EFSUMB History of Ultrasound

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Germany

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Introduction

The modern technical use of ultrasound began at the beginning of the 20th century, stimulated by the sinking of the Titanic in 1912, and with the idea of being able to detect obstacles underwater using ultrasound. The German **Alexander Behm** [(1)] and the Englishman Lewis Richardson [(2)] developed approximately simultaneously and independently from each other, an echo sounder

Figure 1 Alexander Behm, the inventor of the Behm echo sounder. (Source: German Ultrasound Museum [(3)]).

The generation of ultrasonic waves using the piezoelectric effect was a prerequisite for its practical implementation. The principle of analysing echoes generated by emitted short ultrasonic pulses was then introduced in the 1930s for non-destructive testing of metals, proposed by Sergej Sokolov, USSR [(4)] and also **Otto Mühlhauser**, Germany [(5)].
Associated with these technical developments was a closer examination of the characteristics of ultrasound and its effect on biological tissue. The chemist **H. Gohr** and the physician **Th. Wedekind** at the Medical University Clinic in Cologne extensively investigated the effect on biological tissue. Based on of their results, they excluded therapeutic use in humans, at least with the high powered ultrasound they used. However, they speculated about the possibility of using ultrasound location - analogous to the maritime echo sounder - to determine the size and shape of internal organs and to detect tumours and abscesses [(6)]. At that time, however,

the ultrasound power required was too high, and the image converter used in the material testing was too insensitive and too sluggish (Soldner R. Personal communication).

The possibility of using ultrasound to generate heat in deeper tissues of the body led to the first widespread use of ultrasound in medicine. This conversion of kinetic energy into thermal energy as a result of absorption in the tissue is based on the law of energy conservation, which, incidentally, was discovered by the German doctor **Robert Mayer**, Heilbronn, in 1845: "… where movement is lost, heat is generated". This form of therapy was introduced in 1939 by **Reimar Pohlmann** (Berlin), but with lower intensities for the treatment of the epicondylitis of violin players and other of musculoskeletal problems [(7)]. Pohlmann has already carried out experimental studies on the imaging of objects using sound waves at the physicochemical institute of the University of Berlin [(8)].

Figure 2 Ultrasound treatment by R. Pohlmann (Source: German Ultrasound Museum).

Ultrasound diagnostics with one-dimensional A-Mode in Germany

In 1949, a first international congress "Ultrasound in Medicine" took place in Erlangen, at which the bioeffects of ultrasound in general and the experiments and results of ultrasound treatment of various diseases - from herpes zoster to duodenal ulcer - were reported [(9)]. The first ultrasound association in Germany was also established there with **L. Bergmann** (physics), **Boris Rajewsky** ("Biological Matters"), and **Otto Grütz** (medicine) as board members.

Figure 3 „Der Ultraschall in der Medizin", 1. Conference in Erlangen 1949, cover of congress report. (Source: German Ultrasound Museum Lennep).

Two lectures at this 1949 Congress dealt with experiments to use ultrasound for diagnostics. However, not using the echo sounder, i.e., the reflection method, but analogous to X-ray diagnostics by scanning through a body section and analysing the different absorption. Karl Dussik (Vienna, Austria) presented his experiments, started in 1942, to create a projection image of the brain due to the different absorption of ultrasound in the tissue [(10)]. However, Güttner and co-workers suggested that his widely published image of the ventricular system was an artefact [(11)]. **Wolf Dieter Keidel** (Erlangen, Germany) registered the different absorption of a one-dimensional ultrasound beam after passage through the thorax at heart level over time, depending on the state of filling of the heart, in order to analyse the time course of diastolic filling and systolic ejection [(12)].

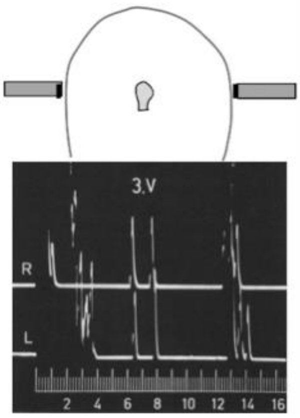
A little later, the ultrasound echo method was introduced into medical diagnostics, such as for the detection of gallstones, analogous to the detection of defects in metals. George D. Ludwig (Bethesda, USA) tried around 1946 to search for foreign bodies in tissue experimentally, such as gallstones [(13)]. John Julian Wild (1949) - experimentally used surgical specimens to examine the possibility of diagnosing tumours using ultrasound [(14)].

The devices developed for non-destructive material testing with one-dimensional technology (A-mode) were used, which were initially only externally adapted to this new use. The manufacturer in Germany in 1949 was the company ´Krautkrämer´ founded in Cologne by the brothers **Dr. Josef and Herbert Krautkrämer** in a garage. Siemens company concluded a contract in 1956 with this company and took over their devices for medical diagnostics.

Figure 4 **Device from Krautkrämer (left) for material testing and Siemens (right) for echoencephalography (a) (Source: German Ultrasound Museum Lennep). Measurement of the third cerebral ventricle from right and left (b). (Source: German Ultrasound Museum).**

a

b



This procedure was first established in neurosurgery and ophthalmology: After the first publication by Lars Leksell [(15)] on the detection of intracranial bleeding after trauma due to a shift in the so-called central echo in Germany, **Ekkehard Kazner** (Erlangen), **Werner Pia, Wilhelm Feuerlein** and **Frieder Lahoda** (Ingolstadt) further developed what they called echoencephalography to one that at that time, prior to the development computed tomography was an essential tool in neurotraumatology. In 1967 E. Kazner published the textbook “Clinical Echo-Encephalography”, which was followed in 1968 by an English version [(16)]. Kazner was also the driving force and first president of the “German Working Group for Ultrasound Diagnostics” (DAUD, the forerunner of DEGUM) founded in 1971 in Germany (West).

Figure 5 E. Kazner, 1st Chairman of DAUD (Source: German Ultrasound Museum Lennep).

The echo method was introduced into ophthalmology with higher ultrasound frequencies (8 - 14 MHz), mainly for the eye’s biometry. After the first publications by Henry Mundt and William Hughes from the USA [(17)] and Arvo Oksala [(18)] **Werner Buschmann** was an early German pioneer. At the Charité in East Berlin (GDR) he worked systematically on the basics of diagnostics and in collaboration with the company Kretz (Austria) on the further development of the devices up to a fast B-image device for the eye, a concave curved array with ten elements [(19)]. At that time, Buschmann worked closely with the Institute for Medical Physics at Charité Berlin. In 1966 he published an "Introduction to Ophthalmic Ultrasound Diagnostics" [(20)]. After moving to the University of Würzburg, he regularly conducted introductory courses together with **Hans Georg Trier** (Bonn) and also published a textbook with H. G. Trier in 1989 on “Ophthalmological Ultrasound Diagnostics” [(21)].

Figure 6 Werner Buschmann, Berlin and Würzburg (Source: German Ultrasound Museum Lennep).

The early importance of ultrasound in these two fields is underlined by the fact that during an international symposium in East Berlin in 1964, W. Buschmann called for the founding of the international ultrasound society of ophthalmologists "Societas Internationalis de Diagnostica Ultrasonica in Ophthalmologia" (SIDUO). According to the announcement by Buschmann, physicians and engineers agreed at their first meeting (SIDUO I) to continue working in a loose "DDR Ultrasound Diagnostics Association", which arose under his leadership. From 1964, Buschmann conducted the first courses and internships at the Charité His department became a "place of pilgrimage" for those interested in ultrasound from East and West. Buschmann left the DDR in 1976 due to increasing hindrance to his research and international collaboration and continued his work in Würzburg.

