COSMA 36M Progress Report

Publishable Summary

for the 2nd reporting period from 1 December 2010 to 31 May 2012.

By today, aircraft noise engineering has ever focused on achieving lower noise levels for individual events and at close distances from the runway. The achievements are measured in the standardised effective perceived noise levels (EPNL) which is also the noise certification relevant value worldwide. COSMA will help to improve the understanding of the effects of aircraft noise in the airport surrounding community, to develop techniques for modelling the impact of aircraft noise around airports under the aspect of annoyance and to develop engineering guidelines and methods implementing suitable design and operating practices aimed to minimise community aircraft noise annoyance, supported by a set of validated tools. 21 partners from 9 European countries are collaborating in COSMA.

The specification task of **WP1** has been completed during the previous period. However an additional request was put forward to investigate the possibilities of covering Open Rotor (OR) engine configurations. WP1 then reviewed and assessed several possible options for including OR sounds in Lab testing. An optimal approach was identified and described, to be performed in two steps.

Beyond the specification preliminary requirements from the systems aspects were provided, activity related to the Aviation Noise Impact Knowledge Base and Exchange Mechanism (ANIKBEM) has been given more time to better formulate the concept and associated issues. In anticipation of further steps in concept formulation, a preliminary analysis of wider aspects and potential issues has been carried out. To address the second issue, it has been decided to include these exchange mechanism aspects in the more general dialogue initiated between the X-Noise network and its US counterpart, PARTNER on possible collaboration in the area of Annoyance related research. A common workshop should be organized in the next 3 months to address principles of cooperation, including data exchange.

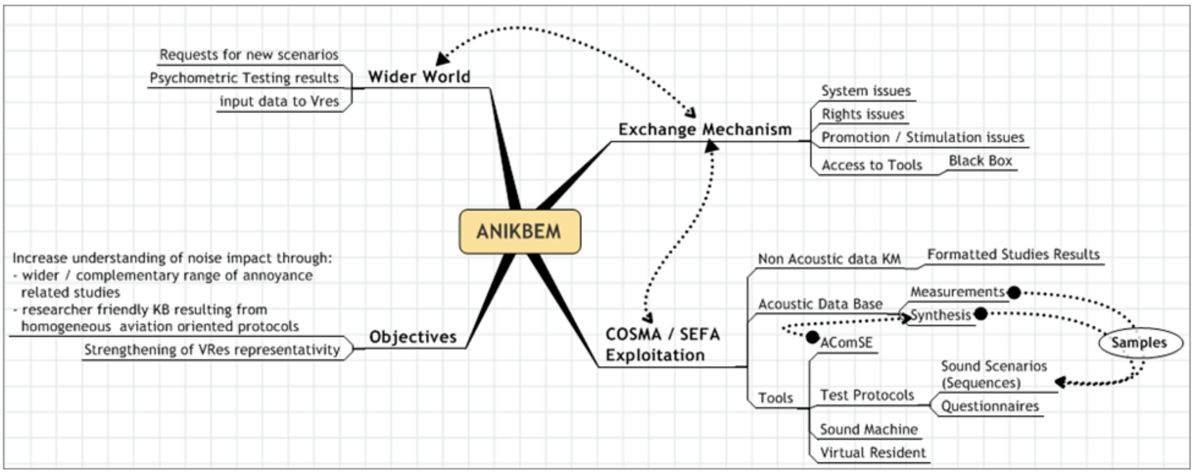

Figure 1: ANIKBEM concept - preliminary analysis.

Firm plans have now been made for the organization of the Final Workshop. The general concept and objectives were approved by the consortium at the 36 Month meeting. The event will be held in January 2013 in Budapest and will be organized by BME with support from the Management Team.

Finally, the dedicated COSMA Public Website is on-line at: http://fp7-cosma.eu/ since the previous period has been maintained and updated.

The field study examinations in **WP2** were carried out around Heathrow (London), Arlanda (Stockholm) and Cologne/Bonn airport, with the aim to provide information about the current aircraft noise annoyance around Arlanda, Cologne/Bonn and Heathrow Airport. The relation between several types of aircraft noise annoyance and a broad range of objectively measurable parameters of aircraft noise (sound pressure level and derived characteristic values, frequency spectrum, number and distribution of flyover sounds per period) will be analysed. The key question is: 'What are the most important factors in the evolution of aircraft noise annoyance?' A better understanding of the contribution of short-term and event-based annoyance for the evolution of long-term aircraft noise annoyance is targeted. The extensive field study examinations have been finished in April 2012, final results of the evaluations are expected end of 2012.

