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Presented at the FIG Working Week 2017,
May 29 - June 2, 2017 in Helsinki, Finland

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Helsinki Finland

29 May - 2 June 2017



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From digitalisation to augmented reality

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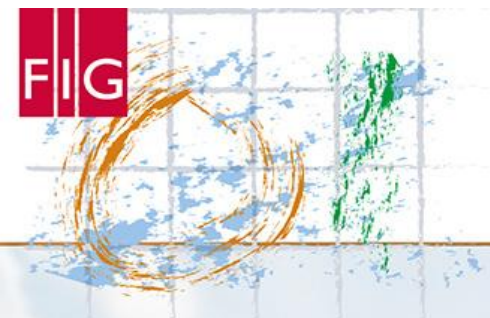


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Humanitarian Demining - UAV-BASED DETECTION OF LAND MINES

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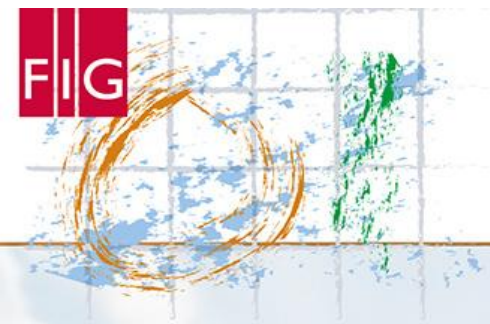


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Humanitarian Demining - UAV-BASED DETECTION OF LAND MINES

- Introduction and Motivation
- Mine action
- The FindMine Project (0 & 1)
- Basic System
- Sensors
- Current Status & Conclusions



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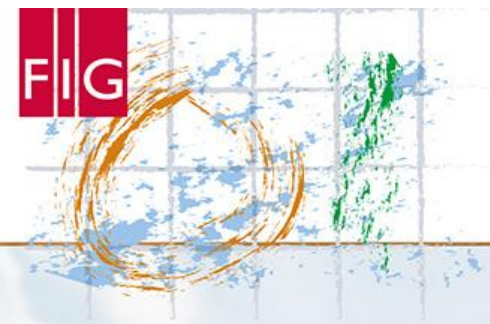


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Introduction and Motivation

- Every day approximately 10 people around the world lose their lives or their limbs to a landmine or through explosive remnants of war (ERW). .
- This means that about 4,000 people are hurt or killed worldwide every year.
- Approximately 60 countries around the world are contaminated by landmines and / or ERWs.
- Landmines / ERW prevent the productive use of the land (eg agriculture). They generate a lasting sense of insecurity long after the end of war conflicts, delay peace processes and hinder the development of the affected countries for many years



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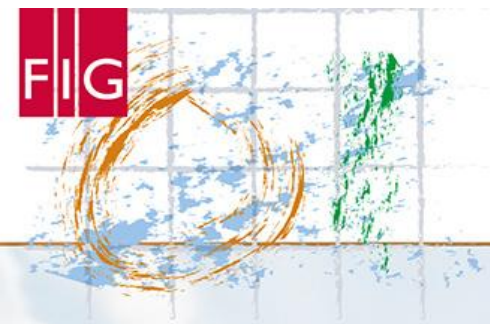


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- Nobody knows exactly how many mines have been laid in the ground worldwide (in the literature one finds estimates of 60 to 100 million). The actual number is less important than its impact: a few mines or the mere suspicion of their presence can make a piece of land unusable.
- An important feature of the antipersonnel-mines is that they are designed to maim rather than kill a human (military aspects).
- In the meantime, antipersonnel mines are also being used against the civilian population to terrorize communities, to prevent access to agricultural land and to restrict freedom of movement.
- The average cost of locating and clearing landmines is US\$ 2.25 (US\$ 0.6 - 8.75) / m² [<http://www.mineactionreview.org>]. Further to this, the average area searched to find one mine is approximately 2500 m² (i.e. US \$ 5625 per mine found and cleared.).



