Portable lidar-based MM equipment from the German company dhp:i (Dr. Hesse & Partner Ingenieure). The complete system weighs a beefy 46 lbs, including harness and backpack. The building in the background houses the Yugoslavian Tribunal.

BEYOND THE POINT CLOUD

A retrospective view on SPAR-Europe and ELMF 2011

"This is a death trap" answered Edwin Galea when questioned about the escape route from where he stood in case of a sudden fire. His answer was the opposite of a surprise in view of the excellent and enlightening presentation he had just delivered, titled "Burning Questions—Model Answers." He advised his audience to study fire escape routes in each and every building by following by foot the entire route to the final exit door, preferably eyes closed. Check that door, as many such doors cannot be opened by hand from the inside! A very useful 'take home message.'

Did Galea's presentation somehow relate to laser scanning? Hardly, when regarded from a limited point cloud-oriented perspective. From an application point of view, however, the presentation offered a textbook example of what can be achieved with state-of-the-art dynamic spatial modeling. Because it is the predominant technology for swiftly and efficiently acquiring as-built data, laser scanning is at the heart of spatial modeling. But one needs to think "beyond the point cloud." That's not just a recommendation; it's an imperative. Laser scanning produces datasets by the terabyte in no time. Therefore this technology needs to be considered from the perspective of information oriented data-*processing*, and not merely data-*acquisition*. Considering such a process includes the purpose or aim of that process. Hence, the emphasis is—or

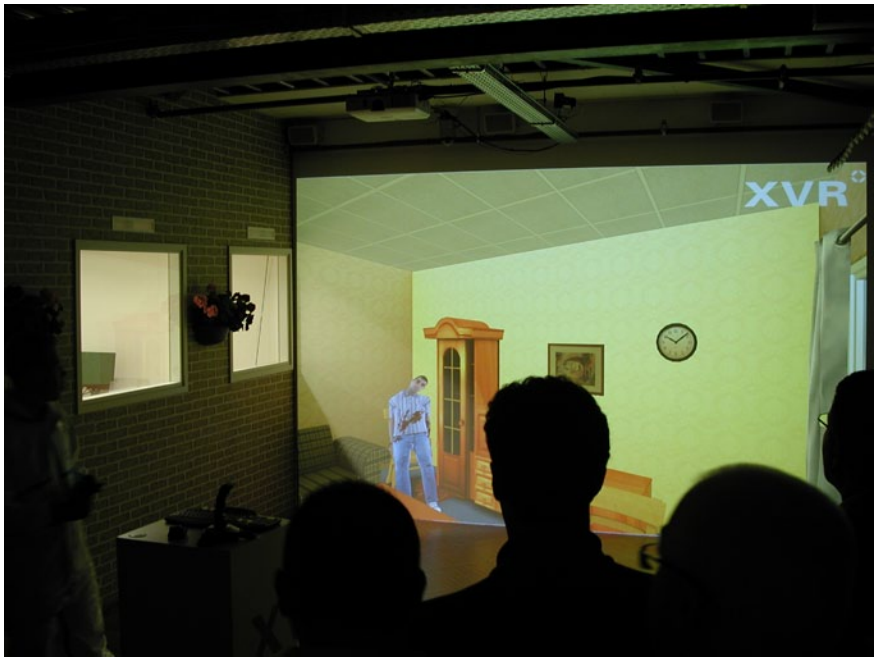
BY JAN H. LOEDEMAN

should be—on the application, as in "Burning Questions—Model Answers."

This point of view was clearly reflected by what was recently presented at SPAR-E in The Hague, Netherlands, November 7-9, and ELMF in Salzburg Austria, November 29-30. Though SPAR was more oriented towards terrestrial scanning, ELMF's emphasis was on aerial scanning, yet the overlap in applications was significant. The latter was clearly visible by a train of mobile mapping vehicles that stood in front of each of the two venues, respectively the World Forum (The Hague) and the Salzburg Congress.

