European
Commission

JRC SCIENTIFIC AND POLICY REPORTS

Unmanned Aerial Systems for Rapid Mapping UASRapidMap 2013

4th JRC ECML
Crisis Management
Technology Workshop

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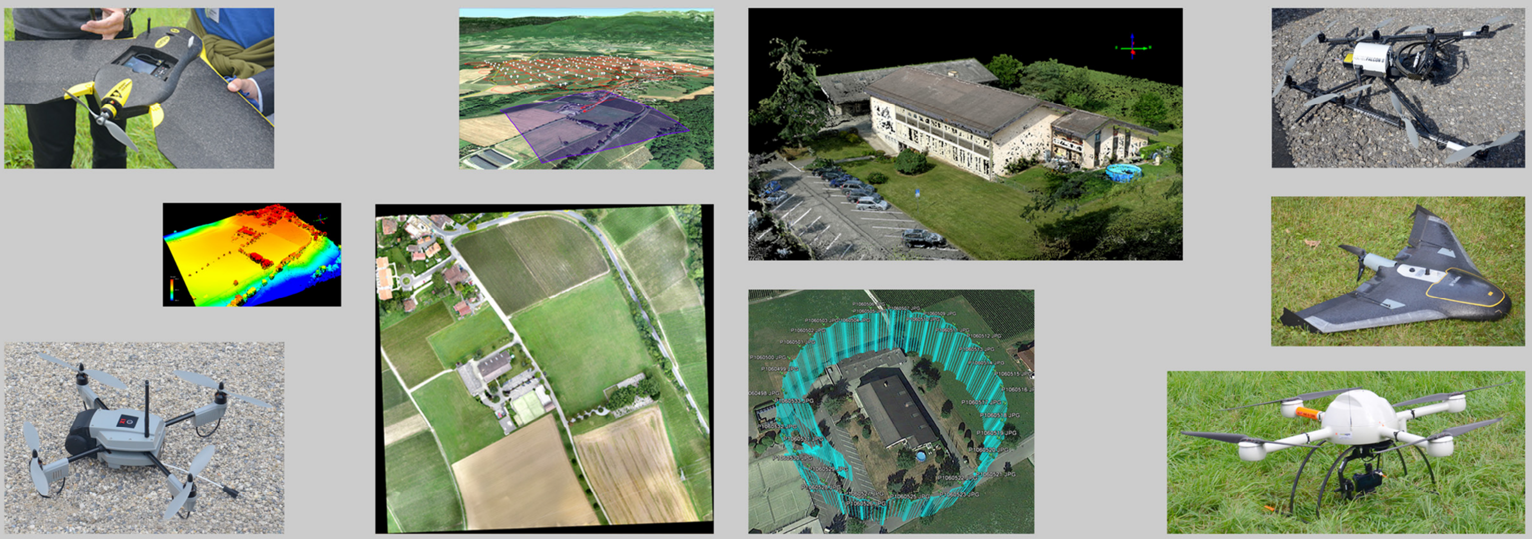
2013



Report EUR 26451 EN

Joint Research Centre

European Commission
Joint Research Centre
Institute for the Protection and Security of the Citizen

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JRC85538

EUR 26451 EN

ISBN 978-92-79-35107-5

ISSN 1831-9424

doi:10.2788/58375

Luxembourg: Publications Office of the European Union, 2013

Images: Courtesy of Olivier Küng (Pix4D), Sonja Betschart (Pix4D), Liam Dawson (Danoffice IT), Bernhard Dräyer (in-Terra), Andrea Hildebrand (senseFly), Klaas Pauly (Gatewing / Trimble), Brecht Lonneville (Gatewing / Trimble), Emil Siegrist (Omnisight), Harald Skinnemoen (AnsuR), Jan Kucera (EC JRC), Peter Spruyt (EC JRC), Markus Rester (EC JRC).

Printed in Italy

European Commission
Joint Research Centre
Institute for the Protection and Security of the Citizen
Global Security and Crisis Management Unit

United Nations
Institute for Training and Research
Operational Satellite Applications Programme

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4th JRC ECML Crisis Management Technology Workshop

Organised conjointly by:
European Commission Joint Research Centre &
United Nations UNITAR - UNOSAT

11-13 September 2013
Geneva, Switzerland

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1 Executive Summary

The 4th JRC ECML Crisis Management Technology Workshop on Unmanned Aerial Vehicles for Rapid Mapping (UAS) was co-organised by the European Commission Joint Research Centre (EC JRC) and the United Nations Institute for Training and Research - Operational Satellite Applications Programme (UNITAR - UNOSAT). It took place in Geneva, Switzerland from 11 to 13 September 2013. For impressions please see media coverage: http://www.youtube.com/watch?v=3lU0-KqGqkg

The workshop's purpose was to present, demonstrate, and explore the state-of-the-art and future potential of unmanned aerial systems for rapid mapping applications in the context of humanitarian crisis aid and natural disaster relief operations.

A scenario based exercise challenged industry participants to deploy and setup their systems and acquire data on day 1 and post-process the collected data and generate / present final products on day 2 of the workshop (see flight plan document in Annex A). The workshop aimed at identification of promising directions for fostering the benefit of UASs to support crisis management.

The UASRapidMap workshop successfully brought together members of industry, academia, Civil Protection and humanitarian actors to explore the technology's readiness for rapid mapping and other civilian applications. The workshop spanned three days: the first day unfolded in Dardagny, Geneva, where the UASs were demonstrated and data collected; the second and third days took place at the International Environment House where post-processing presentations (day 2) and thematic sessions (day 3) awaited 74 participants.

Five mature, off-the-shelf systems took to the sky on day 1: the Gatewing/Trimble UX5 and senseFly eBee, fixed wing systems with impressive rapid mapping capabilities and terrain model generation; the Sky-Watch Huginn X1, which has emergency management applications for rescue operations and effective relief work; the AscTec Falcon 8 whose aerial images can be used e.g., to generate high resolution maps and 3D models; and finally the microdrones md4-1000, which also provides aerial terrain mapping and was demonstrated together with the ASIGN image transfer technology by AnsuR. These last three systems were all copters (quadro- / octo-copters). Each system successfully completed its flight plan and collected the relevant data.

Day two offered participants the opportunity to learn more about how the software used in the data post-processing phase could generate accurate maps or 3D building models. Pix4D gave a comprehensive overview and introduction to data post-processing. Industry participants presented the results of the previous day's flight missions. Accurate flight plans and high-performance and robust systems yielded impressively detailed and geo-referenced maps, 3D point clouds, and video footage.

The workshop ended on day three with the thematic sessions. Several fascinating presentations were given on topics as diverse as user requirements and R&D needs, urban search and rescue, legal aspects of UAS operations, autonomy & artificial intelligence and swarm deployment. Presenters included researchers, experts, and end-users. A question/comment segment after each presentation ensured a lively, ongoing debate.

Main impressions from the workshop were the diversity in technological solutions for various practical uses, the rapid turnaround time from flight to having useable data at hand in the field and a reality check on what are still challenges related to flight permissions, especially outside Europe and the USA. Within the European Union a process on the harmonisation of the diverse regulations for UAS operations and the introduction of UAS into the civil airspace is ongoing. It was reported at the workshop that the introduction of UASs into the United States' airspace is predicted to generate more than 70000 jobs in the U.S.

The UAS technology will most likely make a large impact on data collection in future emergency situations. In addition, based on what was demonstrated, the tools are also useful for disaster risk reduction activities. The formula of allowing close interaction between UAS providers and the humanitarian end user community was highly successful according to the participants. The latter encourages the continuation with the general principle of all ECML workshops: bringing together academia, industry, and end-users to drive the process of continuous improvement of technology supporting crisis management and disaster relief.

1.1 UAS Systems

The following 5 UASs were presented and deployed on day 1 of the workshop by the mentioned operators/providers:

Make	Model	Operator	
AscTec	Falcon 8	in-Terra	
Gatewing / Trimble	UX5	Gatewing / Trimble	
microdrones	md4-1000	omnisight Demonstrated together with ASIGN by AnsuR	
senseFly	eBee	senseFly	
Sky-Watch	Huggin X1	Danoffice IT	

1.2 Participants

74 participants from 53 different organisations from UN and EC stakeholders, academia, and industry attended the workshop (see Table 1).

