The RAIN Project : Reduction of airframe and installation noise

Le projet RAIN : Réduction du bruit des fuselages

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This paper gives a brief description of the three years RAIN research programme and the results, which is partly funded by the European Commission. RAIN will benefit the environment in reducing noise around airports. Together with the other concurrent exterior noise programmes being funded through 4th Brite-Euram framework, it is expected that the total noise can be reduced by 6 EPNdB in eight years.

Cet article propose une présentation rapide du programme de recherche RAIN ainsi que les résultats des 3 années qui ont été partiellement financées par la Commission européenne. RAIN devra améliorer l'environnement en réduisant le bruit autour des aéroports. Avec les autres programmes de recherche financés grâce au 4° programme BRITE-EURAM, on espère une réduction du bruit de 6 EPNdB en 8 ans.

Introduction

The principal aircraft and engine manufacturers in Europe are facing increasing pressure to reduce aircraft noise levels. This arises both from the community expectations of improved quality of life and from the need to compensate for the expected growth in air traffic. Although aircraft and especially their engines have become significantly quieter in the last decades through technological progress, the overall annoyance is increasing as a result of the growth in traffic. The continual development of quiet engines over the years have resulted in airframe noise levels comparable with the engine noise at approach. Airframe noise will become an equally significant noise source for the proposed future large aircraft. A summary of the aircraft noise sources is given in Figure 1.

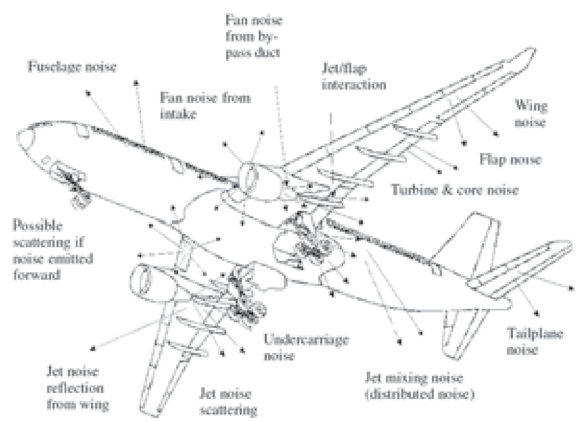


Fig. 1 : Aircraft noise sources

The engine noise interaction with the aircraft installation is another area which requires better understanding if the total aircraft exterior noise is to be reduced. Specific work on airframe noise and installation effects is being conducted in the Reduction of Airframe and Installation Noise (RAIN), which is a three years European research programme partly supported by the European Commission. The objectives of the work are to identify noise generation mechanisms, develop and assess low noise schemes and to improve prediction models. This paper describes the research work scheduled and some of the RAIN, combined with complementary proposals Reduction of Engine Source Noise through Understanding and Novel Design (RESOUND), Reduction of Aircraft Noise by Nacelle Treatment and Active Control (RANNTAC), Study of Optimisation procedures for decreasing the Impact of Noise (SOURDINE) and basic research on duct acoustics and radiation (DUCAT), which are all partly funded by European Commission in the 4th Brite-Euram framework and coordinated through the X-Noise thematic network that has been formed in Europe (see Figure 2). The aims are to reduce