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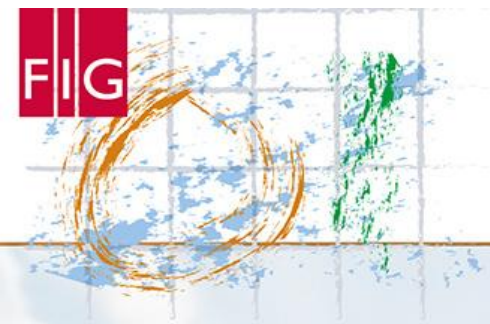


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Mine Action

- Mine Action aims to reduce the social, economic and environmental impacts of mines and UXO (unexploded ordnance) so that people in the affected regions can live safely again, resulting in an economic, social and health-positive development.
- MineAction consists of five components:
 - Humanitarian demining
 - Survivor assistance
 - Mine risk education
 - Stockpile destruction
 - Diplomacy



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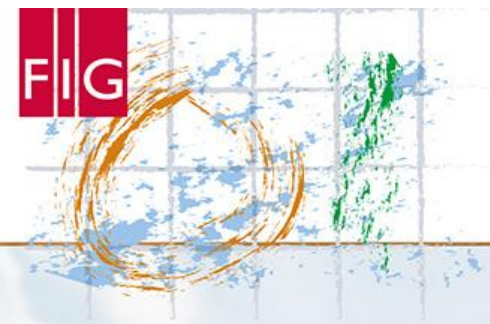


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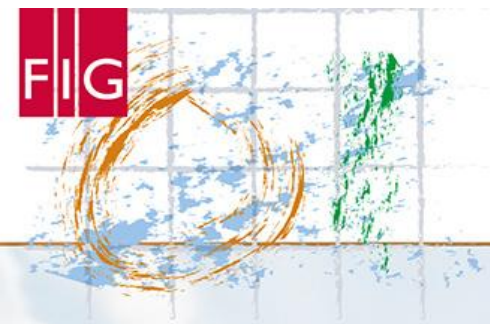


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- According to the current Mine Action Standards <http://www.mineactionstandards.org/fileadmin/MAS/documents/imas-international-standards/english>
- the mine search and removal process has three stages:
- **land release** (2013) *in the context of mine action, the term describes the process of applying all reasonable effort to identify, define, and remove all presence and suspicion of mines/ERW through*
- **non-technical survey (NTS),**
- **technical survey (TS)**
- **and/or clearance.**



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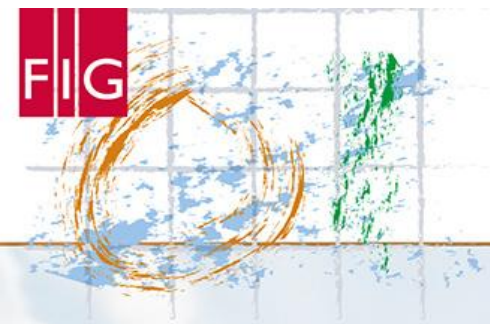


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FindMine0 – The Idea

- At the end of 2014, the idea of using UAV/UAS with an appropriate mine detecting sensor system was discussed at the FHNW.
- A study project was initiated (financed by the FHNW Foundation <http://www.stiftungfhnw.ch>) to check the feasibility of these ideas.
- The study project was finalized in July 2015 and the results summarized in an internal study report (Gottwald et.al 2015).
- Following this study, it was decided to set up an R&D project with the aim to develop an operational system by the end of 2018.



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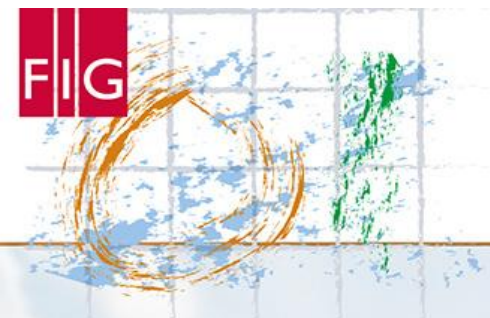