Stakeholder / Academia / Industry
ActionArm Foundation
Austrian Federal Ministry of the Interior
Danish Emergency Management Agency (DEMA)
European Commission DG Enterprise & Industry (EC DG ENTR)
European Commission DG Humanitarian Aid & Civil Protection (EC DG ECHO)
European Commission Joint Research Centre (EC JRC) Global Security and Crisis Management Unit
European Union FRONTEX Agency
European Union Satellite Centre (EU SATCEN)
Geneva International Centre for Humanitarian Demining (GICHD)
German Bundeswehr
German Federal Office of Civil Protection (BBK)
Human Rights Watch (HRW)
Humanitarian OpenStreetMap Team (HOT)
IMPACT Initiatives
Intl Centre for Integrated Mountain Development (ICIMOD)
Intl Federation of Red Cross and Red Crescent Soc. (IFRC)
Intl Committee of the Red Cross (ICRC)
Intl Organization for Migration (IOM)
Italian Department of Civil Protection (PC)
Liverpool School of Tropical Medicine
MapAction
Swiss Agency for Development and Cooperation (SDC)
Swiss Federal Office of Topography (swisstopo)
U.S. Department of State (US DoS)
U.S. Geological Survey (USGS)
UN Children's Fund (UNICEF)
UN Dept of Peacekeeping Operations (UNDPKO) / UN Mission in South Sudan (UNMISS)
UN High Commissioner for Refugees (UNHCR)
UN Institute for Training and Research (UNITAR)
UN Mission in South Sudan (UNMISS)
UN Office for the Coordination of Humanitarian Affairs (UN OCHA) International Search and Rescue Advisory Group (INSARAG)
UN Office for the Coordination of Humanitarian Affairs (UN OCHA)
UN Institute for Training and Research - Operational Satellite Applications Programme (UNITAR – UNOSAT)
UN World Food Programme (WFP)
Ecole polytechnique fédérale de Lausanne (EPFL)
Fraunhofer, Institute of Optronics, System Technologies, Image Exploitation (IOSB)
German Aerospace Center (DLR)
University of Bern, Centre for Development and Environment
University of Salzburg, Department of Geoinformatics - Z_GIS
University of South Florida
University of Zurich (UZH)
AnsuR Technologies AS
Barnard Microsystems Ltd.
DELIV'AIR
Danoffice IT
Drone Air Services
Esri
Gatewing NV / Trimble
in-Terra Ltd.
Omnisight GmbH
Pix4D SA
senseFly Ltd.
TeraBee

Table 1: List of participants by stakeholders, academia, and industry.

1.3 Outcomes and Conclusions

Unmanned Aerial Systems (UASs) are generally classified into 2 main categories, which are fixed wing and rotary wing platforms. Fixed wing platforms have the advantage of being able to fly at higher speeds for relative long duration. Some fixed wing UASs have the disadvantage of requiring a runway or launcher for take-off and/or landing. On the other hand, rotary wing UASs have the advantage of being able to hover and to take-off and land vertically. They have however lower speed and shorter flight range. In general, lightweight UASs have limitations in flight time (some 30 minutes to around 2 hours).

Both types are suited for being used in emergency situations, rotary wing solutions (copters) being most applicable for e.g., search and rescue operations or inspection tasks. Fixed wing solutions have their strength in mapping applications of small areas (up to 10 km2) that need to be covered with a high spatial detail (e.g., 10 cm). The deployment time of both types is very short and ensures great timeliness of collected data.

The imagery is post-processed in a typical photogrammetric workflow including e.g., setting ground control points, point cloud and digital surface model generation, and image ortho-rectification and mosaicking. Depending on project size, computing power, etc. final geo-referenced maps are usually available within hours after data collection.

Lightweight UAS technology has become a mature market component. Off-the-shelf systems including the necessary software for post-processing and that address minimum technical requirements and data quality for rapid mapping operations are currently starting around 10000 - 15000 €.

An advantage of UASs and important operational consideration is related to data rights. Opposed to most satellite imagery, all data acquired with UASs and resulting map products are owned by the customer, who can then decide solely how to share the outputs with third parties.

UASs are operational alternatives to satellite imagery for disaster monitoring and damage assessment supporting consistent impact mapping over a disaster area, response and recovery operations, post disaster needs assessments, and rapid revisits (monitoring).

One of the most important next steps for fully taking advantage of UAS technology is related to legal aspects. The regulatory situation differs significantly from country to country. In urgent cases of declared states of emergency the operation by national authorities is most likely no problem. The authorisation of a civilian use is on the other hand often a big issue and liability and insurance regulations are diverse. In Europe and the United States of America efforts are made to proceed with the necessary establishment and/or harmonisation of proper regulations.

2 UAS Demonstration

2.1 Day 1: UAS Setup and Deployment, Data Acquisition

The original scenario plan was the mapping of an area of approximately 1 km^2 mapped from an above ground level of about 300 – 400 m. While the required distance to any airport of 5 km according to Swiss law was taken care of (see Figure 1), unfortunately the flight zone was also in the control zone of Geneva airport because of being located just inside the approach corridor. Aviation authorities did not give clearance for an above ground level of more than 150 m and restricted the area of operation to 300 meters radius around coordinate 46.189011 N 005.998916 E. This yielded in a smaller ground sampling distance than what is feasible in a realistic rapid mapping mission in disaster events and crisis situations.

Despite the smaller GSD all other steps in the data acquisition and post-processing necessary are identical and so the scenario was adapted to the given constraints and provided to the participating system and service providers (see Annex B: Practical Information UAS Exercise/Demo).

Figure 1: Flight zone in Dardagny. Geneva airport with 5 km measurement in yellow (in the back).

2.2 Day 2: Data Post-Processing & Final Product Presentation

Day 2 was opened by Olivier Küng of Pix4D giving a comprehensive overview on the foundations and necessary steps in post-processing aerial imagery (see Figure 2).

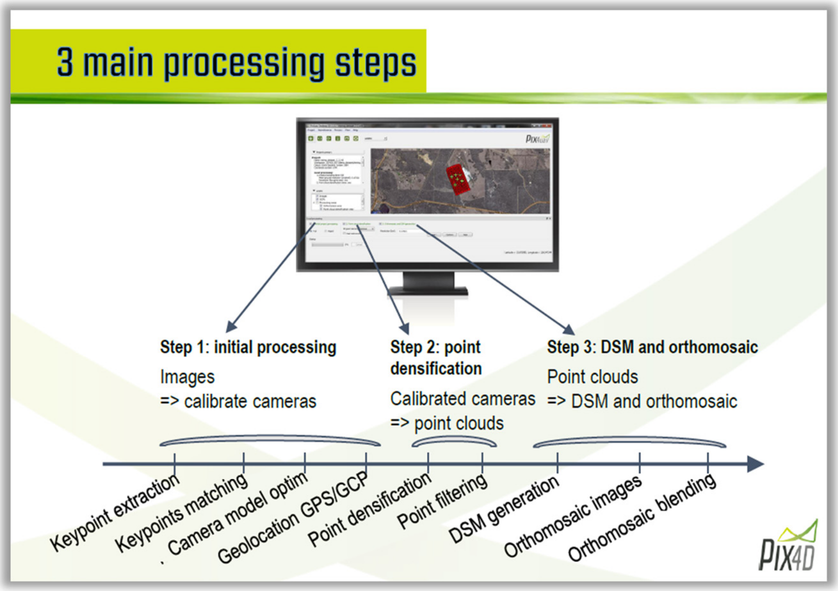

Figure 2: Pix4D main steps in data post-processing.

2.3 AscTec Falcon 8 (operated by in-Terra)

The AscTec Flacon 8 is an octo-copter platform and therefore especially powerful in inspection tasks that need hovering or exact positioning at given points (see Figure 3). That was also the reason for the decision to demonstrate the accuracy achievable today with this UAS including the use of a new version of Pix4D's post-processing software currently under development. The flight plan circled the multi-purpose hall where the workshop took place on day 1 (see Figure 4).

Figure 3: AscTec Falcon 8.