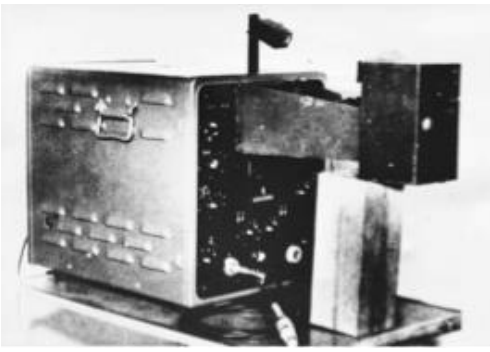
Echocardiography

The pioneers of echocardiography in Lund, Sweden, the German **Carl Hellmuth Hertz*** (physicist and son of Nobel price winner Gustav Hertz), and his Swedish colleague Inge Edler (cardiologist) initially used a device for material testing to extract echoes from the heart. However, it was necessary to continuously register the echoes, such as the mitral valve, to analyze their movements. A correspondingly modified prototype was made available by Siemens in 1953 [(22)]. This technique of registering the echoes over time has become the basis of echocardiography for many years as "time motion" ("TM mode").

Figure 7 **German echo pioneer C. H. Hertz * (physicist) and his Swedish colleague Inge Edler (cardiologist).**

Figure 8 **The first ultrasound device (one-dimensional type device for material testing) converted for cardiac diagnostics with a film camera (Siemens / Edler and Hertz 1953). (Source R. Soldner, Siemens). b. Atrial myxoma: pre-operative (top) post-operative (bottom). (Source: S. Effert).**

a



b

This method developed in Lund, Sweden, was brought to Düsseldorf and later Aachen by **Sven Effert.** At first, however, there was little recognition of its value, perhaps because the development of cardiac catheter techniques was the focus of cardiologists' interest. Greater attention was then paid to echocardiography in the USA. There Harvey Feigenbaum was the recognized specialist in echocardiography. His publications were increasingly recognised. In 1976 he wrote the standard work of echocardiography in the USA [(23)]. His book was translated into German by **Gernot Autenrieth** (Munich), who was visiting him [(24)], This book contributed to increasing acceptance and dissemination of the technique. **Ekkehard Köhler** (Düsseldorf) was also actively involved in the diffusion of echocardiography in Germany with his books [(25, 26)].

The further technical development of the fast B-scan methods, which enabled the use of imaging ultrasound in cardiac diagnostics, then contributed to increasing acceptance and spread. Already at the 2nd World Congress in Rotterdam in 1973, the Dutchman Nicolas Bom presented a multi-element transducer for cardiac diagnostics with the company Organon [(27)]. From 1974 **Jürgen Gehrke** used the Vidoson (see below) for imaging diagnostics of the heart in Germany. Special devices with a sector-shaped image were more suitable for the transthoracic examination.

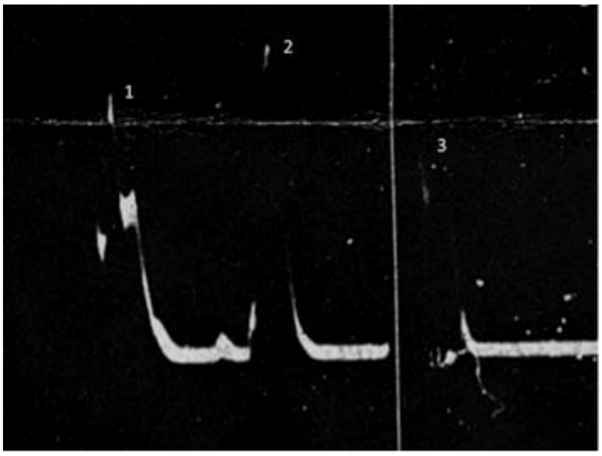
Ultrasound sectional mode (B-scan)

With the one-dimensional A-mode, attempts were made early to obtain information from the abdominal cavity. In addition to the American pioneer Ludwig (see above), Japanese pioneers, Toshio Wagai (surgeon), Yoshimitsu Kikuchi, and Rokuru Uchida (engineers), also examined its use for identifying abdominal pathology, e.g. gallstones experimental and transcutaneous as well as in connection with laparoscopy. The method was also suitable for the detection of pathological fluid accumulations such as ascites and pleural effusions. The surgeon **Günther Ortmann** (Erfurt, East Germany) worked with this A-mode procedure and already by 1972 presented remarkably good results of transcutaneous diagnosis of gallstones. At that time, B-scan devices were not yet available in the GDR [(28)].

Figure 9 A-mode gallbladder: a. normal gallbladder (echo 1 = abdominal wall, echo 2 =

front wall of the gallbladder, echo 3 = rear wall), b. multiple gallstones: multiple echoes in the gallbladder. (Source: G. Ortmann).

a



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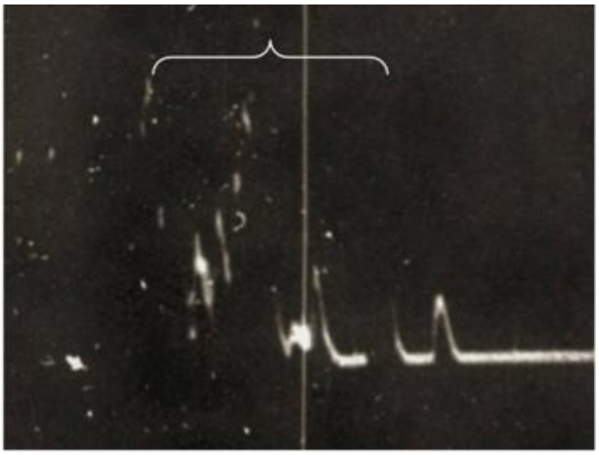


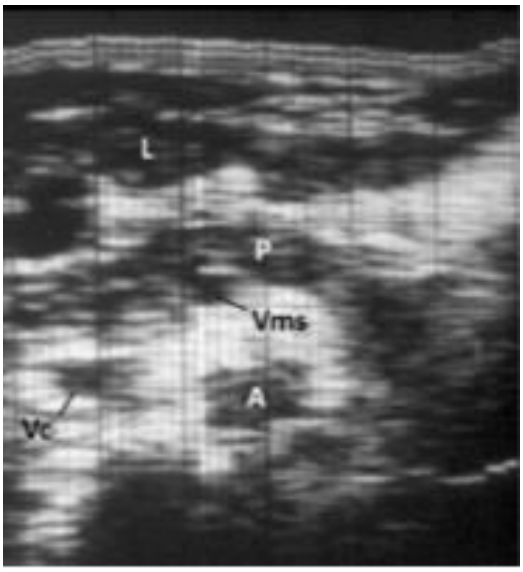
The notable progress for abdominal diagnostics in internal medicine, as well as in gynaecology and obstetrics, was the development of two-dimensional imaging devices (B-scan), initially the bistable compound scan system. In these systems, the single transducer was moved by hand with direct contact over the region of the body of interest, whereby swiveling movements were carried out at the same time (“compound”). From an adjustable threshold, the generated echoes were mapped onto a memory tube as “bright” pixels (“bistable”). The transition from the A-mode to the still bistable compound system is clearly shown in the textbook published in 1968 by the Austrian Alfred Kratochwil [(29)].

Compound scan devices were also used in Germany in internal medicine, primarily in abdominal diagnostics. In 1973 **Peter Otto** (Hannover) published his experiences with the compound scan device in a book [(30)]. More extensive monographs on the same subject appeared in 1977 by the gynaecologist A. Kratochwil (Vienna, Austria) and the radiologist Gisela Schneekloth (St. Gallen, Switzerland). The book by A. Kratochwil still based on the compound scan method, partly with the grayscale technique developed for these devices from 1972 [(31)], while images in the book by G. Schneekloth all based on grayscale-technique, but expressed in negative style [(32)].

