Norwegian People's Aid

Testing of unmanned aerial vehicles with a thermal camera to detect explosive devices at contaminated areas and development of a methodology for survey and risk assessment

Darvin Lisica, Milan Bajić, Braco Pandurević, Saša Džinić

Presented by Milan Bajić and Braco Pandurević

16th International Symposium MINE ACTION 2019
8th - 11th April 2019, Slano, Croatia

September - November 2018, first stage of testing performed by Norwegian People‘s Aid in Bosnia and Herzegovina

Unmanned aerial vehicle (UAV) DJI Matrice 200

1) Thermal camera Zenmuse XT, 640 × 512 pixels digital image format or analog video 30 Hz (NTSC 720x480 pixels) and 9mm lens
2) Color camera Zenmuse w/X4S CMOS 1” 20MP, 5472x3648 pixels.
3) The PIX4D and DJI GO 4 software suite are used for analysis of images.

ZENMUSE X4S

Testing thermal cameras on UAV for detecting the explosive devices on the ground

Development of the survey and the risk assessment methodology

Objectives:

1) Matching parameters of the survey to features of the targets and the environment;
2) Provision of needed detecting probability for the considered targets and the environment;
3) Optimizing the UAV based thermal acquisition for non-technical/technical survey;
4) Quality monitoring of demining operations, and risk assessment of ammunition storage sites.

First phase of testing

Use of UAV for thermal detection of known explosive items

Three locations:

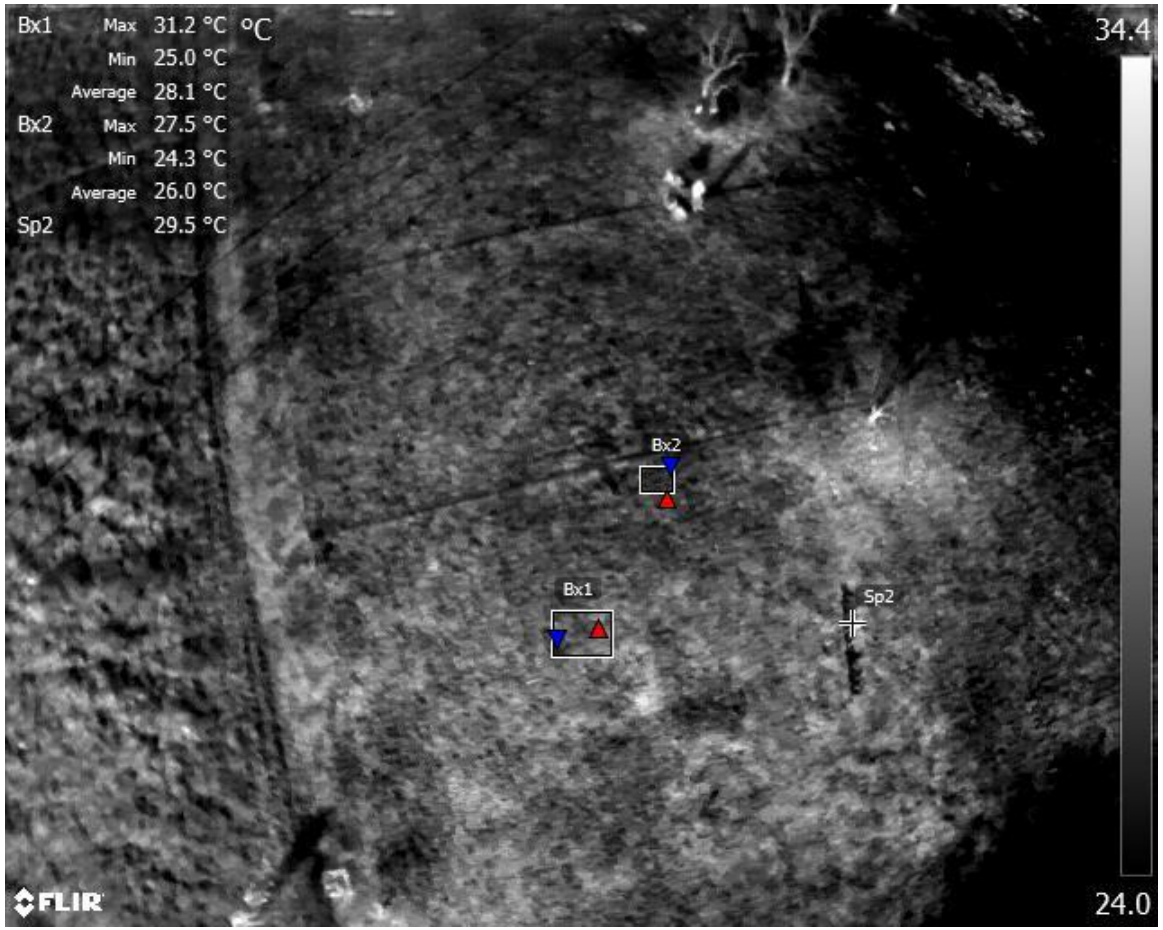
- NPA training areas in Blagovac as key testing field due to various items there,
- Areas contaminated with landmines at locations Kamena and Rotimlja, Mostar, Bosnia and Herzegovina