The laboratory studies have been performed involving residents from two major airports in West and East Europe - Paris (CDG), Budapest Ferihegy Airport (BUD) - and from a regional airport Lyon Saint Exupéry (LYS). The objective of these studies was to assess the perception and the annoyance from airport noise based on experiments performed with optimised and synthesised aircraft noise scenarios. During each experiment, participants, exposed to aircraft traffic noise, had to perform various "like at home" activities and cognitive tasks, and also assess noises from single flyovers. The final experiments involving 96 subjects in each laboratory started by January 2012 and were finished in April-May 2012. The statistical analysis of the data was carried out between March and June 2012. The final report will be available by end of July 2012.

The interactive SOUND SYNTHESIS MACHINE (SSM) examinations will be used to get an overall view of virtual future aircraft sounds. In this experiment, subjects had the possibility to create their own preferred sounds for different aircraft (target sounds) by using faders assigned to attenuate or amplify several distinct acoustical parameters like buzz saw, tonal components, airframe noise, etc. Basic technical constraints will be considered.

The development of the SSM was done in **WP3**, the examinations started in July 2011 after extensive pre-tests. The examinations clearly showed that the newly developed Sound Machine is a very suitable instrument to identify and alter sound components to achieve less annoying aircraft sounds which promises valid results for further problems in the future.

Noise propagation models were developed in WP3, which include the effects of atmospheric temperature gradients and non-uniform wind on sound and effects of rough ground and atmospheric absorption on aircraft noise. The SSM was further developed and completed. The final tool was delivered to WP2 for dedicated SSM listening tests. An extensive description of the tool is given and the tool with all necessary configuration files and user manuals is deployed on the COSMA secure website.

Beside the SSM, the ANCS (Airport Noise Climate Synthesizer) is an important tool of COSMA. The tool was finalized and the complete ANCS chain from source spectra to synthesized flyover noise was successfully validated in a joint WP3/5 activity to test and validate the ANCS chain including the modelling of the AC noise sources and their propagation to the ground, the synthesis of audio signals and their comparison to noise recordings. The exercise was done for an Airbus A320 in take-off and approach condition. Public domain source prediction models were developed for i) airframe noise, ii) fan-compressor noise and iii) jet noise. In order to find out whether the ANCS synthesized sounds correspond to natural aircraft sounds, a laboratory listening test was set up (22 subjects) for comparing both types of sound psychometrically relative to various perceptual attributes such as loudness, annoyance, tonality and pitch. This psychometric validation showed, that the ANCS synthetic sounds are very well able to simulate authentic aircraft flyover events. It was furthermore shown that the 3D method is capable to successfully simulate a spatial sound environment which is much more effective than one generated by stereo or mono sound reproduction.

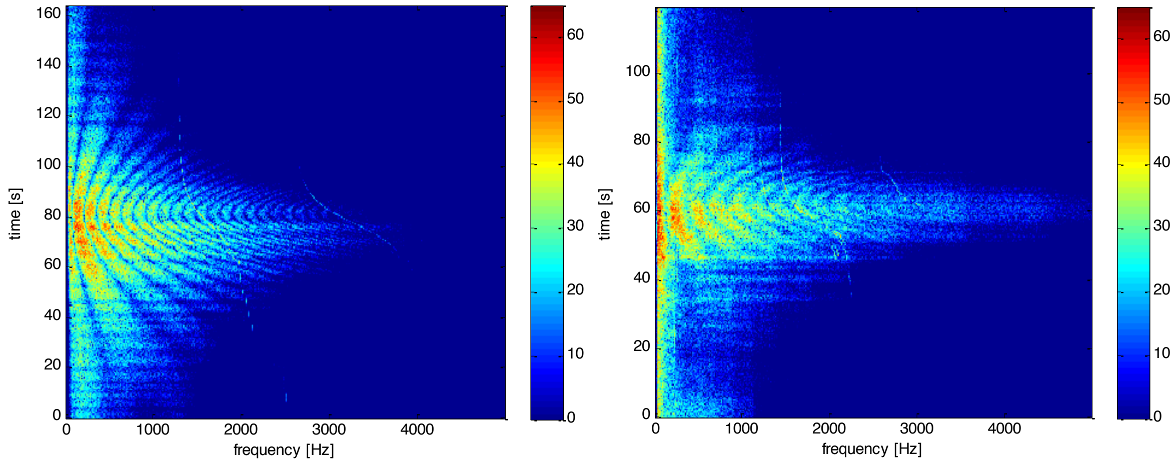

Figure 2: Noise fingerprint for landing: (left) ANCS synthesis, (right) noise recording

