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3D PluraView



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Working out what are suspected locations of unexploded bombs, and what are tree crowns or open manhole covers: With the utmost meticulousness, the Hamburg Fire Service interprets wartime aerial photographs to clarify whether or not there might be unexploded ordnance present. 3D stereoscopy helps to differentiate between small craters and mounds.

Hamburg is one of the German cities that suffered most during the Second World War. The number of homes destroyed in the Hanseatic city was equivalent to the entire number of homes in the cities of Nuremberg, Augsburg, Ludwigshafen, Würzburg and Regensburg combined. Between May 18, 1940 and April 17,

1945, a total of 213 air raids were flown against Hamburg and a total of some 107,000 high-explosive bombs, 3 million incendiary bombs

“With stereoscopy we’re embarking on a “trip through time”. Stereo work with the 3D PluraView monitor gives us a vivid, spatial, 3D impression of the situation on-site 70 years ago”

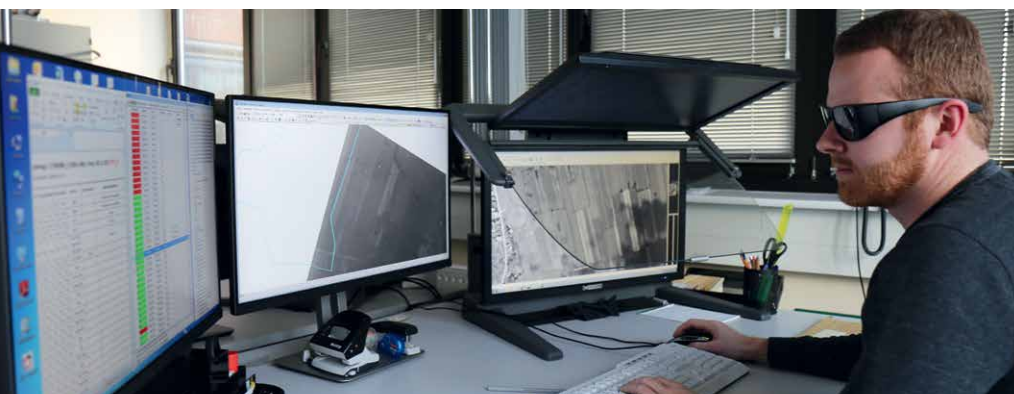
and 300,000 phosphorous fire-bombs were dropped. This resulted in significant infrastructure damage, where approximately 70% of the city's buildings were destroyed. All of the explosive ordnance of the time rained down from the skies. The largest bunker-busting bombs weighed 12,000 pounds, with the smallest incendiary bombs weighing 4 pounds. And it was all documented. Over no other city

in the world were so many aerial photographs taken during the war. At the present time there are more than 30,000 known aerial photographs of Hamburg. “Another advantage is that there was hardly any ground combat in Hamburg. Quite unlike in Cologne or Berlin. This means we can assume that the effects of war came solely from air raids and not from artillery bombardment”, explains Thomas Otto, head of the Hamburg Fire Brigades risk and unexploded ordnance survey (GEKV) department. The GEKV department is responsible for categorising construction sites within the municipal area in terms of their potential risk for the presence of ordnance. Categorisation is based on the evaluation of historical aerial photographs, sourced from both Allied and German armed forces from the period between 1940 to 1946. Where available, secondary sources such as logbooks or other written records are used to further ensure a correct decision. Before any construction work begins in Hamburg, it is necessary to precisely review whether unrecovered unexploded bombs might still be buried on the intended construction site.

Precise stereoscopic aerial photograph interpretation – even in daylight

The wartime aerial photographs are stereoscopically interpreted on a total of 20 high-end PluraView stereo displays from Schneider Digital e.K. in Miesbach, Bavaria. The 3D PluraView monitor is an enhanced version of the passive 3D-stereo display technology of the PLANAR beam-splitter series discontinued a few years ago. Innovative, reliable technology forms the basis for precise stereoscopic representation of the highest quality. For this, the 3D PluraView beam-splitter technology delivers full monitor resolutions of up to 4K in brilliant brightness, thanks to two display screens.