Figure 10 **Compound scan, bistable: upper abdominal cross-section at the level of the pancreas (source: H. H. Holm) b. Vidoson 635: middle upper abdomen. The compound scan image shows an entire cross-section, the Vidoson only a section. However, the grayscale technique enables a clear demarcation of the pancreas. The recognizable vertical image lines according to the image structure from individual image lines (A = aorta, L = liver, P = pancreas, Sp = spleen, St = stomach with contents, Vc = vena cava).**

a

b



Radiologists in Germany also began to become interested in ultrasound diagnostics in Germany around 1974. The compound scan method was preferred by them because it depicted the entire body cross-sections. **Dietmar Koischwitz** and **Hermann Frommhold** in Bonn, and **Gerhard van Kaick** in Heidelberg were the first users. Koischwitz and Frommhold published their first book in 1975 with title "Ultrasound examinations on the organs of the upper abdomen" [(33)]. There they used only bistable images.

G. van Kaick was also one of the ultrasound pioneers in German radiology. He developed his nuclear medicine department at the German Cancer Research Center in Heidelberg into a leading center in ultrasound diagnostics. He dealt intensively with sonographic texture analysis.

In the field of obstetrics and gynecology, from 1965, **Hans-Jürgen Holländer** tried a new type of ultrasound machine in Münster from Siemens (see below), the Vidoson 635. **Manfred Hansmann** (Bonn), on the other hand, initially worked with a compound scan device from 1968. In the beginning, he mainly dealt with exact biometry of the foetus using ultrasound to determine the gestational age precisely and contributed significantly to the standardisation of measurement technology. As early as 1972, he used ultrasound-targeted amniocentesis to carry out intrauterine transfusions and developed a differentiated intrauterine therapy. Over the years, Hansmann has taken the leading role in Germany in obstetric ultrasound diagnostics. Together with his colleague **Jochen Hackelöer**, he introduced the world's first ultrasound screening for pregnant women in Germany in 1979.

Figure 11 **Hans-Jürgen Holländer at the Vidoson in the Ultrasound Museum 2011 (Source: German Ultrasound Museum Lennep).**

Figure 12 **Manfred Hansmann 1969 in Bonn (Source: German Ultrasound Museum Lennep).**

The development and spread of ultrasound diagnostics in (West) Germany were significantly influenced in these early years by a new device developed by Siemens, Erlangen. In 1962 the engineer **Richard Soldner** was commissioned to develop a device system for breast diagnostics. He designed a completely new device. His goal was to exclude movement artifacts and avoid tissue displacements due to the transducer's displacement on the skin. Furthermore, errors due to individual variations in the use of the examiner's transducer could be excluded utilising automatic scanning of the object.

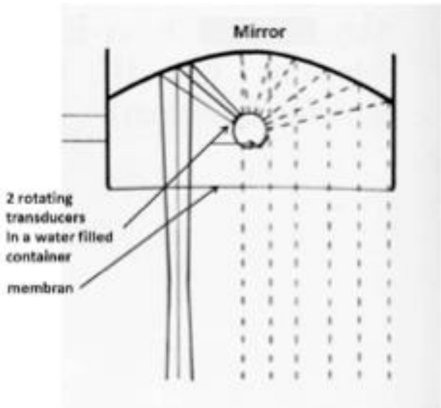
Figure 13 Richard Soldner, the 'father' of Vidoson (Source: German Ultrasound Museum Lennep).

For the fast and automatic scanning of the object, two, later three sound transducers (2.5 MHz) were arranged on a rotating axis in a water tank, which sent impulses against a parabolic mirror and from there, were directed in parallel through a membrane into the study area (Fig. 13b). The imaging width was limited to 12 cm with a penetration depth of 16 cm by an image frequency of 12-16 / second to achieve and be able to observe movements directly.

Figure 14 Vidoson 635 (a, Source: Siemens Museum). Sketch of the Vidoson principle (b, Source: German Ultrasound Museum Lennep)

a

b



In contrast to the bistable compound scan system, the echoes were displayed on the screen at different brightnesses depending on their strength (Fig. 14). In this way, he developed the first commercial device with real-time technology and gray scale display [(34)].

The Vidoson 635 was initially tested as intended for breast diagnostics in 1965 but did not produce any satisfactory results due to poor resolution. In contrast, the **gynecologist Hans-Jürgen Holländer** at the University Hospital in Münster quickly recognized the benefits of examining the small pelvis for suspected tumours and especially in (early) pregnancy (Fig. 14) [(35)]. He reported on his experiences at the 1st World Congress of Ultrasound Diagnostics in Vienna 1969 [(36)] and in 1972 he wrote his first book "Ultrasound Diagnostics in Pregnancy" [(37)].

Figure 15 Comparison of twins and placenta: a. Compound scan, bistable. P = placenta, R-1 and R-2 torso of the twins in cross-section (a, Source: A. Kratochwil, 1968).

Vidoson: heads of twins, front wall placenta. (b, Source: H. J. Holländer, 1966).

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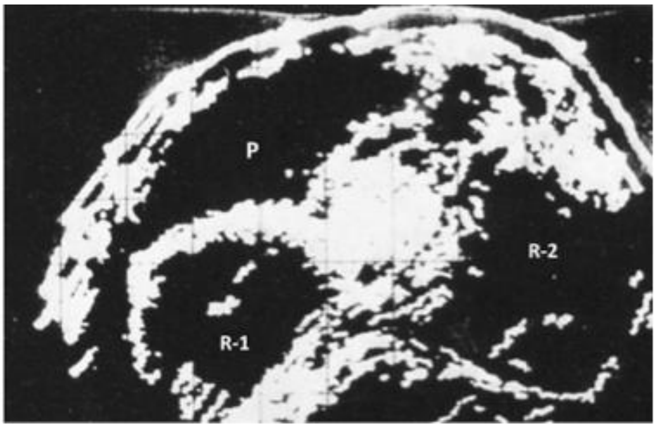

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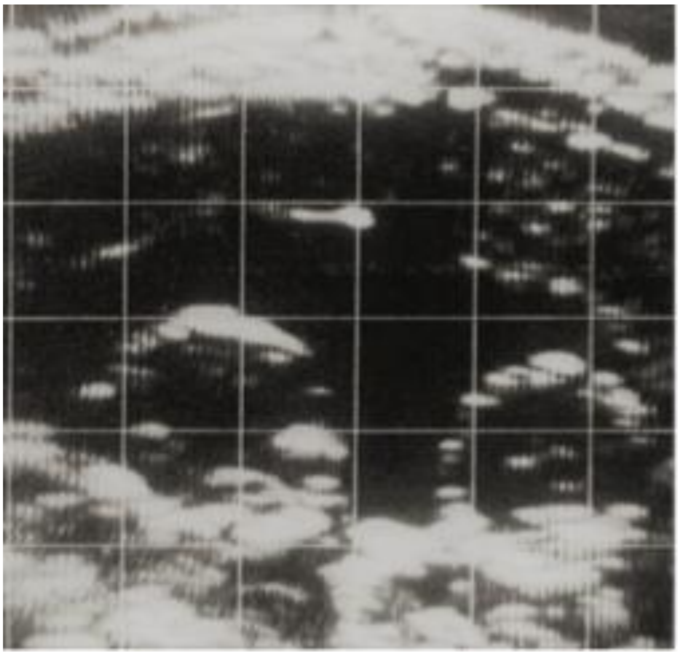

Then the Vidoson was also tested in internal abdominal diagnostics by **Gerhard Rettenmaier** at the University of Erlangen. As a hepatologist, he saw clear advantages as a result of the brightness-modulated representation of the internal echoes in parenchymatous organs such as the liver, which also made it possible to detect diffuse diseases such as fatty liver or cirrhosis, and in the direct representation of movements, such as the pulsation of the aorta (Fig. 15). He also presented his experiences at the 1. World Congress in Vienna in 1969 [(38)].