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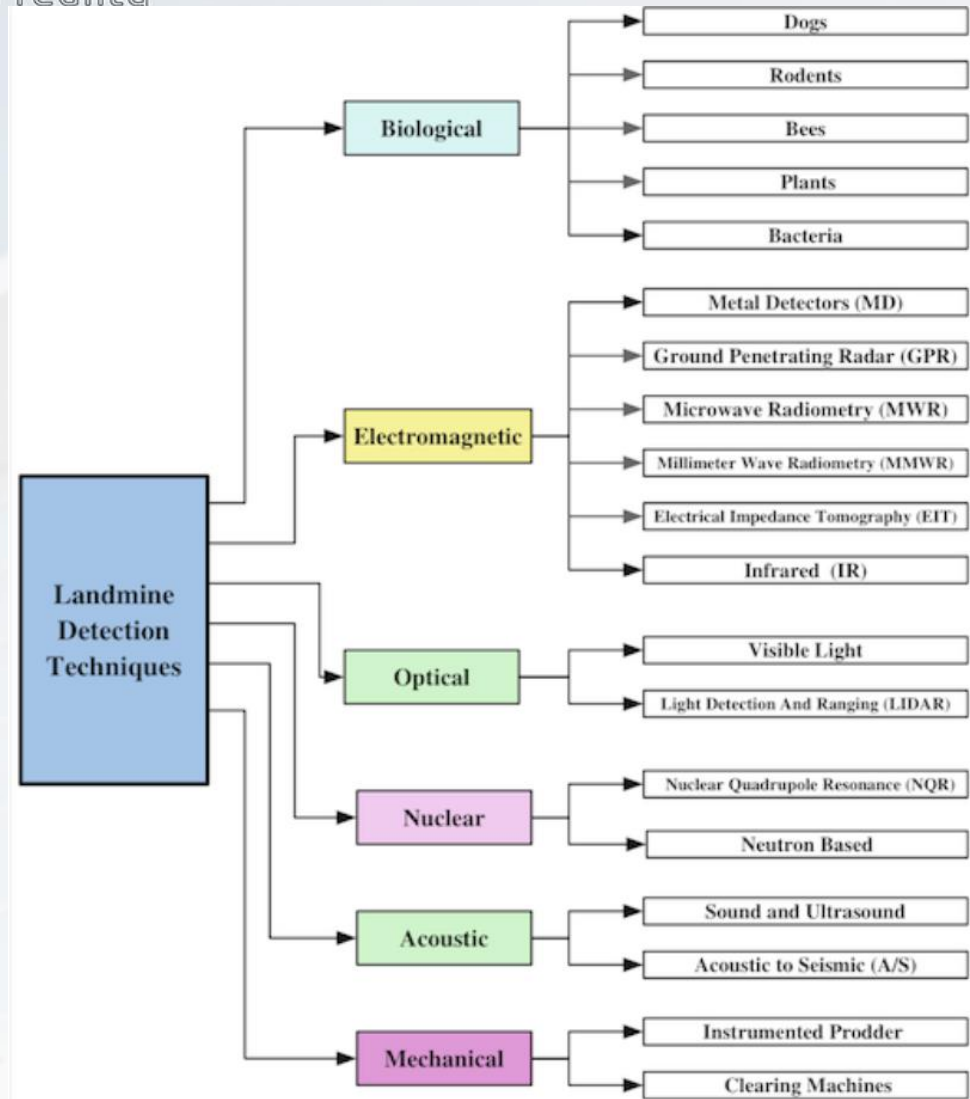
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FindMine 0

Mine Detection Technologies

GICHD (2006) Guidebook on Detection Technologies and Systems for Humanitarian Demining – Geneva International Centre for Humanitarian Demining



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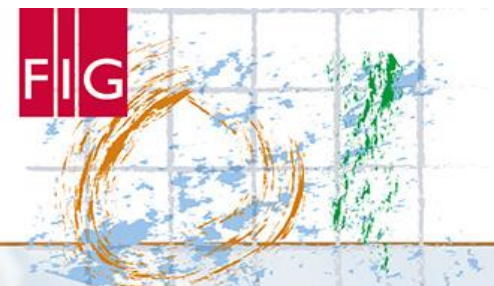


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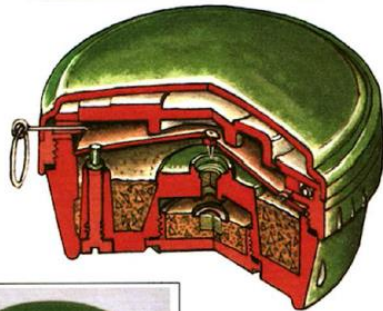
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Types of Mines (4 out of 771) – just to get an idea (TIRAMISU_DataBase)

Type 72 – A/P Blast Mine – China



Photograph of the Type 72 A/P Mine

Technical Specifications	
Largest Diameter	- 78mm
Overall Height	- 38mm
Overall Weight	- 140gm
Explosive Weight	- 51gm
Explosive Type	- TNT
Fuse Type	- Pressure
Operating Pressure	- 5-10kg
Body Material	- Plastic
Mine Effect	- Blast
Colour	- Green
Fuse Employed	- Diaphragm Operated

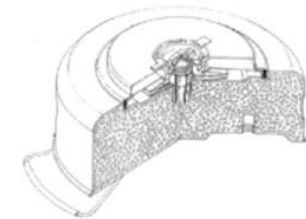
PMN-2 – A/P Blast Mine – Soviet



Photograph of the PMN-2

Technical Specifications	
Largest Diameter	- 120mm
Overall Height	- 53mm
Overall Weight	- 420gm
Explosive Weight	- 100gm
Explosive Type	- TNT/RDX
Fuse Type	- Pressure
Operating Pressure	- 15kg
Body Material	- Bakelite
Mine Effect	- Blast
Colour	- Black, cruciform Pressure Plate, Green or Brown body
Fuse Employed	- Integral Cocked Striker

