PROCEEDINGS of the
23rd International Congress on Acoustics

9 to 13 September 2019 in Aachen, Germany

The consolidation of Engineering Acoustics as an example of contextual history of science

Joachim SCHEUREN

Müller-BBM GmbH, Germany

ABSTRACT

Following widespread practice in natural sciences, the history of Acoustics is mostly understood and depicted as a sequence of scientific ideas and achievements provided by ingenious individual scientists or scientific schools. Even if this approach is accepted because it foregrounds the sequence and relation of ideas, it risks to ignore the driving energy of any social and technical context. This is particularly true for applied sciences like acoustics which, from a certain level of scientific insight, are much more driven by the needs of technology than by purely scientific interest and curiosity.

The mutual influence and dependence of scientific, technological and social determinants can be illustrated exemplarily for the renaissance of acoustics in the mid of the last century. Being underestimated as conclusively understood and lacking new challenges, the relevance of Acoustics changed significantly with the demands of the post-war era. The respective requirements were able to initiate an iterative process linking technological progress and needs with new scientific insight. With reference to some typical examples it will be shown how these interactive efforts finally established the disciplines of engineering acoustics and noise control which essentially contributed to renew and strengthen acoustics as an indispensable interdisciplinary field.

Keywords: History, Engineering Acoustics

1. INTRODUCTION

Being - from a superficial point of view - a chronology of relevant scientific events and findings only, any deeper interest and insight in - as well as benefit from - history crucially depends on understanding the context, i.e. the mutual dependencies, influences and impacts which drive or co-drive at least all historic developments and relationships. This equally holds for the history of science where the temptation to undervalue scientific and social contexts is increased by the fascination of many outstanding singular scientific findings of excellent individuals.

However, the real benefit of historical considerations can be found if all “who”s, “when”s and “how”s are complemented by understanding the “why”s. This may particularly apply to physical disciplines of high technological impact. A well-known example is given by the extremely rapid progress of nuclear physics forced by political urgency and priority in the last years of world war II. Although being a most questionable example of forced, even misguided technical progress, it can be stated that extreme promotion and support only enabled great physical and technological progress in an unimaginably short time.

Comparable conditions of highest needs were found in the reconstructive era after world war II where the many wartime devastations had to be overcome as fast as possible. The urgency of basic reconstructions together with increasing demands later provided an environment of exceptional fertility for developing, understanding and applying sound control, its preconditions and its implications.

Thus, the then occurring revival of Acoustics was characterized by the growing need to apply physical insight to actively influence and control our environment, the world around us. Although it belongs to the basic branches of physics, there was, in the 19th century even, no imagination yet about the immense technological all-day relevance acoustics might have in some future. On the contrary, mechanization had to become very advanced to make aware that all its requirements needed a systematic involvement of acoustic aspects. Thus, starting from “Technical Acoustics” as defined and developed in the first half of the 20th century, engineers more and more developed, applied and finally consolidated the acoustics they needed: “Engineering Acoustics”.

It is obvious from this mutual interaction that the relevance of technical and engineering acoustics caused a revival of acoustics as a whole by initiating many new research and development activities and thus - in an iterative procedure - by contributing to and benefiting from progress in the wide field of acoustics. So, the stimulus which continuously turned acoustic demands to modern technology, has promoted acoustics to become an important part of applied science again which - by its most interdisciplinary character – is crucially linked up with nearly all technological disciplines and thus became a highly needed, essential part of today's technology and science.

It is interesting and instructive to have a closer, historical look to inventiveness and scientific/technological successes of this period. They all appear as results of pioneering works and ideas of individual scientists. In spite of the short temporal distance since then, a historical classification of outstanding lifetime achievements of the most relevant German "schools" of this time can be found in volumes 10 and 11 of a series of publications recently edited by the German Acoustical Society, DEGA ([1]). However, these enlightening booklets do not aim to identify and follow the close links between physical, technical, social, political and individual needs and deliverables which enabled and promoted scientific progress of acoustics in the interdisciplinary field of engineering and technology by mutual interaction.

It is this context, the simultaneousness and mutual incentive of (human) needs, (physical/scientific) insight and (technical) realisability, which launched a fruitful renaissance of acoustics in tow behind engineering acoustics. And it is this context which this paper tries to deal with by illustrating the mutual dependence and driving energy of needs, scientific findings and practical solutions. If consequently followed up and concluded, this approach should have the potential to complement and consolidate the review of individual scientific achievements, as compiled and acknowledged in [1], by revealing the environment which - at the same time - required and enabled them. And this is what we understand and aim as contextual history.