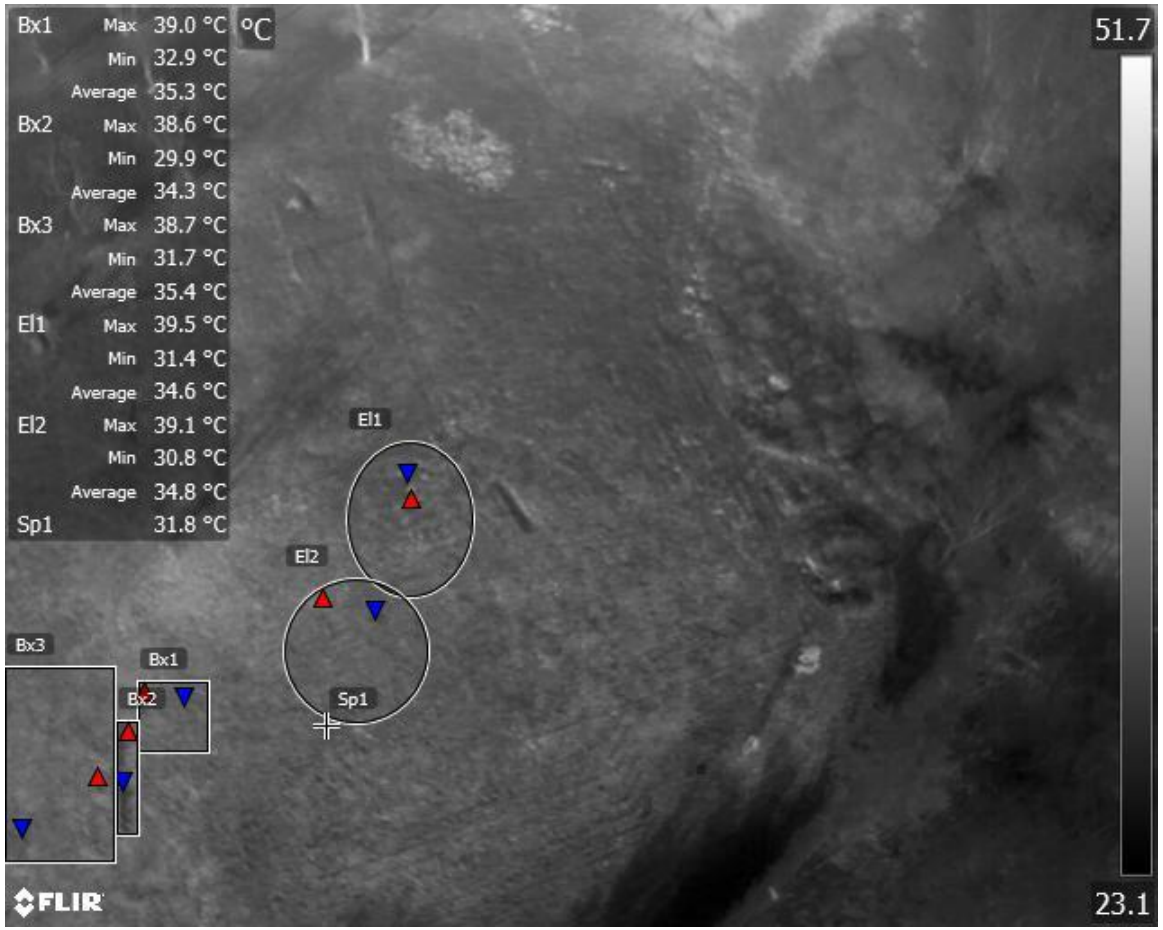
Designing survey process for applied flight techniques and development of standard operational procedure (SOP)