M 15



Specifications	
Country of Origin	USA
Made of	Steel
Mine Action/Effect	Pressure actuated blast
Explosive Content	10.33kg of Comp B + 11g RDX booster
Operating pressure	135kg
Weight	14.27kg
Height	125mm
Diameter	337mm
Fuze options	M-603/608 Mechanical pressure
Anti-lift wells	2 at the side and bottom

Type 72 Non-Metallic



Specifications	
Country of Origin	China
Made of	Plastic
Mine Action/Effect	Pressure Actuated Blast
Explosive Content	5.4kg of RDX/TNT (50/50)
Operating pressure	300kg
Weight	6.5kg
Height	100mm
Diameter	270mm
Fuze options	Type 72 Mechanical pressure (blast resistant), Type 69 Mechanical pressure (double impulse), Type 81 (single impulse)
Anti-lift wells	No



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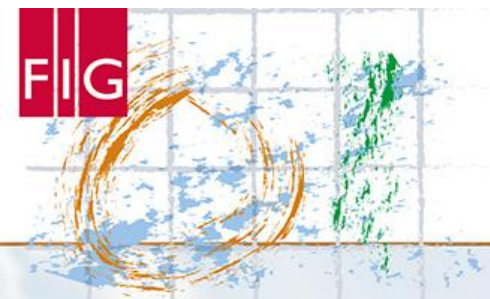


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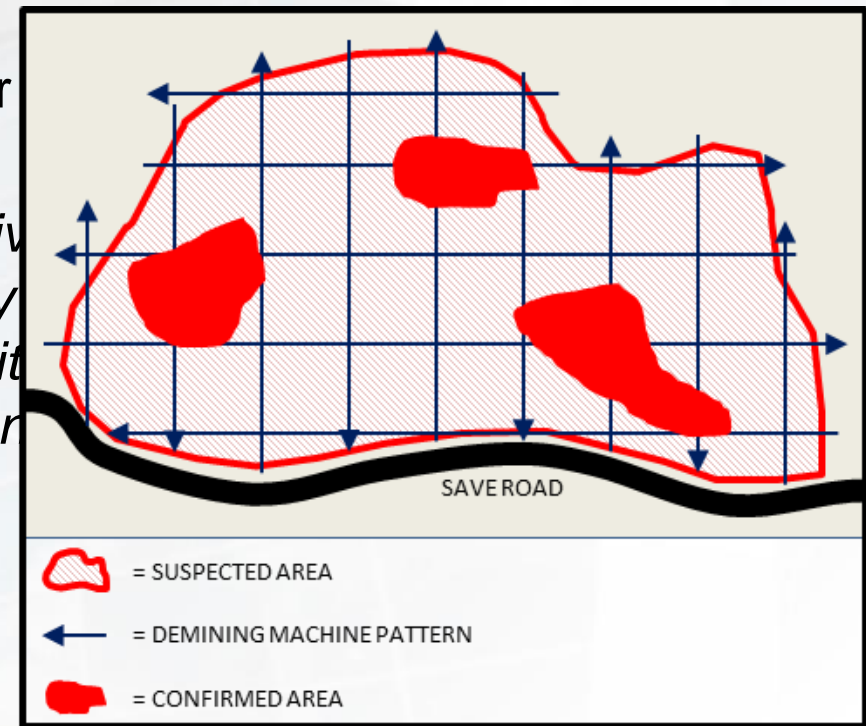
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FindMine 1

- The main target of FindMine is to reduce the time-consuming search for confirmed areas (TS).
- The currently used demining machines, which are expensive to buy and use, can clean an area of about 1000 m² per hour. In comparison, a human deminer can clean 35 m² per hour [FINDMINE1, 2016].
- An UAV/UAS-based system should be cheaper about 10'000 - 20'000 m² per hour.
- *The main priority for the Findmine1 is to save lives of civilians to accidentally enter hazardous areas by reporting hazardous areas to national authorities. In addition to speed up the release of areas to the community for agriculture and development.*



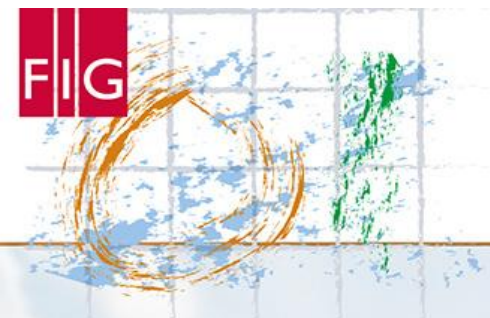


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Project goals:

- Significant optimization of today's mineaction (landrelease) by fast and secure technical survey (TS) - ie. detecting and marking contaminated land surfaces
- Production of georeferenced maps/orthophotos with perimeter data and possible minelocations (as base for the clearance process); Documentation in standardized GISystems (eg QGIS-> GICHD-INSMA).
- LowCostSystem - easy-to-learn / easy-to-use; High availability and stability.
- Focus on LandMines (requirement) - no booby traps or similar (not for the time being).