Accepting some abstracting simplification, the mutual interaction of growing demands (requirements), progressive insight (science) and innovative technology (realisation) can be depicted schematically within an iterative cycle of research and development. As long as practical engineering tasks and solutions are involved, such interaction between research and development is not driven for its own sake. Instead it typically follows practical needs and technical possibilities. Therefore, any practice oriented cycle of research and development involves

- technical implementation and realization of new research results and approaches,
- practical application of technical realisations to meet given demands and
- increasing demands stimulating new research again.

It is interesting and fascinating to identify and to illustrate the mechanism of interdependence and mutual influence between research and development as driven by and for practical, i.e. applied sound control engineering.

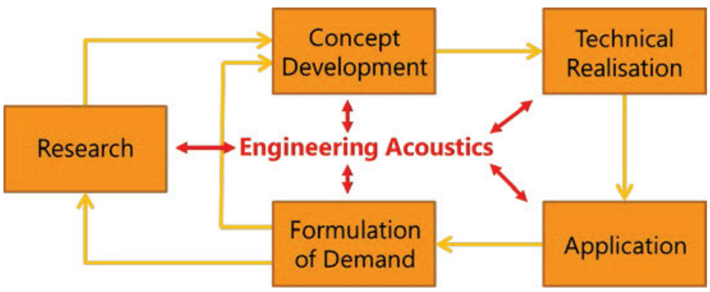

Figure 1 – Iterative cycle of research and development involving implementation and application

Fig. 1 schematically illustrates this cyclic procedure which also defines the interactive role of engineering acoustics ([2]). Following this flowchart shows how - starting from direct contributions to research - engineering acoustics can help to

- develop concepts and solutions, then to
- technically implement these to solve practical acoustic problems, to
- apply the technical solutions to reality and finally - by assessing its success - to
- formulate the need for improvements or new approaches which should be a matter of research again and thus finishes the closed cycle loop.

It was this ongoing procedure which maintained progress and success of engineering acoustics from the mid of the 20th century to these days and which thus initiated the recapture of acoustics from a basic and well-established discipline of physics to a highly topical discipline of modern technology.

2. TECHNICAL ACOUSTICS BEFORE 1950

Although the term "Acoustics" first appeared in 1693, the science of sound may be traced back to the cradle of our culture (e.g. Pythagoras). Starting from relating qualitative hearing events to quantitative numerical ratios by Pythagoras, the cultures of our world were able to continuously develop and provide a deep understanding of our hearing and its physical causalities and relationships. Consequently, the scientific understanding of acoustics could be summarized in advanced, comprehensive theories of sound in the 19th century already. Hermann von Helmholtz' "On the Sensations of Tone" (1862) as well as Lord Rayleigh's "Theory of Sound" (1894/96) are the most prominent and lasting examples.

In parallel to the scientific exploration of Acoustics the end of the 19th century saw a rapid development of electroacoustic technologies to transduce, register, transmit and reproduce sound. Thus established "Technical Acoustics" was the starting point for growing relevance and involvement of acoustic issues within the process of industrialization in the 20th century ([3]). At first this development focused on providing and supporting desired sounds (sound transmission, -reproduction and -distribution). In addition to developing and extending worldwide broadcasting of sound signals via phone and radio networks as well as tape and disc recordings, W.C. Sabine was able to lay the foundation for targeted design and layout of auditory rooms to best adapt them to speech and music.

However, technical reduction of undesired sounds was increasingly recognized as an important discipline, indispensable even for progressive mechanization of our world. Significantly interested circles thus were sure in the early 20th century already that noise abatement was a public duty, being claimed for instance by the first German noise abatement society founded in 1908.

Acoustics and Technical Acoustics tried to meet the respective requirements by successful research activities as well as by new findings and development results. Apart from complementing and completing the far-sighted frameworks of Helmholtz and Rayleigh, this led to increasingly systematic investigations of sound generating, sound transmitting and sound controlling mechanisms. Exemplary examples were

- Berger's mass law (1910)
- Derivation and validation of practical approximation formulas
- Introduction of "dB" (1920s)
- Introduction of loudness characterization in "phon" (1926)
- Derivation and experimental verification of coincidence effect by Cremer and Eisenberg (1942/48)
- Development and provision of versatile measurement technology
- Development and provision of theoretically and empirically well-founded state-of-the-art for the most important disciplines of Technical Acoustics.

In total, in the middle of the last century Technical Acoustics may be described as a discipline which feels committed to the fascination of new technical possibilities (electro acoustics) and quality-conscious hearing requirements (room acoustics) but also to a still weak social awareness of detrimental noise effects (noise control). By orienting successive insight along the requirements of increasing mechanization, Acoustics had been able to recommend itself as an important instrument of prudent engineering activities: Technical Acoustics thus had become Engineering Acoustics.

