HARMONIOUS

UAS Techniques for Environmental Monitoring

Petr Dvorak & Josef Bruna – Valencia – February 15, 2017

cost
EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

Funded by the Horizon 2020 Framework Programme
of the European Union

Unmanned aircraft for alien plant species detection and monitoring

cost
EUROPEAN COOPERATION
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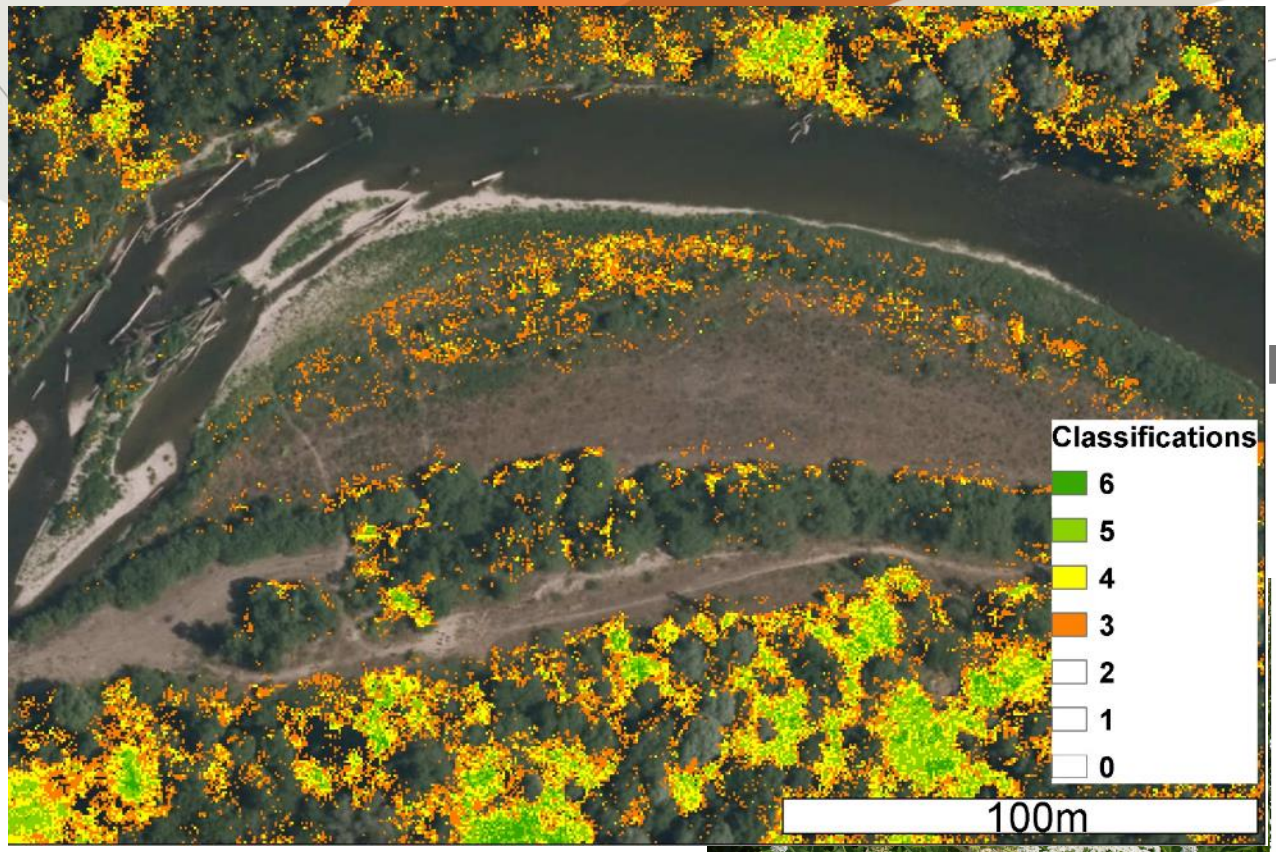
HARMONIOUS
UAS for environmental monitoring