First phase of testing

NPA training areas in Blagovac/Field investigation

First phase of testing





NPA training areas in Blagovac/Analysis of flight investigation results

First phase of testing

960 thermal images were recorded

1) The targets are recognized on 70 images;
2) 113 images require additional analysis since targets are expected;
3) 777 images are rejected since don't contain data on the explosive threat.

Classification of techniques for data collection and assessment using UAV according to NPA SOP

Non-technical (NTS) and technical survey (TS):

A. Investigating evidence through a visual check of the physical existence of explosive threat;
B. Investigating areas in the given directions that may provide additional data on explosive contamination, environmental and operational condition for further interventions;
C. Re-distribution of suspected hazardous areas (SHAs) and/or their cancellation.

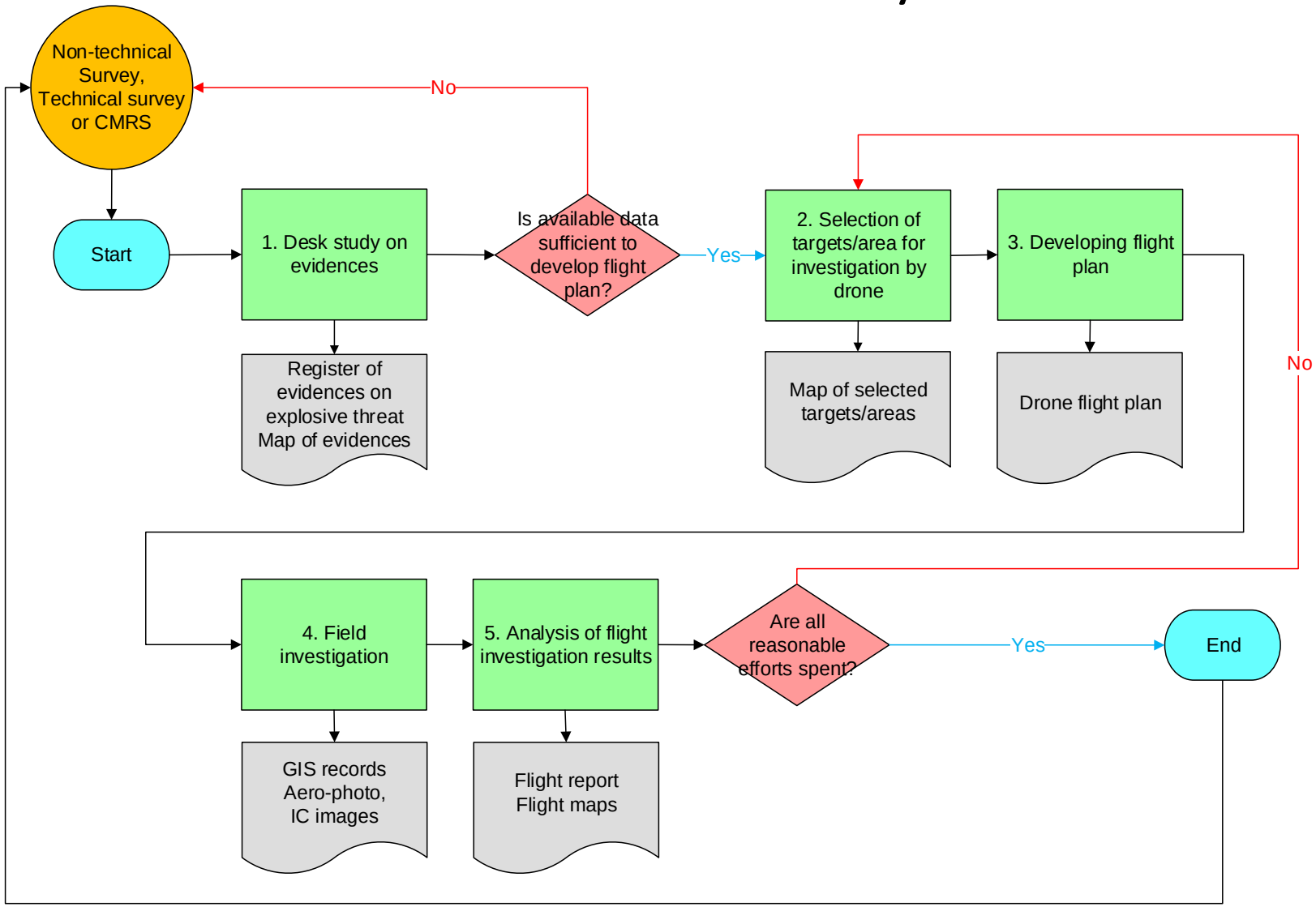
Quality monitoring of different type of demining operation:

D. Monitoring of team movements during operations;
E. Monitoring of the site condition during operations (marking, the layout of the work site, etc.);
F. Monitoring and security control of the area during explosive ordnance disposal (EOD) operations;

Risk assessment related to ammunition storages sites (ASS):

G. Survey after an unplanned explosion of ASS;
H. Risk assessment of populated places in the vicinity of ASS.

Example: The process of investigation with UAV for non-technical and technical survey



Testing of unmanned aerial vehicles with a thermal camera to detect explosive devices at contaminated areas and development of a methodology for survey and risk assessment

The second phase of the testing of UAV DJI Matrice 200 with thermal and color camera

1) Testing of SOP, its processes and techniques in the various real operational conditions and its review.
2) Identification of various explosive items in the contaminated areas

Locations

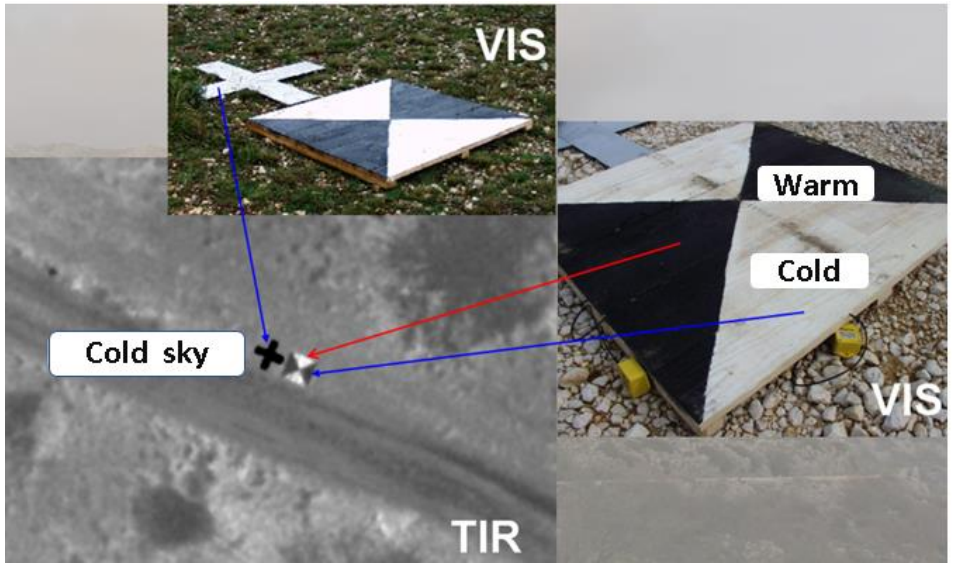
1) Montenegro – 7 locations (Cluster munition remnants, explosive remnants from I and II WW, ammunition storage sites)
2) Iraq – Improvised explosive devices

Pillars of Longwave Infra Red (thermal - TIR) detection of targets on ground surface from UAV

1) Matching parameters of the survey to features of the targets and the environment
2) Provision of needed TIR detecting probability for the considered targets and the environment
3) Optimizing the UAV based TIR acquisition for non-technical/technical survey

Aluminum cross 1x1 m, width 0,2 m.