Figure 16 Gerhard Rettenmaier, founder of "internistic or clinical sonography" in

Germany (Source: K. H. Seitz)

Figure 17 **Right liver lobe and kidney with "normal" internal structure (a). Fatty liver with "dense" echo structure (b), Source: Harald Lutz.**

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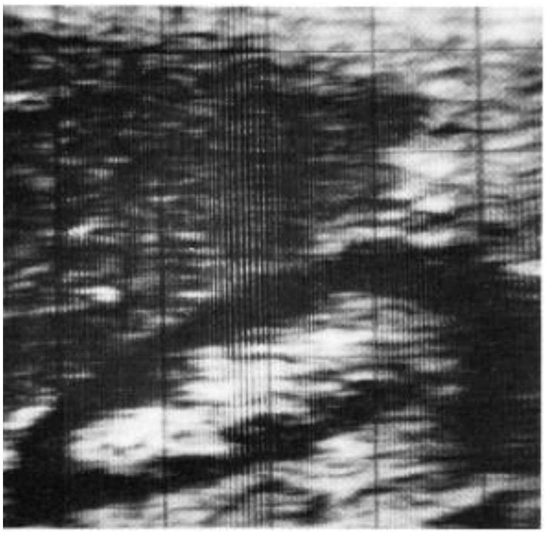

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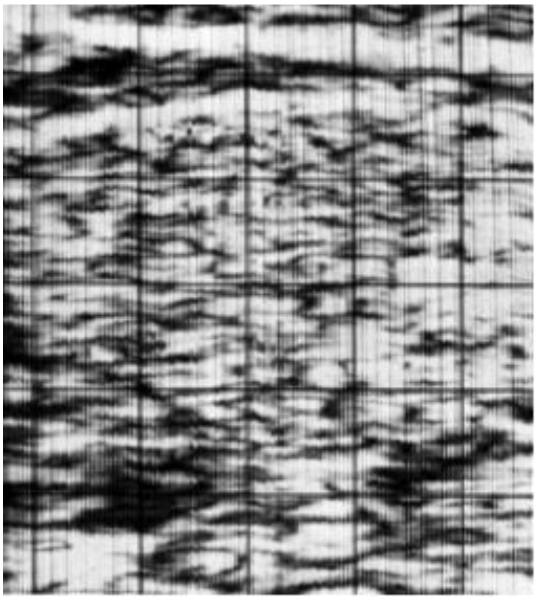


The Vidoson was quickly adopted and not only in Germany due to its new properties: it enabled short examination times due to the fast image build-up, was mobile, and could, therefore, also be used “bedside” in the admission ward or intensive care units. In comparison to the compound scan systems, it was also significantly cheaper. Although George Kossoff (Sydney, Australia) [(39)] developed gray scale technology for compound scanners, these devices were ultimately replaced by the development of further smaller but more powerful “real time” imaging devices between 1975 and 1985. The Austrian company Kretz developed a mechanical device with five rotating transducers in 1979, which were no longer arranged in a bulky water container and provided a sector-shaped image (Combison 100). From 1975 the “linear array” electronic devices developed in US (ADR 2130, in Europe from 1975 onwards) and Japan (Toshiba SAL-20 in 1979) also came to Europe. Due to the great success of the Vidoson, the Siemens company itself - unfortunately - held on to its Vidoson device system for too long, although Richard Soldner had already developed an array system himself. It was not until 1982 that Siemens launched its own newly developed Linear Array device, the Sonoline 8000, the first fully digitised ultrasound device. Compared to the countries where compound scan devices were originally used, such as in Anglo-American countries, ultrasound diagnostics have been developed in Germany (West) from the start, it means from the early development of the first Vidoson, based on real-time technique, mainly. The short examination times allowed the doctor to carry out the examination himself in direct contact to patient. The creation of ultrasound images by assistant staff, sonographers, and subsequent evaluation by the specialist did not save time and therefore was not useful. The examination could also be carried out by the responsible specialist himself. – That was the spread opinion of the German Ultrasound pioneers, that there was no need for a specialist in ultrasound diagnostics and no dedicated ultrasound department or assignment to a central x-ray department. Ultrasound diagnostics spread to many specialist areas and in the area of outpatient care as 'clinical sonography' with free access to all specialist disciplines.

In these early years, the first centers of ultrasound diagnostics for abdominal diseases developed: in Hanover at the medical university, led by **Peter Otto** and later **Michael Gebel**, and in Erlangen at the medical university clinic led by Gerhard Rettenmaier. He moved to Böblingen and developed a centre for clinical research and, above all, for training and further education in internal ultrasound diagnostics together with **Karlheiz Seitz**. **Harald Lutz** continued the ultrasound department at the Medical University Clinic Erlangen. In 1978 he published his first book about Ultrasound diagnostics in internal medicine which used only the modern images of Vidoson [(40)]. He also set up the Erlangen ultrasound school to meet the great demand for further training. In Marburg, there was initially an obstetric centre with Jochen Hackelöer, who was also committed to further training with courses starting to run at an early stage. Ultrasound diagnostics in internal medicine was developed there by **Wolf Schwerk**. Especially in Germany, Gotthard. v. Klinggräf and Jürgen Gebhardt (Hamburg), Adelheid and Hagen Weiss (Ludwigshafen/Mannheim), Peter Linhardt and Jörg Bönhof (Wiesbaden) and Horst Kremer (Munich) were involved in training in Germany.

In the beginning, the majority of internists oriented to gastroenterology also developed sonographic kidney diagnostics, including ultrasound-guided punctures. In the urological field, **Henning Bartels**, who started his work in Wuppertal in 1969, became the leading pioneer in West Germany. In 1981 he published his first book on "Uro-Sonography" by Springer Verlag [(41)], and coined the term uro-sonography. This was an area in which he was very committed to providing training and further education

Figure 18 Henning Bartels 1975 with kidney sonography (Source: H. Bartels).

Paediatrician **Dieter Weitzel** gained his first ultrasound diagnostics experience from P. Otto in Hannover with compound scan devices in kidney diagnostics. In 1973 he moved to the University Children's Hospital in Mainz, where he developed sonography in paediatrics using from the beginning the real-time device, Vidoson. At first the focus was on kidney diagnostics and later on the examination of the infant's hip to introduce a newborn screening. There were also the first attempts at heart diagnosis in childhood with the Vidoson. In 1984 he published his textbook [(42)]. Another pioneer in the field of paediatric ultrasound in West Germany was Reinhard Schulz from Düsseldorf and Stuttgart.

Figure 19 **a. Pediatrician Dieter Weitzel examining an infant (Source: D. Weitzel) b. Volker Hofmann, paediatric surgeon in Halle, a pioneer in East Germany (Source: V. Hofmann).**

a

b

The paediatric surgeon **Volker Hofmann** became the head of the newly founded Department for paediatric surgery at the St. Barbara hospital in Halle (GDR) in 1977. Thanks to church donations, he was able to use a Vidoson there. He gained experience with this new method being largely self-taught because an exchange with West German colleagues was not possible at the time. Initially, the focus was on kidney diagnostics and ultrasound-controlled punctures and drainage. He also used the method to quickly diagnose acute abdominal problems, such as invagination and trauma. In 1981 he published his experiences in his book [(43)], the first ultrasound textbook in the former GDR. After the merger of the two German states, he was accepted into the DEGUM board to represent the interests of colleagues from the former GDR. After the development of small, portable Doppler devices in the late 1960s, as suggested by Gene Strandness in Seattle (US) and Leandré Pourcelot (Tours, France), Doppler sonography was also used in a few centres by neurologists and angiologists in Germany. The neurologists first examined the vessels supplying the brain for stenoses and occlusion indirectly via the medial frontal artery or trochlear artery, and later utilising a direct examination of the vessels supplying the brain. The first centre in Germany was in the Freiburg area with the neurologists **Joachim von Büdingen, Hans-Joachim Freund, Michael Hennerici** and **Gerhard-Michael von Reutern.** The angiologists were represented by **Doris Neuerburg-Heusler** (Engelskirchen), who later became chair of the interdisciplinary working group "Vascular Diagnostics" in DEGUM. Interestingly, the imaging and doppler technology representatives met simultaneously at the annual meetings of German society (neurologists, angiologists), but in separate sessions. Only the technical development of the devices for duplex technology and the colour doppler system brought the two groups closer together in the later 1990s.