nt species



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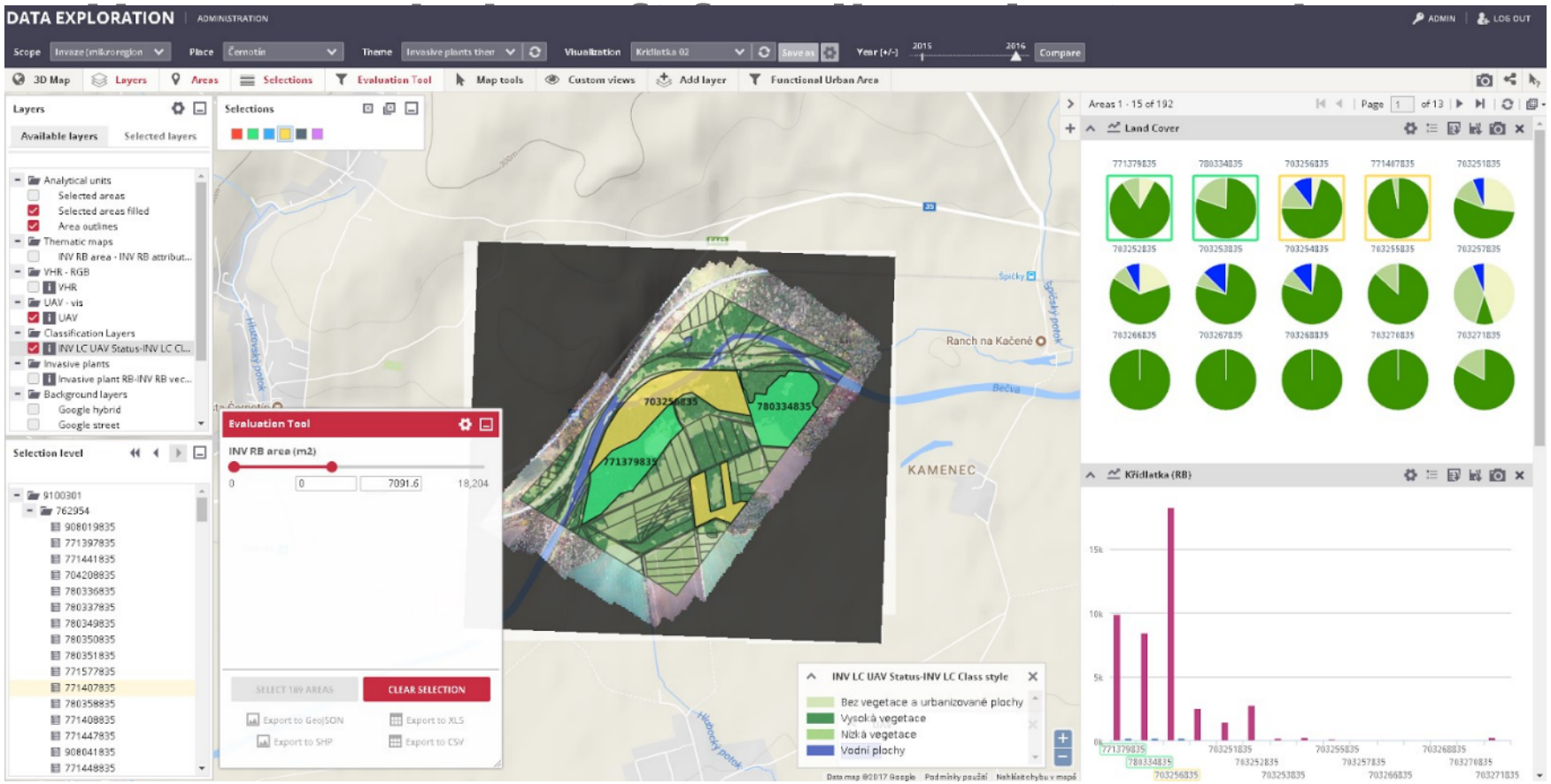


cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

HARMONIOUS
UAS for environmental monitoring

Institute of Aerospace Engineering

VUT 001 Marabu experimental, designed, build and in-flight tested by IAE

VUT 100 Cobra 4-seat aircraft designed and tested by IAE

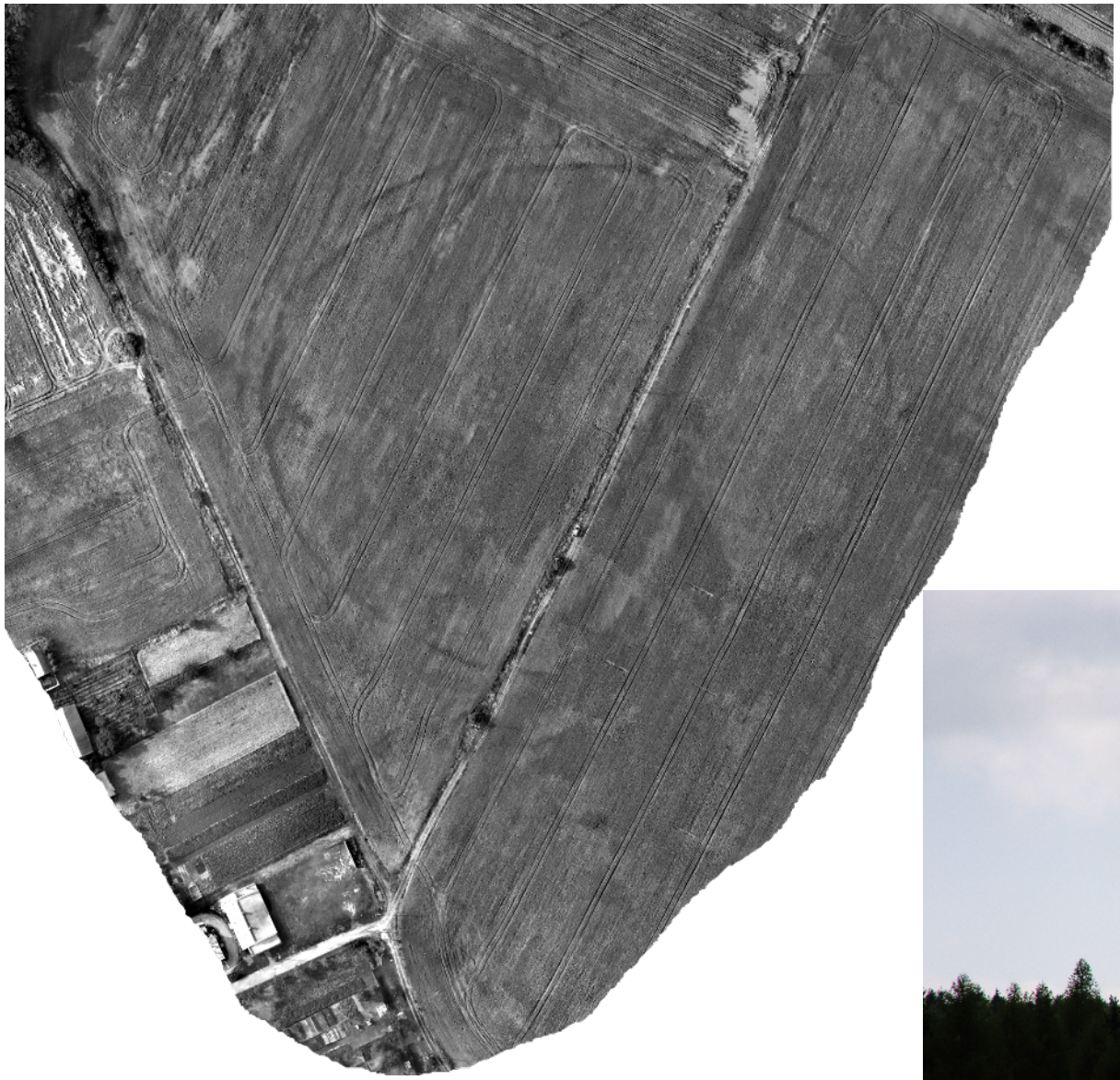
KP-2U Sova microlight airplane designed and tested by IAE

LETECKÝ ÚSTAV
Institute of Aerospace Engineering

SPARTAN Mars lander demonstrator

Institute of Aerospace Engineering - UAVs

Institute of Aerospace Engineering - UAVs



Institute of Aerospace Engineering - BRS

GALAXY GBS 10

UAV PARACHUTE BALLISTIC RESCUE SYSTEM

DEVELOPMENT AND TESTING

Galaxy GRS

RCE SYSTEMS

Indet Safety Systems
Nippon Kayaku Group

LETECKÝ ÚSTAV
Institute of Aerospace Engineering

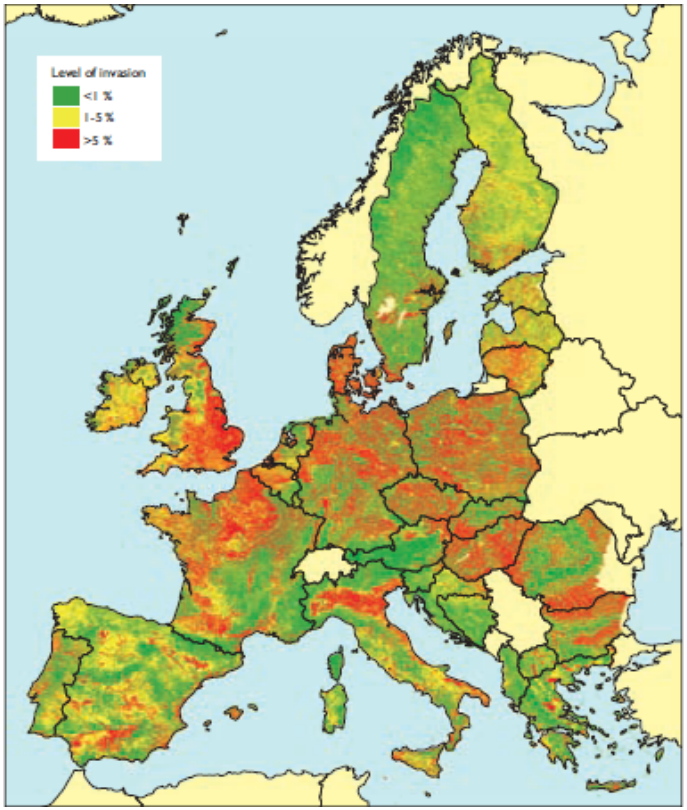
VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

Institute of Aerospace Engineering – UGVs/boats?

