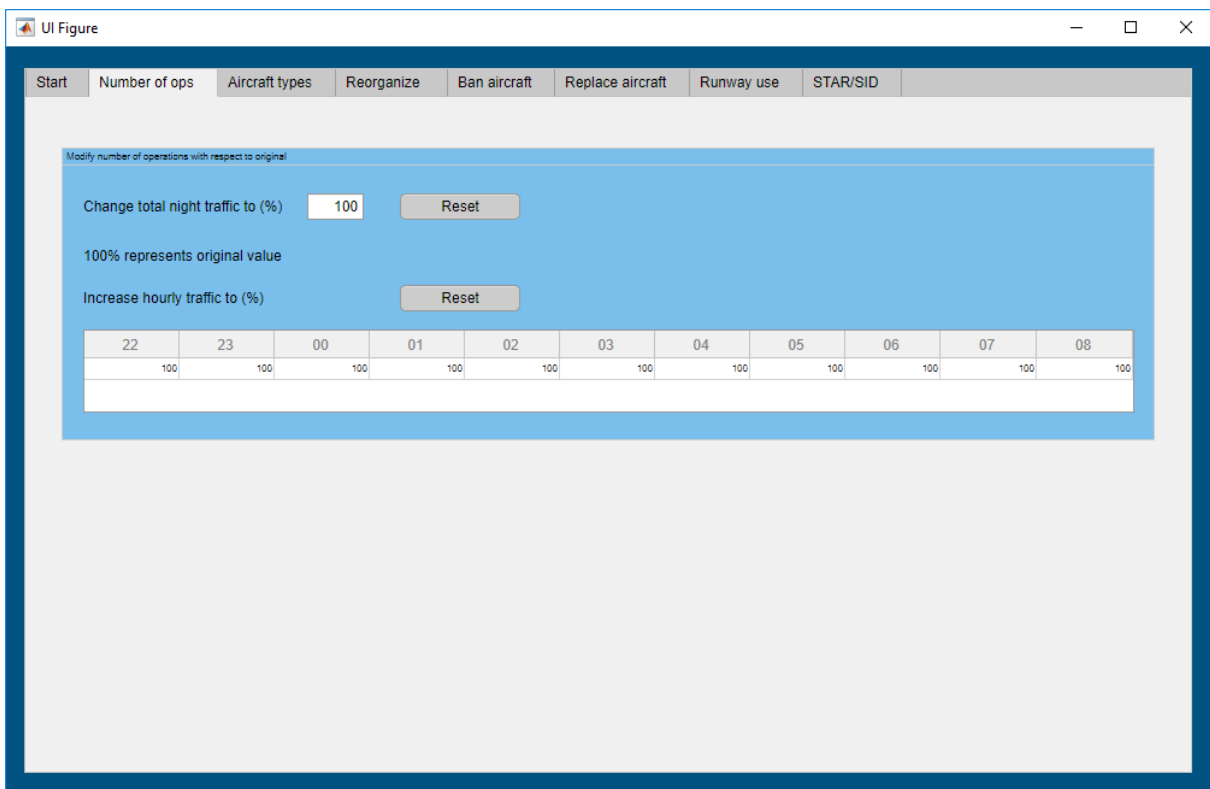


Figure 5: Number of operations tab

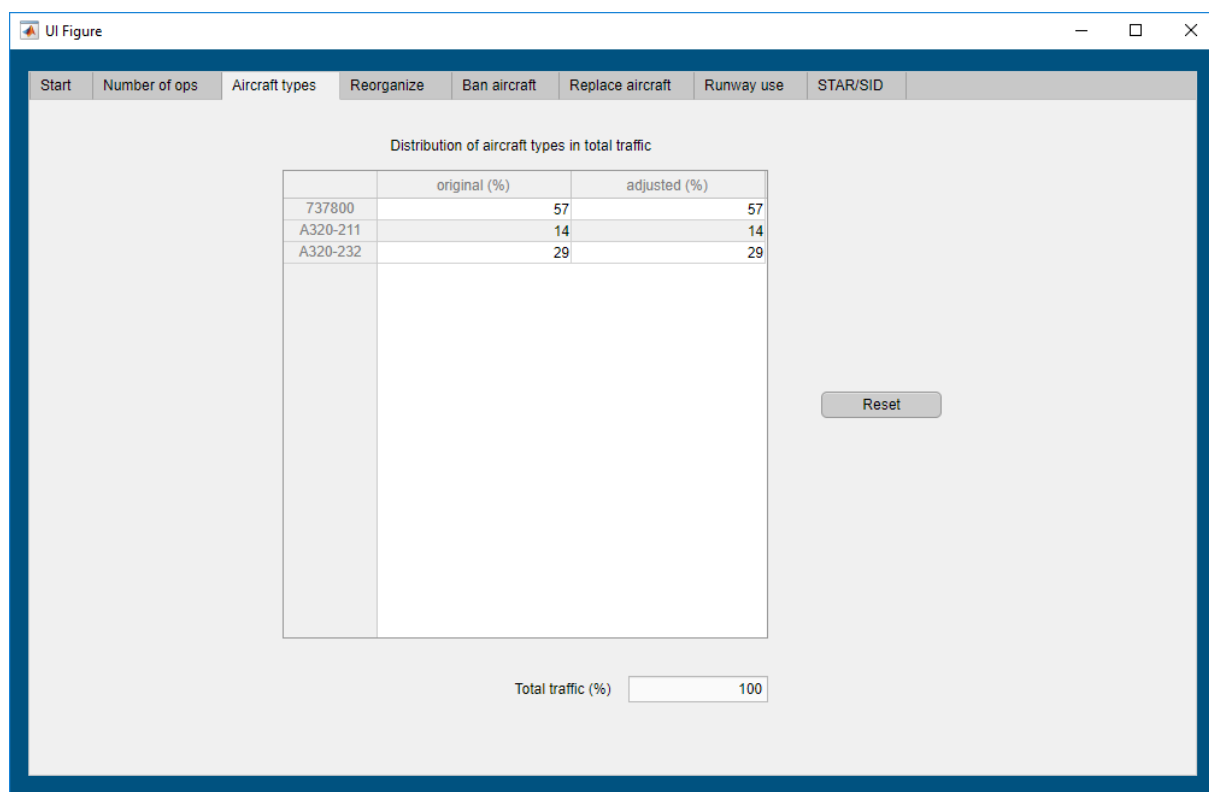


Figure 6 : Aircraft types tab

4.3. Reorganise the hourly distribution of the flight traffic

In the Reorganize tab (Figure 7) the user can reorganize the night time air traffic by moving flights from a given hour to another, later or earlier hour.

At the start the diagonal cells of the table (as shown in the figure) are populated with the average number of flights in the schedule for each hour. All other cells are zero.

The user can shift flights from a given hour to another by lowering (or setting to zero) a cell in the

diagonal and entering the change into (a) different column(s) in the same row.

To help keep the traffic volume the same, the original values and the sum of the modified values are displayed on the right side in the 'Orig' and 'Sum' fields respectively.

This is one of the most important features of the Virtual Community Tool since the sleep disturbance of the residents do depend on the time of the flight as opposed to the classical acoustical measures (e.g. $L_{Aeq,night}$), which are not influenced by the timing of the operations. This way the user can get a clear vision, for instance, how early morning flights degrade sleep quality of residents.