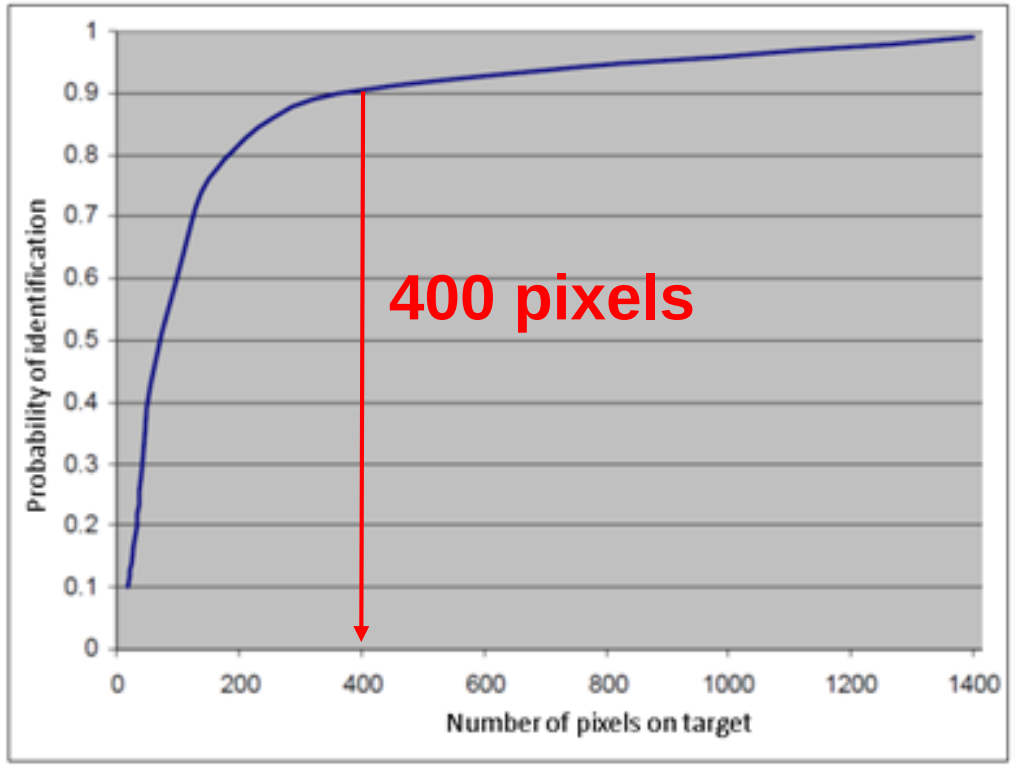
Cold sky reflects thus TIR image is black



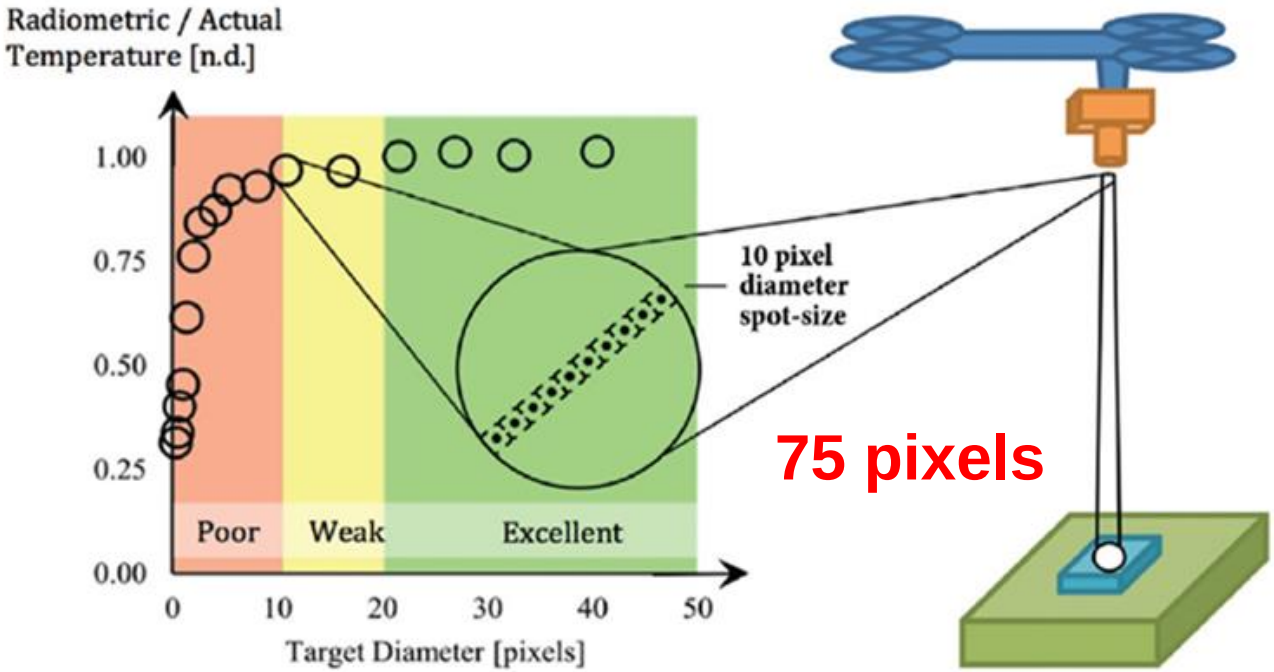
Wooden plate 1x1m, triangles painted black are warm on TIR image white

