Acoustics in Sweden 1940-2013

Introduction and the Swedish Acoustical Society

Hans Jonasson

This very condensed history of Swedish acoustics after 1940 has been written by Hans Jonasson, president of the Swedish Acoustical Society (SAS) since 2007. In 2013 SAS had 229 members including 11 supporting members. SAS was founded in 1945 and has had the following presidents:

1945: Gunnar Heimbürger, ci, KTH, building technology
1948: Vilhelm Nasiell, med dr
1949: Stellan Dahlstedt, technical manager on Swedish Film industry 1945 - 1961.
1950 – 1960: Erik Mattsson, director, Radiotjänst (Swedish Radio)
1961 - 1965: Stellan Dahlstedt
1966 - 1975: Gunnar Fant, professor, speech transmission laboratory, KTH (Royal Institute of Technology)
1976 – 1980: Johan Sundberg, professor, Musical Acoustics, KTH
1981 – 1986: Bertil Johansson, Technical Audiology, KI (Caroline Institute)
1987 – 1989: Sven Lindblad, professor, Technical Acoustics, LTH
1990 – 1995: Tor Kihlman, professor, Teknisk akustik, CTH
1996 – 1999: Per-Anders Hellström, Swedish Defence
2000 – 2006: Leif Åkerlöf, ÅF-Ingemansson
2007 - : Hans Jonasson, SP Technical Research Institute of Sweden

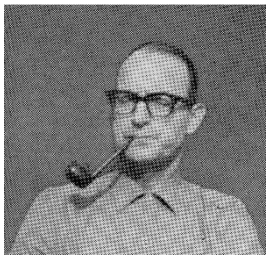
Several SAS members have contributed to this historical overview but the time available has not permitted a full coverage of all fields of acoustics or check of all facts. There are bound to be important gaps and may be some errors as well.

Early history 1940-1960 "The starting up period"

At the beginning of the above time we encounter several famous names. At the end of WW II Per Brüel came to Sweden and got involved in starting up the first laboratory in acoustics at Chalmers in Göteborg. At Chalmers he met Uno Ingård who graduated in 1944 and became head of the acoustic activities at Chalmers when Per Brüel went back to Denmark, bringing with him one of the most famous future B&K products, namely the logarithmic level recorder which was developed during his time at Chalmers. In 1942 he had founded the company Brüel & Kjœr together with Viggo Kjœr.

Per Brüel 1987

In 1945 Per Brüel was one of the 9 founding fathers of the Swedish Acoustical Society. Some of the others were the architect Gunnar Heimbürger, the technical head of the Swedish Film Industry (SF) Stellan Dahlstedt and Ove Brandt, special teacher in building acoustics at the



Ove Brandt ca. 1960

Royal Institute of Technology (KTH) in Stockholm. In 1958 Ove Brandt published handbook no. 1 (!) of the Swedish Building Research Council, *Akustisk planering*, which was a great help in creating the high standard (relative other countries at that time) in building acoustics achieved in Sweden later in the 1960-ies and 70-ies. Stellan Dahlstedt left SF in 1961 when he founded Akustikbyrån.

Uno Ingard (from internet)

1950 Uno Ingård left for MIT where he met Philip Morse together with whom he later wrote the well-known book *Theoretical Acoustics*. Before he left, Ingård recruited Stig Ingemansson into acoustics. In 1956 Stig Ingemansson founded Ingemanssons Ingenjörsbyrå in Göteborg, which 20 years later was to become the second largest acoustic consultant in the world, second only to the famous BBN in Boston. Ingemanssons is now part of ÅF.

Stig Ingemansson 1987

At KTH in Stockholm Ove Brandt taught building acoustics for civil engineers whereas Gunnar Fant pioneered the field of speech transmission, which was important for the Swedish tele communication industry. Gunnar Fant earned his doctor's degree at KTH in 1958. Like Uno Ingård he spent a few years, 1949-51, at MIT. During 1951-1966 he lead the work at the speech transmission laboratory and in 1966 he received a personal professorship at KTH.

Gunnar Fant (from internet)

1960-1979 "Building of new laboratories"

During this period the results of 100 years of continuous high economic growth in Sweden without taking part in any wars became visible. The public sector expanded enormously and huge investments were made in infrastructure, dwellings and education. The rest of Europe had still not recovered completely from the war and Sweden was despite its small size a leading country with respect to building acoustics and noise abatement. In 1963 the department of audiology at the Caroline Institute starts up with Bertil Johansson as head. In 1966 the new technical university Lund Institute of Technology inaugurates a well-equipped building acoustical laboratory with Tor Kihlman as provisional head. A year later Tor Kihlman becomes the first doctor in Sweden in building acoustics by explaining the extreme vertical flanking transmission of lightweight concrete elements, which had recently been introduced on the Swedish market. In 1969 he moves back to Göteborg and Chalmers to become the first Swedish professor in building acoustics. By that time Chalmers has also got a new fully equipped laboratory with focus on building acoustics.