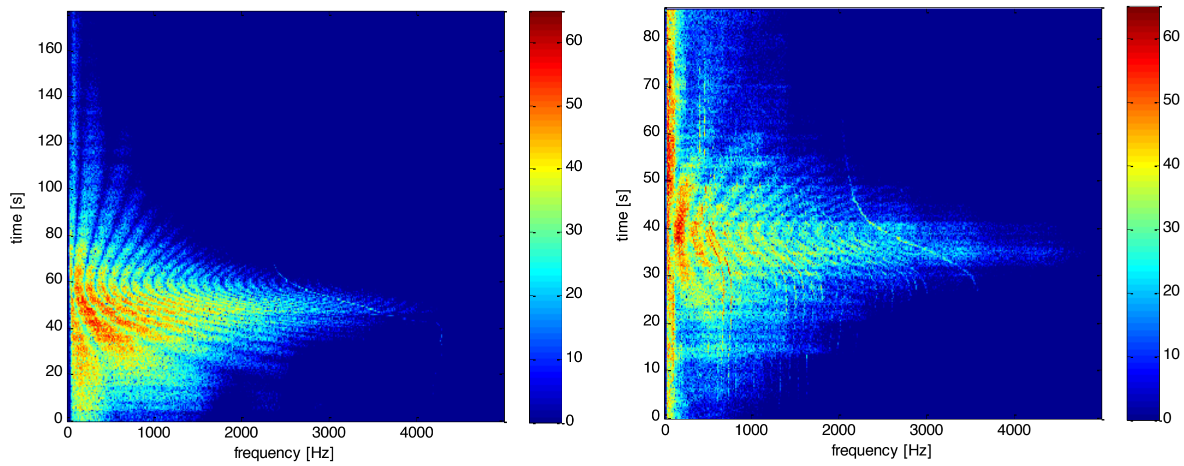

Figure 3: Noise fingerprint for take-off: (left) ANCS synthesis, (right) noise recording

For the use of the noise prediction scheme of SOPRANO, numerical models were built for i) airframe, ii) engine and iii) full aircraft. The numerical results were compared with experimental data from literature for an assessment of SOPRANO. The airframe model results were found to reproduce the experimental data in almost all situations. The numerical engine models are of much lower quality due to missing parameters and data.

In order to overcome the disadvantage of monaural sound reproduction, which is a loss of authenticity which may influence the perception of annoyance significantly, a 3D sound reproduction method was developed to enhance the degree of authenticity.

Finally, the synthesis of different airport scenario sounds was one very important task in WP3. Those sounds are used in the WP2 laboratory tests to investigate the importance of i) aircraft sound quality and ii) flight path on the perception of annoyance.

The development of intelligent Data Reduction and Transformation (iDRT) module has been done in **WP4**. This is the module, which transforms sound recordings of individual sound quality tests and large databases of acoustic and non-acoustic features from field studies onto more compact representation so that the core algorithm can effectively handle the amount of data. Also the core algorithm for the Virtual Resident (VRes) tool was developed, using BME's Neural Network model. The VRes post-processor was prototyped in two annoyance maps computation tools: The first one is a sound diagnosis tool which extracts the perception-relevant noise annoyance features from an aircraft flyover (see Fig. 4) and maps the critical, threshold exceeding values on top of the time-frequency spectrogram of the noise signal. The second tool computes and visualizes the spatio-temporal distribution of noise annoyance features in an airport community resulting from aircraft sounds.

During the validation task, individual tools have been validated separately. The validation tool producing estimations for the hourly annoyance raises some difficulties. In mathematics, mean error, correlation etc. is computed to quantify the accuracy of predictor models. A kind of grouping and averaging of computed and real annoyance ratings seemed to be meaningful. In case of enough samples can be found for each of such groups, their mean values and standard deviations can be used as accuracy indicators. I.e. the nearer is the predicted mean annoyance for a group to the mean of the ratings related to the standard deviation of the group's ratings, the better is the estimator. WP4 is currently looking for adequate parameters for groupings and has addressed to problems also to experts too.

