

Report from the Scientific Advisory Board on the Activities of the Acoustics Research Institute of the Austrian Academy of Sciences (December, 2011)

0. Preamble

The Scientific Advisory Board of the Acoustics Research Institute (ARI) of the Austrian Academy of Sciences (ÖAW) met on the 5th December 2011. Those from the Scientific Advisory Board (SAB) attending this meeting, which opened at 9 a.m., included Ao Univ. Prof. Dr. W. Baumgartner, Prof. E. Carletti, Prof. Dr. G. Dogil, Prof. Dr.-Ing. O. von Estorff, Prof. Dr.-Ing. H. Fastl (Deputy Chair), Prof. Dr. J. Harrington (Chair), Prof. Dr. Dr. B. Kollmeier, Dr habil. R. Kronland-Martinet, Prof. N. Peake, and Prof. Dr. B. Torrèsani.

In addition, Prof. Dr. U. Dressler and em. Prof. Dr. G. Guttman of the Austrian Academy of Sciences attended as guests of the SAB.

The SAB was presented with a series of talks by each of the ARI's project groups (see below) as well an overview by the current Centre Director, Prof. Deutsch, of the current state of the ARI. A presentation of proposed future directions of the ARI was also given by Doz. Balazs, who will take over as Centre Director from 1.1.2012.

The following documents were presented to the SAB prior to the meeting: a list of publications in 2010 and in 2011; a document by Doz. Balazs on the 'Concept for the successful scientific future development of the Acoustics Research Institute'; the annual report of the Austrian Academy of Sciences in 2010; and a fragment of a larger document with heading 'Tabellarische Darstellung und wissenschaftliche Kennzahlen' listing various aspects of the ARI including details of its current members and projects.

The meeting closed at 4.40 p.m on the 5.12.11.

The remainder of this report includes an evaluation of the ARI and its components (section 1) and then some recommendations for action (section 2). Our evaluation (as in our previous reports) makes use of the scale outstanding, excellent, very good, good, average.

1. Evaluation of the ARI

1.1 The structure and mission of the ARI

The overall mission of the ARI is to contribute to several of the major fields that are specified in the Physics and Astronomy Classification System (PACS 43) provided by the American Institute of Physics, and more generally to make contributions to acoustics in research fields that are at the intersection of life sciences and engineering. In order to do so, the ARI concerns itself with a wide range of topics in acoustics including structural acoustics, noise and vibration, physiological acoustics, psychological acoustics, and human speech production and perception. At the ARI, these areas are currently subsumed within the four research groups *Acoustic Phonetics*, *Audiological Acoustics* and *Psychoacoustics* (which now includes *Psychoacoustics-Genuine* that had been established as a separate group in 2011), *Computational and Numerical Acoustics*, and *Mathematics and Signal Processing in Acoustics*. Each of these groups has its own team leader.

The general consensus of the SAB was that **the ARI is continuing to pursue a very clearly structured and comprehensive set of research objectives in acoustics** that are, for the large part, appropriately covered by the range of expertise spanning the four main project groups. The ARI pursues long-term basic research objectives in acoustics that complement the numerous applied research investigations in areas such as cochlear implants, automatic speaker recognition, and analyses of vibration and noise barriers in railway environments.

While the division into the project groups allows individual specializations to be pursued in depth, **the ARI has done much to exploit the possibility for innovative between-group collaborations in various areas**. These cross-disciplinary collaborations within acoustics have been enhanced by the development over several years both of a

common software environment (S_Tools-Stx) for the analysis of acoustic signals that supports all of the research activities in the ARI, as well as by a database framework which has made available a vast amount of experimental data for many different types of research investigation.

1.2. Evaluation of the ARI as a whole

The ARI is an Institute **that is unique in Austria and quite possibly in Europe** because of the way that it conducts **high-level, cutting-edge interdisciplinary research into so many facets of acoustics**. The inter-disciplinary approach is entirely appropriate to the nature of the subject because acoustics is both critical to, and interconnects, a diversity of areas. These extend over engineering, natural sciences, life sciences, social sciences, and humanities, including for example fields as diverse as vibration and noise, such as the psychological interpretation of the speech signal, the sociological indices of speech as inferred from acoustic analyses, the human-machine communication systems, the medical aspects of acoustics including cochlear implantation, and the development of digital filter algorithms.

