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An article by FRANK KÖSTER and THOMAS THIES

For several hundred years the means of determining the water depth and positioning in the Port of Hamburg have hardly varied. The lead line has played a crucial role for hydrographic measurements. Starting with the introduction of the first echo sounder and the use of satellite navigation the electrotechnics took over the essential part in delivering ever more refined measurement instrumentation for hydrographic surveying. The adoption of computers for data acquisition and processing provides many exciting and seminal prospects. More and more digital products and workflows replace the paper charts opening a new variety of analysis tools that the customers of the Hamburg Port Authority already start to implement. – *Part 1**

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Introduction

The Hydrographic Surveying Department of the Hamburg Port Authority (HPA) and its institutional predecessors have accompanied the development of long periods during the evolution of the Port of Hamburg from a fortified settlement and the birth of the port to the industrial revolution and the port how it is today. For several hundred years the means of determining the water depth and positioning have hardly varied. The lead line has played a crucial role for hydrographic measurements. Starting with the introduction of the first echo sounder used for depth measurements and the use of satellite navigation to a multi-sensor platform the electrotechnics took over the essential part in delivering ever more refined measurement instrumentation for hydrographic surveying. The adoption of computers for data acquisition on board of survey vessels and in the office for data processing provides many exciting and seminal prospects. More and more digital products and workflows replace the paper charts – still widely in use – opening a new variety of analysis tools that the customers of the Hydrographic Surveying Department already start to implement.

Fig. 1: An artificial 3D picture created for the Archeological Museum in Hamburg. The scene shows how the *Hammaburg* might have looked like by 845. On the right the *Hammaburg* and on the left the first harbour is depicted. The stream, where the harbour was once situated, no longer exists nowadays

Fig. 2: Model of the City of Hamburg showing the status of 1644. This model is situated in the Hamburg Museum. The port area was still limited to the rivers Bille on the right and the dammed Alster. The Elbe river on the bottom had not been utilised for shipping activities by then

Historical overview of the development in the Port of Hamburg

At the beginning of the 9th century many fishermen, craftsmen and traders settled in the vicinity of the *Hammaburg,* a wooden missionary base. The first harbour close to this settlement was situated between the rivers Alster and Bille (see Fig. 1).

Despite the destruction of the infrastructure by the Vikings in 850 the city began to prosper. During the following 420 years the city belonged to different dukes and counties while the core around the *Hammaburg* still stayed in the hands of the bishop. On the 7th May of 1189 a charter was issued by Emperor Frederick Barbarossa, that gave Hamburg the privileges for free shipping on the Elbe river and free trade in the area of the county Holstein. The charter was later identified as partly counterfeit. Nevertheless, the date of issue is regarded as the official birth of the Port of Hamburg and is celebrated yearly. In 1270 finally the old Hamburg around the *Hammaburg* and the new Hamburg, that had spread around it, were unified in the so-called »Ordeelbook«, which also contains a description of rules on how ship crews have to navigate in the port area.

By the end of the 15th century the port area had expanded to the Elbe river. After this expansion the development of the port was slowed down. One of the main reasons was the sedimentation of the Elbe river, so that in 1529 two Dutch specialists had to advise Hamburg on dredging. In 1548 the Düpe-Commission was founded. The civil servants of this government agency – the so-called »Fleetenkieker« – were obliged to monitor and maintain the depth (Low German: Düpe) of the port area. During the following two centuries several hydraulic adjustments were made in order to raise the strength of the current for reducing the sedimentation. Besides the technical challenges Hamburg was menaced from the Danish King

Christian IV until 1645 where Denmark and Sweden had signed a peace treaty, that opened a free passage on the Elbe river again. Fig. 2 shows how the port looked like at that time.

In 1715 the depth of the Elbe river and the port area had reached a critical state, so that the *Elbe-deputation* was introduced in order to provide a sufficient water depth. The two heads of the Düpe-Commission belonged to this administration. Depth maintenance was manual work by then. Dry falling shoals were removed with shovels during ebb tide. Scratches were utilised to work with the current. In 1790 a first »Hamburg Dredging Machine« – the *Drehewer* – made this work much easier and reached an effectivity of 6 m^3 per day.