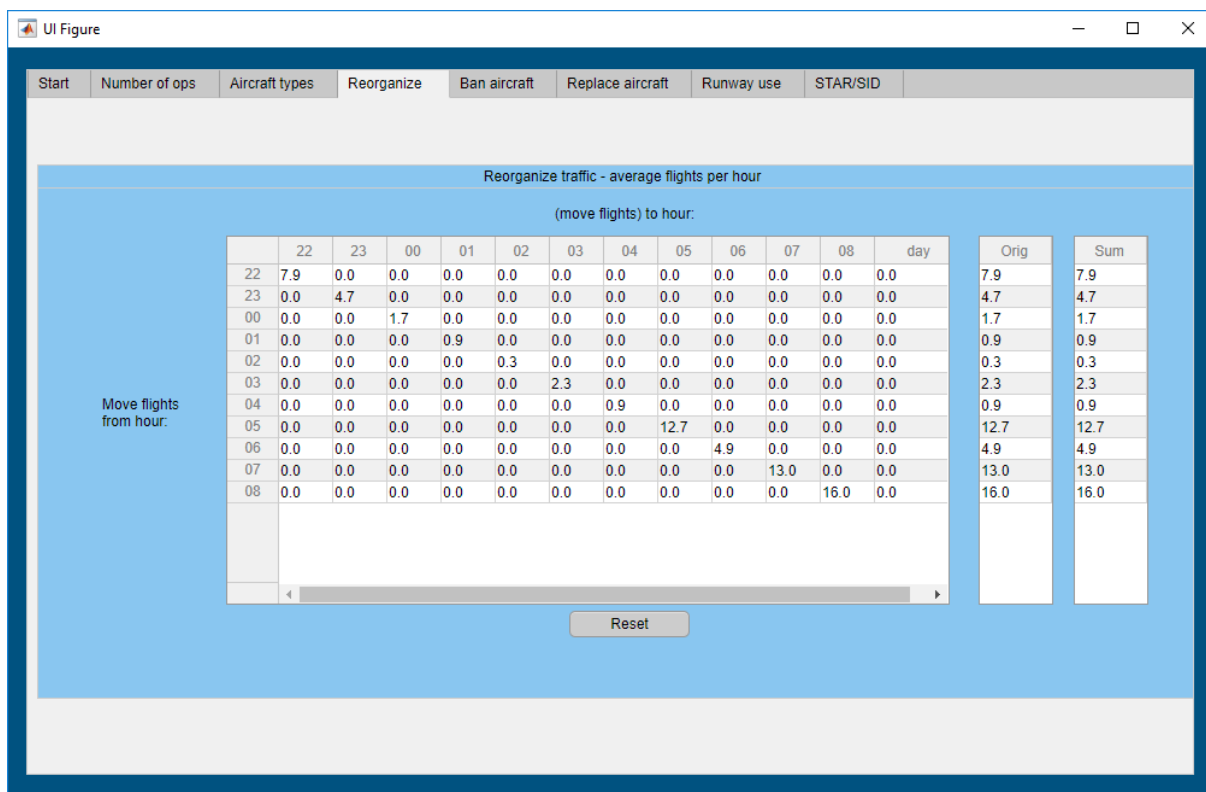


Figure 7 : Reorganize tab

4.4. Completely ban aircraft types

Airport operators know by experience and measurements that some aircraft are much noisier than others. The effect of banning an aircraft type from the airport can easily be investigated with the settings on the Ban aircraft tab (Figure 8).

The '**Allowed aircraft types**' field lists all the aircraft types of the selected schedule. A given type can be moved to '**Banned aircraft**' field by pressing the '**Ban aircraft**' button. Flight traffic data of the aircraft on the banned list will be disregarded during computations, as if those aircraft were simply not flying.

The aircraft can be moved back to the allowed list by pressing the '**Allow aircraft**' button.