It is because interdisciplinary approaches to acoustics have been at the core of the ARI's activities that the ARI is uniquely placed to provide innovative solutions that are common to, and that connect, many of these disparate areas. Fundamental to such innovation is **the establishment by the ARI of a critical mass over many decades in individual areas of acoustics** (see 1.3 below) but also **the creation of a research climate that fosters the sharing of research ideas across the groups** that constitute the ARI: from this point of view, the separate research specializations **have provided added value to acoustics resulting in many important breakthroughs in the field**.

Beyond these general issues, the ARI's clear research strengths can be identified by many of the usual indicators of excellence in international research, in particular:

- a **highly successful publication output** as evidenced, for example, by 24 (excluding conference proceedings) publications in the last two years in high-quality, peer-reviewed international journals. This output is especially impressive in relation to the relatively small size of research personnel at the ARI that has included up to Dec. 2011, apart from the Centre Director (Prof. Deutsch, only four other senior researchers. Such productivity illustrates the **highly cost-effective nature of the ARI**.
- its **highly visible international profile** as evidenced by an enviable list of collaborative projects with various laboratories in Europe, the U.S.A, and Australia.
- the **strong track record of the ARI in attracting external funding** with over 30% of its funding derived from external sources (219.000 € and 225.000 € of external funding in 2010 and 2011 respectively). Much of this is derived from highly competitive funding sources such as the FWF and the European Union. The ability of the ARI to attract funding in relation to the small number of scientists is another clear indicator of the productivity of the ARI and more generally of its excellence in research.

For all these reasons, the SAB continues to **rank the ARI as excellent**.

1.3 Separate research groups

1.3.1 Acoustic Phonetics

This research group has continued to adopt many of the tasks that might normally be pursued within a Chair of Phonetics and Speech Science (of which there is none in Austria) under the direction of its group leader, Doz. Sylvia Moosmüller. The activities of this research group have been extended in 2011 via a joint German Research Council and FWF to support this group's **international recognition for its research on the acoustic phonetic bases of various varieties (dialects) of Austrian German** and how these are evolving under

the influences of social change. This group has done much to establish perhaps **the most extensive repository of speech materials of Austrian German in the world** that helps to provide the infrastructure for the group's equally successful research on automatic speaker identification/verification and the forensic analysis of speech that has become increasingly important in security applications. From this point of view, the group has made effective use of its database resources to build connections between basic and applied research.

The group is **especially renowned in Austria and Europe not only for its research on Austrian German but also for its contributions to forensic speech science**. The group's considerable progress owes much to the inter-disciplinary nature of the ARI and to the possibilities of integrating basic phonetic research with signal processing. The ARI is the official representative of Austria in the ENFSI (European Network of Forensic Science Institutes) working group (Forensic Speech and Audio Analysis Working Group) and Doz. Moosmüller is the General Secretary of the International Association for Forensic Phonetics and Acoustics. This research has important applications in security research that is one of the designated priority areas of the EU's Seventh Framework Programme for Research and Technological Development.

The SAB recommends that this group should continue to build upon its research strengths of Austrian German and their connections to forensic phonetics. The SAB also sees considerable potential for this group to carry out joint research with the group *Audiological Acoustics and Psychoacoustics* on a range of topics including, for example, speech production variability and prosodic deficiencies in cochlear-implanted children. The SAB also noted that there is considerable potential to broadcast its results in the media both on forensic phonetics and on dialect change of Austrian German. For all these reasons, and given that the improvement in publication output in internationally acclaimed journals, **the SAB ranks this group as excellent**.

1.3.2 Audiological Acoustics and Psychoacoustics

The group carries out fundamental and applied research in psychoacoustics in cochlear-implant, normal-hearing and hearing-impaired listeners. The group has again made significant progress in its main research field, spatial hearing, particularly the investigation of origins of reduced spatial hearing ability of cochlear-implant relative to normal-hearing listeners. It has further expanded high-profile international co-operations, including the Massachusetts Eye & Ear Infirmary at MIT and Harvard University. The group's international patent for a method to improve spatial hearing has now also been approved in the USA. The activities of the group are reflected **by an outstanding publication output in peer-reviewed journals and book chapters**. The SAB was especially impressed with the huge potential to expand this group's activities in a number of innovative research directions, including time-frequency masking in normal hearing, the brain plasticity in sound localization, and the cochlear-phase response in normal and impaired hearing. The group was successful in receiving funding for two new three-year FWF-projects. To better account for the fundamental-science orientation of the group, the SAB suggests the following group name: Psychoacoustics in Normal Hearing, Electric Hearing, and Hearing Impairment. **The SAB ranks this group as between excellent and outstanding**.

