Ansökan för projekt:

**SAFT - Simulering av Atmosfär och Flygtrafik för en Tystare omvärld**
Summary

In the research project SAFT it is proposed to establish a computational platform which allows for the simulation of noise exposure on ground from air traffic, taking into account the complete chain: type of aircraft/engine, trajectory, aircraft-/engine condition, noise generation and sound propagation in the given weather condition.

Through future studies with the SAFT-tool it is anticipated that adequate means for noise mitigation could be identified. This could be through studies on existing aircraft/air traffic and procedures as well as on future engine/airframe technology or forecasted partly replaced aircraft fleet and their movements.

The SAFT tool is primarily intended to form a complement to today’s so called “integrated methods”, but will go far beyond those methods when it comes to functionality. Central differences between a “physics based” simulation tool like SAFT and an integrated tool is that the latter do not allow for a separation between the individual sound sources on an aircraft, it is neither able to separate the source at one hand, and the sound propagation on the other, and it do not include any frequency information. While integrated tools primarily focus on long term noise patterns, typically total yearly air traffic, simulation tools like the planned SAFT are far better suited for single-event studies of new procedures, new engines etc.

Another strength is the possibility to include local atmospheric/weather effects in sound predictions. This option can be used for finding patterns over longer time periods, but also for noise forecasts equivalent of today’s weather forecasts - that is, "Almost real-time forecasting" - which could be used for trajectory optimisation or as input for ATM decisions on runway use at larger airports with multiple runways.

The simulation tool SAFT will mainly consist of new computational code blocks and modules, but some existing programs will be used as well.
Description of work SAFT - Simulation of Atmosphere and air traffic For a quieter environment

Purpose and aims

The research project SAFT aims at the development of a computation and simulation tool for aircraft noise. The tool is intended to take into account all the elements in an aircraft type/engine and the operation of it, along with the atmospheric conditions (weather) at the time for the flight, which effects the resulting noise on ground (1).

SAFT may, as yet, be seen as a complement to the so-called "Integrated tools/methods", like INM (2) and ECAC Doc.29 (3), and as such a complement that goes beyond the capabilities of those. The integrated methods are, despite their well-known limitations such as dissolving effects of individual variations in flight operations and aircraft/engine design, able to fulfill their purpose to visualize and quantify noise exposure from an operational activity over longer periods of time (1 year) and to identify trends.

If the focus of planned studies instead are on noise effects of new approach and take-off procedures, new or modified aircraft engines or configurations, special or typical weather situations, the integrated methods have serious limitations. In these situations, one need to decouple the noise sources from the sound propagation, as well as separate the different noise sources (such as "jet noise", "fan noise" and "landing gear" etc.). Furthermore, one needs to resolve the frequency content, both in order to carry out the sound propagation accurate enough, but also to assess the degree of disturbance when the sound reaches receivers on the ground. The described type of studies could though be possible with the SAFT tool. SAFT could further on, also be used for noise forecasts like today's weather forecasts, or for noise calculations in almost real time, partly based on atmospheric data recorded by the aircraft themselves. Studies of the mentioned types could in turn be part of noise mitigation studies, studies related to construction of new runways (including a partly replaced aircraft fleet), building of new residential areas in the vicinity of airports etc.

Moreover, by establishing a “physics based” simulation platform like SAFT we also aim to support Swedish aircraft noise research in the long term by providing a framework in which successful research in the field and newly developed techniques can be implemented and utilized.

Simulation tools – background and survey of the field

Integrated methods and input data versus simulation methods

When "integrated tools" were introduced for noise mapping in the 80s (first INM version came in 1978, first ECAC Doc.29 published in 1986, was initiated in 1982) one had to restrict computational complexity and data amounts in every possible way due to the limited computer performance and data capacity at that time. The methodology, which is based on reduced/integrated source and sound propagation data, was developed according to this situation. Databases, linked to aircraft certification measurements, well suited to the integrated methods and giving “just enough” information for those, were established (today found in the ANP - Aircraft Noise and Performance - database with the NPD - Noise Power Distance - data). This situation, including the relative ease with which calculations may be carried out, probably pawed the way for this common and transparent way to handle aircraft noise estimations for airports – today often linked with regulations. Though, as a side-effect, it may also have contributed to the current monopoly-like situation, with an understandable unwillingness to change and complicate the governing situation, which in turn reduces the possibilities for simulation-tools to be developed. A natural reason behind the rather limited availability of more detailed noise data within
open sources is of course also the reluctance to disclose commercial secrets within the aviation industry, probably most pronounced among engine manufacturers. Despite this, reversed engineering together with open sources data tend to be sufficient to accomplish most needs for a simulation tool today.