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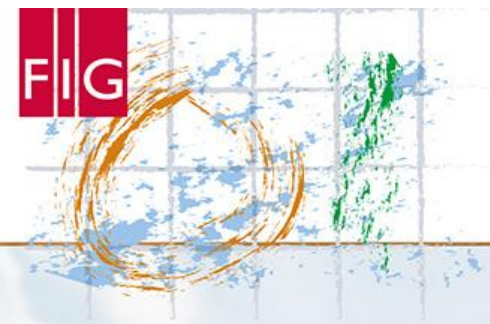


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Technical conditions:

- UAV as transport system - payload approx. 5 kg – flight altitude above ground 2 – 3 m – absolute positioning accuracy <2 cm (GNSS-RTK / IMU) – anti collision detection
- Correct georeferenced basic informations (Maps, Orthophoto, Digital Terrainmodell)
- Flight planning for 'sensor flight' (sensor-dependent, if applicable) - autonomous sensor flight - detection of common mine-types
- data analysis in postprocessing
- SAR / GPR is implemented as the first sensor component
- ThinkTank for additional sensor technologies (gas, thermal / multispectral, metal, ...)
- Fulfilling the specifications 'MineAction GICHD'



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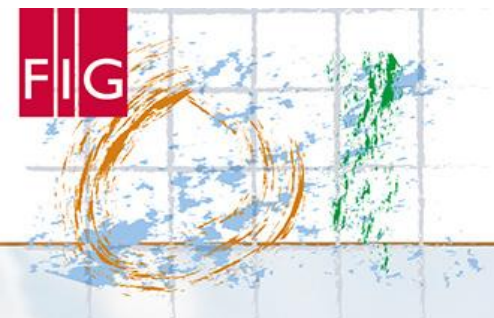


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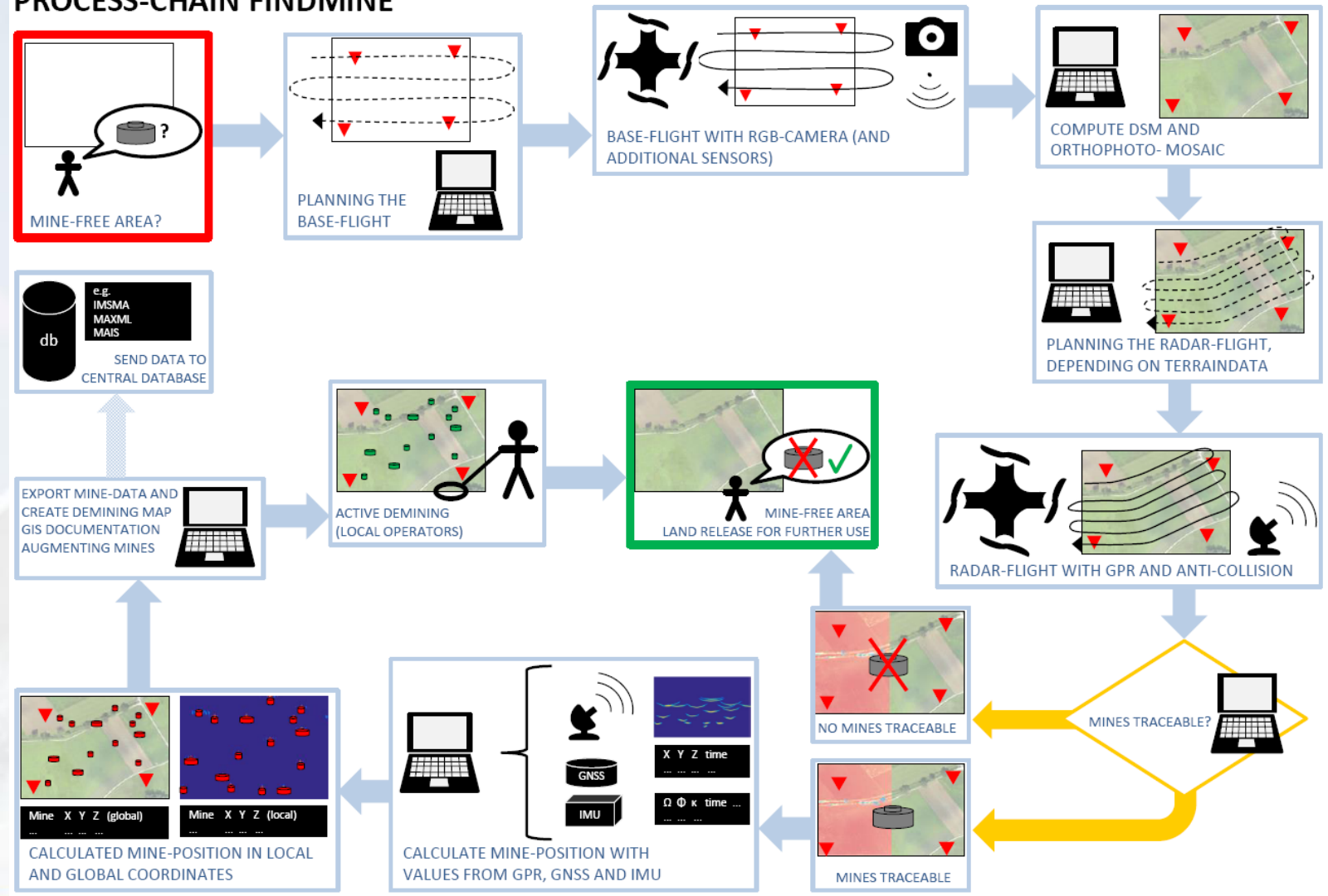
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PROCESS-CHAIN FINDMINE