Tor Kihlman 2009

In 1977 Göran Gadefeldt becomes the first professor in technical acoustics at KTH. His professorship was sponsored by Marcus Wallenberg and Atlas Copco. The same year Statens Provningsanstalt, now SP Technical Research Institute of Sweden, inaugurates a new, large and very well equipped acoustical laboratory in Borås in West Sweden with Hans Jonasson as head. Hans Jonasson became the second doctor in building acoustics in Sweden in 1971 with the thesis *Sound propagation over ground with and without acoustic barriers*. At about the same time Rockwool built a laboratory for measurements of sound absorption and sound insulation in Skövde. This laboratory was later to be taken over by Ralf Friberg who founded Akustikverkstan. In 1979 Johan Sundberg becomes the first professor in musical acoustics at KTH.

Johan Sundberg 1987

Göran Gadefelt 1974

During the 1970-ies large amounts of money became available for noise abatement measures in the Swedish industry thanks to a new fund for protection at work, Arbetsmiljöfonden. Working groups were created for the noise abatement within different industrial sectors, e.g. the paper and pulp industry, the engineering industry, the food industry, the concrete product industry, the graphic industry, the saw milling industry and the wood working industry. Each working group consisted of an acoustical consultant and representatives from the trade unions and the companies involved. Great progress was made and a great number of practical test cases were made and reported. A review of noise abatement principles for machinery was published 1977 in the book Noise abatement – principles and application (Bullerbekämpning - principer och tillämpning) created by Stig Ingemansson and Hans Elvhammar. This book became very popular and was translated into English and distributed internationally by the Acoustical Society of America.

During this time there were significant cooperation between Nordic authorities, e.g. with respect to building regulations and prediction methods for environmental noise and thanks to this we got a coordinated Nordic view and significant influence on European level whenever

decisions were taken within these fields. In 1977 we got a common Nordic prediction method for road traffic noise. This method was to a large extent based on research carried out at LTH in the beginning of the 1970-ies. For its time it was quite advanced as it was based on the same theoretical grounds as the later Nord2000 and Harmonoise methods. The main difference was that it did not deal with the meteorological effects on sound propagation. As to building regulations we failed to get exactly the same sound requirements. Although they became very similar there were a few deviations between the countries.

During this period several acousticians receive distinguished rewards. In 1965 Göran Gadefeldt receives the gold medal of the Royal Swedish Academy of Engineering Sciences, IVA, for achievements within the fields of impact and noise abatement. In 1970 Uno Ingård receives the Gustav Dalén medal from Chalmers. In 1977 Gunnar Fant receives the great award of KTH. In 1978 Gunnar Fant receives an honorary doctorate from Grenoble University.

1980 – 1999 Consolidation

During this period Sweden is well established in acoustics. In 1988 the International Congress on the Biological Effects of Noise, ICBEN 1988 is arranged in Stockholm and in 1990 Internoise is arranged in Göteborg with more than 1000 participants.

In 1989 Anders Nilsson succeeds Göran Gadefeldt as professor in technical acoustics at KTH and 8 years later he can inaugurate the new, expanded Marcus Wallenberg Laboratory (MWL) for sound and vibration research.

In 1994 the government proposition 1993/94:215 *Action plan against noise* is approved by Riksdagen. The main message was: Annoyance from noise in the society shall be limited strongly and sound levels shall be lowered in order to expose fewer people for noise. The proposition was based on a one-man investigation carried out by Tor Kihlman. This investigation led later to an introduction of a voluntary sound rating of buildings. It started with a Building Research Publication: The sound guide – Selection of sound quality in building by Leif Åkerlöf and in 1996 we got a new Swedish standard SS 25267 Building acoustics – Sound rating of rooms in buildings – Dwellings. Here, for the first time, specified requirements stricter than current building code regulations were introduced. As an example three classes, A, B and C, were introduced for sound insulation. C was the minimum, regulatory requirement whereas B was 4 dB better, and A further 4 dB better than B. This approach turned out to be very successful and nowadays most new dwellings meet class B requirements and some even class A.