“A very important element of our work is spatial 3D-stereo representation, because that lets us see whether a black spot on the image is a subsidence or an elevation: A subsidence can be an indication of an unexploded bomb that entered the ground, but did not detonate”, explains aerial photograph interpreter Matthias Otto, citing another example in which the overlapping of two photos helps to determine a suspected case: “Stereoscopy makes it easier to see, whether or not the intermediate floors were present in damaged buildings. If they were still there, that part of the site is no longer under suspicion, but if none of the floors remained, it most definitely is.” It is impressive to see the Sherlock Holmes-like meticulousness and sensitivity employed by the team on this “trip through time” and how the 3D PluraView Display technology from Schneider Digital helps to track



The high-resolution 3D PluraView displays (2,560 x 1,440 pixels) are completely integrated into the analysis process chain of the Hamburg Fire Brigade.

down dangerous bombs and left-overs from the war. Matthias Otto sums it up by explaining that “stereoscopy with the PluraView monitor gives us a vivid, spatial, even quasi-virtual impression of the situation on-site more than 70 years ago”.

A prerequisite for an interpretation of this type is that two overlapping photographs of the same scene are available. “A continuous series of images was taken in most cases, with the camera being triggered at closely-spaced, fixed intervals. The aerial photography interpreter goes on to explain that “the altitude at which the reconnaissance planes flew was not constant, resulting in distortions within the aerial photographs. Suitable measures enable these distortions to be almost eliminated, so that interpretation with very accurate

on the 27” or 28” screens, that the 3D PluraView display provides. The units are certified for all common 3D-stereo software applications in GIS, photogrammetry and mapping, not just from the already mentioned system suppliers Hexagon (Geomedia) and esri (ArcGIS) but also from Trimble (Match-AT/DTMaster/UASMaster), ERDAS IMAGINE (Stereo Analyst), TerraSolid (TerraStereo), RhinoTerrain SAS, PurView (PurVIEW) or Leica HxMap. The Hamburg Fire Brigade was the first customer for the new 3D PluraView generation of monitors. Schneider Digital unveiled it for the first time at the international GIS trade fair Intergeo in October 2016, and the first units were delivered to Hamburg just one month later. Compared with PLANAR beam-splitter monitors, there

was established. As long ago as 1990, Thomas Otto began to prepare for the Hamburg Fire Brigades a systematic evaluation and database of aerial photographs, originating from both primary and secondary sources. He acquired the necessary, extensive knowledge himself and later set up a staff training program, because “there simply isn’t any professional training for detecting hazards, using wartime aerial photographs.”

3D PluraView as a benchmark for 3D stereoscopy

Since 2004, all analysis of wartime aerial photographs by the Hamburg Fire Brigade has been done digitally. From this point onwards,



positioning is nevertheless possible”. “When a dark spot can only be seen on one photo it’s obvious that this is an artefact, or conversely, it may be the case that a black dot on the mono image reveals for example the presence of just an advertising column in the stereo image.” The main interpretation software used by the Hamburg Fire Brigade is ERDAS IMAGINE from Hexagon Geospatial and ArcGIS by esri.

Technological progress in “leaps and bounds”

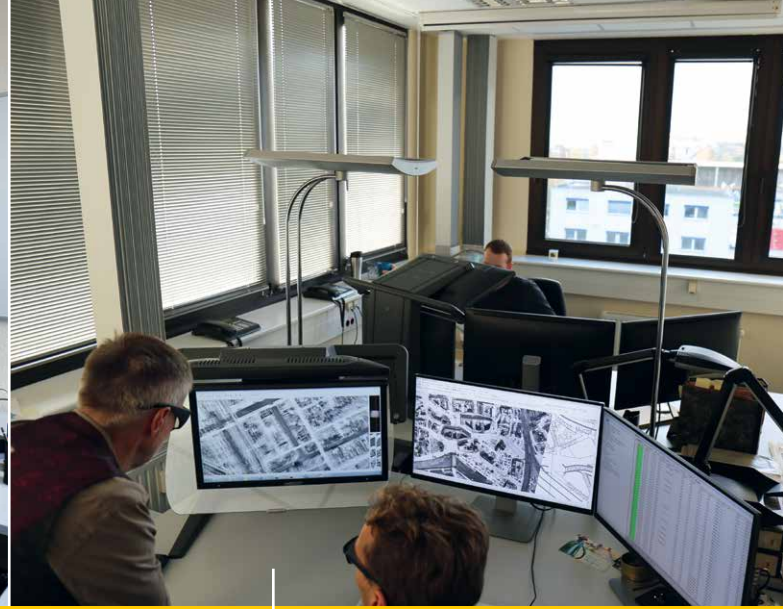
“The only option in the past for those who needed professional, high-resolution 3D-stereo visualisation in geo-informatics, was the PLANAR beam-splitter monitor series. The specialist company for 3D-stereo, virtual reality (VR/AR), 4K and high-end hardware, Schneider Digital, based in the town of Miesbach in Upper Bavaria, has invested heavily into the enhancement of beam-splitter technology. This has resulted in an innovative, completely new generation of 3D monitors called “3D PluraView”, which are now recognised as the display benchmark in passive 3D-stereo technology for the entire industry. Unlike active 3D monitors, the 3D PluraView is completely flicker-free, which makes it ideally suited to continuous, professional use, that is easy on the eyes throughout the working day - even in office daylight conditions. Head of department Thomas Otto affirms that “working in darkened rooms, like in the 1990s, is a thing of the past since the arrival of 3D PluraViews”. The market is delighted with the razor-sharp picture quality of up to 4K/UHD per eye and the representation of the finest details