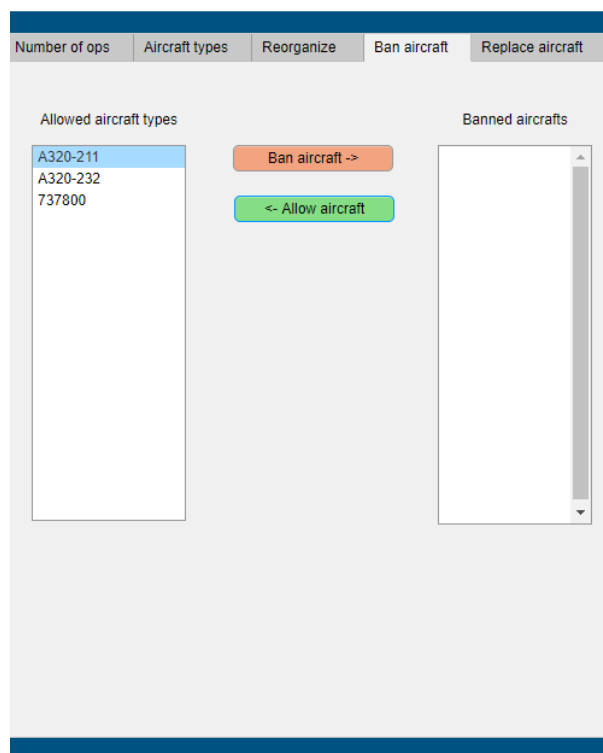


Figure 8 : Ban aircraft tab

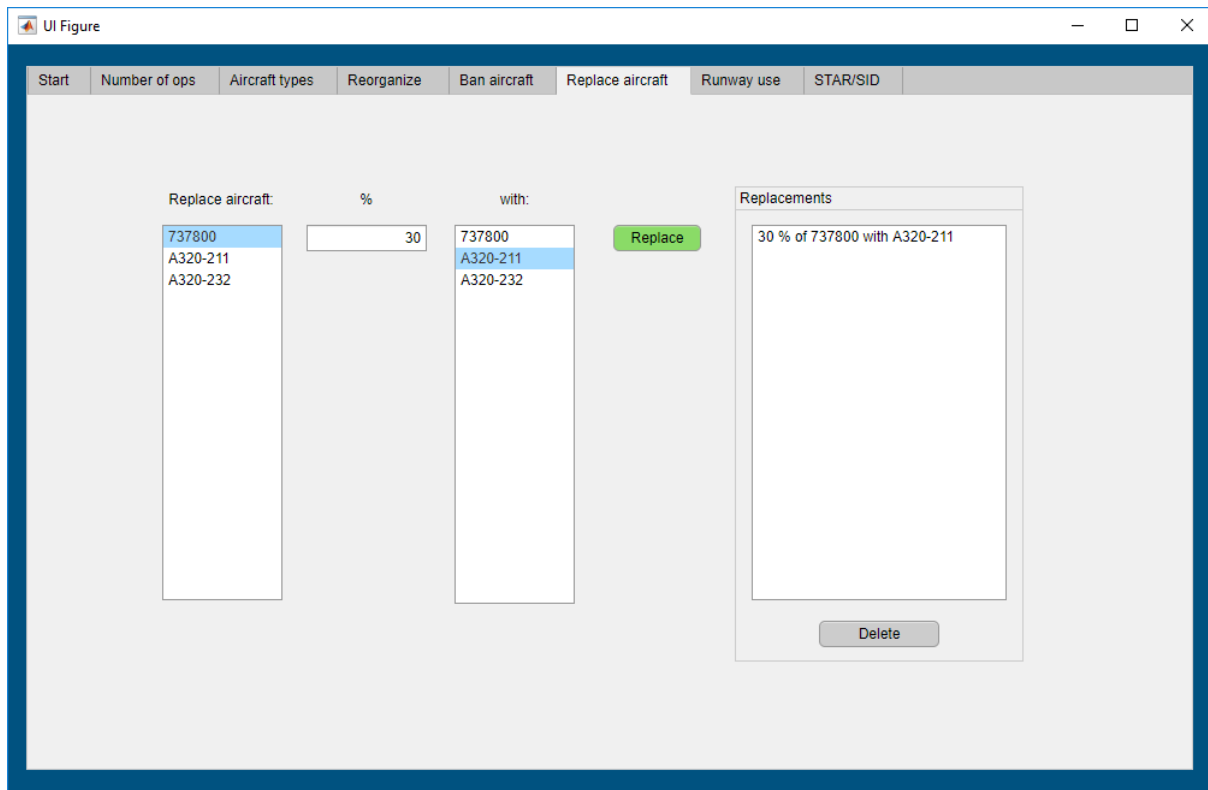


Figure 9 : Replace aircraft tab

4.5. Replace aircraft types

While the previous Ban aircraft tab simply makes the computations disregard a given aircraft type and the related flight data, on the Replace aircraft tab (Figure 9) the user has the possibility of replacing a given aircraft type by another. This tab allows, for example, studying the effect of newer aircraft (gradually) replacing older ones. In this case the flight traffic data is used in the computations but with the parameters of the other aircraft with which the given type was replaced.