In this context it is interesting to note that in ECAC Doc.29 from 2005 it is expressed that simulation methods in the future may be used not only as a research tools, but also as replacements for integrated approaches:

a) "**integrated models represent current best practice**“ [referring to longtime averages] and
b) “**This situation** [i.e., that simulation methods is also used for long-term noise mapping] **may change at some point in the future:** 'simulation' models have greater potential and it is only a shortage of the comprehensive data they Require, and their higher demands on computing capacity, that presently restrict them to special applications (including research).”

Great efforts with regard to "simulation tools" of the type we outline here, were put in already in the late 70's and early 80's at NASA in the calculation tool ANOPP (4). Several other national approaches in the same spirit have been added to the list of simulation tools since then. But, it is only in recent years, when the computing and storage capacity do not any longer constitute a real obstacle, we have seen a broader and more intensive development of this kind of codes. Among these initiatives are: A renewed effort put into an ANOPP2 (5) and the commercial code SOPRANO from the company Anotec in Spain. This last code was recently used in the Clean Sky project ARMONEA (6). ONERA and NLR have attached great importance to reproduction and synthesizing of sound from noise events/air passages in their codes CARMEN (7) and VCNS (8) respectively. University of Manchester seems to have come a long way with their code FLIGHT (9) as well as DLR with their PANAMA (10). The Swiss research institute EMPA has previously developed the code FLULA (11) - which involved estimated frequency- and directivity dependent noise sources for different types of aircraft - and has now taken the step of individually separated noise sources including weather effects in their new code SONAIR (12).

In the table below we show our view on differences between Simulation- and Integrated methods respectively.

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<thead>
<tr>
<th>Typical application</th>
<th>Simulation tools</th>
<th>Integrated tools</th>
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<tr>
<td>Sound source</td>
<td>Separated from propagation</td>
<td>Merged with propagation</td>
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<td></td>
<td>Semi-empirical, physics-based</td>
<td>Measured</td>
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<td>Frequency and space resolved</td>
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<td>Source data availability</td>
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<td>Very good OASPL data found in the open ANP-database (Noise-Power-Distance, NPD-data)</td>
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<tr>
<td>Sound propagation</td>
<td>Yes - separated from sound source</td>
<td>No - not separated from source</td>
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<td>Studies of noise abatement flight procedures</td>
<td>Yes - Possible to simulate</td>
<td>No - or very limited possibilities</td>
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<td>Time history for noise events</td>
<td>Yes - Possible to simulate (as well as listening tests based on these)</td>
<td>No – not possible to extract</td>
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<td>Atmosphere impact</td>
<td>Yes - Possible to include</td>
<td>No - not included (ANP/NPD data established under certain “standard atm. conditions”)</td>
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<td>New technology studies</td>
<td>Yes – possible to simulate new aircraft or engine concepts</td>
<td>No – not possible to include</td>
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<td>Computational time</td>
<td>Computationally more “heavy”</td>
<td>Computationally fast</td>
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**Table 1. Summary of Simulation versus Integrated tools pros and cons.**
Trends in air traffic and aircraft noise situation

A look at trends in Swedish (as well as European and global) air traffic compared with the expected achievements for the noise reduction through new aircraft technology imply a strong need also for alternative noise measures. Over a time span of more than 50 years, we have experienced a substantially increased air traffic. This increase is judged to continue in the foreseeable future.

Figure 1. N. of flight passengers in Sweden 1974-2014

The Swedish Transport Administration predicts a growth of about 3.5% per year (13) and the government agency Transport Analysis (14) presented the statistics shown in Figure 1 above. Though, a relieving effect with regard to the trend of noise exposure has been the renewed aircraft fleet. In Germany, for example, the number of passengers has increased by 168% between 1991 and 2014, but the number of flight movements only by 57% (15) due to the partly exchanged of fleet – in general equipped with more silent technology. Figure 2 (from 2010) we see the forecasted “reduction of noise at the source” and that the expected dB-gain tend to flatten out without technological breakthroughs¹ (16), (17). With a lifecycle of a typical aircraft of 20 years or more it would take quite some time to reach a significant alleviation compared with today’s situation even with “revolutionary technologies”. In order to have the chance to achieve more noise reduction than what we can expect from “Reduction of Noise at the source”, i.e. the first of four principal ways to assess noise reduction in ICAO’s so called “Balanced Approach” stated in 2001 (18), we need to focus strongly on the third way of the “Balanced Approach” as well. See Figure 3 below.