10.01.2017/DN



Workflow - GPR



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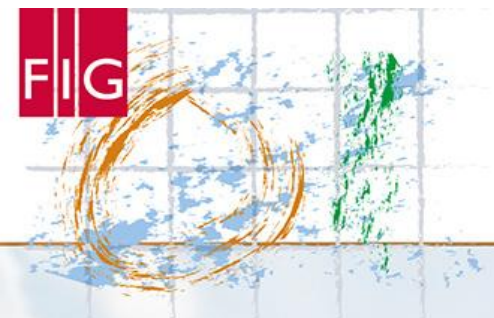


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UAV(DJI1000S)/GPR
operational since mid
of April 2017



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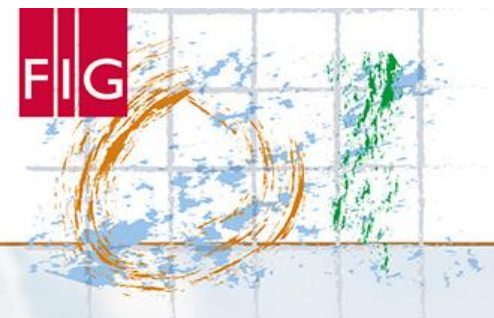


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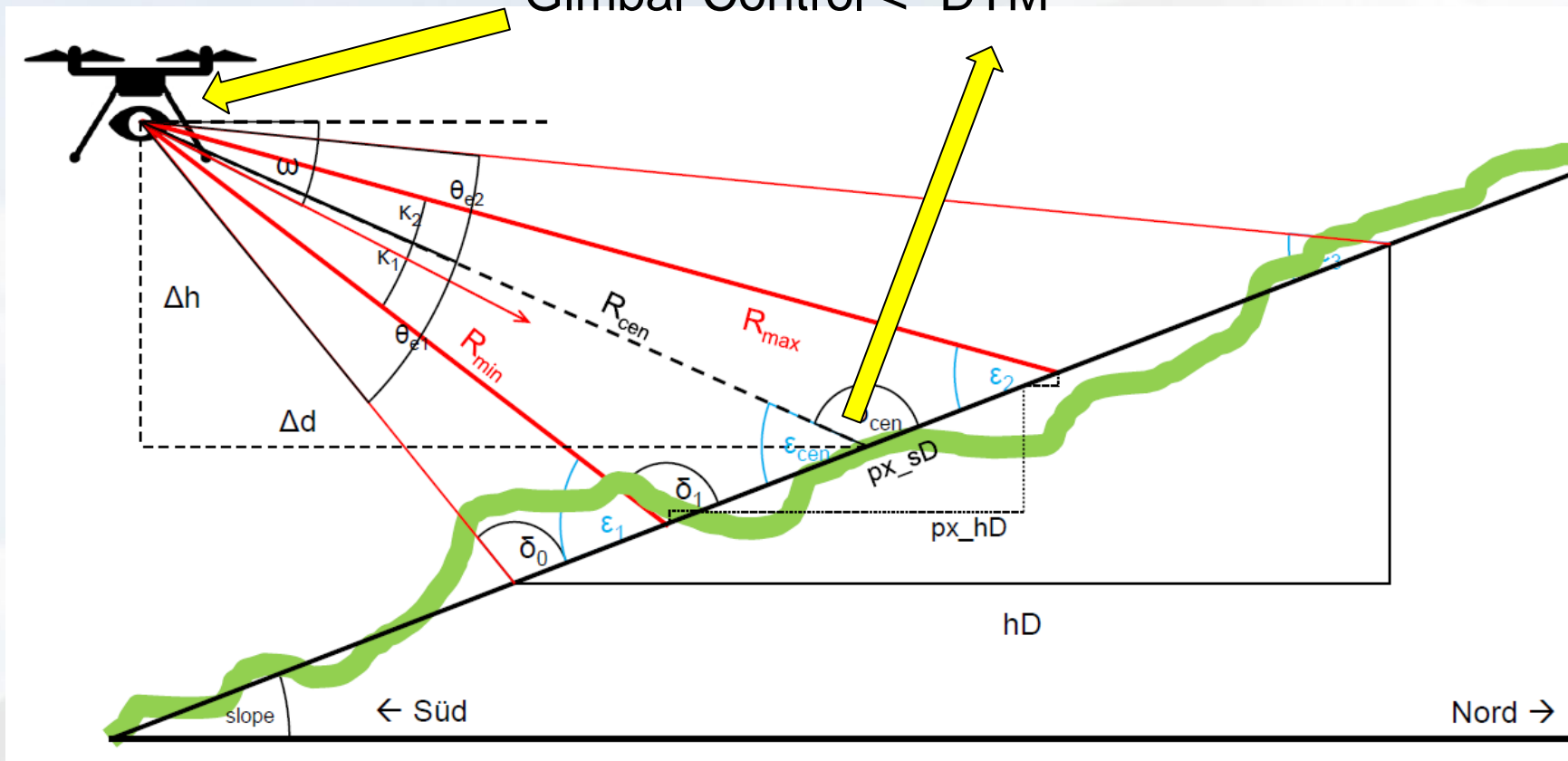
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FindMine 1 - GPR – Angle of Depression vs. Terrain

Gimbal-Control <- DTM



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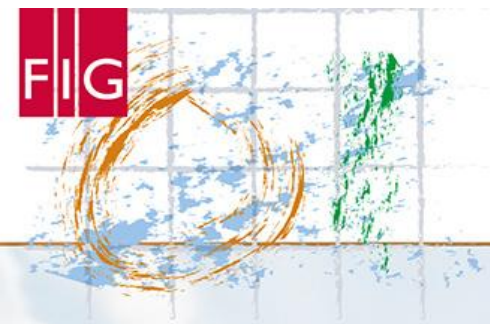


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Problems / risks

- GPR radio permits D / CH (GPR approx. 1 - 4 GHz interference with telecom, GNSS,), Possible interferences GPR -> GNSS?
- New flight restrictions for UAV (Germany)