Mobile Mapping Systems (MMSs) are definitely 'hot'. However, despite an enormous leap in MM-technology over the last decade, some problems are rather persistent, most notably a sudden bias in position and orientation due to an improper—or even lacking—GNSS constellation. Such biases deteriorate the geometric reliability—accuracy—of results despite the high precision and point rate a laser scanner itself can deliver. The heart of this problem is in the inherent dynamics when using a MMS. One of the exhibitors at SPAR-E—when questioned for his technological wish-list with respect to MMS—quickly replied: "Mobile mapping without GPS!" This wish—rephrased as a question—was put forward at EMLF in a technical session presented by Graham Hunter of 3D Laser Mapping (UK). His answer was that in case of a malfunctioning GNSS (due to a partially blocked sky in an urban canyon) the only alternative solution is by acquiring positions of topographic features via additional classical surveying.

All in all, the terms 'laser scanning' and 'LiDAR' are too incomplete to cover the many relevant issues addressed



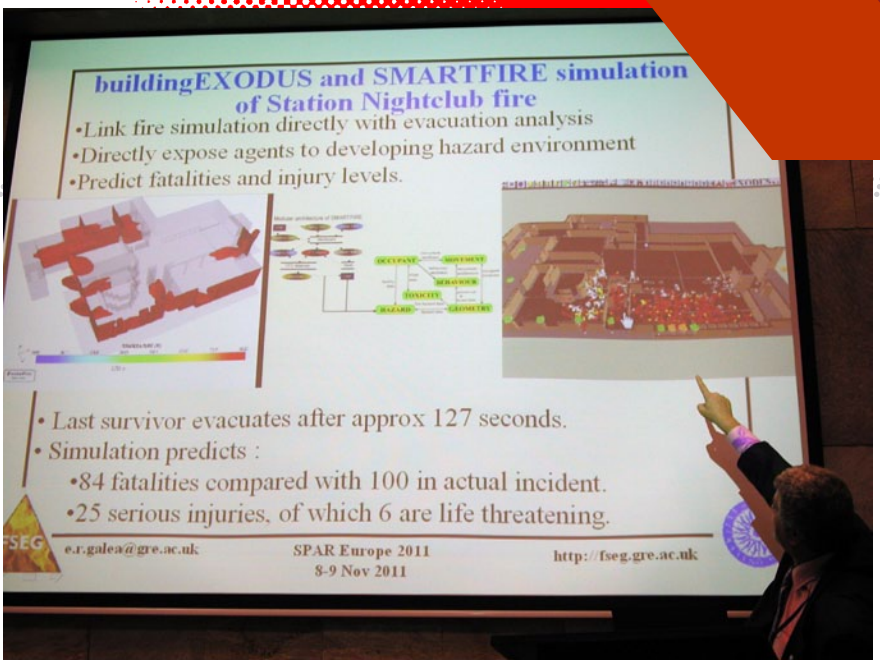
At the pre-conference excursion to the Netherlands Forensic Institute in The Hague, the Dutch company e-semble gave a demonstration of its XVR software 1.

at both SPAR-E and ELMF, such as: systems integration, data handling & management on-the-fly, autonomous feature extraction and spatial modeling. Other interesting issues that go beyond LiDAR alone are, for instance, truly portable MM equipment, and data acquisition in a double-dynamic setting. The latter means that both the sensor and the recorded object aren't static with respect to the spatial reference frame. The only portable LiDAR-based MM equipment on show at SPAR-E was from the German company Dr. Hesse & Partner Ingenieure — acronym dhp:i. The complete system weighs a beefy 46 lbs, including harness and rucksack .

Indoor applications were prominently on the agenda at SPAR-E, but less so at ELMF. And though photogrammetry featured on both agendas, photogrammetric solutions mainly addressed draping imagery over LiDAR point clouds. Attempts at some booths to discuss basic photogrammetric concepts like triangulation and bundle adjustment all failed. Point clouds can be generated by both LiDAR and photogrammetry. Though hand-held image-based (i.e. photogrammetric) systems were featured in some presentations at SPAR-E, none of these were demonstrated at the show. May be classical photogrammetry will see a revival if hand-held portability surfaces as a serious issue. And it definitely is expected to do so in settings where space is limited and portability is essential, i.e. in short-range indoor applications.

SPAR-Europe

Though the actual two-day show started on Tuesday November 8, two pre-conference activities had been scheduled for the preceding Monday.



Wrap-up of the last but most impressive presentation at SPAR-Europe.