After the French revolution in 1789 Hamburg stayed neutral until 1806 when it was occupied by the French and all administration was restructured. In 1814 the French troops were banished. This gave the possibility to rethink the administration of the port, so that the Düpe-Commission was integrated in the *Hafen- und Schiffahrtsdeputation*. This agency had centralised many responsibilities, like port development, maintenance of navigation aids and depth management. In 1834 the first dredger that was driven by a steam-engine started its work in Hamburg.

In 1842 the City of Hamburg burned down in the Great Fire. On the one hand this catastrophe had a negative economic impact but on the other hand it gave way to a more modern infrastructure. During the following years a fundamental discussion about the direction of port development between the supporters of a wet dock and a tidal port was led, which was decided in 1858 in favour of a tidal port.

The following period saw the creation of the first artificial port – the Sandtorhafen (1866), which is a museum harbour today – and the expansion of the port area to the southern shore of the Elbe river (see Fig. 3). In 1864 the *Hafen- und Schiffahrtsdeputation* was split into an agency responsible for port construction (Amt für Strom- und Hafenbau) and a separate department, which was responsible for the rest of the administrative tasks. After the accession of Hamburg to the North German Union under the lead and pressure of Prussia (1866) and the following integration into the German Empire (1871) negotiations started for a unified customs policy.

By 1881 Hamburg had lost its status as a free port, but was granted to maintain its own free port area which led to the erection of the warehouse complex *Speicherstadt* (from 1888 to 1914), which is still the largest of its kind in the world. Due to an economic boom the free port area had expanded from the initially planned 426 to around 1,000 hectares by 1910. On the southern shore of the Elbe river the port expanded rapidly with different industries like dockyards (Blohm & Voss), movement of goods for the HAPAG and oil, so that many new harbour basins were constructed on both sides of the Köhlbrand. The Köhlbrand has been the connection between the northern and the southern Elbe streams for centuries. From 1866 until 1908 three contracts between Prussia and Hamburg have been agreed on (Köhlbrandverträge), that regulate different river engineering measures.

Until 1914 Hamburg had become the third largest port after New York and London, but short after the beginning of the First World War trade was nearly fully halted and did not recover until a shortly economic rise from 1924 to 1928, when the global economic crisis started (see Fig. 4).

In 1929 a state treaty between Hamburg and Prussia was concluded, so that a common port expansion of the two Prussian ports (Altona, Harburg) and Hamburg was agreed on.

In 1933 the National Socialists took over and

* Part 2 of the article will be published in the next issue where a selection of topical projects is presented

Fig. 3: In 1885 on the Grasbrook Island, situated on the northern shore of the Elbe, the Sandtorhafen was already in use since 1866, the Grasbrookhafen followed in 1881. By 1886 also the Baakenhafen and Strandhafen had been finished. The port had spread to the southern shore of the Elbe to the Kleiner Grasbrook and Steinwerder

Fig. 4: By 1925 the Port of Hamburg nearly had reached the form how it looks today. The Köhlbrand was relocated, the port areas around the Waltershofer Hafen, the Vorhafen and Hansahafen had been developed. The general layout hardly changed since then

Fig. 5: The general layout of the Port of Hamburg was kept as it can be seen here in the port map of 2005. In 2002 the last larger port expansion project – the construction of the Container Terminal Altenwerder was finalised

focused the port on the arms industry. In 1937 Hamburg was united with the industrial cities of Harburg, Altona and Wandsbek, which pushed the industrialisation even more. The handling of cargo collapsed again with the beginning of the Second World War in 1939. The bombing of Hamburg destroyed nearly the whole infrastructure of the port and left several wrecks blocking harbour areas.