Figure 2. X3-noise - Aims for reduction at source

Figure 3. ICAO’s Balanced Approach (19)

1 Up to now we may interpret the Pratt & Whitney PW1000G-series as the one and only breakthrough of this kind. Comparing Airbus A320 certification data for the A320neo equipped with PW1127G-JM with other lately produced aero engines, reveal a mean gain of around 3 dB EPNL in each certification point – ca 4.5 dB in lateral point, and around 2-2.5 dB in flyover and approach points (i.e. at least a step of ca 3 dB compared with the ACARE-goals of 10 dB).
Project description

Outline research plan and methods

The SAFT project will stretch over several disciplines and functional blocks. With this situation follows that the overall data flow, and the interfaces between the blocks, has an equally important role as the individual functional blocks themselves. In order to identify eventual gaps and shortcomings in the draft plans an “upside-down” approach will be taken in the sense that the initial goal will be to establish a “beta draft tool” with focus on the dataflow through the complete chain, trajectory to noise map, but with rather low initial demands on accuracy in the individual blocks or for the entire system. The draft SAFT architecture is outlined in Figure 4 and Figure 5 below. First the work packages (WP)/functional blocks together with the related foreseen input and output flow in Figure 4:

![Figure 4. Overview functional blocks + input/output](image)

Next, before going to the presentations of approach for the individual functional blocks/WP’s, an overview of the preliminary tools/methods these different parts will rely on, is shown in Figure 5 below. Methods are shown in dashed blue boxes, - , and the related modulefunctional block are also here shown in blue solid line boxes -:

![Figure 5. Overview functional blocks + respective supporting methods/tools](image)
The project is planned to last for 2 years and will be a cooperation between KTH-MWL (Marcus Wallenberg Laboratory for Sound and Vibration) and CTH Turbomachinery and Aeroacoustics. KTH-MWL is project leader and as indicated in Figure 4 the CTH responsibility is offset towards flight/engine systems while the KTH responsibility is more directed to noise related matters, though both partners are involved in the complete computational chain.

As one of the initial steps in SAFT an existing aircraft type, representative for operations at the main Swedish airports, will be selected. This in order to be a test-case and the first aircraft/engine combination to be fully modelled in SAFT. This choice of aircraft will fall either on some model from the Boeing737NG series or on an Airbus A321.

It should be noted that during this 2 year development phase of SAFT there will be no extra effort spent on establishment of a catalogue or database of several aircraft models able to run. Such actions are foreseen to be taken in combination with future studies with SAFT where a step by step extension of the number of aircraft/engine models can be foreseen. Expected during this 2 year project is to stay at one, or at the most, a few aircraft models.

The principle of "Noise Forecasts" that is planned to be realizable with SAFT have its roots in a shooting noise tool based on ray tracing that employees at KTH-MWL have developed for FMV and the Swedish Armed Forces. This tool is today used on a daily bases at two of Sweden's largest military shooting ranges (20).

**Flight operations and Study input – Work Package 1**

**Responsible: KTH**
Duration: 6 months  Man months: KTH 2, CTH 1

In this initial functional block the user of SAFT is to decide the general input for the computation:

1. Which aircraft model is to be studied (A321/V2500, ...)
2. The flight mission and type of operation is defined at a high level.

At least two different paths for the input and data flow down to sound source input can be foreseen here:

a) Trajectory input to manually given by the user.
   E.g. take off, approach, landing, - or only a short section or one trajectory point of one of these - landing gear in or out, curved flight, ... etc. Could include exact or approximate trajectory coordinates (x,y,z in a Cartesian coordinate system or latitude, longitude and altitude).

b) Trajectory – coordinates + detailed flight condition data – given by FDR data

3. **Type of computation and wanted output (draft choices below)**
   a. Refractive atmosphere/non-refractive (straight rays)
   b. Wanted output and metric(s):
      i. Noise map (grid) or limited receiving points (time record)
      ii. Noise maps of $L_{A_{max}}$ only (time records not computed)
      iii. Noise maps of $L_{A_{max}}$, SEL, EPNL, ...
      iv. Population within noise bands [implementation subject to the available time and resources]
      v. (to be defined) ...

4. **Ground receiving grid**
   a. Resolution and extension
   b. Receiver height

5. **Meteorological input**
a. From standard/sample library without TKE\(^2\) (choice for non-refractive atm.)
b. From standard/sample library with TKE (choice for refractive atm.)
c. From FDR-data (choice for non-refractive atm.)
d. (to be defined: from balloon sounding or else …)

6. Static data use
   a. Ground – hard ground/ground type classification and impedance model
   b. Population model [implementation subject to the available time and resources]

Essential support to the specification of the SAFT-tool needs and requirements will be given by Novair (Henrik Ekstrand). Contribution will be given as well from the KTH initiated CSA applications Brantare (21) and ULLA (22).