1.3.3 Computational and Numerical Acoustics

In our previous two reports we applauded the way in which this group has provided a vital service to the other groups through development of signal analysis and computational software, while at the same time pursuing its own innovative research agenda. We are delighted to see that this pattern continues to be very much maintained and extended, and that the group goes from strength to strength.

One significant and continuing activity has been the development of a major project for ÖBB, the Austrian Railways, concerned with the important practical issue of community noise pollution close to busy passenger and freight routes. The project represents a close collaborative effort between this group and the Mathematics and Signal Processing in Acoustics group, exemplifying the Institute's great strength in drawing together an interdisciplinary team to focus on a major project, in which a full range of acoustic expertise is brought to bear on a problem of practical importance. A new development this year is the project on vocal tract modelling, in close collaboration with both the Acoustic Phonetics group and the Mathematics and Signal Processing in Acoustics group. The key idea here is to use the group's expertise in Boundary Element Modelling to develop three-dimensional models of the nasal tract using anatomical data. This seems to us to be a very promising way forward, and again represents a research avenue which can only be explored thanks to the Institute's unique interdisciplinary character. Another new project, this time in collaboration with the Audiological Acoustics & Psychoacoustics Group, concerns the development of a tool for generating computational meshes from photographs, thereby offering the possibility of the efficient calculation of the head related transfer functions which are so crucial for the Institute's work on cochlea implants.

We are pleased to note that the group has also continued to develop its excellent activity in the formulation and development of computational methods, especially with regard to finite and boundary element methods in the time domain. In spite of the considerable time taken up by the group in applications that cannot always lead directly to publications, the group's publication output continues to be highly impressive. We very much admire the group's energy and creativity in the breadth and volume of its activities.

Overall, **the SAB ranks this group as excellent.**

1.3.4 Mathematics and Signal Processing in Acoustics

This group has an impressive range of activities in fundamental mathematics, mathematical signal processing and its applications to acoustics. The **research is highly original** in particular as regard to linking mathematics, numerical methods, and its applications. The group has **a strong international reputation** as evidenced for example by its **excellent publication record** in the last two years of 9 publications in peer-reviewed journals and also by its involvement in many international cooperation programs. Both the application of multiplier techniques to time-frequency sound masking as well as the pole-zero decomposition of speech are further examples of the **unique way that the ARI is in a position to facilitate collaboration across diverse groups in acoustics**. A structure such as ARI is definitely the right place for developing approaches such as time-frequency multipliers applied to sound masking, since they require constant goings and comings between mathematics, models and experiments.

More formal mathematical modelling, involving sparsity and thresholding related methods, might provide avenues for new research that could build upon this group's current successes. The group might also consider ways of extending their achievements in abstract mathematics (for example, the work on weighted and controlled frames, or properties of abstract frame multipliers) to applications (e.g., with frames obtained by the non-stationary Gabor transform, time-frequency frames with ERB-like frequency design, or adaptive methods). Recent years have proven the ability of this group to develop original research in a variety of theoretical and applied domains. Given the small size of the group, there may be an advantage in focussing on a smaller range of its activities, which would certainly allow it to attain the top level ranking.

Overall, **the SAB ranks this group as excellent.**

1.3.5 Software development

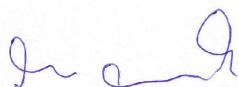
This group has been successful in developing over several years a common software environment (S_Tools-Stx) for the analysis of acoustic signals that supports all of the research activities in the ARI. There is a clear need for continued support of this system in view of the downloads in 2010 and 2011 by 453 and 448 separate users respectively. The group should consider the potential advantages of making the software open source.

2. Recommendations

Our main recommendation is that **the ARI should continue in its present form with the implementation of the current, very successful research objectives**, taking into account some of the suggestions from the preceding sections. For all the reasons outlined above, the ARI has built a critical mass of research over the last decade that has produced an unique internationally acclaimed centre of research excellence which provides a strong basis for further advancing the field of acoustics in the future.

3. Future meetings

The SAB would appreciate as soon as possible confirmation of the date of the next advisory board meeting, preferably to take place on a single day between 10 a.m. and 4 p.m. in the first week of December 2012.



Prof. Dr. Jonathan Harrington

On behalf of the Scientific Advisory Board, Acoustics Research Institute.