3. ENGINEERING ACOUSTICS AFTER 1950

Reconstruction in Europe after devastating world war II had to fulfil so many basic needs that minor relevance only could be given to all questions of sound comfort. But it just was the mechanization which - being consciously experienced during new reconstruction - resulted in increased prosperity and thus implicated higher quality demands. Slowly but steady, in the following years these demands then found their way into planning and approval procedures. The consideration of quality demands became more and more important when new efficient and material-saving construction and production methods at the same time had to fulfil higher durability and stability and improved acoustical/vibrational characteristics. Engineering Acoustics thus was given a growing, indispensable cross-sectional function within almost all engineering disciplines. Without timely involving Engineering Acoustics, it became more and more difficult to realize optimal operating conditions, environmental compatibility of technical systems, plants and processes or even growing demands for better functionality and comfort of technical products.

In Germany, the nucleus for managing and upgrading this acoustic engineering work was found in some prominent scientific centers which were founded or further developed after the war in Berlin, Dresden and Göttingen. Soon, acoustic engineering offices evolved from these centers which could provide acoustic know-how and experience as well as acoustic specialist knowledge to companies and authorities which thus were able to cope with new acoustic issues and problems. Iterative interaction of these scientific centers with the practice oriented work of acoustic engineers continuously enhanced state-of-the-art knowledge and thus set the basis for development of a new interdisciplinary discipline.

Although a growing number of private and public institutions today have own acoustic competence, specialized acoustic engineering companies still are of central relevance. Apart from their specific potential of knowledge and experience, this relevance is based on exchange of acoustic insight and methods between different application fields. While the work of specialized departments often is constrained by their limited applicative area, diversified acoustic engineering companies benefit from experiences and methods which initially were tailored to different applications.

4. FOCUS OF ENGINEERING ACOUSTICS TODAY

Today, engineering acoustics is a widely acknowledged cross-sectional discipline which necessarily has to be involved systematically to meet ambitious requirements to environmental compatibility of systems, plants and products. Although recent requirements may particularly focus on traffic and transportation noise, other areas like effective limitation of industrial and neighborhood noise or noise at working places need competent involvement of Engineering Acoustics in planning, design, approval and layout. In addition to this, engineering acoustics today equally play a significant role in actively designing various sounds, particularly if rooms are to be acoustically optimized for specific use or if specific product sounds are to be realized.

Engineering acoustics has been able to cope with this profile of requirements by growing standardization and automatization of its planning and developing activity and today has got modern tools which essentially facilitate analysis and assessment, prediction and targeted control of sounds. Illustrative examples of successfully involving and applying engineering acoustics are

- modern computer-aided technology and methods to register and evaluate acoustic signals,
- integration of subjective parameters and assessments into the characterization and assessment of sounds and their effects,
- progress in problem-oriented modelling of acoustic fields and mechanisms for application specific simulations and predictions,
- continuous development of simulative calculations and assessment criteria in room acoustics,
- targeted definition and realization of product sounds particularly for automotive sounds,
- essential progress in technical analysis and reduction of road-, rail, and aircraft noise,
- high environmental compatibility of industrial plants by technical means,
- successful research, provision and implementation of innovative methods for active control of sounds and noise.

These examples illustrate how engineering acoustics has successfully established itself as an indispensable part of modern engineering and technology. This in turn has revitalized the classic field of acoustics which, at the time, tended to be underestimated as conclusively understood and lacking new challenges. The roots of this turnaround were clearly set in the diverse environment of after war reorientation. Therefore, this is an impressive example of the effectivity of many mutually reinforcing influential factors on partial disciplines of science and technology, an example of the importance of context and its mutual dependencies.

5. CONCLUSION AND OUTLOOK

In spite of all progress in the last years and decades: the physically complicated wave nature of sound and vibration fields remains a challenge to continuously improving state-of-the-art engineering acoustics by innovative research and development. This is because only powerful engineering acoustics are able to ensure high standards and environmental compatibility for growing mechanization and mobilization of our world.

Although being the result of numerous individual efforts and successes, the overall development of engineering acoustics was strongly determined by the specific melting pot of the postwar period. This impressive example of contextual energies would deserve a complete, well balanced investigation and representation of the underlying historical relationships.

REFERENCES

1. Költzsch, P. Schriftenreihe zur Geschichte der Akustik. Vol 1 - 11, published by DEGA, Deutsche Gesellschaft für Akustik, Berlin, www.dega-akustik.de
2. Scheuren, J. Entwicklung, Bedeutung und Perspektiven der Ingenieurakustik zwischen physikalischer Wissenschaft und angewandter Technologie. Fortschritte der Akustik, DAGA 2016, Aachen, p.1-14, Deutsche Gesellschaft für Akustik, Berlin, 2016.
3. Beyer, R.T. Sounds of our times. Springer, Berlin, 1999
4. Scheuren, J. 100 Jahre Technische Lärmminderung in Deutschland. Zeitschrift für Lärmbekämpfung 49(6), 2002, S.199–218.