Note, that a given aircraft type can be replaced with multiple other aircraft types.

4.6. Runway use (under development)

The runway use tab will provide the possibility to study the effect of shifting a certain amount of traffic from one runway to another (or others). The software will intelligently (internally) adjust the flight-routes and recalculate all indicators. Naturally this adjustment could be performed in hourly distribution.

4.7. Redistribute traffic among STARs/SIDs (under development)

This tab will allow the redistribution of flight routes. Similarly to the runways feature, the user will be able to shift flights from one route to one or more others. Here too, the software will intelligently (internally) adjust the runway usage (as far as possible) and will then recalculate all indicators.

5. CONCLUSIONS AND FUTURE WORK

In the frame of ANIMA, a toolchain is being developed, making it possible to calculate noise and noise related annoyance indicators around an airport for all types of traffic scenarios.

The main purpose of the mock-up version (presented in this paper) is to receive early feedback form potential end-users on the interface and functionalities of the VCT, based on which detailed specifications will be obtained for the final implementation in a web-based tool as part of the Noise Management Toolset, which will be available through the ANIMA Aviation Noise Community Platform. An example of a first prototype of this web-based tool is given in Figure 10.

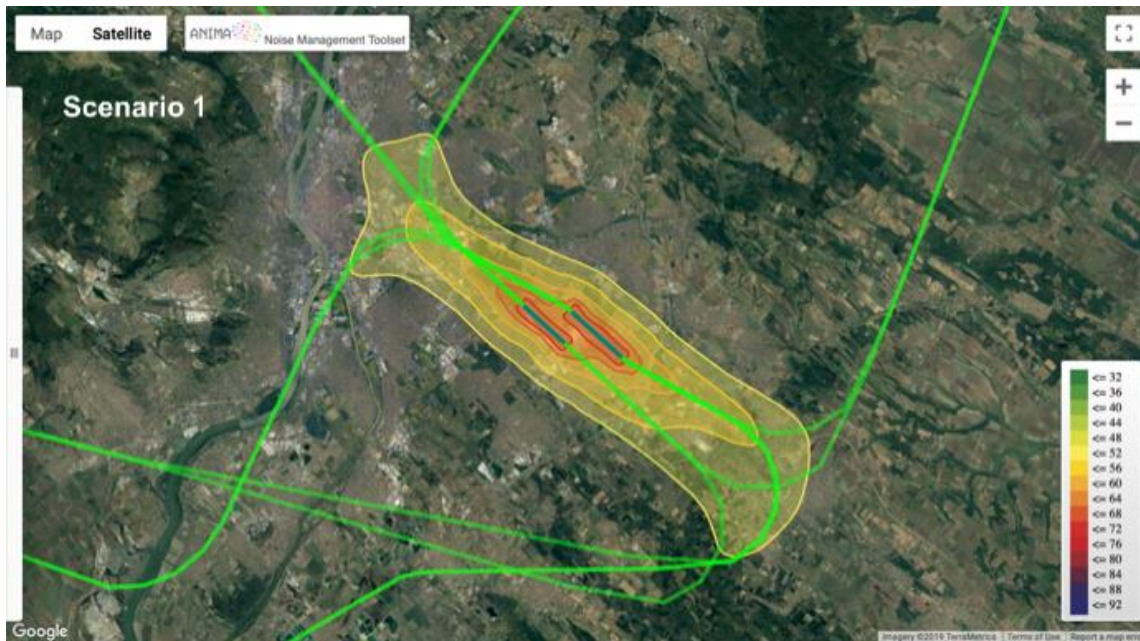


Figure 10. Example of web based tool

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