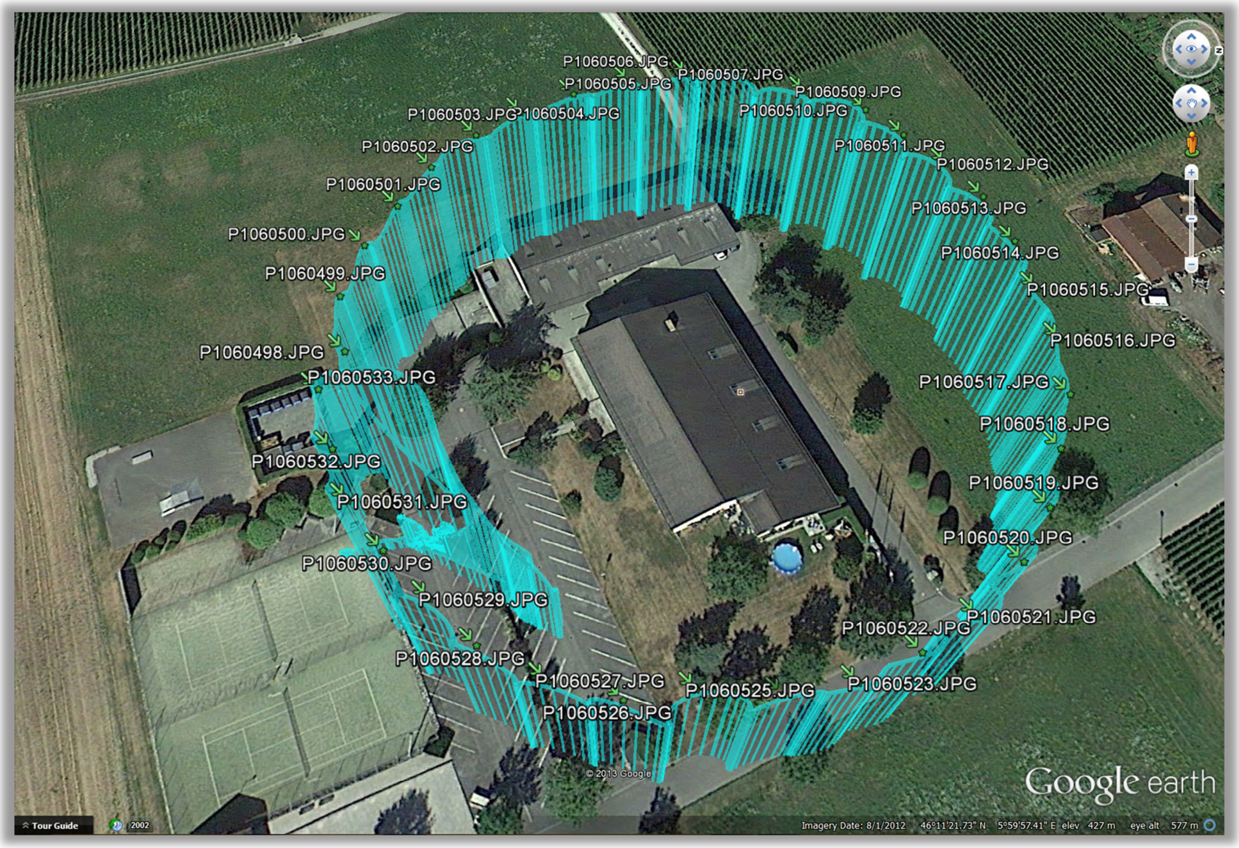

Figure 4: AscTec Falcon 8 log of flight to model the building / area of interest.

34 pictures were taken from non-nadir perspectives (see Figure 4 and Figure 5). The resulting point cloud after post-processing with Pix4D software is of great accuracy and detail. Even traffic signs and their poles of only a few cm of width are well modelled in the output (see Figure 6 and Figure 7).

Figure 5: AscTec Falcon 8 non-nadir image.

Figure 6: AscTec Falcon 8 & Pix4D resulting point cloud.

Figure 7: AscTec Falcon 8 & Pix4D details of resulting point cloud.

2.4 Gatewing / Trimble UX5

The Gatewing/Trimble UX5 is a fixed wing UAS platform introduced in 2013. It is launched with the help of a foldable ramp (see Figure 8). The system follows automatically the necessary flight path to map the given area of interest.

In Dardagny two flights were carried out: one with a regular camera system and another one with a close infrared camera system. The latter has its applications in e.g., vegetation monitoring or in flood scenarios.

The UX5 takes nadir pictures with the required overlap for post-processing (see Figure 9). For post-processing of the data, i.e. entering ground control points, point cloud (see Figure 11 and Figure 12) and digital surface model generation, ortho-rectification (see Figure 10) the photogrammetry module of Trimble Business Center (TBC) is utilised.

Figure 8: Gatewing/Trimble UX5 with foldable launch ramp.

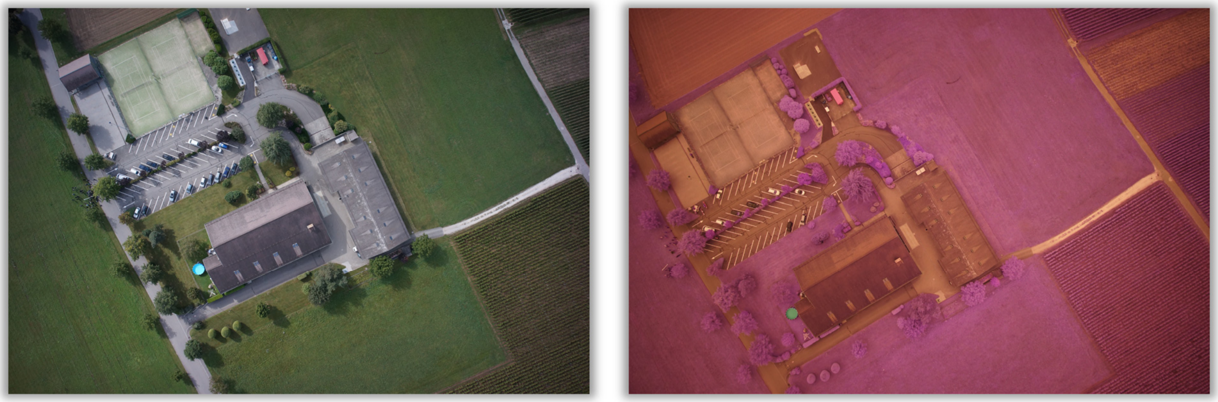

Figure 9: Gatewing/Trimble UX5 nadir pictures (regular and close infrared camera system).

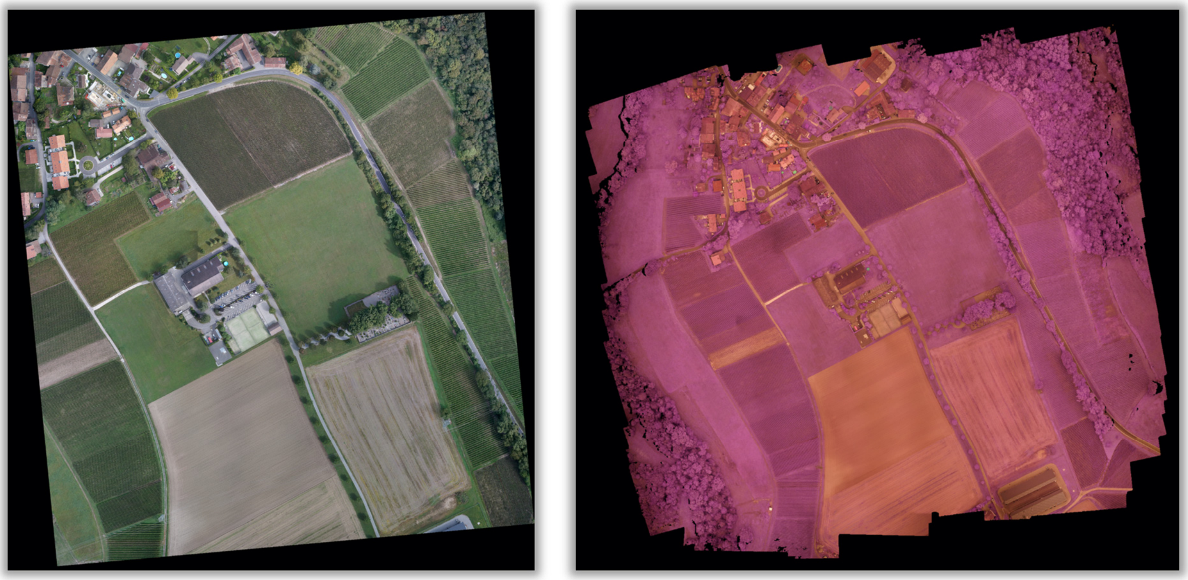

Figure 10: Gatewing/Trimble UX5 resulting ortho-rectified maps (regular and close infrared camera system).

