UNIVERSITY OF Southampton

Report

Title: A brief history of the Rolls-Royce University Technology Centre in Gas Turbine Noise at the Institute of Sound and Vibration Research

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Over the last two decades Rolls-Royce plc has set up a network of University Technology Centres to support academic research in a range of key technology areas. Long-term relationships have been established at different universities as part of the Rolls-Royce research and development strategy, with a view to building and maintaining a critical mass of knowledge and expertise in different subject areas at the UTCs. Today this global network consists of thirty UTCs, and the subject areas include materials, heat transfer and aerodynamics, controls and systems engineering, gas turbine transmission systems and gas turbine noise.

The UTC in gas turbine noise was officially launched on Tuesday 30th November 1999, and is based at the Institute of Sound and Vibration Research, University of Southampton. Initially Rolls-Royce planned to invest £1.6M over five years to establish the new noise UTC. At the onset, the key aim of the noise UTC was to work on problems related to generation and propagation of noise from gas turbine engines. Aircraft noise is a critical technical issue which needs to be addressed. One of the principal aims in the ACARE (Advisory Council for Aeronautics Research in Europe) 2020 vision is a 50% reduction in the perceived average noise levels. Notwithstanding the major advances that have been made in the past to reduce noise from aircraft engines, along with considerable investment in aircraft noise research, this vision still requires significant technological advances to make aeroplanes substantially quieter.

The original director of the noise UTC was Professor Philip Nelson. Subsequently Professor Nelson was promoted to director of ISVR and then deputy vice-chancellor of the University of Southampton. Thus, in September 2001, Professor Jeremy Astley took over the role of UTC director. Professor Astley has now been the UTC director for ten years; more recently he has combined this role with the directorship of ISVR.

The centre was originally managed by Dr Mike Fisher. Dr Fisher had worked in collaboration with Rolls-Royce for over thirty years prior to the inception of the UTC, and his long-standing efforts to establish and sustain a link between the ISVR and Rolls-Royce was undoubtedly a key factor in the formation of the noise UTC at the Institute. Dr Fisher was awarded the AIAA aeroacoustics award in 2005, prior to his retirement in 2006. Since then the UTC has been managed by Dr Rod Self. At present the UTC has around twenty-five staff, which includes University staff, Research Fellows, Research Associates and Doctoral students. Each year several new doctoral students will join the UTC and start PhD or EngD projects, whilst a number of doctoral students will graduate, so the total number of UTC staff generally remains year-on-year fairly static.

The framework of the UTC is a relationship which provides unique links not only to Rolls-Royce but through it and through joint activities to many organisations and industrial partners in the aerospace sector within the UK and throughout Europe. As well as direct funding from Rolls-Royce, research income is sought from UK and European programmes. During the last decade the UTC has participated in a range of UK and EC projects. The original X-Noise project started in 1998, and when the UTC started (in 1999) the group were involved with the European projects RESOUND, RANNTAC, RAIN and DUCAT, all of which were organised under the auspices of the newly formed X-Noise consortium. Since then the UTC has participated in many subsequent EC projects, including two major noise projects: SILENCE(R) and OPENAIR. Also the ISVR/UTC acts as the national focal point for the new X-Noise EV project. Through its participation in National and European noise projects, and direct collaboration with Rolls-Royce, the UTC group has been able to accumulate and retain a critical mass of experience and expertise in aircraft noise research.

The UTC group's activities encompass a wide range of experimental, theoretical and computational work which is applied to investigate all aspects of aircraft noise, in particular noise from turbofan engines and (more recently) open rotors. Broadly the technical work can be categorized as: fan and turbine noise: duct acoustics; jet noise; and, advanced measurement techniques.

Over the past decade, the group has investigated fan tone and turbomachinery broadband noise. Key research activities have included developing an engineering prediction method to predict “buzz-saw” or “multiple pure tone” noise from turbofan engines, and a range of predictive schemes to investigate broadband noise sources such as rotor-wake/stator interaction noise and rotor trailing edge (self) noise. Also advanced measurement techniques have been applied to broadband source localisation and characterisation, such as separating rotor and stator noise sources.

Much of the effort on duct acoustics has focused on the use of linear acoustic propagation codes to investigate sound propagation and radiation from turbofan inlet and bypass ducts. These ducts contain acoustic lining, which has proved to be a highly effective noise control method. A key requirement is the ability to predict sound attenuation in lined flow ducts, and to understand how the attenuation can be increased. The group have researched various ways to improve sound attenuation in turbofan duct systems, including splice-less liners, segmented and other novel liner configurations, as well as the effect on the attenuation caused by non-uniform flow and geometry.

The basis of much of the group’s jet noise research has been to develop engineering prediction schemes which incorporate aerodynamic data related to the turbulent flow field obtained from CFD simulations and input to the acoustic model. Over the past decade, a range of predictive schemes have been developed to examine single and coaxial jets, also taking into account temperature effects. The overall aim is to be able to address a variety of turbulent flow fields, including those generated by serrated and other non-axisymmetric nozzles. Other important elements of the group’s jet noise research has included improving near-field prediction capability, and examining how to predict noise inside the cone of silence.

Advanced measurement techniques have been developed for model-scale and full-scale testing. Research facilities for noise research at the UTC include the DARP and Doak-jet facilities. The DARP (Defence and Aerospace Research Partnership) facility was commissioned in 2006 and is a low-turbulence, low-noise open-jet wind-tunnel facility housed in the ISVR anechoic chamber for the measurement of aerodynamic noise. The newly commissioned Doak-jet facility is a state-of-the-art facility for conducting laboratory scale jet-noise experiments, and has been used recently for a measurement program testing novel bleed valve designs. The UTC is well known for its work on applying inverse techniques to quantify acoustic sources on engines. A key long-standing research programme has involved the use of inverse techniques to identify acoustic sources in reverberant environments, so that acoustic testing could be conducted in test-cells, which traditionally would be highly unsuitable environments to gather any acoustic data for jet engines.

More recently focus has turned to noise generated by open rotors, which offer the potential to be more fuel efficient compared to turbofan jet engines, but pose some challenging technical issues related to noise. Other areas of new research such as aircraft engine installation acoustics are also becoming more important as a more holistic approach to the noise problem is sought, and novel ideas and concepts such as using the airframe to shield noise are investigated more thoroughly.

The Rolls-Royce University Technology Centre in Gas Turbine Noise at ISVR is an example of a long-standing collaborative arrangement between one of the UK’s (and the world’s) premier engineering companies, and one of the world’s leading research institutes on sound and vibration engineering. The relationship between academic research and its impact on people, society, and the economy, is one which is important to highlight and to promote in order to maximise the usefulness of new knowledge and technological advances. Noise research at the UTC covers the whole range of technology readiness levels. Over the past decade the noise UTC has proved a successful venture bringing together academic and industry research and development on aircraft noise.

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