Requirements for detection – identification are >> then for temperature measurement

Detection identification > 400 pixels on target surface



Thermal measurements >75 pixels on object surface



Critical parameters

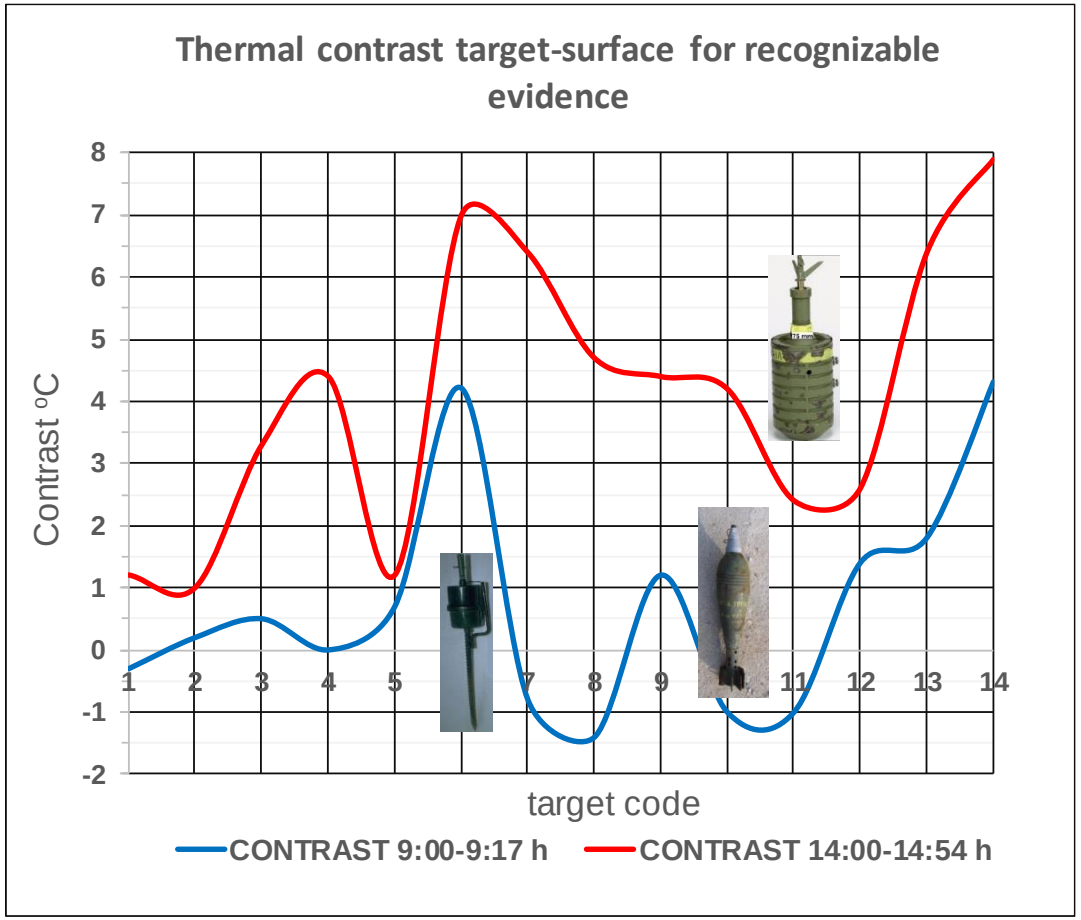
Emissivity, reflection, atmospere attenuation, imaging angle decrease the probability of the target detection & identification via the TIR measurement.