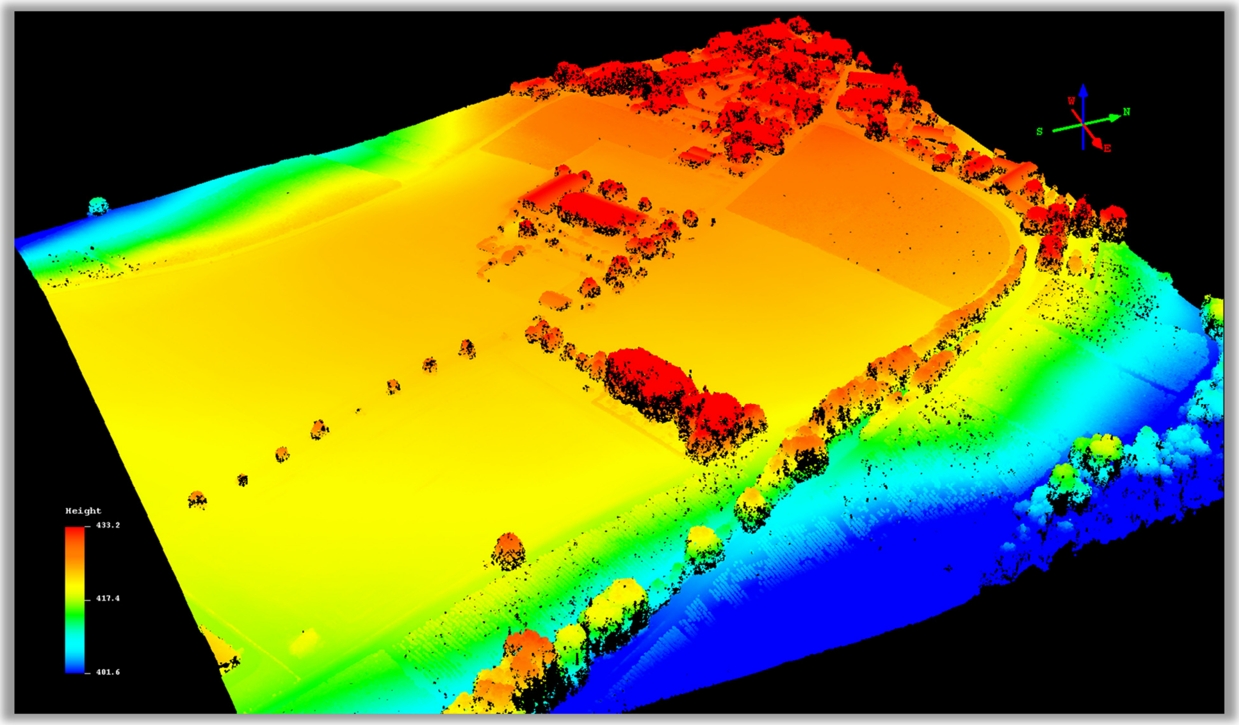

Figure 11: Gatewing/Trimble UX5 resulting point cloud colour coded by height.

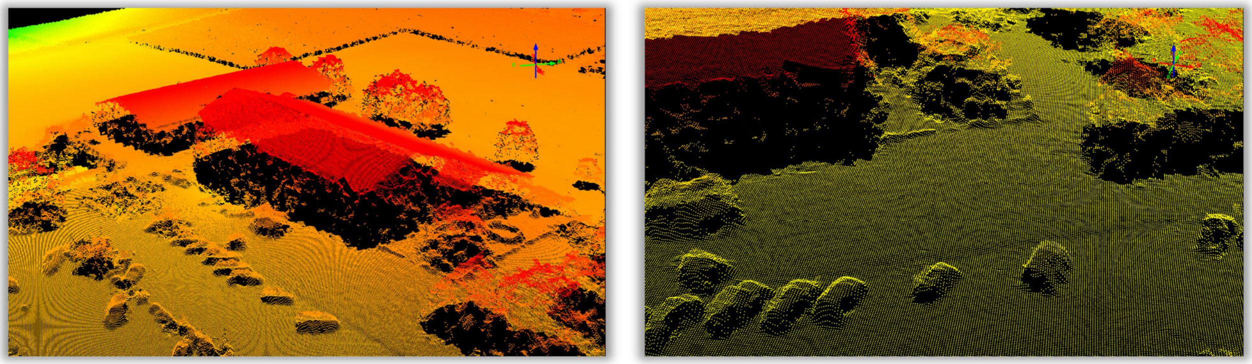

Figure 12: Gatewing/Trimble UX5 resulting point cloud details.

2.5 microdrones md4-1000 (operated by omnisight)

The microdrones md4-1000 is a quadro-copter platform (see Figure 13). Like all vertical take-off and landing (VTOL) systems it is powerful in inspection tasks that require e.g., hovering. Fully automated flight paths are also possible and allow for mapping applications (see Figure 14 and Figure 15). The endurance of the md4-1000 is like with any other copter system usually shorter compared to a fixed wing platform but still missions like an alps crossing are feasible (cf. http://www.youtube.com/watch?v=7Fl6IAutax0).

Figure 13: microdrones md4-1000.

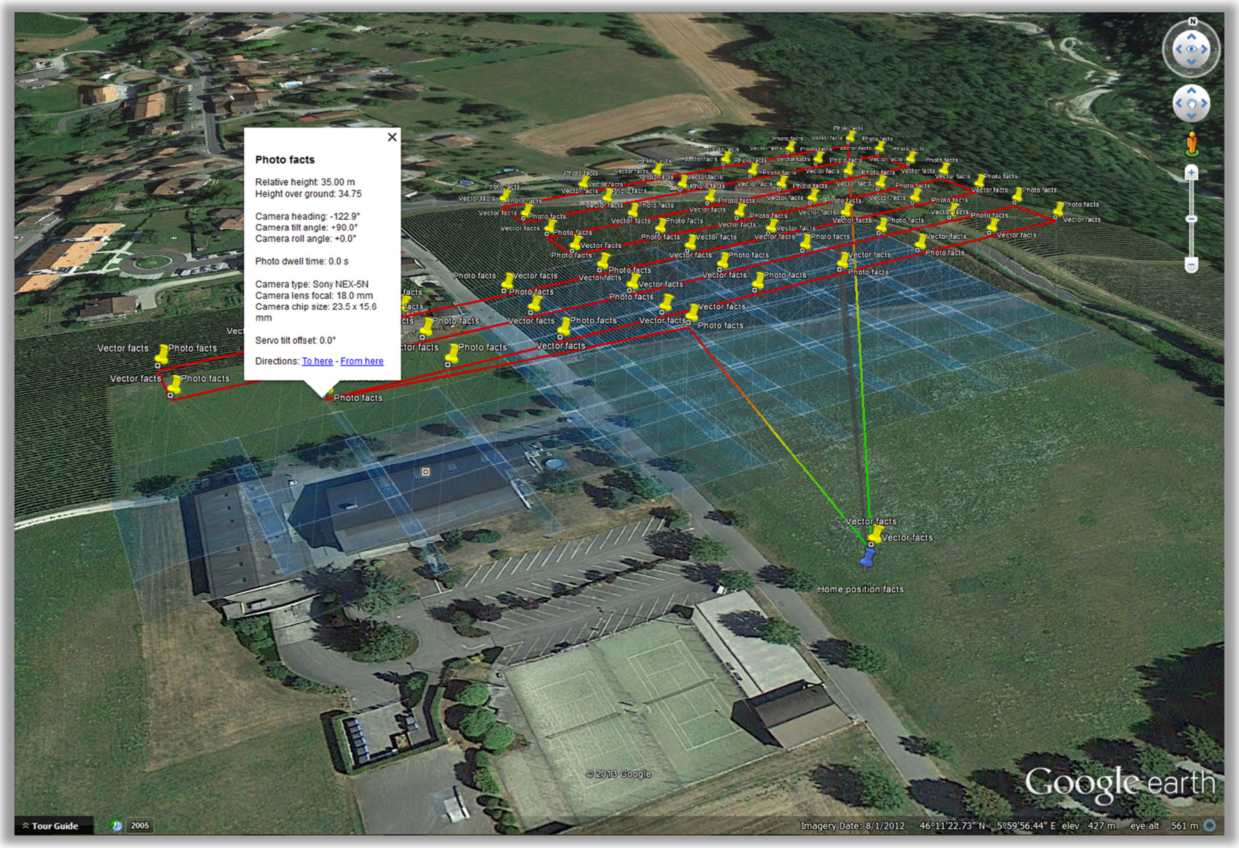

Figure 14: microdrones md4-1000 flight plan.