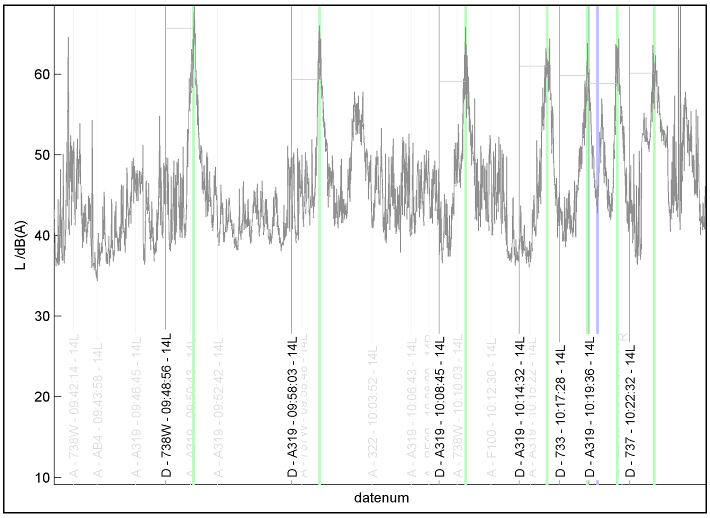

Figure 4: Example of found events in the SPL-Log (green lines) and the assigned flights from the schedule (black lines with text). The grey lines with text are the remaining events from the schedule. The meaning of the texts: "[D]eparture or [A]pproach – Aircraft type – Time – Runway".

The analysis models implemented in the Multidisciplinary Conceptual Design Optimization (MCDO) framework FRIDA provides a complete description of the aircraft in **WP5**, addressing all the disciplines involved in the design process. Within the present context, the interplay between aerodynamics, propulsion, flight mechanics and aeroacoustics is crucial and the models related to these aspects were described. The theoretical development of the optimization strategy has been completed and after a careful analysis of the objectives and constraints, a multi-objective approach has been identified as the most appropriate.

Results related to the optimized noise procedure delivered by AIRBUS in terms of SEL and EPNL maps on the ground are presented, also results of the procedure multi-objective optimization, the design multi-objective optimization, and the optimization of the future scenario, where design parameters taken into account pertains the wing system, as the procedural once have been already optimized. The used evolutionary-type algorithms are optimization algorithms based on evolutionary schemes. Genetic algorithms are currently implemented in the optimization framework, and some good results have been obtained with this algorithm. Figure 5 shows an example for a procedure optimization.

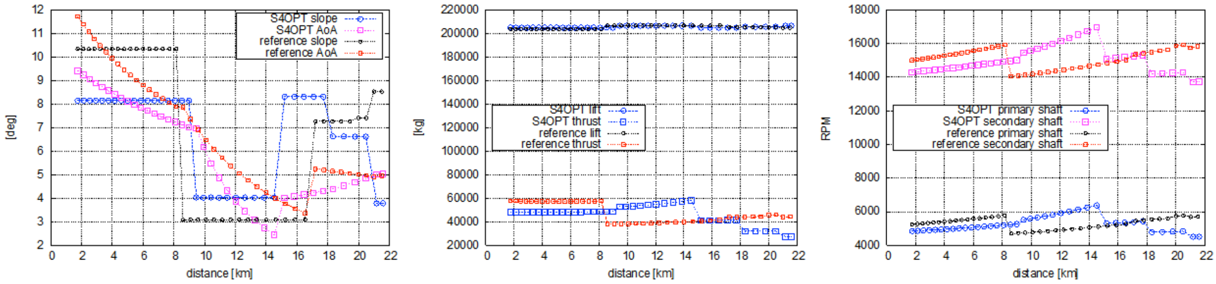

Figure 5: AC2 take-off: slope and aircraft attitude & lift, thrust and shafts' RPM for the optimal solution.

During reporting period a joint activity between WP3 and WP5 was carried out. Specifically UNIROMA TRE provided to WP3 a noise static spectra database corresponding to the optimized procedures, to be used in sound synthesis. The sound spectra database was obtained through simplified noise prediction models, specifically the ones already included in FRIDA were employed. Details about the use of the noise models in sound synthesis are described by WP3.