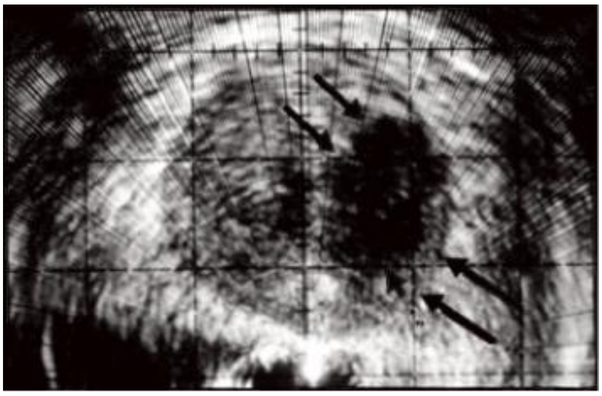
Endosonography

A important technical advance was the miniaturisation of the ultrasound probes, which allowed the use of intracavitary ultrasound probes. Early in the 1960s, pioneers John J. Wild and John M. Reid (US) experimentally investigated the possibility of detecting tumours using probes inserted into the gastrointestinal tract, and they also tried transrectal diagnostics of the prostate [(44)]. Further early studies were carried out in Japan: T. Ebina and Motonao Tanaka developed the transoesophageal diagnosis of the heart with ultrasound transducers mounted on the tip of an endoscope [(45)]. Hiroki Watanabe (Japan) developed the transrectal ultrasound diagnosis of prostatic pathology [(46)]. A centre for urological diagnostics was headed by Hans Henrik Holm Copenhavn (Denmark) [(47)]. In 1981 the Japanese company Olympus presented the first commercial ultrasound endoscope with a mechanical 360 ° scanner and a side view optic.

A pioneer of transoesophageal diagnostics (TOE) in Germany was **Peter Hanrath** (Aachen) [(48)].

For transrectal prostate diagnostics **Hagen Bertermann** and **Bernd Frentzel-Beyme** were the first German users to summarise their experiences in a book [(49)].

Figure 20 **Endosonography of prostate in prostate carcinoma (Source: B. Frentzel-Beyme).**



Wolf D. Strohm and **Meinhard Classen**, Frankfurt, and the Erlangen group dealt with transgastric diagnostics. The latter started with a one-dimensional ultrasound probe that could be inserted through the instrumentation channel of a surgical gastroscope [(50)].

Figure 21 A one-dimensional ultrasound probe (4 MHz) inserted through a commercially available gastroscope (Source: H. Lutz).

The Frankfurt group had early access to the Olympus ultrasound gastroscope prototype, which came onto the market in 1981 [(51)]. In 1983 Siemens also developed an ultrasonic gastroscope (Pentax, foresight optics) with a linear array at the tip (7.5 MHz, based on Sonoline 8000).

Figure 22 Ultrasound gastroscope placed in the stomach (a). Transoesophageal representation of the aortic valve, Time Motion and B-scan (b) (Source: H.

Lutz).

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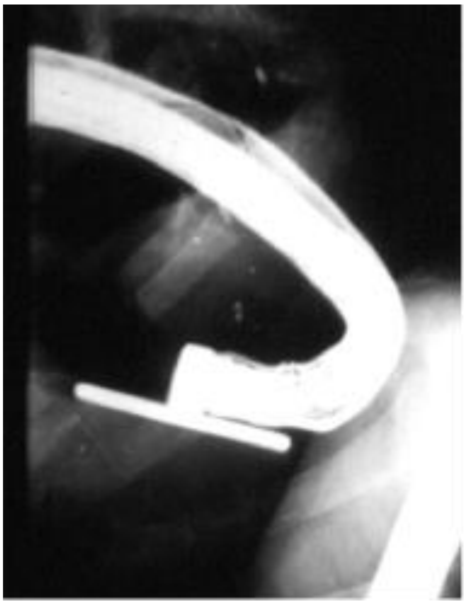

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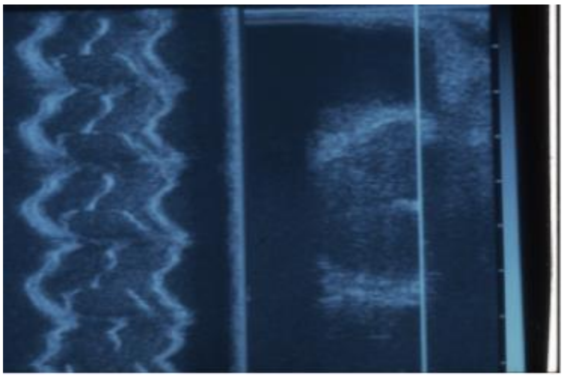
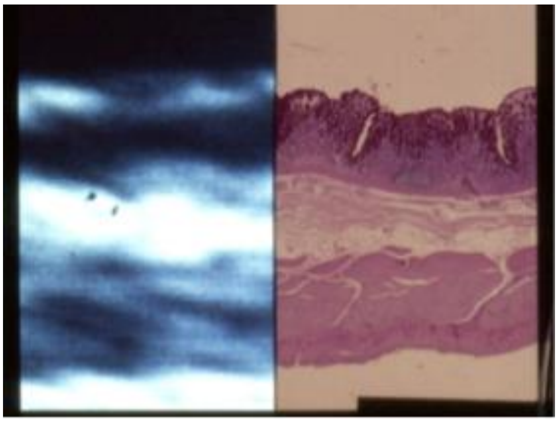


The original target of these investigations was the pancreas, which often was difficult to assess externally. However, later interest turned to the wall of the gastrointestinal tract itself because it was possible for the first time with these high-resolution probes to display the different layers of the wall of the gastrointestinal tract separately [(52)].

Figure 23 **Stomach wall ultrasound image and specimen. Layer 2, 3 u. 4 of the US image correspond to the anatomical layers, 1 and 5 are physically related inputs, and exit echoes (a). Endoscopic picture (b) and an ultrasound image of a small carcinoid of the stomach wall (c) (Source: H. Lutz).**

a



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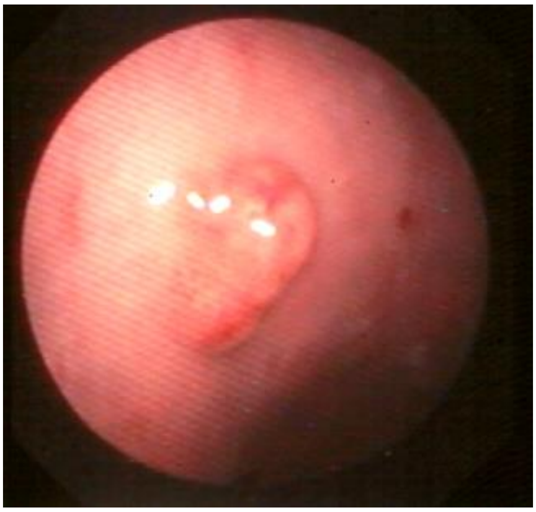


c

The first applications of the transrectal examination in Germany, for example, for the staging of rectal cancer, were carried out in Homburg by **Gernot Feifel** and **Ulrich Hildebrandt** [(53)]. The beginnings of interventional sonography go back to Kratochvil (see above). Significant progress also came from the institute of Hans-Henrik Holm (Copenhagen). Early German users and further developers of the method included Lutz, Heckemann, Weiss, Otto and Hansmann. The term Arthrosonography was first coined in US. In Germany, **Horst Sattler** had been dealing with the question of using ultrasound at the joints since 1977. The development of the area was significantly influenced by the work of Reinhard Graf (Austria). In Germany also **Ulrich Harland** was an early protagonist of the method.