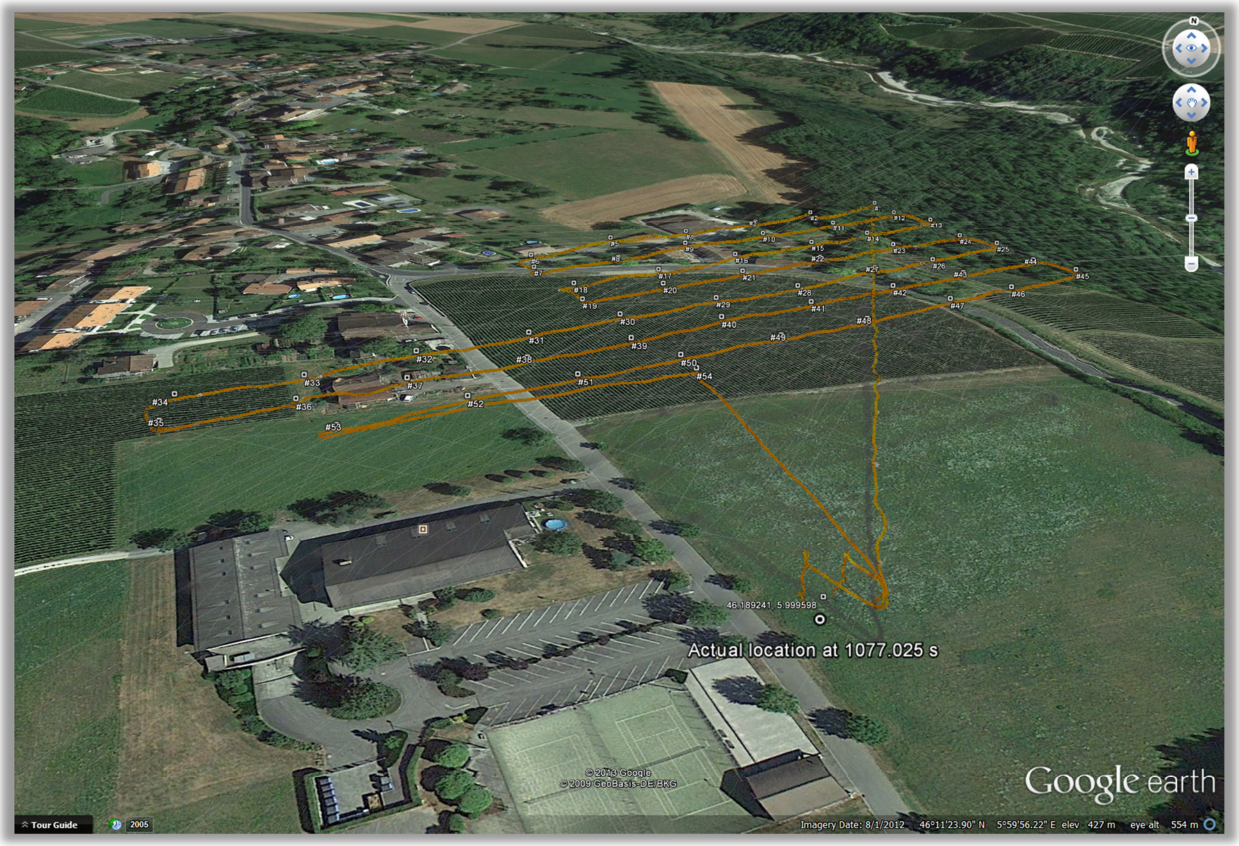

Figure 15: microdrones md4-1000 flight recorder log.

2.6 ASIGN by AnsuR

ASIGN (Adaptive System Image-communications in Global Networks) was demonstrated together with the microdrones platform operated by omnisight. It enables the exchange of data (e.g., geo-referenced images, video, audio, text) over Inmarsat Broadband Global Area Network (BGAN) satellite terminals or over mobile technologies (e.g., 3G/GPRS). Field reports are transferred instantly and are available on a server-side platform (see Figure 16).

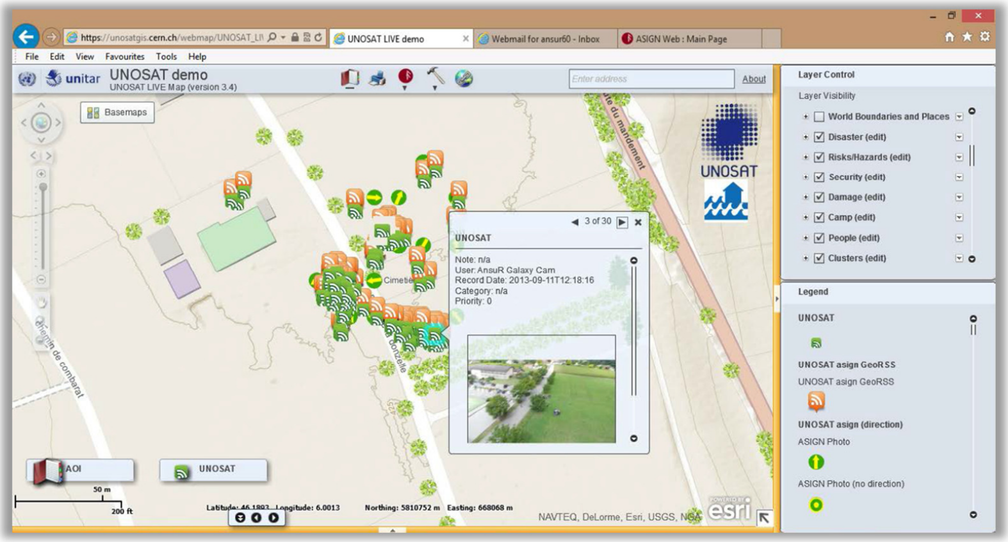

Figure 16: AnsuR ASIGN live server side platform showing collected imagery.

ASIGN is specifically designed to work with the often limited bandwidth resources available in crisis or disaster situations. To minimise required data transfer for example only the areas of specific interest are requested and transferred in higher detail whereas the important context is still available in low detail (see Figure 17).

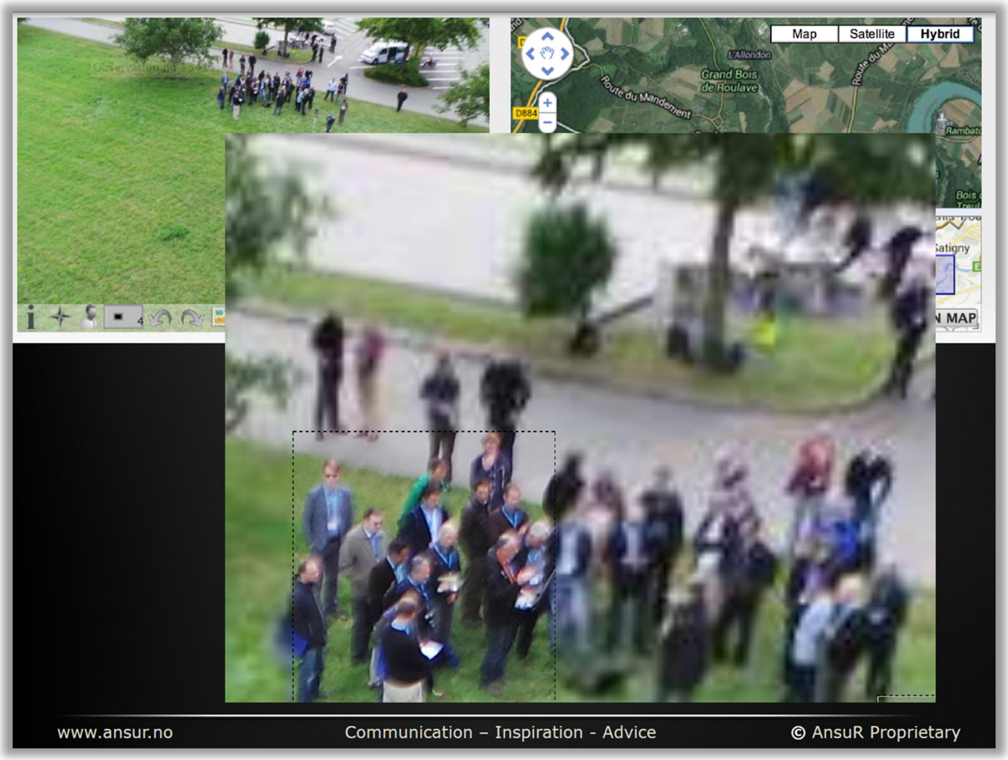

Figure 17: AnsuR ASIGN higher resolution for area of interest and still available context.

2.7 senseFly eBee

The senseFly eBee is a fixed wing platform (see Figure 18). It is launched by hand which decreases the weight of necessary equipment significantly. Together with the fully automatic flight (see Figure 19) and landing procedure (belly landing) minimal training is required for the operation of this platform. The senseFly system utilises Pix4D software for post-processing. eBees were used recently to map and model the Matterhorn in great detail (cf. https://www.youtube.com/watch?v=NuZUSe87miY).

The senseFly eBee collects nadir images (see Figure 20 left) which are the post-processed with Pix4D software to generate point clouds, digital surface models, and ortho-rectified maps (see Figure 20 right and Figure 21).

Figure 18: senseFly eBee.

Figure 19: senseFly eBee flight recorder log.

Figure 20: senseFly eBee nadir picture (left) and detail of resulting ortho-rectified map (right).

Figure 21: senseFly eBee resulting ortho-rectified map.

2.8 Sky-Watch Huggin X1 (operated by Danoffice IT)

The Sky-Watch Huginn X1 is a quadro-copter platform (see Figure 22) with integrated pivoting HD video camera and optional FLIR Quark 640 longwave infrared thermal sensor. Packing dimensions are very low and operation requires minimal training. The platform is operated using a ruggedized handheld tablet computer. Both automatic waypoint navigation as well as drag and drop positioning is available. More direct manual operation is also possible via small joystick.