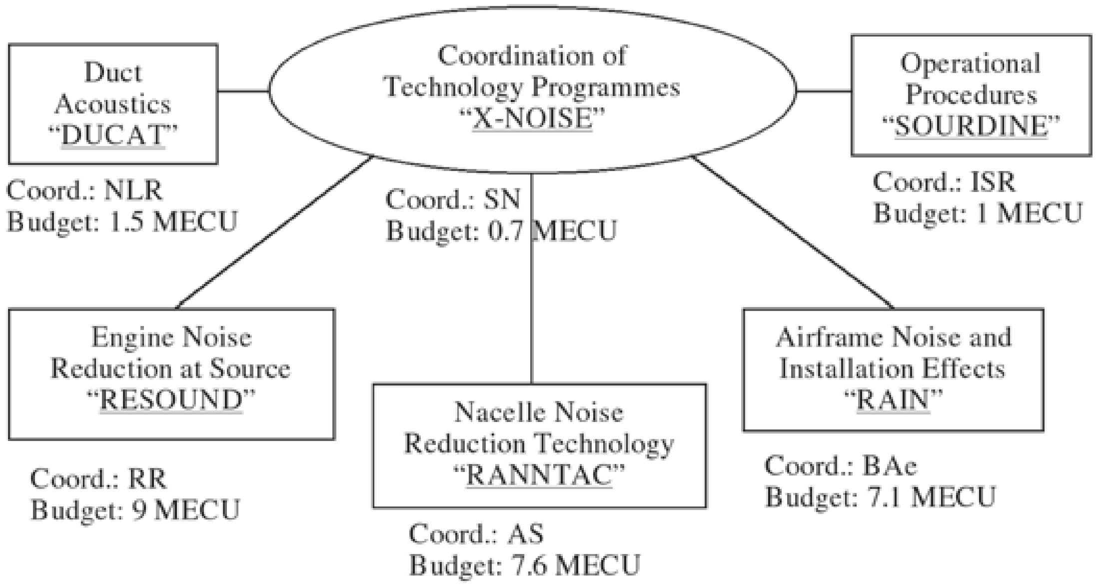


Fig. 2 : X-Noise thematic network

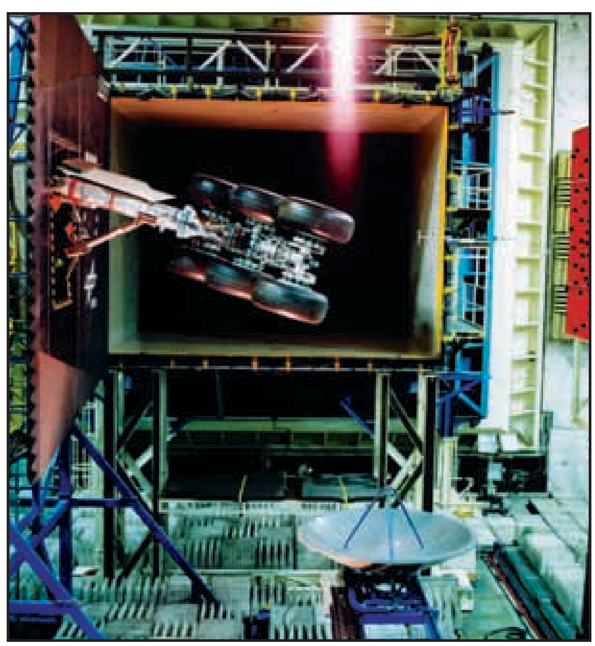
Airframe noise research

Airframe noise is defined as the noise generated as a result of the airframe moving through the air. The main airframe components which lead to airframe noise radiation are landing gears and high lift devices. Some initial airframe noise studies were carried out in the 1970's. A very good summary of the airframe noise research work is given in reference [1]. Due to the lack of a sound understanding of noise source mechanisms and radiation characteristics, in conjunction with the extremely complex configuration and aerodynamics associated with landing gears and wing/high lift devices, a good noise prediction scheme remains to be developed. The lack of funding in the 1980's towards research on airframe noise caused the technology to remain at the 1970's level. During the last few years airframe noise research has been taken up again in the USA. In a combined effort between NASA and the aircraft industry both the analytical and experimental work were carried out. Noise testing was performed on scaled aircraft models and adequate noise localisation techniques were developed. Triggered by this US initiative and the intended development of a very large aircraft, Airbus Industrie in 1995 sponsored two airframe noise related research projects. These include the full scale noise testing of the A320 landing gears and scaled aircraft model high lift devices in wind tunnels [2,3].

Full scale A340 landing gears and a wing with high lift devices as well as scaled aircraft models have been aerodynamically and acoustically tested in the wind tunnels within RAIN. The results have been compared with full scale aircraft flight test noise measurements at approach. The existing landing gears, high lift devices and the total airframe noise prediction models have been reviewed and modified to improve the prediction accuracy. Realistic noise reduction solutions have been designed and tested

Figure 3 shows a typical landing gear being noise tested in the wind tunnel. The noise reduction schemes being tested show significant noise reduction potential. Figure 4 displays the full scale wing noise test set up in the wind tunnel.

For both the scaled aircraft model and full flight noise tests, advanced source localisation technique has also been used to locate the airframe noise on the aircraft airframe (as given in Figures 5a and 5b). The technique has been proved to be extremely powerful and very promising data has been obtained.



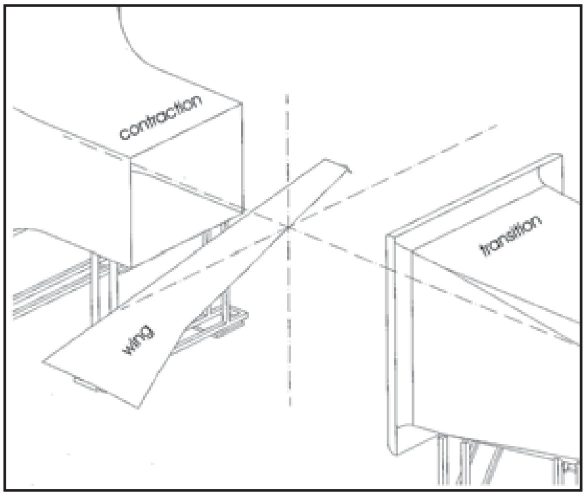


Fig. 4 : Wing airframe noise test set up

Fig. 5 (a) : Source localisation instrumentation

Installation effects on engine fan, jet and core noise

The potential improvements in thermodynamic efficiency and specific fuel consumption (SFC) offered by Ultra High Bypass Ratio (UHBR) engines risk not being realised if the associated noise hazards are not contained. Whilst the control of engine noise at source is of paramount importance, there is a vital need to understand its interaction with the aircraft installation. Of particular concern is the risk from the largely unknown effect of the engine installation on the fan, jet and core noise which is likely to have an impact on the aircraft flight noise levels.

For the fan noise studies, the diffraction of sound by the airframe and the scattering of sound by vortical wakes will be investigated, by both theoretical studies and model tests in wind tunnels. In the latter, engine installation will be both under the wing and at various positions at the rear of the fuselage. A synthesis of the measured near and far field data will be used as a basis for the development of a semi-empirical prediction code. Experiments will also be conducted to validate computation models for the transmission of sound through vortical flows.

For the jet noise studies, both the wing and fuselage mounted installations have been tested with the variations of the nozzle type, operating conditions, relative wing/nozzle position, jet/flap interaction. The noise generation/interaction mechanisms considered include reflection and diffraction of the sound field by solid surfaces, jet/surface interaction noise, scrubbing noise and aerodynamic shielding. The modelling of reflection and edge diffraction effects has been based on the application of ray theory to simplified geometries.

For the core noise studies, a model experimental study examined the effect of the engine installation on the core noise using a core noise simulator. The tests included the use of existing rectangular flat plate, wing-plan flat plate and 3D wing models and different exhaust models, to derive and validate predictive models. In order to identify small acoustic changes due to the installation, the wing model is capable of being removed during the test while maintaining the model exhaust conditions. A similar technique has been used with the core noise simulator.

Acknowledgement

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