- No (dummy) mines available -> replacements? (Anti-Personnel Landmines Convention, Ottawa 1997)
- GPR - View into the Earth - Reliability, Interference, Limitations??
- Easy to learn / easy to use -System



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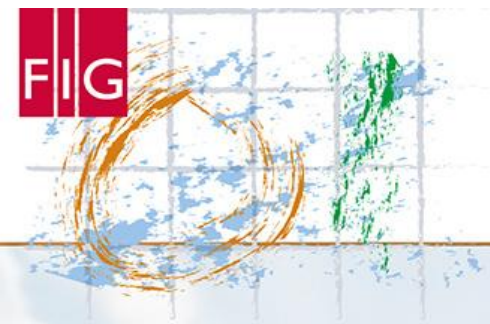


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Current status of FindMine 1

- UAV operative – proved RTK positioning accuracy <1 cm
- Gimbal for GPR operational
- GPR standalone operative (test stand) - radar reflectors above and below ground (sand) detectable (Jan. 2017)
- Flight planning 'radar flight' including collision management created - GUI pendent (Jan 2017)
- First Successful system flight (UAV / GPR) on April 18, 2017



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- FindMine 1 - UAV/GPR 1 - Testflight 18.04.2017

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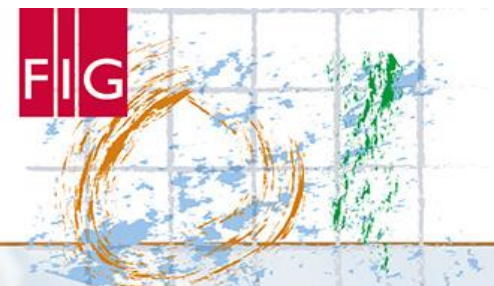