Flight mechanics & Engine conditions – Work Package 2

Responsible: CTH
Duration: 18 months
Man months: CTH 6.5

The scope of this work package is to take the input from work package 1, “Flight operations and study input”, trajectory input specifications through a number of modelling steps:

1. For a given engine architecture and modelling definition predict engine performance for a number of operating points.
2. Assess the combined engine and aircraft performance allowing to establish the necessary input for computing the noise sources to be specified under work package 3.

Engine modelling

To develop characteristics for a selected engine a number of generic steps can be isolated:

- Collect public data of engine. This can correspond to data released by the engine manufacturer (23). For instance the engine architecture (two spool/three spool/geared), and performance data such as thrust and SFC in cruise and take-off conditions.
- Estimates on the technology level available at the time of the engine entry into service will have to be defined. This entails defining turbomachinery efficiencies, material capabilities and metallurgical limits, cooling technology, aerodynamic design limits.
- Complement the technology estimates with data made available in engine certification tests (if the engine is an existing engine and not a future concept)
- Implement compiled data to model the engine in a 1D engine performance tool (a schematic of typical turbofan model is presented in Figure 6 for demonstration purpose only). Here, the Chalmers in-house tool GESTPAN (GEneral Stationary and Transient Propulsion ANalysis) (24) will be used to acquire thermodynamic cycle performance data corresponding to the selected engine model. The GESTPAN tools has been developed over the last two decades in a number of national and EU research programmes.
- To match the engine with the available data (collected through public domain) the model has to be executed both in design (frequently top of climb operating point) and a number of off-design points (take-off, cutback, cruise, approach, ground idle, top of descent etc.). To set up a reliable and accurate model it is usually quite important to balance input from a number of sources and operating conditions.
- Interact with aircraft model either linked or through tabulated data based on stand-alone simulations.

\(^2\) Turbulent Kinetic Energy – needed input for sound-shadow propagation model, computed and given in e.g. SMHI-forecast data
• Use thrust input from aircraft modelling and performance model together with a conceptual engine design to establish necessary data needed for noise modelling. This frequently requires resolving flows in the engine to define local flow speeds such as Mach numbers and blade speeds of turbomachinery components. Jet velocities and turbomachinery blade speeds.

**Figure 6. Illustration of a typical Turbofan component model schematic**

**Aircraft modelling**

• Collect weight and geometric data of aircraft configuration to establish the aircraft performance in a number of mission segments defining lift and drag estimates as dependent on the current configuration of the vehicle (clean, flaps settings, landing gear down etc.)

• Use “Flight operations and study input“- data from work package 1 to define the trajectory simulations.

• Use tabulated engine data or linked aircraft engine configurations to perform simulations generating the input for evaluating the noise sources.

WP2 output supporting M1: Demonstrate an initial coupled A321 /V2500 aircraft engine modeling environment, providing necessary input for evaluating the noise sources in WP3. This milestone targets an initial evaluation for an approach condition.

WP2 output supporting M2: Validated A321/V2500 modeling providing necessary input for noise sources in WP3 covering all significant flight phases of a typical mission.

Here Novair (Henrik Ekstrand) is planned to be a contributor of input FDR-data.

**Sound sources – Work Package 3**

Responsible: CTH  Duration: 18 months  Man months: CTH 6.5, KTH 2

Our approach here is to start out from the set of semi-empirical noise sources given in different ANOPP references (25) and prepare for future step-by-step implementations of new or further developed noise-source models found in the literature. This holds for engine related noise sources as well as for airframe noise sources. An upper level architectural representation of the intended integrated aircraft-engine system level source model is presented in Figure 6 respectively.
The selected aircraft and engine configuration (defined in WP1) will be modelled, operating under representative operational conditions (defined in WP1/FDR data).

The sound pressure level corresponding to various aircraft and engine component level (Fan, compressor, combustor, turbine, jet, landing gear, airframe, etc.) will be derived and verified with trends acquired based on the theory.

All noise sources will have directivity resolved in lateral and longitudinal direction as well as in frequency and time. The frequency resolution will be in 1/3-octaves and the span 50 Hz – 10 kHz. For narrow band (tonal) sources, e.g. parts of fan noise, special handling has to be facilitated throughout the computational platform.