Only 15 people participated in the morning excursion to the Netherlands Forensic Institute (NFI) elsewhere in The Hague. The program offered presentations about image-based forensic techniques that NFI and the Dutch police use and develop. Interesting was the visit to NFI's field lab. Here Steven van Campen, project manager at e-semble, gave a demonstration of the company's XVR software (pic 1252). The product enables "serious gaming" and allows for testing scenarios for accident and disaster mitigation as well as for dynamic crime scene visualization. On the other hand of the technological spectrum NFI and TNO—Netherlands Organization for Applied Scientific Research—explored the CSI-potential of an 'of-the-shelf' 3D visualization tool like Microsoft's Kinect (pic 1255). No doubt: serious gaming is coming to the court room in whatever form.

In the afternoon a somewhat larger audience attended the pre-conference tutorial led by Chris Zmijewski. His tips & hints formed a trustworthy guide for coming to grips with a wide spectrum of technology products and applications at both SPAR-E and ELMF. This is his short list of 'current industry trends' in the LiDAR-based industry, with only some of his many remarks included:

- This industry is continuing to grow: "Many people still don't know it is there." (i.e. architects and engineers.)
- Scanners are collecting more points (by the terabytes): "There are still issues with our data capture."
- The move to BIM is driving the use of 3D scanning. (i.e. to get the as-builts BIM requires.)
- U.S. General Services Administration (GSA) is mandating the use of scanning: "Every federal facility must be documented in 3D." (i.e. BIM is a must.)
- Mobile is the hot platform (including hand-held).
- Data interoperability is improving—ASTM standards are here. ("Give me it in a format that I can use.")
- Point clouds are being supported by major CAD vendors: "It's all about surfaces, not single points." And: "3D, not 2D drawings."
- More diverse use of applications (to be enabled by multi-sensor fusion, systems integration, and software development).

Chris emphasized reading the manuals. "Make sure you understand them", which was meant as an antidote against the marketing fuzz one inevitably is exposed to at exhibitions like these. He added: "What is the proper technology for your purpose? Don't be awed by the advancement of technology!" and: "Ask the right questions to vendors! Do you have control when using their software?" In his view, important topics in laser scanning are: accuracy (yet undefined), coping with errors (which are unavoidable) and coordinates (required for standard surveying practices because 3D control is needed). Finally, he strongly advised to look beyond visualization: "One must be able to access the 3D model via software."

Nonetheless, as Douglas Pritchard's contribution to the tutorial demonstrated, visualizations can be stunning. He is an architect and 3D designer, active in the project Historic Scotland. In Glasgow, 1200 buildings have been scanned and put into a single model. Pritchard commented, this "game changer" involved aerial scanning (to get the overall point cloud model), terrestrial scanning (to improve that model) and digital photography of roofs and facades (to drape on the point cloud).

The three keynote speeches on Tuesday started with Ed Lantz, who provided a serious attack on the visual capacity of his audience. He conceptualized what is ahead of us: "holographic wavefront reconstruction" and "next generation cinema." No more movies as we know them. "People are creating their own worlds" he stated. We also need to consider the neurological aspects of "transformative media" and "immersive cinema." Be aware of what comes next to cloud-based

technologies, because, according to Ed: "We are not up to these changes." During this tempting keynote Chris Zmijewski's comments regularly popped into memory.

Visualisations in the next keynote from Doug Pritchard were less intrusive but yet stunning and framed in a down-to-earth context. His presentation was in line with the one on the previous day. Rosslyn Chapel (famous since the Da Vinci Code movie) and Mount Rushmore were only two of the many examples of what modern laser-based technologies can bring about. The bottom line was revealed at the very beginning of his presentation: "It all comes down to sound surveying"; a very reassuring message.

Jurrian Bijhold from the Netherlands Forensic Institute—the third keynote speaker—obviously covered many issues he previously had presented during the NFI excursion. His expectations with respect to emerging technologies in the forensic field go under the banner "CSI The Hague."