Alfred Bunk from Dresden also set stimulated the use of sonography by surgeons through his work in the interventional area. **Jörg Simanowski** and **Hans-Jörg Klotter** performed a similar role in West Germany.

Safety and quality

Last but not least, the method's safety for the examined patients and the examiners were essential for the increasingly widespread use of ultrasound diagnostics. The effects of ultrasound on biological tissue had already been examined during the introduction of ultrasound therapy, for example, by R. Pohlman (see above) and **J. F. Lehmann** [(54)]. With the use of ultrasound diagnostics, especially in obstetrics, examinations have become particularly important. In Germany **Ernst-Gerhard Loch** (Wiesbaden) [(55)] and especially **Harald D. Rott** from the Human Genetic Institute of the University Erlangen studied the safety aspects [(56)]. Rott became a permanent member of the WFUMB's Committee for Bioeffects, the so-called "Watch Dogs", which, in parallel with the technical developments in ultrasound technology, examined possible undesirable effects over the years, evaluated the relevant literature and made regular statements on the safety of ultrasound when used in the intensity necessary for diagnostics.

However, the harmlessness of diagnostic ultrasound and the consequent easy access to ultrasound diagnostics also brought a problem: the method requires appropriate training of the examiner to achieve good results, which was not always seen at the start. Knowledge of ultrasound diagnostics was neither taught during training at the universities, nor was it acquired during the further training period. Many interested colleagues initially looked for suitable training opportunities, particularly in the centres known for their work in the field. A certain order in training and further education was introduced relatively late, initially by the sections of DEGUM, gynaecology, and internal medicine (see above), that were significantly affected. The German gynaecologists developed the 3-stage concept for users with the general aim of improving the quality of the examiners and the trainers. This method was

adopted by the other sections (subjects) and can also be found in the WHO recommendations on ultrasound training [(57)].
At the first meeting of the Quality Assurance Committee of the Interior Section, experienced course leaders were found at Strahlenburg near Heidelberg in 1981 and laid down rules for the implementation of training courses as well as criteria for the course instructors, the so-called **„Seminarleiter“** with the aim of improving the courses providing further training.
These recommendations from DEGUM, have been recognised and adopted by the medical organisations responsible for training and further education.

Ultrasound history in GDR (East Germany)

Compared to the ultimately unsatisfactory situation in West Germany, ultrasound training in the former GDR was regulated in a more thorough and structured manner from the beginning of the 1980s. A three-month full-day training at a confirmed center was required. This training started in 1980 at the Charité in Berlin. Such training was then mandatory from 1987 onwards. At the end of the 80s, there were 49 training facilities for general ultrasound diagnostics and several training facilities for certain specialist areas (urology, pediatrics, etc.). The Central Academy issued a certificate for Continuing Medical Education in the DDR. This is even more remarkable, since the doctors in the former GDR had only a few modern ultrasound machines available at the beginning of the 1980s, mostly from donations to church-run hospitals. A-mode devices from their own production (Carl Zeiss Jena and Ultrasound Technology Halle) were available from 1961. In contrast, the development of own B-scan devices was very problematic because modern electronic components could not be imported. From 1982 onwards, modern ultrasound technology was purchased on the western market for expensive foreign exchange. At least the larger hospitals (university hospitals and district hospitals) have been equipped. These systems were in use around the clock and very l high-volume centers emerged, compensating for the lack of the more expensive computer tomography. It was not until the late 1980s that the first DDR manufactured device came onto the market, the “SB-30” from VEB TUR Dresden, manufactured in Halle’s factory for ultrasound technology. Given the superior western technology that was available from 1990, it was only used to a small extent in practice. Interesting initiatives from this period, such as the job description of the ultrasound assistant or occupational medical “analyzes of the ultrasound workstation,” also fell victim to the rapid and euphoric developments resulting from reunification in the 90s.

Figure 24 First DDR-owned device (a), the "SB-30" from VEB TUR Dresden (b) (Source: German Ultrasound Museum Lennep).

a

TuR DRESDEN

Information

aus dem

VEB Transformatoren- und Röntgenwerk „Hermann Matern"
DDR - 8030 Dresden
Overbeckstraße 48
Telefon: 59 70
Telegramm: VEBTUR Dresden
Telex: 2165 vebtur dd

MLW Intermed-export-import
Volkseigener Außenhandelsbetrieb der Deutschen Demokratischen Republik
DDR - 1020 Berlin
Schicklerstraße 5/7
P. O. B. 17

Ultraschall-Schnittbildgerät TuR SB 30

Das Ultraschall-Schnittbildgerät TUR SB 30 mit Polarscanner ist ein Echtzeit-Diagnostikgerät für den Einsatz in der Gynäkologie/Geburtshilfe und in der Weichteil-Diagnostik.

Die Ultraschallsignale aus dem Polarscanner werden verstärkt und digital in einem mikroelektronischen Speicher festgehalten.

Zusatzfunktionen zur Meßwerterfassung und Erleichterung der Auswertung werden durch den internen Mikrorechner gesteuert, der auch die alphanumerische Einblendung der Untersuchungsdaten in das Bild realisiert.

Die Bildregistrierung erfolgt durch eine eingebaute Kamera mit separatem Monitor. Ein fernsehkompatibler Ausgang ermöglicht den Anschluß eines Videorecorders. Ein modernes Schaltungskonzept sorgt für energiesparenden Betrieb des Gerätes.

Technische Daten

Ultraschall-Frequenzen	3 MHz, 4 MHz
Ultraschall-Bildfrequenz	12,5 Hz
Video-Bildfrequenz	50 Hz, TV-kompatibel
Sektorwinkel	90°
Eindringtiefe	18 cm bei 3 MHz 12 cm bei 4 MHz
Auflösung (axial/lateral)	1,3/1,8 mm bei 3 MHz 1,0/1,2 mm bei 4 MHz
Gesamtverstärkung	50 … 110 dB
Tiefenausgleich	0 … 45 dB
Dynamikumfang	23 dB linear, 45 dB logarithmisch
Bildspeicher	256 x 256 x 4 bit (14 Graustufen)

b

A leading centre in East Germany was the Charité in Berlin, where Werner Buschmann had offered courses and internships not only for ophthalmologists since 1964. At the Charite, the radiologist **Klaus Raab** and **Horst Schilling** were stimulating in the late 1970s.

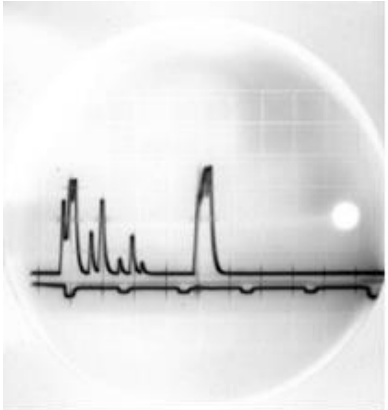
Halle was a lonstanding centre of ultrasound diagnostics in the former DDR. In Halle, in addition to the children's clinic at the St. Barbara Hospital with Volker Hofmann (see above), the Institute for Applied Biophysics (University of Halle) started in 1963 with the cooperation and later management of **Rudolf Millner** (from 1977) with a centre for basic research. Another centre existed at the research institute for experimental physics "Manfred von Ardenne" in Dresden under the management of Weisser Hirsch. The engineer **H. Grossmann** worked on the development of ultrasound devices [(58)]. From 1961, ultrasound devices were developed for medical, diagnostic, and diagnostic purposes in Dresden, and by 1980 a 1000 devices had been produced.