Furthermore, the model will be deployed to make total noise level predictions (Effective Perceived Noise Level - EPNL) corresponding to the three certification points (Lateral, Flyover and approach defined by ICAO) and the acquired predictions will be benchmarked against the noise level measurements provided by the ICAO data.

The WP3 output will support the detailed sound propagation studies that will be carried out in WP4.

Figure 7. An upper level architectural representation of the intended integrated aircraft-engine system level source model

For the validation of sound sources FDR-data is planned to be used together with time correlated sound measurement data. The FDR-data is to be delivered by Novair (Henrik Ekstrand) while measured noise data will come from ULLA.

Sound propagation – Work package 4

Responsible: KTH  
Duration: 18 months  
Man months: KTH 10

Based on the pre-study SAFT (1) the first choice of sound propagation method to select, further develop and fit to the specific needs for air traffic, will be of the ray-tracing type (26). Field methods, such as PE-based ones, might as well be used, but probably more for validation purposes than to be run by the end user of the SAFT-code (27). The main reasons for this preliminary decision are: a) the relative simplicity to couple a ray-tracing algorithm to a directive and frequency dependent source; b) the computational speed and c) the possibility to apply an (semi-empirical) analytical approach for refraction/diffraction of sound energy into acoustic-shadow zones (28), (29).
The strong demands on computational efficiency are based on several factors:
- Relatively high spatial, time- and frequency resolution are needed for the source.
- The same holds for the receiving grids, especially if integrated noise metrics or time records are required over dense/large grid areas for long lasting missions/trajectory with a short time steps.

Some preliminary proposed ways to reduce computational time have been considered:
- Differentiated complexity/accuracy linked with user input:
  o *straight rays* - only humidity/dissipation effects final noise levels beside the geometric loss of sound energy (spherical propagation)
  o Medium: noise metric $L_{A_{\text{max}}}$ chosen - no data but max levels has to be saved between time steps - *ray-tracing (refractive propagation)* 2D computational planes radially out from current aircraft/source position, random ground-hits for rays. Interpolation of levels to final $L_{A_{\text{max}}}$ noise map.
  o Full: for noise mapping of integrated noise metrics or (primary) time-records in all receiving/grid points – *ray-tracing eigen-ray solver*, individual 2D computational planes for each receiving point. Iteration start values rom previous trajectory/receiving point combination.
- Resampling to coarser trajectory time records and interpolation of noise levels between those.
- Limiting noise-event time extension in grid points (-10 dB estimate) before start of computation.
- Multi-processor parallelisation of computations

![Figure 8. Example noise map produced with pre-study SAFT tool.](image8)

![Figure 9. Ex. trajectories, CDA (green), “Standard” (blue) altitude – both scaled a factor 10 in altitude, together with sample grid.](image9)

**Noise mapping (+ sound synthesis) – Work Package 5**

Responsible: KTH  
Duration: 18 months  
Man months: KTH 10

In the SAFT pre-study draft methods for noise mapping and results presentation was surveyed. Based on the study it was decided to select the Google Earth (GE) as the primary output GUI, and the GE kml-file format. This choice has the advantages of full 3D-presentation of trajectories together with noise maps as well as a possibility to simple dissemination of results. A risk here is that GE in the future goes from freeware to strictly commercial software.
The noise mapping is closely linked with the ground-grid meshing. A partly automatic gridding method is planned to be developed. Based on trajectory ground tracks a “grid-ground” track, solely built up by straight lines and circular segments, is established. The idea is that the user give as input the desired width and resolution beneath one or more trajectory points. Curved grid sections keep a constant width and resolution while the straight sections might be given a conical shape, widening with increased trajectory altitude.

In this planned part of the SAFT development it will be possible to save and post-process noise spectra as well as noise events saved as time records. I.e. the code will be prepared to facilitate noise synthetisation in the sense that needed basic data could be produced but no attempt to re-sample the time-records and adding eventual tonal components for listening tests will be taken during this project.

System architecture/interfaces, In- and Output data, Testing of complete chain - Work Package 6
Responsible: KTH Duration: 24 months Man months: KTH 4

The general outline of code blocks and supporting programs is shown in Figure 5. This work package is intended to ensure that: 1) the planned division into different blocks is sufficient or if it should be modified; 2) different parts of the tool can communicate with each other, and 3) whether the need for support tools and requirements for data transfers between the blocks can be met.

The basic program language for established new code blocks and interfaces will be Matlab. Already existing code-blocks, written in other languages and going to be a part of main-program SAFT, will be capsuled as mex-files. Where this step is not found applicable the needed code block has to stay as a separate supporting program outside main-SAFT code (or translated to Matlab if found possible).