Due to the live image feeds and the hovering capability the X1 is predisposed to e.g., search and rescue or inspection operations (see Figure 23 - Figure 25). Thanks to FLIR camera option the X1 is useful in low visibility and/or night-time situations (see Figure 26).

Figure 22: Sky-Watch Huginn X1.

Figure 23: Sky-Watch Huginn X1 horizon view of live video feed

Figure 24: Sky-Watch Huginn X1 live video feed approaching area of interest

Figure 25: Sky-Watch Huginn X1 nadir view of live video feed of area of interest

Figure 26: Sky-Watch Huginn X1 screenshot of infrared video feed clearly showing 5 people (not recorded in Dardagny).

2.9 Fixed Wing vs. Copter Platform

Both platform types have very distinctive strengths. Highly accurate modelling needs call for a VTOL platform capable of hovering and taking necessary imagery from required perspectives. Fixed wing platforms deliver point clouds and derived from that digital surface models too but these are naturally not as accurate especially at vertical object borders because of their nadir view (see Figure 27).

On the other hand, fixed wing platforms are more stable and due to their endurance especially powerful in mapping larger areas accurately (see Figure 28). Both platform types, of course, can to some extent be used in both scenarios but with mentioned constraints.

Figure 27: Typical point clouds produced by copter (left) and fixed wing (right) platforms.

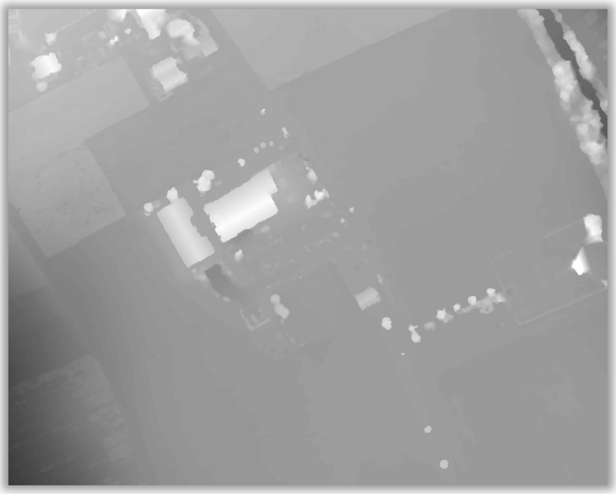

Figure 28: Typical Digital Surface Model (DSM) and ortho-rectified map (details) generated by fixed wing platforms.

3 Summary of Talks & Discussions (Day 3)

On all three workshop days and especially on the third day there was room for exchange of views and ideas and concluding discussions after each thematic session While the sessions were clearly different in terms of focus and content the discussions of course brought all stakeholders together and were not strictly moderated but allowed for hot topics to be addressed.

3.1 UAS: User requirements and R&D needs

Speakers: Luca Dell'Oro (UNOSAT), Frederic Moine (OSM-HOT), Peter Spruyt (EC JRC)

Peter Spruyt (JRC) presented the status and limitations of the Copernicus Emergency Services. For emergency response operations the usefulness of data reduces drastically after 24 h and becomes almost obsolete after 72 h according to a survey by FEMA, USA. Imagery derived from UAS platforms has the appropriate specifications to complement or replace very high resolution (VHR) satellite imagery especially for time-critical applications with a relatively small spatial extent. Experience shows that the resolution limitations of VHR satellite imagery is a serious hamper on accurate damage assessments in urban areas. Quick deployment, price, and a better ground sampling distance makes the airborne imagery (be it collected with UASs or with classic setup utilising piloted aircrafts) competitive against VHR satellite imagery. The JRC is working on defining a roadmap to include UAS solutions in the Copernicus portfolio and will continue in the same direction for tasks related to disaster needs assessments.

Frédéric Moine (OSM-HOT) showed a number of projects where UAS imagery was used in the rapid mapping process of the OpenStreetMap Humanitarian Operations Team (OSM-HOT). The imagery was used mainly to assist field surveys. Imagery can be taken within 2h for an area of 2 km^2 and in time to be used by field teams. The main objectives are to increase security of field teams, to guide survey sampling plans, and to provide quick maps (e.g., for engaging local community). The main issues are radio interference (a risk in particular during a crisis) which cuts control with the UAS, flight regulation and authorisation. Regarding post-processing, compressed products are important in low bandwidth environments. OSM-HOT insists on releasing data with Open Data licenses.

Luca Dell'Oro (UNOSAT) presented UNOSAT's main experience with UAS which was the Haiti case, in collaboration with OSM-HOT and in support of IOM. UAS technology has proven its worth with short deployment times and quick results. Ideas for future improvements could include different sensors (e.g., for vegetation monitoring) and acquisition at different angles (cf. "Pictometry" aerial image capture process). UNOSAT is also promoting the technology in training sessions, but there is still a lot of misunderstanding and uncertainty about the applications and limitations (including regulation and authorisation by aviation authorities). A big advantage of using UAS compared to satellite data is the copyright: satellite data is by default very restricted, while UAS data is by default fully owned by the acquirer.

3.2 (Urban) Search and Rescue – (U)SAR

Speakers: Winston Chang (UN OCHA INSARAG), Ionut Homeag (EC DG ECHO), Bernhard Dräyer (in-Terra), Davide Scaramuzza (UZH)

Winston Change (UN OCHA INSARAG) discussed the potential use of UAS in international search and rescue operations. UAS capacity could potentially be integrated in the certification process of USAR teams. However, the regulatory issues are very important. INSARAG is a network of organisations and has a bottom up approach, and as such has no single legal department that can make decisions. The current short term scope is to define a regulatory framework where teams will require an operating certificate to operate domestically (not for international teams).

Ionut Homeag (EC DG ECHO, ERC) gave an overview of DG ECHO's mandate and operations, and the potential role of UASs. The main tool that can potentially benefit from UASs is the European Civil Protection Mechanism. The example of damage assessment of the Vasilikos power station in Cyprus 2011 illustrated the exploratory use of UASs for an ECHO operation. Regulatory issues included third party liability insurance, but civil aviation permission was not necessary because of the state of emergency.

Bernhard Dräyer (in-Terra) presented rapid mapping applications for debris flows in the Swiss region of Lötschental. During the workshop, Bernhard had showcased the Falcon 8 system in detail. In his talk, he presented other applications, in particular for Urban Search and Rescue (USAR). In the presented situations, again because of being a state of emergency, the permission to fly was easily given by local authorities. But coordination with helicopters operating in the area was necessary, as well as the obligation for having eye contact (visual line of sight) to the UAV at all times. No additional authorisation from civil aviation authorities was necessary in accordance to Swiss law.

Davide Scaramuzza (UZH) gave insights on robotics for Search and Rescue (SAR), going beyond UASs. Autonomous robots, both airborne and ground vehicles, working in collaboration are able to achieve impressive in-door navigation, remote sensing, and manipulation of objects. He presented also the sFly project (FP7 / 2007-2013 /°231855). There several small UASs were developed that can fly autonomously in city-like environments and which can be used to assist humans in tasks like search and rescue or situation monitoring (see http://www.sfly.org).

3.3 Applications in border situation monitoring.

Speakers: Zdravko Kolev (EU Frontex), Tobias Schuchert (Fraunhofer)

Zdravko Kolev (EU Frontex) laid out the requirements for border monitoring in the FRONTEX mandate. The end-user needs for UAS identified by the Research and Development Unit of FRONTEX are: 24/7 all weather systems and devices; sensors to facilitate interception; capability for the exchange of information; exploitation of information for being able to react. Main use cases include the detection of small boats used for cross border crime and migration and the detection of migration on land in forest conditions. The FRONTEX Fusion Centre aims at merging several data sources, including UAS data, into a common operational picture. Additional sensing can then be tasked based on the common operational picture (COP). Also technical and human resources then are deployed. This includes also a mobile situation centre, gathering sensor data from UAS, mobile vans, and ships. These systems should be "fat-finger" solutions that means being easily useable in difficult field conditions. Some of the challenges are the detection of small and fast ships in near real time at great distance over large area. In addition, UASs must be cost-effective compared to piloted flights and be integrated in non-segregated airspace. FRONTEX has organised several events with large UAS platforms tested during multiple days in Aktio, Greece and Istres, France in 2011. Another application is the support to ground patrols. The main applications are missions that cannot be done by manned vehicles, including long range and long endurance flights. UASs need to prove cost effectiveness and usefulness (including legal/regulatory feasibility).