were a number of improvements, besides display size, brightness and resolution. For example the monitor is now of a much more rigid construction – top-quality “Made in Germany” – with the result that there is no screen vibration when touched. Also a thing of the past are the tapered mirror edges of its predecessor, which could prevent an observer standing to the side, to evaluate certain sections of the image, as Matthias Otto explains. He also points to another very convincing argument: “The 3D PluraView monitor enables fatigue-free working all day long – even in daylight and without the need to darken the rooms.”

Unexploded bombs can sink into the ground and vanish

The Hamburg metropolitan area is 755 km² in size. Every discovered impact point is precisely measured and an allowance is made for the unexploded bombs’ drift. In the beginning, it was assumed that the maximum difference between the point of entry into the ground and the final location would be between 4 and 5 m. “However, today we know that it could be as much as 9 m offset. Last year, three unexploded bombs were found in places where during the 1990s, searches were made for them in a radius of 5 m around the impact point and nothing was found”, says the department’s head Thomas Otto. Around 11,000 reports of unexploded bombs are known, dating back to the outbreak of the war, some of which were dealt with during the war. The use of wartime reports gives rise to particular challenges, because there was no comprehensive documentation of bomb disposal operations before the GEKV department

software was available for adding symbol markers for example, and for enabling work with approximate values for focal distances and altitudes. Back then, NewVision Systems CRT monitors were being purchased from Schneider Digital. A system with shutter glasses was previously used, “which put great strain on the eyes”. The glass reflection from the monitors was so significant that although you could see yourself very clearly, you could only weakly recognise the aerial images”, recalls Thomas Otto with a grin. In 2009, the defining moment came with the arrival of the first, passive 3D-stereo PLANAR monitor system, utilizing beam-splitter technology. They took 3D-stereo visualization to a completely new level of quality. These 20 stereo aerial photography interpretation workstations are now equipped with 3D PluraView technology, replacing the PLANAR displays. How did the workflows change in the wake of digitisation? Thomas Otto makes it clear from the start: “Due to the amount of applications for site investigations to be dealt with, it was evident that we’d have to employ new staff. Whereas there were just over 200 applications prior to digitisation in 2004, today the number is around 11,000 per year – due also to the amended Munitions Ordnance regulations.” But why are there so many applications for investigation managed by the risk and unexploded ordnance survey department? After all, the war has been over for more than 70 years! In Hamburg, a survey must be conducted before construction work can start. This requires the site owner, or the party wishing to excavate the ground, to submit an application to the GEKV department for the purpose of risk investigation /



The Hamburg Fire Brigade operates a total of 20 workstations with passive 3D-stereo monitors for the remote sensing of potential dangers.

3D PluraView monitors allow precise, stereoscopic photo interpretation with maximum picture quality. The monitor allows fatigue-free working all day long – even in daylight.

1, 2 & 3 | Hamburg is one of the German cities that suffered the most during the Second World War. The amount of housing stock destroyed in the Hanseatic city was equivalent to the entire housing stock in the cities of Nuremberg, Augsburg, Ludwigshafen, Würzburg and Regensburg combined. **Figure 2** shows an aerial photograph of the destroyed Church of St. Nicholas, **Figure 3** the effects of war in the Hamburg-Wilhelmsburg area.