Experiences from a previous establishment of a noise forecasting system (weather dependent artillery noise) will be exploited here.

For input data the following sub-sections holds that they all involves:
- specification of data needs, type and format
- identification of sources of these data
- acquisition of data and finally
- programming of computer routines to read and process these data

FDR-data – cont. Work Package 6

When it comes to input data a crucial point is FDR-data. This work package is about ensuring that FDR-data is made available. Specification of wanted data, request for enough and correct data as well as analysis and application of FDR-data.

FDR-data acquisition is planned to be the responsibility of SAFT’s sister project Brantare, see ref. (21). The FDR-data itself is to be delivered by Novair (Henrik Ekstrand).

Meteorological data – cont. Work Package 6

Preliminary data, possibilities and limitations for the different sources of atmospheric data:
- SMHI: HIRLAM or AROME model based data (30). Data needed in the development phase of SAFT, covered by this proposal, is supposed to be handled by the sister project ULLA (22).
  o The project group have good experiences of implementing HIRLAM and other meteorological data in noise propagation models
Before end of year 1 of the project a decision with regard to establishment of special local meteorological models has to be taken, a need or an option? If regarded a need subcontracting will be actualised
- FDR data – limitations/possibilities with regard to meteorology data (see FDR-data above).
- Sounding – balloon or SODAR possibilities?

During the first year of the project it is planned to use sample meteorological data already at hand at KTH.

Other non-flight system data – cont. Work Package 6

Preliminary data and preliminary data resources options.
- Topography data, “Lantmäteriet” 50 m grid resolution - free
- Ground type data (to be used as input to ground acoustic impedance models) - free
- Population distribution data, free data exist but for more detailed data this will involve an extra cost.

Testing of complete chain – cont. Work Package 6

This part involves a validation of the complete chain – including testing against measurements and FDR-data anticipated in proposed CSA sister projects ULLA (“Undersökningar medelst Ljudmätningar vid Landningar på Arlanda”) and Brantare respectively.

Project management and time planning - Work Package 7

Responsible: KTH  Duration: 24 months  Man months: 2

Gant-chart and man months distribution

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<td>total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Time table and man months

Deliverables: Month12 – Half-time progress report
Month24 – Final report

The reports will be public and presented at seminars as well as at conferences.

Milestones: Month 12:  Alpha versions of SAFT modules as of WP1 to WP5 able to run individually and together
Responsible: CTH module 1 to 3, KTH module 4 to 5 and combined 1 to 5

Month 24: 1st version of SAFT. Modules as of WP1 to WP5 able to run individually and together. SAFT will be available for all CSA partners as well as CTH.

Responsible: CTH module 1 to 3, KTH module 4 to 5 and combined 1 to 5

Co-operation with other KTH applications

The CSA vision is to establish a world leading Swedish research on air traffic management that enables environmental impacts in particular noise to be minimized. In order to contribute to this the KTH partner in the centre has taken the initiative to four interrelated but still independent projects (SAFT, ULLA, Brantare and INFRA). Each of these projects contribute important parts to the centre vision and their relations with SAFT are described below.

ULLA — “Undersökningar medelst Ljudmätningar vid Landningar på Arlanda”

SAFT will support design of the planned measurements, and vice versa with regard to measurements carried out, which results will be applied for noise source model validations.

Brantare

Beta-versions of SAFT will be applied for studies within Brantare while Brantare will support SAFT with FDR-data and knowledge of system aspects such as operational routines and deviations as well as aircraft configurational issues.

INFRA

While SAFT will have a two-way interaction and exchange with the projects ULLA and Brantare the interaction with INFRA will be mainly one-way, i.e., as a new tool the impact and use of which should be analysed in INFRA (31).

![Diagram](image)

Figure 10. Interdependencies among the four KTH applications.

Project reference group

This group will be set up during the first 3 months of the project. The purpose is to get feedback from potential users of SAFT and to link to related research for instance in EU.
References


Bilaga B

**Budget SAFT**

The project duration is 24 months with a planned start date July 1st 2016.