Figure 25 A-mode-system GA 10, produced in Halle (GDR) between 1968 – 71 and used in gynaecology and obstetrics. (a-c, Source: German Ultrasound Museum Lennep).

a

b

c

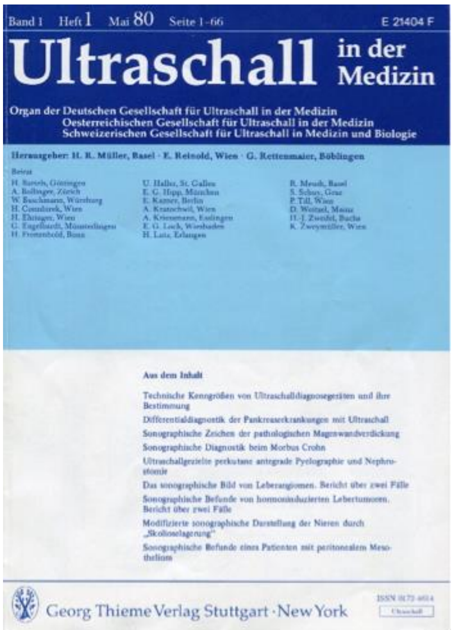


Ultrasound Conferences and Societies

In West Germany, the **German Working Group for Ultrasound Diagnostics (DAUD)** was founded in 1971 by 15 scientists from various disciplines in Erlangen. The initiator and first chairman was Kazner (see above). DAUD initially saw itself as an elite community of scientifically active members. Under the pressure of the rapid expansion of the technique and the rapidly increasing numbers of doctors working in this field, (In 1972, 17, 1975, 115 and by 1983, 1119 members) this attitude inevitably changed. In 1978 the DAUD was renamed as the **German Society for Ultrasound in Medicine (DEGUM)**. DEGUM was divided into sections according to the specialist areas that dealt with ultrasound diagnostics. There were also working groups dealing with interdisciplinary areas, e.g., "Vascular Diagnostics". The annual DEGUM meetings were organised from 1977 together with the ultrasound associations in Austria and Switzerland as **"Dreiländerreffen" (DLT)**. The first three-country meeting took place in Heidelberg in 1976. Until 2019 there were 43 international German-language congresses that, with the number of participants up to 2000, became the essential ultrasound congresses in Europe.

For the three-country meeting in 1980 in Böblingen, the **journal "Ultrasound in Medicine"** was published for the first time by Thieme-Verlag. Gerhard Rettenmaier was the President of the Congress and, together with Rudi Müller (SGUMB) and Emil Reinhold (ÖGUM), was the first editor of this internationally renowned scientific ultrasound journal.

Figure 26 No. 1 of the journal „Ultraschall in der Medizin" founded in 1980. In 2004 the journal became the official journal of the EFSUMB („European Journal of Ultrasound") (Source: German Ultrasound Museum Lennep)



In 1971, almost at the same time as DAUD (DEGUM) started, the **Society for Ultrasound in Medicine of the GDR (GUM)** was founded with the first chairman Millner, who regularly held national congresses. In the following years, working groups for the individual specialist areas were founded with increasing interest within the GUM, which regularly held workshops later with international and limited Western expert participation. Also, international cooperation was promoted with joint conferences (UBIOMED) with the companies in Poland and the CSSR (later on from Hungary and the Soviet Union).

Figure 27 **Rudolf Millner, the first President of GUM together with Gerhard van Kaick in 1990 (Source: German Ultrasound Museum Lennep).**

The development of ultrasound diagnostics in the DDR in the 1970s and 1980s is associated with names like G. Ströhmann, I. Schmidt, Th. Neumann (radiology), W. Wermke, Frind, Truöl, H. Kleinau (internal medicine), K. Meinel, R. Bollmann (gynaecology), H. Heynemann, Seeger (urology/nephrology), E. Rosenfeld, M. Petzold (physics). Both German ultrasound associations were founding members of the European umbrella organization **EFSUMB (European Federation of Societies for Ultrasound in Medicine and Biology)**, founded in Basel in 1972.

After the fall of the wall, members of both associations met for talks, and they agreed that all members of the GUM should be given the opportunity to become members of DEGUM without any preconditions. The GUM dissolved at the end of 1990. The first joint DLT was in Bregenz in 1990. The first three-country meeting in the area of the former DDR took place in 1995 in Dresden.

The first major joint congress of ultrasound scientists from East and West Germany took place in Potsdam in 1991 as the Berlin-Brandenburg Ultrasound Conference. This initiative gave rise to the tradition of the Berlin-Brandenburg ultrasound conference of a regional seminar leader from DEGUM from East and West.

Further development DEGUM in Europe after 1990

The further development of ultrasound diagnostics in the 1990s in Europe was significantly influenced by German representatives and initiatives. Some of the following data underlines that. The **number of members of DAUD & DEGUM (incl. GUM)** increased rapidly:

Table 1 Number of members of DAUD & DEGUM (incl. GUM).

Year	Members	Year	Members
1972	17	1986	1743
1973	35	1987	1928
1974	55	1988	2141
1975	113	1989	2372
1878	152	1990	2621 *
1979	210	1991	3234
1980	480	1992	3559
1981	793	1993	3694
1982	946	1994	3952

1983	1119	1995	4098
1984	1321	1996	4348
1985	1507	1997	4678

*Integrated the members of GUM

That development continues after the year 2000 rapidly. Today the number is greater than 11.000 members.

Figure 28 DEGUM members after 1990 (Source: https://www.degum.de/degum/mitglieder.html)

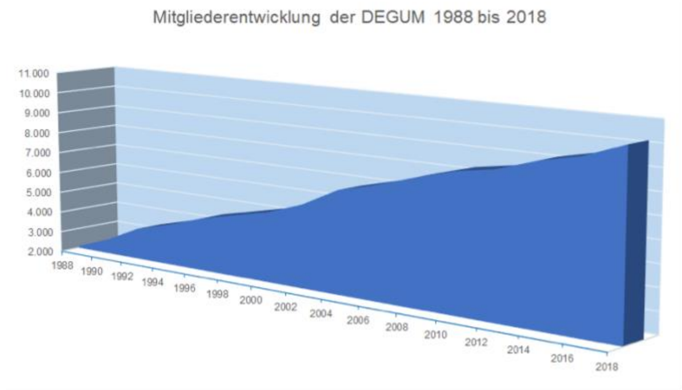


Table 2 Former presidents and DEGUM member nominated as Honorary Members of society (→ https://www.degum.de/degum/mitglieder/ehrenmitglieder-ehrungen.html)

- **2019** Prof. Dr. med. Dr. med. dent. Robert Sader, *Frankfurt*
- **2018** Prof. Dr. med. Dieter Nürnberg, *Neuruppin*
- **2017** Prof. Dr. med. Christian Arning, *Hamburg*
- **2016** Prof. Dr. med. Karl-Heinz Deeg, *Bamberg*
- **2015** Prof. Dr. med. Dr. h. c. Eberhard Merz, *Frankfurt*
- **2013** Prof. Dr. Dr. med. Ulrich Mende, *Heidelberg*
- **2013** Prof. Dr. Svein Oedegaard, *Bergen*
- **2011** Prof. Dr. med. Michael Gebel, *Hannover*
- **2010** Prof. Dr. med. B.-Joachim Hackelöer, *Hamburg*
- **2009** Prof. Prim. Dr. Reinhard Graf, *Stolzalpe*
- **2008** Prof. Dr. Dr. Bernhard Widder, *Günzburg*
- **2007** Prof. Dr. med. Hagen Weiss, *Mannheim*
- **2007** Prof. Dr. Dr. h. c. Wolf Mann, *Mainz*
- **2007** Prof. Dr. med. Gerhard Bernaschek, *Wien*
- **2006** Prof. Dr. med. Kurt A. Jäger, *Basel*
- **2006** Dr. med. Henning Bartels, *Göttingen*
- **2005** Prof. Dr. med. Dieter Weitzel, *Wiesbaden*