The exhibition, though relatively small with 26 booths, had more on offer than can be covered here. The next two examples are included because of a personal bias towards photogrammetry. The one example is the SpheroCam HDR and the related Spheron SceneWorks software. Both are from SpheronVR AG, a German company. The other example is the VMC-F5 system from the Israeli company Mantis Vision. Strange enough, Mantis was not represented at SPAR. The F5 featured in a video as part of a presentation by Shabtay Negry, VP business development at Mantis Vision. The Spheron and Mantis products—Mantis not on show at EMLF—are briefly discussed below.

Spheron camera on show in the booth of the German company Spheron-VR AG.

Spheron's SceneWorks software is information-oriented. It enables far more than merely producing photogrammetric point measurements in a 3D-coordinate system from SpheroCam imagery. The emphasis is on managing, processing and documenting a recorded site via a visual user interface as in a GIS, but in 3D instead of 2D.

The SpheroCam is not a normal digital camera; it is a 360° horizontally rotating linear-array scanner. The lens is exchangeable, which allows for adapting the vertical field of view up to 180°, producing a nearly full spherical view. A specific characteristic of the SpheroCam is its extraordinary high dynamic range (26 f-stops, 32-bits), which precludes exposure problems under poor lighting conditions. Making two scans one after another with a vertical displacement between the two positions enables 3D (stereo) measurements. This was one of the few truly photogrammetric applications at SPAR. Yet the camera is designed to be used in co-existence with a laser scanner. A special bracket ensures that after an exchange of the two sensors the nodal point of the camera lens coincides with that of the

laser's optics. The software drapes the camera image over the laser point cloud. Regarding the scan time of the camera and the required exchange of camera and laser, the combination is completely unsuited for an instantaneous record of a dynamic site.

When recording dynamic sites is an issue, the Mantis Vision F5 hand-held 3D camera system (VMC-F5) leaves few wishes unfulfilled. The system is specifically designed for a freehand record of dynamic sites. Regarding Mantis' military applications this is hardly surprising. In essence the VMC-F5 is a photogrammetric system comprising a camera and a projector at a fixed base. The crux is in the projection of an array of dots by means of near-IR; approximately 50,000 dots per frame. Because of the known array and fixed base, dot patterns in successive images can be photogrammetrically connected via on-line triangulation. This makes external geometric control superfluous. The resulting data is a 3D point cloud. A visual display enables to "see what you get" during recording. The hand-held system is compact and light (6 lbs, including display). Due to the compact construction (small base between projector and camera), the operational range is limited to 3 meters (10 ft).

The presentations addressed many interesting subjects of which only one features in this recap for a specific reason. Building Information Modeling (BIM) is a hot issue related to laser scanning, as Chris Zmijewski stressed in his tutorial. BIM is a kind of linking pin between the surveying world (geometric modeling) and the building & construction arena (architectural & structural modeling). As-builts—required for modeling existing facilities—are acquired mainly by means of laser scanning. The modeling process starts with the point cloud. So far, so good. Software for architectural (BIM) modeling, however, is based on design-concepts that apply for modern architecture: mathematically shaped elements, square angles, constant diameters etc. Such geometric concepts aren't fit for many—if not most—ancient buildings that fall in the cultural heritage category. This misfit creates serious problems when BIM must be applied for such buildings, as Alexandra Grounds put forth in her presentation at SPAR. If the resulting architectural model doesn't fit, then the structural model—which in turn could be derived from this architectural model—most likely will not fit. Hence the BIM for that building is inherently inaccurate. Simply stated: the result can be that the structural integrity of a sound and sturdy age-old could be compromised. The cause is a significant geometric gap between the initial measurements (point cloud) and the model derived from these measurements. The solution is in improving the architectural modeling software in order to adopt oddly shaped construction elements. When interviewed after her presentation. Grounds stated that a solution requires providers of point clouds—surveyors—and model builders—CAD developers—to cooperate.

> "A direct relation between the "real" world (i.e. a building) and a "true" structural model of it in BIM is a long way off."

When recently asked for advice, the Dutch member of ICIS—the International Construction Information Society—fully confirmed Alexandra's point. According to this spokesman the real problem related to BIM is in the development of international standards in various areas. At ELMF, Pointools' application engineer Dan Cutler commented that a direct relation between the "real" world (i.e. a building) and a "true" structural model of it in BIM is a long way off.