<table>
<thead>
<tr>
<th>Staff</th>
<th>Role</th>
<th>Man-months</th>
<th>Cost (SEK)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>KTH</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mats Åbom</td>
<td>Project leader</td>
<td>2</td>
<td>400.000</td>
</tr>
<tr>
<td>Ulf Tengzelius</td>
<td>Leader WP 1,4,5,6</td>
<td>24</td>
<td>3.400.000</td>
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<tr>
<td>Ilkka Karasalo</td>
<td>Researcher WP 4,5,6</td>
<td>4</td>
<td>630.000</td>
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<td><strong>CTH</strong></td>
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</tr>
<tr>
<td>Tomas Grönstedt</td>
<td>Leader WP 2+3</td>
<td>2</td>
<td>400.000</td>
</tr>
<tr>
<td>Fakhre Ali</td>
<td>Researcher WP 1,2,3</td>
<td>12</td>
<td>1.100.000</td>
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<tr>
<td>Travel</td>
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<td>30.000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>5.960.000</strong></td>
</tr>
</tbody>
</table>

The costs are based on the actual salaries (2016) for the involved persons including social taxes and the university overheads. The travel is to cover trips (train) between Stockholm and Göteborg for the project personnel during 2 years.

The cost for the two PI:s (professors) involved Mats Åbom, KTH and Tomas Grönstedt, CTH will be considered in-kind from KTH and CTH. **The total amount applied for is therefore: 5.160.000 kr.**

Based on the total number of man-months 44 this cost corresponds to **a project cost of 1.407.000 kr per man-year.**
Bilaga C   CV:s

KTH:

Name: Mats Åbom   540606

Current Positions
Title/position at employer
Professor in Fluid Acoustics, KTH-The Marcus Wallenberg Laboratory for Sound and Vibration Research.

Role in the project: Project leader (PI)

Experiences

1990-1995   Company/Employer – Position/title
Assistant Professor (Forskarassistent), Dept. of Technical Acoustics, KTH

1995-1996   Company/Employer – Position/title
Senior researcher “Docent”, The Marcus Wallenberg Laboratory for Sound and Vibration Research (MWL), KTH

ABB Corporate Research, Västerås, Sweden. Specialist and main project leader for acoustic related projects.

2000-       Company/Employer – Position/title
Professor in Fluid Acoustics, KTH from September 1:st 2000.

Head of the Marcus Wallenberg Laboratory for Sound and Vibration Research, KTH.

2011-2017   Vice-Director Competence Centre for Gas Exchange, KTH-CCGEx.

2014-2016   Vice-President European Acoustical Association

2015-       Director Centre for Sustainable Aviation, KTH-CSA

Education

1978        MSc Engineering Physics, KTH
1989        PhD Technical Acoustics, KTH
1995        “Docent” Technical Acoustics

Research, Publications: Focus on aeroacoustics, ducts and noise control for vehicles. A total of over 2300 citations (h-index 23), scholar.google.se/citations?user=NOz2tEMAAAAJ&hl=sv. Co-author of 9 patents.
Name: Ulf Tengzelius 580622

Education

1980-1985 Master of Science Royal Institute of Technology (KTH), Stockholm

Employments

1985-86 Akelab – Consultancy in Electroacoustics

1986-90 Telub – Consultancy Acoustics, Speech intelligibility and communication

1990-94 KM (3K) Akustikbyrå - Consultancy Acoustics, Structural dynamics and programming

1994-2001 FFA, Flygtekniska Försöksanstalten – Acoustics research, vibrations and internal noise in aircraft cabins, active noise control, noise propagation

2001-2015 FOI - Acoustics research and surveys, external-/internal noise aircraft, noise propagation, vibrations, signal processing and analysis, programming. CFD/aerodynamics computations and studies in the field of aeronautics, modelling and meshing, project managing, support in environmental matters such as processes related to environmental permits. Studies of environmental impact from future supersonic aircraft fleets.

2015- KTH-MWL

Selected project involvement during last 5 years

EU FP7:
NINHA - Noise Impact of aircraft with Novel engine configurations in mid to High-Altitude operations (research leader FOI, High Fidelity noise propagation models)
FAST20xx- Future High-Altitude High Speed Transport 20XX (responsible for environmental WP - noise/emissions).

National Swedish:
Project manager and system architect for a noise forecasting system for Swedish artillery shooting ranges. The system was launched 2015 and is used on a daily basis to avoid noise disturbances in neighbouring cities and smaller countryside agglomerations.
Name: Ilkka Karasalo 461106

Education

1969 Master of Engineering in Technical Physics, Royal Institute of Technology (KTH), Stockholm.

1975 Dr. Techn. in Numerical Analysis, KTH.

1984 Docent in Numerical Analysis, KTH.

Employments

1975 Mathematician, Lawrence Berkeley Laboratory, Berkeley, California, USA. Theoretical and numerical studies of capillary stability of fluids at low gravity.


1978 Mathematician, Lawrence Berkeley Laboratory, Berkeley, California, USA. Numerical studies of ignition and flame propagation in combustive gas fuels.