The atmosphere attenuation is dependent on the weather conditions (humidity, air temperature). Negliglible if UAV heights are lower then 10 m.

The thermal contrast Tt/Tn of the target Tt and the neighborhood Tn shows significant daily changes.

The minimum thermal difference which can be detected by a considered sensor (Sensitivity) is <50mK. Combined with contrast Tt/Tn the camera thermal sensitivity determines the probability of target identification.

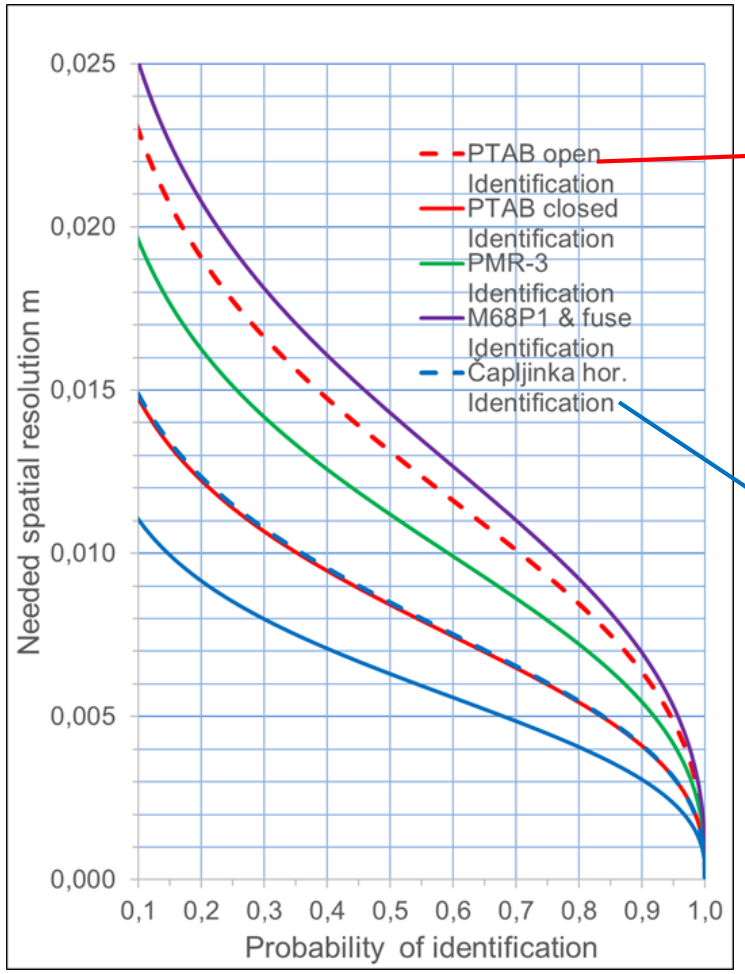
Thermal contrast target/ground surface



Contrast	9:00-9:17 h	14:00-14:45 h
St.Dev.	1,719	2,174
Median	0,35	4,3
Average	0,7	4,079
Max	4,3	7,9
Min	-1,4	1

Nr.	CATEGORY	TYPE	MATERIAL
1	UXO	MB M:62 mm	Aluminum
2	FUSE	M:125 mm	Steel-brass
3	UXO	TTM RP	Aluminum-plastic
4	UXO	Hand grenade	Gus
5	UXO	Hand grenade	Iron
6	AP	PMR capljinka	Plastic
7	UXO	Bullet 20 mm	Brass-plastic
8	UXO	Bullet 30,2 mm	Brass-plastic
9	AP	PMR 2A	Gus
10	UXO	MB M:82 mm	Steel
11	AP	PMR 3	Steel
12	UXO	TTM RP	Aluminum-plastic
13	UXO	Bullet 40 mm	Brass-plastic
14	UXO	Bullets 7,62 mm	Copper-brass

Spatial resolution & identification probability



Modified Johnson's criteria

The SOPs for TIR survey shall include:
- selection of suitable parts of the day and needed contrast Tt/Tn
- modified Johnson's criteria

The acquired TIR video or digital images can be used in many ways of interpretation, e.g. by Computer-Assisted Photography Interpretation (CAPI)