Under the direction of the Hamburg Port Authority (HPA), that had been founded by the British occupying forces, the wrecks were removed and the heavily silted harbour basins were dredged. Step by step the British Hamburg Port Authority transferred the control back to the Germans. The HPA was disbanded and the former structure was reimplemented, so that the Amt für Strom- und Hafenbau took over the reconstruction.

The economic miracle in the 1950s reproduced the strength of the Port of Hamburg. At the beginning of the 1970s the containerisation demanded another restructuring of the port, so that the container activities were bundled in the Waltershofer Hafen, which is still the most important harbour for container handing in Hamburg.

At the beginning of the 1990s the Eastern Bloc broke. Since then Hamburg has retrieved its importance as the access point to the eastern European countries like Poland, the Czech Republic and Russia. In 2005 the new Hamburg Port Authority was founded and unified all port-related tasks

and services once again. The extents of the Port of Hamburg can be seen in Fig. 5.

Historical development of hydrographic surveying in the Port of Hamburg

Despite the Port of Hamburg exists for more than 850 years little is known about the development of the depth measurement techniques. It can be assumed, that the means of determining the water depth hardly changed during the centuries. The archive of depth atlases in the Hamburg Port Authority starts in 1842 (see Fig. 6).

By 1938 the atlases were gradually replaced with paper charts until the last atlas was produced in 1940. The general nature of the depth information was not modified. Profiles across the river were measured with depths derived from lead line plumbing.

In the late 1940s when the port administration was returned from the British Hamburg Port Authority to the Amt für Strom- und Hafenbau two hand lead line crews consisting of eight or ten persons were installed. The two teams were positioned in two separate areas of the port in order to quickly reach the area to survey. The »Peilmudding« was situated at the pontoon at Neuhof right in the middle of the port. It was used as the office-, store- and common room. The vessel »Peiler« brought the crew to the survey area (see Fig. 7).

For each cross section a pole on one shore was erected. Afterwards the »Set Fast« spanned a wire to the other shore using a winch aboard. The wire had been marked every 2.5 metres. A dinghy staffed with three persons moved from one marking to the next. The first person was responsible for pulling at the rope to keep the dinghy at position, the second was plumbing and the third was noting the measured depth. Additionally another person was placed at the closest tide gauge recording the gauge height (see Fig. 8).

In 1961 the first surveying vessel for Hamburg with an echo sounder was built in the Menzer dockyard, Hamburg-Bergedorf – the »Deepenschriewer I«. It was equipped with an Atlas echo sounder Deso 10 and replaced one of the two hand lead line crews. In 1970 the »Deepenschriewer II« was brought into service. Coming also from the Menzer dockyard the ship was equipped primarily with a Deso 10 echo sounder and in 1974 the innovative multichannel system BOMA 20, introducing the first area based echo sounder to Hamburg and pushing an intensive scientific exchange between the manufacturer and the user in order to get the system fully operational. Together with the new multichannel system an Anschütz-Gyro was introduced in order to determine the heading of the system. In 1983 the third survey vessel »Deepenschriewer III« was introduced – a converted vessel, which had already been built in 1964. This modification soon proved inappropriate, so that a new ship had to be constructed in 1988 at the Buschmann dockyard in Hamburg-