1985 Senior Research Officer (Laborator), FOA, Stockholm. Development of high-resolution signal processing methods for sensor arrays. Development of numerical methods and software for wave propagation in layered media.


1989 Adjunct Professor at the Marcus Wallenberg Laboratory of Sound and Vibration Research, Department of Aeronautical and Vehicle Engineering, Royal Institute of Technology (KTH), Stockholm. PhD student assistant supervisor (Sven Ivansson 1994). PhD student supervisor (Elias Parastates 1999, Alex Cederholm 2003, Elin Svensson 2007).
Name: Tomas Grönstedt 700103

Education

2012 Professor in turbomachinery, Chalmers University

2004 Docent degree in thermo and fluid dynamics, Chalmers University.

2000 Ph. D. degree in thermo and fluid dynamics at Chalmers University

1994 Master of Science, engineering chemistry with engineering physics, Chalmers University

Employments & involvement

2015- Head of Turbomachinery & Aero-acoustics group (senior lecturer, assistant professor, two post- doctoral research students and 8 Ph.D. students), division of fluid dynamics, department of applied mechanics, Chalmers University of Technology.

2015- Coordinator of Horizon 2020 ULTIMATE project. Co-author of the Swedish flight research agenda (2010, 2013, 2016)

Selected project involvement during last 5 years

EU: FP6 NEWAC/DREAM (research leader Chalmers), FP7: ENOVAL/LEMCOTEC/E-BREAK (research leader Chalmers), Horizon 2020: ULTIMATE (project coordinator)

National (NFFP 6): Green Engines II, MotorER och Aerodynamik for framtida EFFektiva flygplan (MEREFF), Design For Performance, Innovativ Framdrivning och Motorinstallation, Virtual Integrated Compressor
Name: Fakhre Ali

Age, Gender: 29, Male

Contact information: fakhre.ali@chalmers.se

Education

Dr. Fakhre Ali has recently completed his Enhanced Engineering Doctorate (EngD) from Cranfield University, United Kingdom.

2010 MSc Advanced Mechanical Engineering, Cranfield University, UK
2015 Enhanced Engineering Doctorate (EngD), Cranfield University, UK

In the context of his EngD research work, he developed a multidisciplinary simulation framework for the design, optimization and environmental assessment of integrated rotorcraft systems and rotorcraft operations. His work was focused particularly on developing alternative engine conceptual design and analyses including aeroengine performance modelling and optimization towards reduced fuel consumption and emissions. His work was placed within the context of the EU FP7 Clean Sky Joint Technology Initiative and benefits from a strong collaboration with major industrial partners from the EU rotorcraft community.

Current Position

Title/position at employer
Post-doctoral Research Fellow, Chalmers University of Technology, Applied Mechanics Department, Fluid Dynamics Division, Gothenburg, Sweden.

Role in the Project: CTH Work Packages Leader

Merits, & Publications

Dr. Fakhre Ali has published more than 20 papers on scientific journals and international peer-reviewed conferences since 2013 and was awarded with the ‘American Society of Mechanical Engineers, International Gas turbine Institute, Young Engineer Award in June 2015. His current research is focused on understanding the subsonic aircraft system level noise and towards development of analytical methods for modelling existing and advanced system level concepts targeting reduction in aircraft total noise level.
Bilaga D

Publikationslista för huvudsökande och medsökande under de senaste fem åren.

Publications 2011–2015, Mats Åbom

Journal Publications (reversed chronological order)


doi: 10.1115/1.4003593.

**Conference Publications** (reversed chronological order)


Keynotes and invited lectures


49. Mats Åbom, 2014. Turbocharger noise-generation and control. SAE NVH Brazil, 4-5 Nov, Florianopolis, Brazil.

Publications 2011-2015, Ulf Tengzelius

1. Ilkka Karasalo, Brodd Leif Andersson, Ulf Tengzelius. D1.3 - PE model for long range propagation of aircraft noise. s.l. : EU-project NINHA (Noise Impact of aircraft with Novel engine configurations in mid- to High Altitude operations), 2012.


Publications 2011-2015, Ilkka Karasalo


Publications 2011 (april) -2016 (april), Tomas Grönstedt


28. X. Zhao and Grönstedt T., ”First and Second Law Analysis of Intercooled Turbofan Engine”, ASME Turbo Expo, GT2015-43187, Montreal, Canada.


34. V. Raja, S. Samuelsson, O. Isaksson, T. Grönstedt, ”Exploring Influence of Static Engine Component Design Variables on System Level Performance”, ISABE2015-20082


In books

Strategic publications


Patents

Published Journal Articles


Published Conference Papers