ELMF

In his keynote speech, Alexander Weichert, director of Microsoft's Vexcel, compared imaging to laser-scanning. Summarizing the use of Vexel's UltraCam digital aerial camera and new photogrammetric work-flows, he stressed that generating point clouds is no longer restricted to LiDAR. From each pair of overlapping digital images a very dense point cloud can be generated. Stitching together all these individual clouds is a proven photogrammetric procedure. Regarding a required point density, using the UltraCam results in less flight lines compared to LiDAR, thus provides better acquisition efficiency. Due to rapid advancements

The Hohensalzburg Castle—constructed in 1077—towers over the medieval city center of Salzburg.

in digital technology and network computing, data handling no longer is an issue. However, Weichert explained that despite a substantial demand for computing power, the aerial digital imaging business currently is not "cloud computing friendly" due to the kind of projects and related working processes. Nonetheless he sees a potential for the future, especially with regard to large projects. Whether photogrammetric point cloud generation can do better than LiDAR depends on the application. Photogrammetry falls short when it comes to terrain models of densely vegetated areas such as forests. The same holds for recording fine linear features such as power lines. Improvements are needed in these areas. With respect to future trends in the use of point clouds, Weichert sees a parallel with imagery made available via Google. He expects point clouds and surface models to become the next "for free" consumer products. It can be produced photogrammetrically from the same imagery that is currently being made publicly available. When questioned about the use of all the imagery and point clouds, Weichert addressed the problem of automated feature extraction: "It's still one of the hot topics in photogrammetry, and is not solved at all." Point clouds alone do not provide sufficient information for feature extraction. When draped over a point cloud, it is the imagery that provides the additional information needed for feature extraction. Referring to LiDAR, he commented: "We are both in the same boat. What are we going to do with this amount of data?"

Dr. Laurent Smadja demonstrating at ELMF a working "rollator" prototype of Viametris' indoor MMS.

In the plenary panel session following Weichert's keynote, two related questions were at stake. The one question addressed open source LiDAR data; the other point cloud services. From a technological point of view it is obvious that LiDAR—like other geo-data—must be provided in exchangeable formats. Open data sources require open standards. However, "open" or "on-line" is not synonymous with "free." With respect to on-line data, ownership is an issue that needs a solution. The discussion had a strong resemblance to the one a decade or so ago in the U.S. about the best procurement model for aerial and satellite imagery. The bottom line is, as stressed in other presentations at ELMF as well, that the future is headed to on-line data and services.

In the plenary session one of the panel members—William Waggeveld, Fugro Aerial Mapping—stressed that much information can be extracted from point clouds and aerial imagery, but is not yet automated. In other presentations feature extraction turned up with respect

A working prototype of an indoor MMS developed by the French company Viametris.

to various applications. "Semantics is the real complicated part," Gyögy Szabo of Budapest University said when discussing urban object extraction. Others addressed—to present some examples—the automated extraction of power lines around Moscow (Konstantin Konakov, Opten Zao), railroads and overhead wires (Claudia Gedrange, Univ. of Dresden; Gerarld Zach, Riegl), tarp camps and rubble-blocked roads in earthquake-destroyed Port au Prince, Haiti (Beau Legeer, Exelis), road lines, lampposts and traffic signs (Laurent Smadja, Viametris).

The need for good and reliable GNSS reception for mobile mapping was a subject that appeared in several presentations and workshops. Chris Cox, data processing manager with 3D Laser Mapping, UK, concluded at the end of his presentation about mobile mapping systems: "Poor GPS is the problem, not a lack of GPS." In a preceding workshop, Jens Kremer from IGI GmbH had made the same point. On the exhibition floor the conclusion was confirmed by Bruna Bastelaere, of Teccon, Belgium. Though the addition of GLONASS to GPS mitigates the problem to some extent, there is no effective cure that works in all conditions. Intuitively, mobile mapping in tunnels is expected to be a mission impossible, the "no GPS" problem actually is far less serious than in urban canyons. In a tunnel mobile mapping achieves an absolute positional accuracy comparable to that in a "no GPS" urban canyon. In a tunnel the absolute positional accuracy of the tunnel wall, and what is behind it, is irrelevant. Thus the relative positional accuracy, which is good enough, suffices. In an urban canyon, however, a same relative accuracy does not suffice, because the absolute positional accuracy is key. A significant positional shift (bias) in a building's wall cannot be tolerated, where it is harmless in case of a tunnel's wall. Moreover, a tunnel's trajectory is already precisely surveyed during construction.