Thobias Schuchert (Fraunhofer) showed the ABUL video exploitation system, able to provide and process real-time data (see www.iosb.fraunhofer.de/servlet/is/28468/ABUL.pdf). Several applications have been presented, including the real-time stitching of live video streams into a map product. The main functionalities of ABUL include:

- Live Mapping: Flight paths of UAV are visualised in real-time in geographical maps.
- Geocoded Mosaicing: Video images are stitched to panorama images in real-time. By additional user input the mosaics are geocoded.
- Image Stabilization: Processing the video stream with m³motion®, the displayed output is stabilised in real-time.
- Image-based Moving Target Indication: Moving targets are automatically detected.
- Vehicle Tracking: Interactively marked vehicles are automatically tracked.

3.4 Legal Aspects of UAS Operations

Speakers: Jean-Pierre Lentz (EC DG Enterprise & Industry), Michael Hutt (USGS)

Jean-Pierre Lentz (EC DG Enterprise & Industry) presented the efforts that have been made in the last years to develop the European Remotely Piloted Aircraft Systems (RPAS) Roadmap (see: http://ec.europa.eu/enterprise/sectors/aerospace/uas/). Subjects presented and discussed included the following:

- There is urgent need to move towards harmonisation of standards and requirements to deploy RPAS in EU countries. This will bring clarity to both end-users and industry and enable and allow future RPAS operation. The aviation authorities need to be closely involved to see progress in this direction.
- The transition after future harmonisation is to some extent uncertain for businesses as some likely will need to adapt their business models.
- The primary goal initially is to integrate RPAS into regular air traffic
- Cooperation between civil and military entities is beneficial to find common grounds on appropriate specifications for large RPAS.
- Insurance thresholds do not have to be too low and may need to be revised. Liability varies from country to country. Insurance offers need to be developed. Therefore insurers need more information on the safety and robustness of UASs. A consequence of worthiness and reliability would be lower premiums.
- Privacy regulations established in Europe have to be respected or revised and will have heavy impact on the RPAS market.
- Consensus must be achieved on the safety requirements for RPASs based on a risk-based approach.
- There are more and more derogation rules for civil aviation. E.g., in emergencies, regulations adopted for RPAS are not the same as for civil aviation.
- In the long term it is very possible that regulations will become more flexible as the technology evolves.

Michael Hutt (USGS) explained the legal and regulatory situation in the United States and the use of UASs by the U.S. Geological Survey (USGS) and the US Department of the Interior (cf. http://rmgsc.cr.usgs.gov/UAS/). Subjects discussed included the following:

- UAS technology is very appealing to users in terms of price and costs compared to manned aircraft.
- The U.S. Federal Aviation Administration (FAA) is moving aggressively to fully integrate UASs in airspace.
- Spectrum allocation and privacy issues are important questions to be addressed.
- Many states in the U.S. are uncomfortable with the idea of using UASs for law enforcement and are more amenable to civilian applications.
- By 2020 it is predicted that UASs will provide most of the data used by the Department of the Interior.

3.5 Autonomy & AI, swarm deployment

Speakers: Felix Schill (EPFL), Davide Scaramuzza (UZH)

Felix Schill (EPFL) presented the many activities on bio-inspired aerial robotics at the Laboratory of Intelligent Systems (LIS), Ecole polytechnique fédérale de Lausanne (http://lis.epfl.ch/). Impressive achievements in areas like the following were showed: Vision-based flight in cluttered areas; sonar-based flight; land-air hybrid robots; autonomous UAS swarms to establish radio network; mid-air collision avoidance in dense traffic; projects SMAVNET II (Swarming Micro Air Vehicle Network) and SWARMIX (Synergistic Interactions in Swarms of Heterogeneous Agents).

Davide Scaramuzza (UZH) presented the diverse activities on vision-controlled autonomous micro aerial vehicles (MAVs) at the Robotics and Perception Group, University of Zurich (http://rpg.ifi.uzh.ch/). He provided an introduction on how computer vision works, its application in UASs, and the challenges in the field. Dense 3D mapping with multiple MAVs or urban geo-localization without GPS are research topics of Davide and his group. For vision based UASs to be able to do aggressive manoeuvres (e.g., flips) new approaches using non-conventional camera systems are promising.

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Annex 1: Regulatory Approach
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Annex 2: Strategic Research Plan
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Annex 3: Study on the Societal Impact
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5 Annex A: Workshop Schedule

European Commission Joint Research Centre (JRC)
Institute for the Protection and Security of the Citizen (IPSC)
4th European Crisis Management Laboratory (ECML) Workshop

United Nations Institute for Training and Research (UNITAR)
Operational Satellite Applications Programme (UNOSAT)

Unmanned Aerial Systems for Rapid Mapping

11-13 September 2013, Geneva, Switzerland

Participants

European civil protection bodies, European Commission DGs, EU Agencies, EU member states, UNITAR-UNOSAT stakeholders, partners, and beneficiaries, UAS hardware/service suppliers

Goals

Presentation, demonstration, and exploration of mature UAV systems for rapid mapping applications.

Participating systems will have to support the whole process chain of UAV flight planning, data acquisition, data post-processing, and map production.

Innovative companies are invited to demonstrate their commercial off-the-shelf systems be it e.g., quadro-copters, octo-copters, or flying wing solutions.

An exercise following a predefined scenario and tasks will allow the systems to point out their capabilities with key performance indicators including:

- **Operation**: time needed to set up UAS, preparatory efforts, training needed, mission planning, automated & manual flight
- **Specifications**: weight, payload, available sensors, flight time, costs, flight conditions
- **Data acquisition**: formats provided, live streams, data transfer
- **Data post-processing**: training needed, in field processing requirements, provided server-side services, orthorectification, required HW/SW
- **Map product(s)**: accuracy, time to delivery of intermediate and final product

Please note that the various UASs will be explicitly referenced during the benchmarking exercise. The objective is not to pick winners and losers but to qualitatively compare the systems in such a way that they can showcase their various strengths and most effective uses.

Scenario Tagline

- Setup of field mission, flight planning
- Rapid mapping of disaster area of ca. 500 x 500 m
  a) quick overview map (day 1) &
  b) optimised map (day 2)
- Ca. 5-10 cm Ground Sampling Distance (GSD) due to clearance of 150 m AGL
- 1-4 (as needed) given reference points
- Delivery of positions of known checkpoints
- Both in field data processing (day 1) & accurate / back-end / server-side processing (day 2)

Wednesday, 11.09.2013 – Data Acquisition

09:00 *Transfer to flight zone*
09:30 **Workshop opening**
09:45 **Introduction to data acquisition**, day 1 scope, tasks
10:15 **Gatewing UX5**: setup, flight ops, first map
11:15 **AscTec Falcon 8**: setup, flight ops, first map
12:15 *Lunch break*
13:45 **senseFly eBee**: setup, flight ops, first map
14:45 **Sky-Watch Huginn X1**: setup, flight ops, first map
15:45 **Trigger EasyMap**: setup, flight ops, first map
16:45 **microdrones MD4-1000**: setup, flight ops, first map
17:45 **Day 1 wrap-up: presentation of quick results**
18:00 *Transfer to Geneva*

Thursday, 12.09.2013 – Data Post-Processing

09:00 **Tour de table: end-user requirements for UAS**
09:30 **Introduction to data processing** Olivier Küng, *Pix4D*
10:15 *Coffee break*
10:30 Day 2 scope & tasks
10:40 **Gatewing**: Data processing, final map production
11:25 **in-Terra**: Data processing, final map production
12:10 **Ansur**: Data processing, final map production
12:55 *Lunch break*
14:30 **senseFly**: Data processing, final map production
15:15 **Danoffice**: Data processing, map production plans
15:30 *Sandwich break*
16:00 **Fotomapy**: Data processing, final map production
16:45 **Preliminary outcomes of exercise**
17:00 **Day 2 wrap-up & discussion**

Friday, 13.09.2013 – Application Sessions

09:00 **UAS: User requirements and R&D needs**
Luca Dell'Oro *(UNOSAT)*, Frederic Moine *(OSM-HOT)*, Peter Spruyt *(EC JRC)*
10:00 *Coffee break*
10:15 **(Urban) Search and Rescue – (U)SAR.**
Winston Chang *(UN INSARAG)*, Ionut Homeag *(EC DG ECHO)*, Bernhard Dräyer *(in-Terra)*, Davide Scaramuzza *(UZH)*
11:15 **Applications in border situation monitoring.**
Zdravko Kolev *(EU Frontex)*, Tobias Schuchert *(Fraunhofer)*
12:15 *Lunch break*
13:45 **Legal aspects of UAS operations.**
Jean-Pierre Lentz *(EC DG Enterprise & Industry)*, Michael Hutt *(USGS)*
14:45 **Autonomy & AI, swarm deployment**
Felix Schill *(EPFL)*, Davide Scaramuzza *(UZH)*
15:30 *Sandwich break*
15:45 **Outcomes of exercise**
Tom De Groeve *(EC JRC)*, Peter Spruyt *(EC JRC)*, Luca Dell'Oro *(UNOSAT)*
16:30 **Day 3 wrap-up & discussion, workshop closing**

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6 Annex B: Practical Information UAS Exercise/Demo

European Commission Joint Research Centre (JRC)
Institute for the Protection and Security of the Citizen (IPSC)
4th European Crisis Management Laboratory (ECML) Workshop

United Nations Institute for Training and Research (UNITAR)
Operational Satellite Applications Programme (UNOSAT)

Unmanned Aerial Systems for Rapid Mapping

11-13 September 2013, Geneva, Switzerland

Practical Information UAS Exercise/Demo

Introduction

Following practical guideline/information are suggestions. We encourage the participating companies to try to cover the proposed targets and flight lines as much as possible. Proposed alternative scenarios by the UAV participants can be discussed on day 1 before the start of the exercise. 3 types of UAVs will present, demonstrate, and explore their systems for rapid mapping and related applications: fixed wing, octo- and quadro-copters.