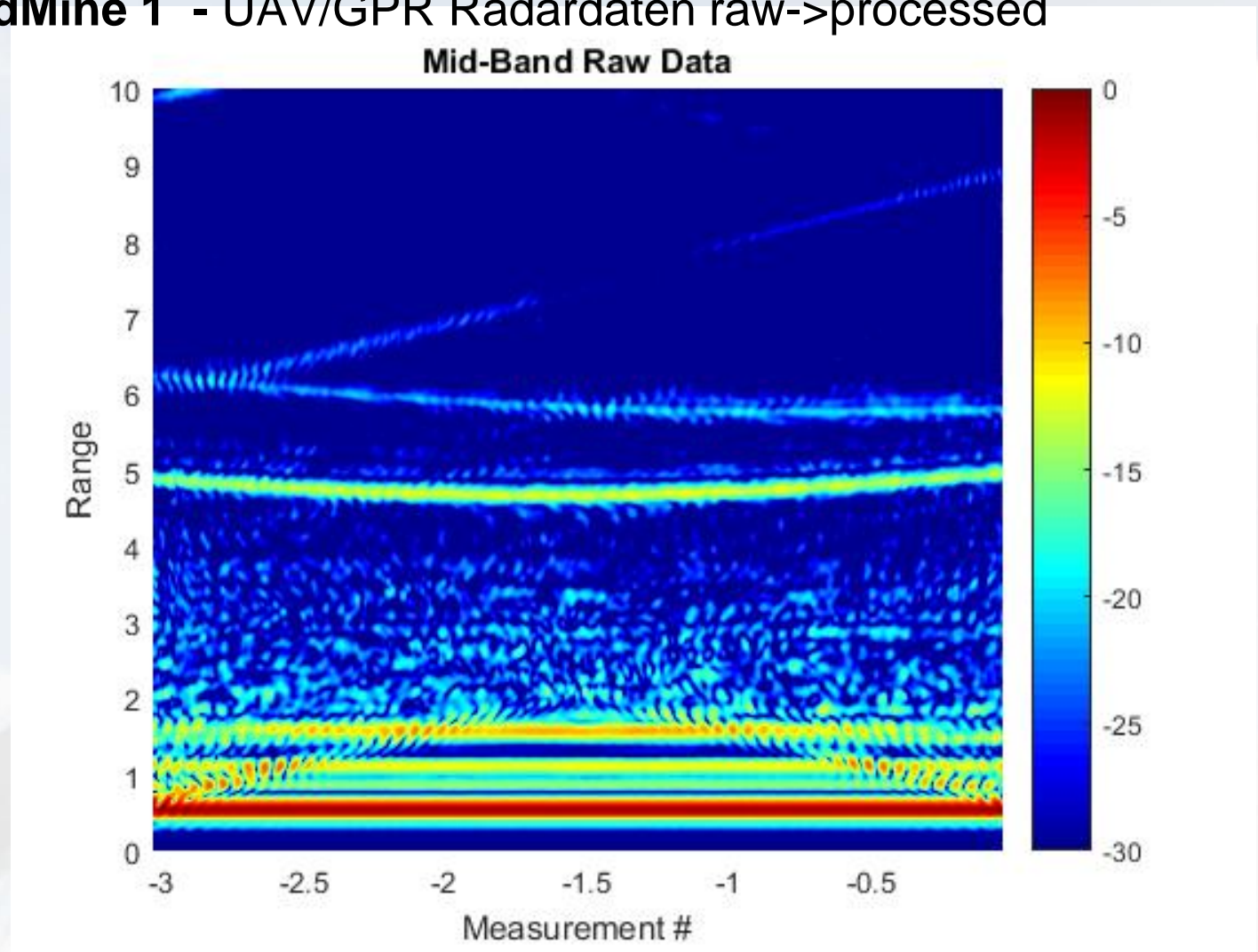
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- **FindMine 1 - UAV/GPR Radardaten raw->processed**



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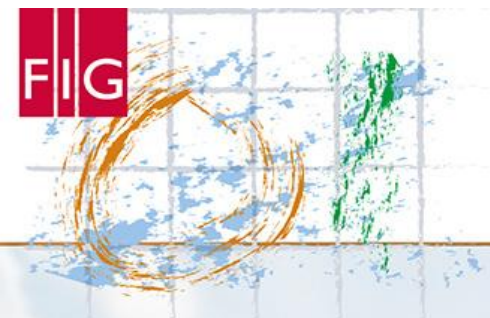


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