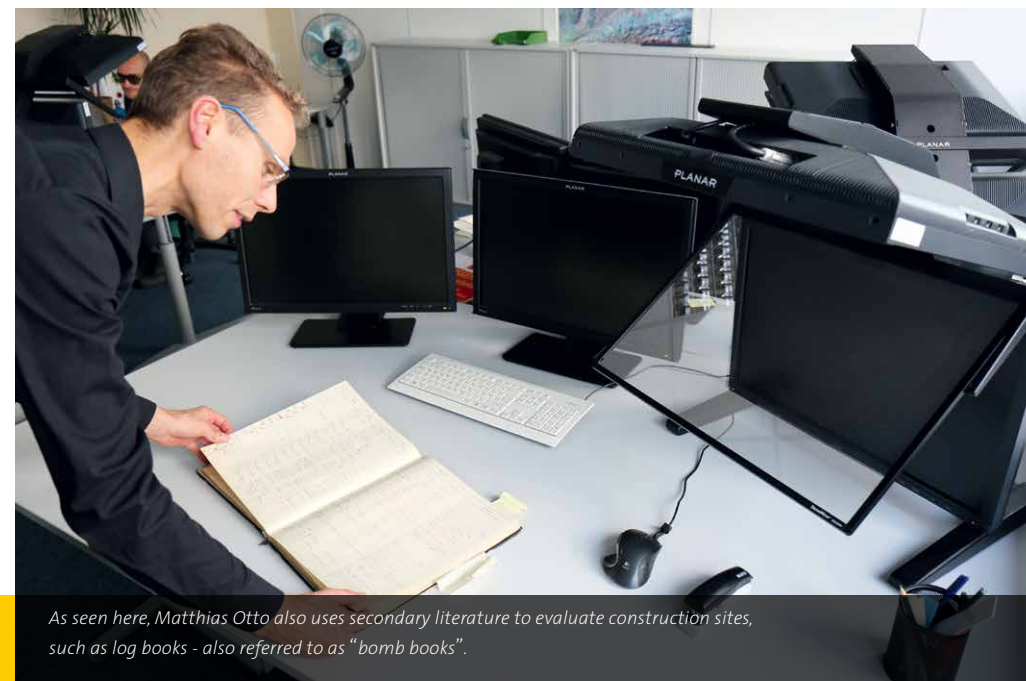
aerial photography interpretation. As a result, the applicant receives a map section of the planned construction site, containing the most precise information possible about potential dangers, so that these can be investigated at minimum cost. A private service provider uses this detailed information from the GEKV department, to conduct an on-site search, if it is suspected that unexploded ordnance might be present. As Thomas Otto affirms, to keep on top of the deluge of orders and to speed up procedures, intensive efforts were made to maximize process automation. For example, all areas of Hamburg were digitally captured with a GIS system and the databases were substantially enhanced. Every aerial photograph, earmarked for interpretation availability, was scanned-in with high resolution. For this purpose, it is of the utmost importance to use only original data, because subsequent image

processing or “optimisation by software” – as was incorrectly done in the past by one over-zealous service provider – can corrupt the information content.

Human Intelligence (HI) surpasses Artificial Intelligence (AI)

In collaboration with the US software provider esri in Switzerland, software was developed based on their ImageServer technology, in order to achieve the fastest possible image retrieval. Matthias Otto adds that one major advantage of these efforts is that several staff can now work simultaneously and in parallel on the same image, something that was previously not possible with physical photographs. “That was a big step towards speeding up our procedures!” Artificial intelligence with its possibilities for pattern recognition is currently

doing the rounds, not only among photogrammetry experts. Aerial photography interpretation would appear to be a suitable area for AI applications. Thomas Otto waves dismissively: “We’ve tested and examined AI very intensively. Pixel-based pattern recognition gets us nowhere, because the number of correct hits in automated image analysis is much too low. Just think: Only a proportion of the bombs that are actually documented in a wartime aerial photography have been verified successfully by AI! That’s way too uncertain! As supporters of systematic digitisation and automation, even we have to admit defeat here. We trust digitisation and automation only where it makes sense, or more specifically, where it helps to obtain the best and most reliable results. To us, that means: Professional GIS software, plus 3D PluraView monitors, plus a human specialist for professional analysis, results in the most reliable interpretation.”