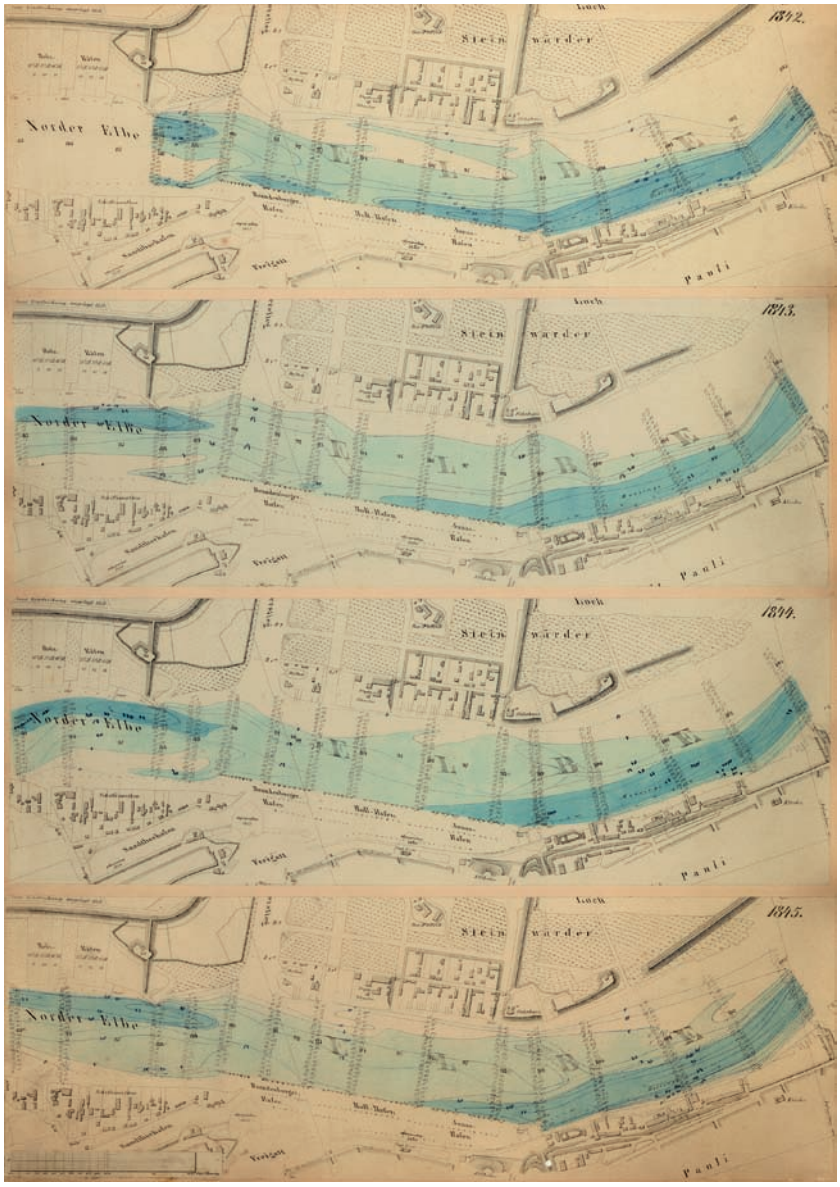

Fig. 6: The oldest paper chart from the archive of the Hamburg Port Authority shows a time series of the Norderelbe from 1842 to 1845. The survey area covers where today the HafenCity and the Landungsbrücken are situated

Fig. 7: The »Set Fast« behind the »Peilmudding«. The vessel lying at the pontoon is the »Peiler«. This picture is taken in the Magdeburger Hafen. In the background the red buildings of the Speicherstadt are visible

Fig. 8: Plumbing a cross section on the Suederelbe in 1950

Wilhelmsburg. This new »Deepenschriewer III« was equipped with a Deso 25 echo sounder and a range bearing system. 1994 saw the introduction of the new hydrographic processing system HydroCAD, that was UNIX based provided by Atlas, and the addition of the »Deepenschriewer IV« to the fleet. The main purpose for this survey vessel was to survey the shallow and narrow parts of the port. During the introduction of the »Deepenschriewer IV« the hand lead line crew was suspended. In 1996 the »Deepenschriewer III« was equipped with the Fansweep 20, the first multibeam echo sounder system used by the port administration supplied together with the first motion sensor Atlas Dynabase in combination with the gyro STD 20 Anschütz. The first surveying projects had to be split into quarters, because the computers were not able to process the full project size at once. The »Deepenschriewer I« was replaced in 1997 with a new construction similar to the »Deepenschriewer III« built at the Grube dockyard in Hamburg-Oortkaten.

In 1999 the »Deepenschriewer II« started into a new era of positioning with the Trimble 4000 SE GPS receiver.