Flight restrictions

Restrictions imposed by the swiss air navigation services (skyguide):

- On the day of operation, the flights have to be announced 15 minutes prior to the beginning to Geneva Tower, by telephone, indicating the reference number: CH2013-702
- The end of the activity has to be announced to Geneva Tower.
- All mini-drone activities must be conducted within the defined activity area: 300 meters radius around coordinate 46.189011 N 005.998916 E, and up to maximum 150 meters above ground level.
- The operators of the mini drones shall apply the principle "see-and-avoid"
- A contact person must be contactable by telephone throughout the duration of the activity. The contact details must be coordinated with Geneva Tower when announcing the activity.

Scenario

The area to cover is fixed as described above. For your convenience we have made an example of flight-lines and photo centres.

Centre point:

Lat, Long (WGS 84)	46.189011 N	005.998916 E
UTM Zone 31 N WGS 84 (x,y)	731416 m	5119421 m

The given example is based on the use of a Sony NEX5R camera with a focal length of 15 mm. The altitude is set to 157 m with a Ground Sampling Distance of 5 cm. The covered area of one camera shot equals 245m x 163m.

Unfortunately, ground control point collection with a Carrier phase GPS receiver in order to obtain cm accuracy was not possible. For the purpose of this exercise an airborne ortho-rectified image (20 cm resolution) has been used as reference (UTM 31 North). We have selected a set of GCPs (green triangles). They can be used during the triangulation process. We propose to use a maximum of 4 GCPs only. The image and GCP shp file will be given to you in order to select alternative GCPs if needed. The projection used is UTM 31 N with Ellipsoid WGS84.

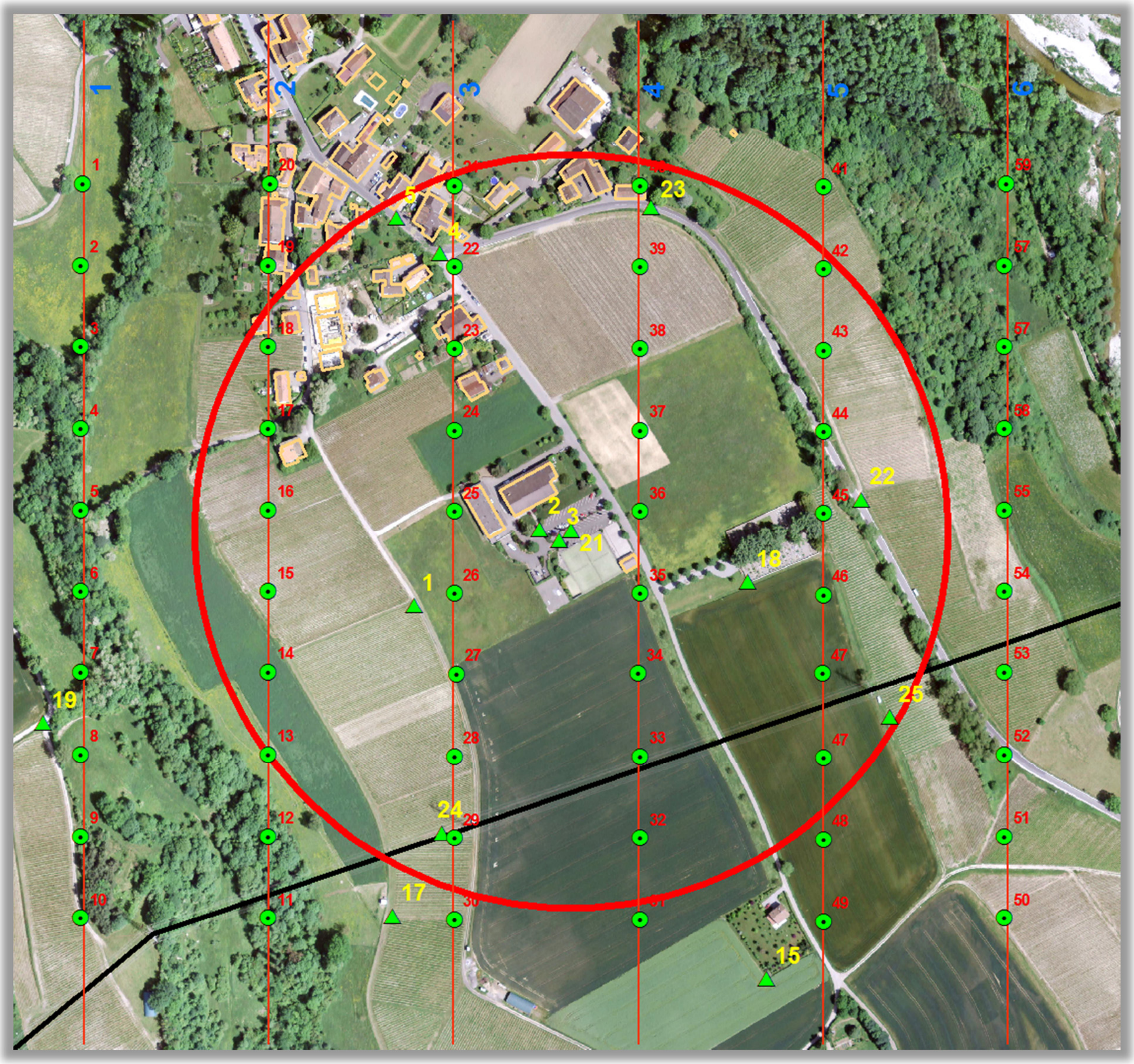

Figure 29: Example of flight lines and image shots.

The UAS/service providers wishing to demonstrate 3D visualisation or visual inspection capabilities are kindly asked to consider as targets a power line (black) with 2 poles within the cleared flight zone and the building complex of Dardagny's multi-purpose hall in the centre of the flight zone.

Observations

Due to the imposed flight restrictions and the fixed area defined we end up in an area without major height differences. We would encourage however the participants to perform a typical photogrammetric workflow in order to generate Digital Elevation Models, Digital Surface Models (if possible) and ortho-rectified imagery on day 2.
The workshop goal is to qualitatively compare UASs in such a way that they can showcase their strengths and most effective uses.

European Commission

EUR 26451 EN – Joint Research Centre – Institute for the Protection and Security of the Citizen

Title: Unmanned Aerial Systems for Rapid Mapping.–UASRapidMap 2013

Authors: Markus Rester, Peter Spruyt, Tom De Groeve, Olivier Van Damme, Adam Ali

Luxembourg: Publications Office of the European Union

2013 – 32 pp. – 21.0 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1831-9424

ISBN 978-92-79-35107-5

doi:10.2788/58375

Abstract
The 4th JRC ECML Crisis Management Technology Workshop on Unmanned Aerial Systems for Rapid Mapping was co-organised by the European Commission Joint Research Centre and the United Nations Institute for Training and Research - Operational Satellite Applications Programme (UNITAR - UNOSAT). It took place in Geneva & Dardagny, Switzerland from 11 to 13 September 2013. 74 participants from UN and EC stakeholders, NGOs, civil protection bodies, academia, and industry attended the workshop. The workshop's purpose was to present, demonstrate, and explore the state-of-the-art and future potential of unmanned aerial systems for rapid mapping applications in the context of humanitarian crisis aid and natural disaster relief operations. Main impressions from the workshop were the diversity in technological solutions for various practical uses, the rapid turnaround time from flight to having useable data at hand in the field and a reality check on what are still challenges related to flight permissions. Within the European Union a process on the harmonisation of the diverse regulations for UAS operations and the introduction of UAS into the civil airspace is ongoing. The UAS technology will most likely make a large impact on data collection in future emergency situations. In addition, based on what was demonstrated, the tools are also useful for disaster risk reduction activities.

LB-NA-26451-EN-N

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle. Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new methods, tools and standards, and sharing its know-how with the Member States, the scientific community and international partners.

Publications Office

ISBN 978-92-79-35107-5
doi:10.2788/58375