Leif Åkerlöf 2006

In 1996 Sweden introduces, probably as the first country in the world, specific guidance values for frequencies below 100 Hz. At the same time guidance values for high sound pressure levels from music indoors and outdoors are introduced. In this context it should be pointed out that guidance values were taken very seriously in Sweden and usually dealt with like regulatory limit values.

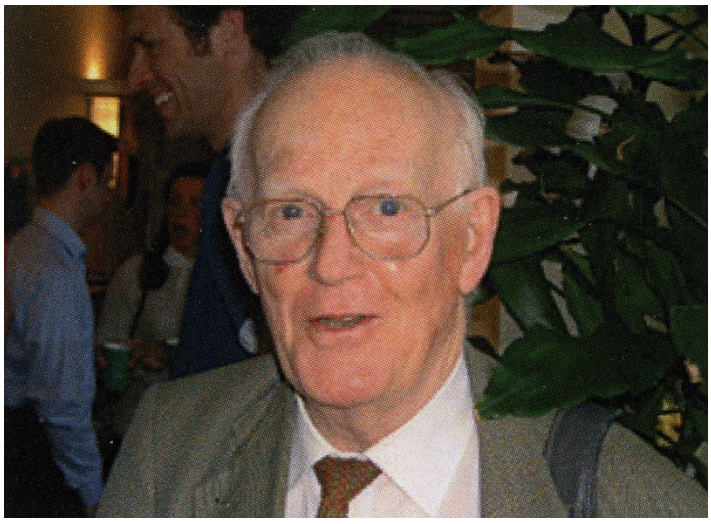
In 1996 the Nordic road and rail administrations financed the Nord2000 project aiming at more accurate prediction methods for traffic noise with the capability to include effects of meteorological conditions on the sound propagation. The work was carried out by SP in Sweden, Delta in Denmark, SINTEF in Norway and VTT in Finland. The project was quite successful and the results had great influence on the later European Harmonoise and Imagine projects.

In 1997 the government proposition 1996/97:53 *Infrastructure for future transports* is approved by Riksdagen. For the first time Sweden formally got unambiguous guidance values for road traffic noise.

In 1999 WHO publishes *Guidelines for Community Noise,* behind which there were significant Swedish contributions, notably by Thomas Lindvall and Birgitta Berglund at the Caroline Institute/Stockholm University.

Birgitta Berglund 2011

During this period the following acousticians receive distinguished awards: In 1980 Bertil Johansson receives an honorary doctorate from KTH. In 1985 Stig Ingemansson receives an honorary doctorate from Chalmers. In 1985 Gunnar Fant receives the LM Ericsson award. In 1988 Gunnar Fant receives an honorary doctorate from Stockholm University. In 1998 Gunnar Fant receives the gold medal of the Royal Swedish Academy of Engineering Sciences, IVA, for important achievements as innovator within the field of speech research, which has important consequences for the design of modern tele and data communication systems, aid appliances for hearing and sight damaged persons, for speech science, phonetics and voice therapy, etc.



Bertil Johansson

2000 – today Turning even more international

This period has been dominated by large projects, often co-funded by the European Union and with participation from many countries. Some examples are given in the following table:

Acronym	Field	Swedish participation
Harmonoise	Harmonized prediction methods for environmental noise	SP, VTI
Imagine	Harmonized prediction methods for environmental noise	SP
Quiet	Railway infrastructure optimisation and monitoring for further noise reduction	KTH, MTRS, SLL, Strukton, TBT, Tyréns
HOSANNA	Decreasing noise from road and rail traffic during propagation	Chalmers, Stockholm University
Cargovibes	Human response to ground-borne vibration affecting residents near railway lines	Sahlgrenska Academy
SILVIA	Sustainable Road Surfaces for Traffic Noise Control	Skanska, VTI

Also national Swedish projects have been larger than they used to be and often involving many participants with different fields of expertise.

Among such Swedish projects we have, e.g.:

Mistra with its 8 years long project *Soundscape for better health* with Kjell Spång, former managing director of Ingemansson and Akustikbyrån, as programme head. The project ended in 2007 and one of the most interesting innovations that was studied, was the importance of a quiet side of buildings in urban areas.

Kjell Spång 2012

AkuLite is a research project involving Swedish building industry and acoustic research groups, which aims to develop sound and vibration criteria that are consistent with people's perception in lightweight buildings. Project leader is Klas Hagberg, WSP. Focus has been on

impact sound insulation of lightweight floors, as traditional rating methods have been shown not to work very well for these cases.