2004 oriented the Hydrographic Surveying Department into a new direction. In the past decades Atlas had been the provider of measurement technique and processing software, but in that year several components were replaced and diversified. HydroCAD was replaced by HydroCAD II from the Canadian software company CARIS, the »Deepenschriewer I and III« were equipped with Reson 8101 multibeam systems and the »Deepenschriewer II« got a new multichannel system MCS2000 also from Reson. All three area based surveying vessels received TSS MAHRS motion sensors and Trimble 5700 GPS receivers. QINSy was introduced on all four survey vessels in 2006 as data acquisition software.

In 2008 all TSS MAHRS had been replaced with inertial navigation systems iXBlue HYDRINS and the »Deepenschriewer IV« was substituted with a new construction from the Barthel dockyard in Derben, so that all four survey vessels had become area-based surveying systems. In 2010 the »Deepenschriewer II« became the last vessel to be equipped with a multibeam sensor. New techniques like the laser-scanner RIEGL VZ-400 on the »Deepenschriewer III« (2011) and the Stema Rheotune on the »Deepenschriewer II« (2013) have been established in order to meet the ever expanding demands on the Hydrographic Surveying Department of the Hamburg Port Authority. Fig. 9 shows the »Deepenschriewer« fleet in use today. All four vessels are equipped with Reson multibeam sonars. Additionally the »Deepenschriewer II« utilises a multichannel system. The positioning is done with Trimble SPS 851 GNSS receivers in combination with INS systems iXBlue HYDRINS. ⚓

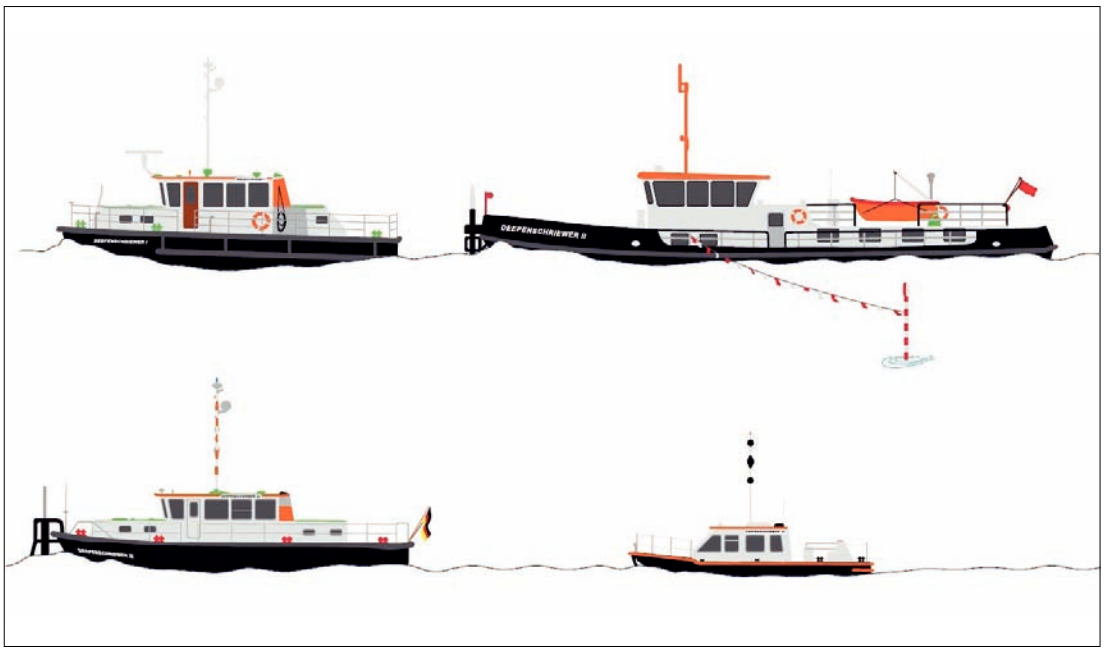

Fig. 9: Artist's impression of the »Deepenschriewer« fleet in 2015 drawn by Wiebke Ahrlich