As seen here, Matthias Otto also uses secondary literature to evaluate construction sites, such as log books – also referred to as “bomb books”.

There was no lack of creativity among the belligerents when it came to designing bombs. Our photo shows an incendiary bomb weighing 4 pounds (about 1.8 kg). However, an impact by this calibre is too small and cannot be directly verified in wartime aerial photographs.



Head of department Thomas Otto and aerial photograph interpreter Matthias Otto at work.



An unexploded bomb in the Hamburg metropolitan area shortly before it was defused

The project at a glance

The task

- Remote sensing of construction sites for unexploded ordnance from the Second World War, using stereoscopy from primary sources (aerial photographs) and secondary literature
- Achieving the greatest possible level of safety against potential dangers on-site
- Professional analysis, using 3D GIS software
- Faster photo interpretation processes, requests dealt with more quickly

The demands placed on 3D visualisation technology

- Highly detailed stereoscopic 3D representation of aerial photographs from the war
- Optimum ergonomics to allow stereoscopic work throughout the day
- Aerial photography interpretation on the screen in daylight conditions
- Compact overall dimensions, robust assembly
- Plug & Play system without the need for special software
- The system must be fully compatible with GIS software applications
- Complete workplace solution with side monitors

The solution - Schneider Digital 3D PluraView

Screen size / resolution:	27", 2,560 x 1,440 pixels per eye
3D display technology:	210 cd/m ² brightness with glasses Linear polarisation: 45°/135° Beam-splitter: semi-transparent reflector
PC and graphics card:	Siemens PCs, NVIDIA Quadro
Infrastructure:	Up to 2 side monitors used for parallel database applications

Software used

Analysis:	ERDAS IMAGINE (Stereo Analyst) by Hexagon Geospatial
GIS:	ArcGIS (esri)
Communication:	MS Office Tools

The result

- A shift to 100% remote sensing on the PC, enabled by high-performance digital photogrammetry. Remote sensing is the only method now used to investigate the suspected presence of ordnance
- Sophisticated beam-splitter technology, enables GEKV staff to work all day productively in 3D-stereo with historical air photos
- All of the photo interpretation and job processing workflows are accelerated
- Working in darkened rooms is a thing of the past
- Precise stereoscopic aerial photography interpretation with 3D-capable GIS software

Portrait

Hamburg Fire Brigade Department (GEKV)

The Hamburg Fire Brigade Department for Risk and Unexploded Ordnance Survey (known by its German abbreviation GEKV) is responsible for categorising areas within the municipal area in terms of their potential risk for the presence of ordnance. On application, the potential risk in the various sites is determined by way of stereoscopic aerial photography interpretation, using 3D PluraView monitors from Schneider Digital. The basis for the detection of potentially hazardous sites are aerial photographs, kept by the GEKV. External companies perform ground surveys on the suspected sites. The basis for the work of the GEKV are more than 30,000 digitised aerial photographs from the Second World War from the archives of the Royal Air Force and the U.S. Air Force. Once ordnance has been detected, the finding is investigated and then made safe by bomb disposal teams.



More information is available at:

www.hamburg.de/innenbehoerde/gefahrenerkundung





Schneider Digital 3D PluraView Monitors

Passive 3D-stereo display reference

Schneider Digital has introduced the 3D PluraView family of beam-splitter, passive 3D-stereo displays in 2016. 3D PluraView monitors are specifically designed for stereoscopic display, interfacing seamlessly to most 3D-capable software applications in photogrammetry, for LiDAR point clouds, CAD, GIS and BIM, but also for medical 3D data visualization. Only with cross-polarized, passive stereo filters, can stereo images, intricate CAD, mesh and other surfaces and textures be reproduced down to the smallest detail.

3D PluraView highlights

- Flicker-free for continuous, professional use
- Highest brightness – Daylight suitable
- Two assembly sizes – 22"/24" and 27"/28"
- Wide Viewing Angle – Group interaction
- Certified for Photogrammetry, VR and GIS
- Resolutions in Full-HD, 2.5K or 4K (UHD)

Our innovative and reliable PluraView beam-splitter technology is the basis for pixel-precise, stereoscopic 3D image displays, offering the highest stereo viewing quality possible. Currently, PluraView stereo displays can be configured with screen diagonals of up to 28", resolutions up to 4K (UHD) and a color depth of 10-bit per pixel.



3D PluraView

www.3d-pluraview.com



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