The ELMF exhibition offered more than the one at SPAR-E simply because of a significantly larger number of exhibitors. In one of the somewhat remote corners Gexel from Italy had its booth. And as "Italy" currently offers tempting subjects for discussion beyond laser scanning, paying a visit was irresistible. Despite popular prejudice—widely fed by the conduct of Italy's recently resigned PM—Italians are highly skilled in technology and very enterprising. This explains a relatively large number of small technology companies like Gexel, according to Prof. Giorgio Vassena, Chair of Topography and Cartography at the University of Brescia in Northern Italy. The software his company had on display triggered a discussion about laser scanning for documenting cultural heritage—with which Italy is sprinkled. Despite the obvious virtues of the technology in this area, he doesn't foresee much of a boom in a BIM-approach for ancient buildings. Why bother, he asked, about their structural stability? A far more effective

Line-up of MMS vehicles in front of the Salzburg Congress.

solution is in his view to scan all relevant buildings and to scan them again in case its structural integrity has become questionable, due to an earthquake for instance. A geometric comparison of the new point-cloud with the initial one will reveal even the slightest deformation.

An item caught my eye in the form of a portable scanning device, found in the VIAMETRIS booth. A rather strange looking contraption in the form of a working prototype, they call the 'I-MMS', meaning INDOOR Mobile Mapping System. It consists of 3 x LiDAR laser scanners, an industrial video camera, flat screen and some electronics. However the key element of the system is in the form of some specialist software using SLAM algorithms.

The 'I-MMS' has been designed for interior mapping, creating a floor plan in real time and generating a 3Dpoint cloud of the environment. The system doesn't use a complex and costly IMU or INS. It also is totally independent and non reliant of GPS location, which is a good thing, considering GPS signals find it hard to penetrate inside buildings.

A brief explanation by Dr. Laurent Smadja—one of the company's research engineers—was immediately followed by an invitation for a trial run of the device (see pics 1442 & 1452). It was rather fun to push the 'I-MMS around the entire ELMF main exhibition hall, meanwhile watching in real time the creation of the 2D floor plan, growing on the screen. It took all of 10 minutes for the scan, after successive data processing another 20 minutes, to complete the job. The completed scan of the hall had accuracy at the sub cm level. Impressive I thought, for a quick practical and accurate scanning device.

In an interview the next day, Dr. Laurent Smadja explained Viametris' roots and product portfolio. The company founded in 2007 is a subsidiary of INDUCT, specializing in "embedded telemetries and vehicle robotics" who in 2005 and 2007 participated in the DARPA Challenge, a competition for autonomous vehicles, organized by the American Scientific Defense Agency.

Viametris focuses on developing software for automatic feature extraction mainly in road mapping, with their innovative software solution called MAGELAAN. Dr. Laurent Smadja made a presentation later on the technical details, at the conference. He explained at a recent trade fair there was serious interest in the 'I-MMS' resulted in several potential clients contacting us. As a result the current prototype is now being industrialized. Watch this space.

Conclusion

There are issues that must be addressed at any such show, whatever the niche might be. These issues relate to three interconnected areas of interest:

1. Applications will increasingly become user-driven and turn-key instead of technology driven and modularly linked.
2. Development will be seen in dynamic—'4D'—modeling, resulting in better 'enhanced virtuality' (serious gaming).
3. Application development as well as modeling reality urges for a move towards standards and open source libraries of various kinds.

In other words, there are three "no-s" to be dealt with in the advancement of this highly dynamic technological field: no 'one-size-fits-all' solutions; no proprietary 'prisons'; no professional 'stove pipes.'

A rather personal take-home message resulting from both shows is that the crux of the matter is not in the hardware, firmware or software, but in the wetware. As with all technology it is finally 'people' that make the clock tick. Hey, surveyors and photogrammetrists, wake up!! Because geometry is a key issue in the point-cloud arena, your expertise and skills are needed. Think beyond delivering point coordinates and line IDs. Put your imagination at work and the sky will be your limit.

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