- **2004** Prof. Dr. med. habil. Volker Hofmann, *Halle/Saale*
- **2004** Prof. Dr. med. Michael Hennerici, *Mannheim*
- **2003** PD Dr. med. Karlheinz Seitz, *Sigmaringen*
- **2003** Prof. Dr. med. Dietmar Koischwitz, *Bonn*
- **2003** Prof. Dr. med. Gerhard Michael von Reutern, *Nidda-Bad Salzhausen*
- **2001** Prof. Dr. med. Hans Georg Trier, *Bonn*
- **2001** Prof. Dr. med. Harald Lutz, *Bayreuth*
- **2000** Prof. Dr. med. Manfred Hansmann (†), *Bonn*
- **2000** Prof. Dr. med. Gerhard van Kaick, *Heidelberg*
- **1999** Dipl.-Ing. Richard Soldner (†), *Herzogenaurach*
- **1999** Dipl.-Ing. Carl Kretz (†), *Seewalchen*
- **1999** Dipl.-Ing. Hermann Kapp (†), *Freiburg*
- Prof. Dr. rer. nat. Klaus Brendel (†), *Braunschweig*
- Prof. Dr. med. Sturla H. Eik-Nes, *Trondheim*
- Prof. Dr. med. Alec Eden (†), *Überlingen*
- Prof. Dr. med. Hans-Jürgen Holländer, *Dinslaken*
- Prof. Dr. med. Alfred Kratochwil, *Wien*
- Dr. med. Doris Neuerburg-Heusler, *Köln*
- Univ.-Prof. Dr. med. Emil Reinold, *Wien*
- Prof. Dr. med. Gerhard Rettenmaier (†), *Böblingen*
- Prof. Dr. med. F. Weill, *Besancon-Cedex*

Table 3 DEGUM representatives (presidents) served in the Executive Bureau of EFSUMB for two periods (underlined).

EFSUMB president	**Country**	**period**
Marinus de Vlieger	Netherland	1972 - 1975
C. Alvisi	Italy	1975 - 1978
Alfred Kratochwil	Austia	1978 - 1981
Christopher R. Hill	UK	1981 - 1984
Francis Weill	France	1984 - 1987
Søren Hancke	Denmark	1987 - 1990
Harald Lutz	**Germany**	**1990 - 1993**
Sturla Eik-Nes	Norway	1993 - 1996
Luigi Bolondi	Italy	1996 - 1999
Michel Claudon	France	1999 - 2002
Kurt Jaeger	Switzerland	2002 - 2005
David H. Evans	UK	2005 - 2007
Norbert Gritzmann	Austria	2007 - 2009
Christian Nolsoe	Denmark	2009 - 2011

Fabio Piscaglia	Italy	2011 – 2013
Christoph F. Dietrich	**Germany**	**2013 – 2015**
Odd Helge Gilja	Norway	2015 – 2017
Paul Sidhu	UK	2017 - 2019

Table 4 Presidents, Secretaries and Treasurers (WEST/EAST Europe)

Period	Presidents	Secretary	Treasurers (West/East)
1972– 1975	Marinus de Vlieger (Netherland)	Hans Rudi Müller (Switzerland)	Salvator Levi/ A Berlenyi (Belgium)
1975 – 1978	C. Alvisi (Italy)	Hans Rudi Müller (Switzerland)	Salvator Levi (Belgium)
1978 – 1981	Alfred Kratochwil (Austria)	Christopher R. Hill (U K)	**Ernst Gerhard Loch** (Germany)
1981 – 1984	Christopher R. Hill (UK)	T. Nordshus (Norway)	**Ernst Gerhard Loch** (Germany)
1984 – 1987	Francis Weill (France)	T. Nordshus (Norway)	Rainer Otto/Ivo Hrazdira (Switzerland/CSSR)
1987 – 1990	Søren. Hancke (Denmark)	N. McDicken (UK)	Kamier Vandenberghe/ Ivo Hrazdira (Belgium / CSSR)
1990 – 1993	**Harald Lutz** (Germany)	N. McDicken (UK)	Kamier Vandenberghe/George Harmat (Belgium/Hungary)
1993 – 1996	Sturla Eik-Nes (Norway)	Hilton Meire (UK)	Jean-Francois Moreau (France)

Table 5 History of „Dreiländertreffen" and conjunction with EUROSON Congress

No	Year	City	remark	No	Year	City	remark
	1972	Wiesbaden	1. Congress of DAUD	22.	1998	Zürich	
	1974	Hannover		23.	**1999**	**Berlin**	**11. Euroson**
1.	1976	Heidelberg	First congress together with ÖGUM and SAGU (SGUM)	24.	2000	Wien	

2.	1977	Wien	DAUD changed to DEGUM	25.	2001	Nürnberg	
3.	1979	Davos		26.	2002	Basel	
4.	1980	Böblingen		27.	2003	Bregenz	
5.	1981	Graz		28.	2004	Hannover	
6.	1982	Bern		29.	**2005**	**Genf**	**17. Euroson**
7.	1983	Erlangen		30.	2006	Graz	
8.	1984	Innsbruck		31.	**2007**	**Leipzig**	**19. Euroson**
9.	1985	Zürich		32.	2008	Davos	
10.	1986	Bonn		33.	2009	Salzburg	
11.	1987	Salzburg		34.	2010	Mainz	
12.	1988	Lugano		35.	**2011**	**Wien**	**23. Euroson**
13.	1989	Hamburg		36.	2012	Davos	
14.	1990	Bregenz	1. time together West- and East-Germany	37.	**2013**	**Stuttgart**	**25. Euroson**
15.	1991	Lausanne		38.	2014	Innsbruck	
16.	1992	Karlsruhe		39.	2015	Davos	
17.	1993	Innsbruck		40.	**2016**	**Leipzig**	**28. Euroson**
18.	1994	Basel		41.	2017	Linz	
19.	1995	Dresden		42.	2018	Basel	
20.	1996	Linz		43.	2019	Leipzig	
21.	1997	Ulm					

Figure 29 The 23rd Dreiländertreffen in Berlin 1999 in conjunction with the 11th Euroson Congress. Congress presidents Dieter Nürnberg and Bernd Frentzel-Beyme. (Source: German Ultrasound Museum Lennep)

In 1990 Luigi Bolondi proposed a postgraduate European School for Ultrasound. In 1993 EFSUMB produced the bylaws for **EUROSON Schools.** In 1996 in Sigmaringen and Thurnau started the first German Euroson School under organization of Harald Lutz and Karlheinz Seitz. It was held successfully until 2004. Later other German Euroson Schools started in Berlin (D. Nürnberg/ K. Schlottmann: Interventional Ultrasound) and in Hannover (H. P. Weskott: Contrast Ultrasound).

Figure 30: German Euroson School in Sigmaringen in 1996 (Source: K.H. Seitz).

a

b

Conclusions

Over the years the development of ultrasound was impressive in both german countries and also after unification. The German ultrasound societies, pioneers and scientists gave a lot of influence to the European ultrasound development. German society founded the European Journal of Ultrasound “Ultraschall in der Medizin”, is hosting the important annual European ultrasound Meeting - the “Dreiländertreffen” - and developed to the biggest ultrasound society in Europe. That means a lot of responsibility for the further development and the quality of ultrasonic diagnostics for the future.

In 1995 Members of DEGUM decided to found the German Ultrasound Museum to conserve old ultrasound technique, literature and facts. To retain facts in memory the Museum and a big collection of past technique is established in Lennep/Remscheid today. Last year the museum board published the book: “Contribution to history of ultrasound diagnostics. Development of medical ultrasonography from German view” [(3)]. This and other publications you can find under https://www.ultraschallmuseum.de. The authors are members of the museum board and invite you to visit the website.

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