Klas Hagberg 2011

In 2002 Ulf Sandberg, together with Jurek Ejsmont, published the extensive *Tyre/Road Noise Reference Book*, covering all state of the art knowledge based on their extensive experience from research and standardization in this field.

Ulf Sandberg 2013

In 2003 the International Congress on Sound and Vibration ICSV took place in Stockholm.

In 2004 Stig Arlinger receives an honorary doctorate from Linköping University for his works in audiology.

Stig Arlinger 2011

The Sound Award of the Swedish Acoustical Society

Every year since 1993 the Swedish Acoustical Society (SAS) awards a person, a company, an institution or an authority that has contributed to or built up conditions for a better sound environment in Sweden with the Sound Award. So far the award has had the following recepients:

1993 SKB Karin Wiklund, sound quality of dwellings
1994 Per Brüel, one of the founders of SAS 1945 and manufacturer of sound and vibration equipment
1995 Sören Norrby, liberal politician behind the national action plan against noise
1996 The Building Research Councilt
1997 Konsumentverket/Råd och rön
1998 Tor Kihlman and Stig Ingemansson
1999 Gösta Bengtsson and Mattias Flock
2000 AMMOT Artists and musicians against tinnitus
2001 The Swedish Rail Administration project Kallhäll - Kungsängen
2002 The sound artist Mikael Strömberg
2003 Universitetslektor Hans Peter "HP" Wallin
2004 Professor Johan Sundberg for his great contributions to the development and understanding of musical acoustics, speech learning and synthetical speech
2005 Kim Kähäri – for great contributions towards prevention of hearing damages among musicians
2006 The Swedish Road Administration for contributions for support and development of quiet road surfaces
2007 The Sound Environment Center at Lund University in Sweden for its innovative strive to create an interdisciplinary research center with an aim to study sound as a phenomenon and how sound environments affect us.
2008 Kjell Spång as leader of the multidisciplinary research program *Soundscape for better*

health.

2009 Anders Bodin Fastigheter AB for progressive work for dwellings with very high sound quality.

2010 Stig Arlinger for his long and dedicated engagement for audiological research, standardization and information.

2011 Hörselskadades riksförbund (HRF) for its campaign "Befria samtalet (Liberate the conversation)" which successfully drew the attention to problems with high sound pressure levels in public spaces.

2012 Birgitta Berglund for internationally successful work for dissemination of knowledge of the harmful influence of environmental noise on human beings.

2013 Bo G. Pettersson as promoter and prompter at The National Board of Health and Welfare (Socialstyrelsen) for guidance values and measurement methods for noise indoors, in particular low frequencies, and high sound pressure levels from music at arrangements indoors and outdoors.

Swedish participation in international standardization

Over the years Sweden has had an ambitious participation in international standardization in acoustics. ISO was set up in 1947, to compare with IEC which was set up already in 1906, and the same year ISO TC 43 Acoustics was one of 67 technical committees to come into operation. 1984-1994 Bertil Johansson was chairman of IEC TC 29 Electroacoustics. He was also heavily involved in ISO TC 43 working with hearing protectors and hearing damage criteria. In 2008 Hans Jonasson became chairman of CEN TC 211 and ISO TC 43 with ISO TC 43/SC 1, the secretariats of which were held by Denmark. ISO TC 43 with subcommittees 1 and 2 met, together with IEC TC 29 in Stockholm in 1979 and in Borås and Stockholm respectively in 2008.

Hans Jonasson during ISO TC 43 plenary in 2009

Some of the most frequent Swedish working group participants have been Ulf Sandberg on tyre/road noise, Bertil Johansson and Stig Arlinger on hearing damage and hearing protectors,

Manfred Klopotek on vehicle noise, and Hans Jonasson in building acoustics and on various noise standards.

In 1973 Nordtest was founded with the purpose of development of harmonized Nordic test methods. Until Nordtest ceased to exist at the beginning of this millennium, a great number of Nordtest projects were carried out with participation from 4-5 Nordic countries. Most of these projects were successful and when CEN required new test methods for the purpose of getting harmonized test methods for the European single market, the starting point was often a Nordtest method. Thus, thanks to Nordtest, the Nordic countries achieved great influence within ISO and CEN in the 1980- and 1990-ies. This is illustrated by the following table:

ISO/CEN-standard	**Nordtest project, method, reports**	**Influence due to the work of Nordtest**
EN ISO 140-3:1993 Airborne sound insulation in the laboratory	NT-project 29-75, 52-76 NT ACOU 013:1979 LL rapport nr 4,1976 NT-project 669-87 NT ACOU 073:1989 SP-AR 1988:36	Rules for flanking correction when measuring windows and doors. Mounting requirements for window size and niche location.
ISO 140-5:1998 Facade sound insulation	NT-project 556-85 NT ACOU 072:1989 SP-RAPP 1986:37 NT-project 494-84,665-87 NT ACOU 074:1989 LI rapport nr 131,1986	Total revision of loudspeaker method. Requirements when using aircraft noise as source.
ISO 140-6:1998 Impact sound insulation in the laboratory	NT-project 279-81 NT ACOU 050:1985 SP-RAPP 1983:01	Practical details, e.g. stationary condition during measurement.
ISO 140-8:1998 Impact sound improvement in the laboratory	NT-project 279-81 NT ACOU 050:1985 SP-RAPP 1983:01	Practical details, e.g. stationary condition during measurement.
ISO 140-10:1991 Sound insulation of small building elements in the laboratory.	NT-project 196-79 NT ACOU 037:1982 SP-RAPP 1980:22	The standard is fully based on the Nordtest method.
ISO/TR 140-13 Guidelines for sound insulation measurements	NT-project 963-91 NT TR 203 Delta report	= Nordtest report.
ISO 354:1985 Sound absorption in reverberation rooms	NT-project 6-74, 27-75 NT ACOU 012:1979 SP-RAPP 1974:30,1977:13	The procedure for determining number and location of diffusers has been copied from the NT-method.
EN ISO 717-1:1996 Rating of airborne sound insulation	NT-project 491-84 NT ACOU 061:1987 SP-RAPP 1985:43	Traffic noise spectrum and calculation methodology taken from NT.
EN ISO 3743-1:1994 Sound power level with reference sound source in hard rooms	NT-project 414-83 NT ACOU 060:1986 SP-RAPP 1984:19	The standard is based on the NT-method

EN ISO 3744:1994 Sound power level in a free field above a reflecting plane	NT-project 667-87 NT ACOU 080:91 LI report nr 142, 1989	Methods for measurements on sources near walls and corners have been taken from NT.
ISO 3747:1991 Sound power level in situ with reference sound source	NT-project 621-86 NT ACOU 078:1988 SP REPORT 1988:03	The basic concept has been taken from the NT-method.
EN ISO 9614-2:1996 Sound power using intensity scanning	NT-project 558-85 INSTA 122 STF44 A86166	The standard is based on the INSTA-method
ISO 10053:1991 Office screen sound attenuation	NT-project 120-77 NT ACOU 036:1981 SP-RAPP 1980:8	The standard is based on the NT-method.
ISO 10847:1997 Insertion loss of traffic barriers	NT-project 496-84 STF44 A86165	The standard contains significant parts of the NT-project.
EN ISO 11546:1995 Airborne sound insulation of enclosures	NT-project 234-80 NT ACOU 058:1986 SP-RAPP 1982:30	The standard is based on the NT-method
EN ISO 11654 Rating of sound absorbers	No NT-project NT ACOU 079:91	The standard is based on the NT-method
EN ISO 11957:1996 Airborne sound insulation of cabins	 NT ACOU 057:1986 DTH in Lyngby	The standard is based on the NT-method
ISO 15186-1:1999 Measuring airborne sound insulation using intensity	NT-project 746-88 NT ACOU 084:1992 SP REPORT 1991:23 NT-proj1065-92 NT ACOU 093:95 VTT Publication 262	The standard is based on the NT-method. NT ACOU 093 refers to small building elements.
ISO 13475-1:2000 Emission from sirens	NT-project 671-87 NT ACOU 081:1991 Delta rapport	The standard is based on the NT-project
EN/ISO 11205:2004 Noise from machines using intensity	NT-project 1129-93 NT ACOU 097:97 SP REPORT 1995:75	The standard is based on the NT-project
EN 1793-3:1997 Traffic noise spectrum for noise barriers	NT-project 491-84 NT ACOU 061:1987 SP-RAPP 1985:43	The EN spectrum is taken from the NT-method.
EN 12096:1997 Vibration declarations	NT-project 964-91 SP REPORT 1992:15	The standard is based on the NT-project
Abbreviations:	LL=Lydteknisk laboratorium (Today: Delta) SP=Sveriges provnings och forsknings institut WD=Working draft CD=Committee draft INSTA=Nordic Standard VTT=Technical Research Centre of Finland	LI=Lydteknisk Institut (Today: Delta) STF=SINTEF WG=Working group DTH=Danmarks tekniske Højskole (Today: Technical Unversity of Denmark)