Why alien plant species?

Why alien plant species?

- threat to biodiversity, ecosystem functionality, traditional landscapes
- impact grows despite the worldwide efforts to control and eradicate
- once fully established - hard to permanently eliminate



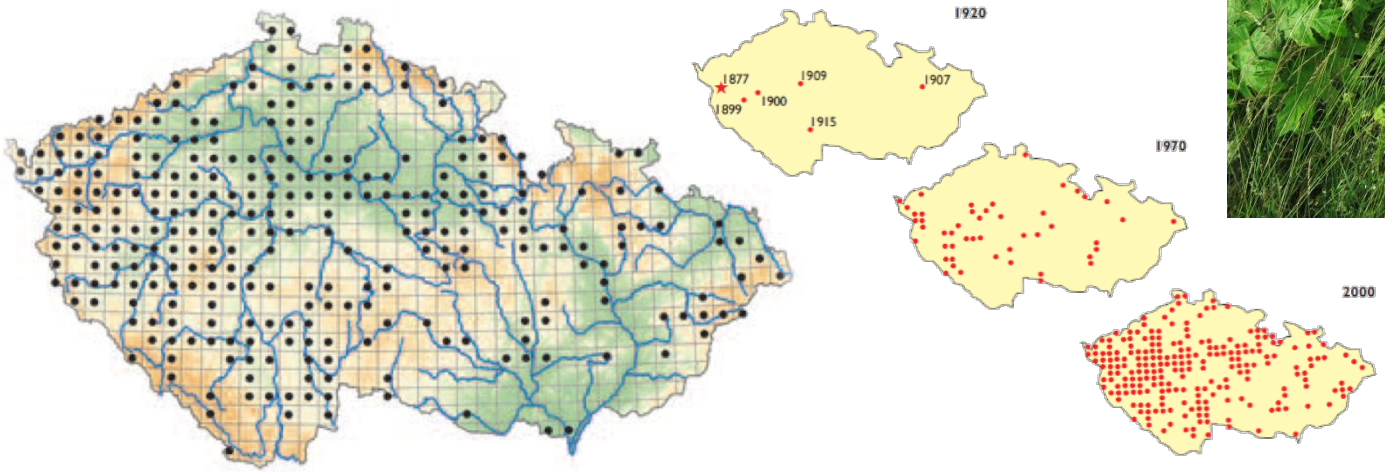
Pyšek et al. (2010): ALARM Biodiversity Atlas, Pensoft.

- -> fast and precise monitoring for rapid actions is crucial

Invasive species of interest

giant hogweed; knotweeds; tree of heaven; black locust

Heracleum mantegazzianum

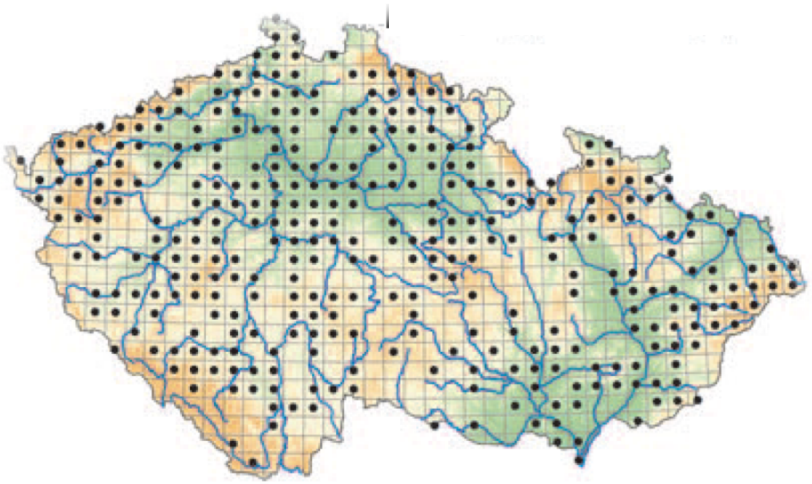


Pyšek et al. (2012): Plant invasions in the Czech Republic: current state, introduction dynamics, invasive species.. Preslia 84: 576–630.

Invasive species of interest

giant hogweed; knotweeds; tree of heaven; black locust

Fallopia japonica, xbohemica, sachalinensis



Pyšek et al. (2012): Plant invasions in the Czech Republic: current state, introduction dynamics, invasive species.. Preslia 84: 576–630.

Invasive species of interest

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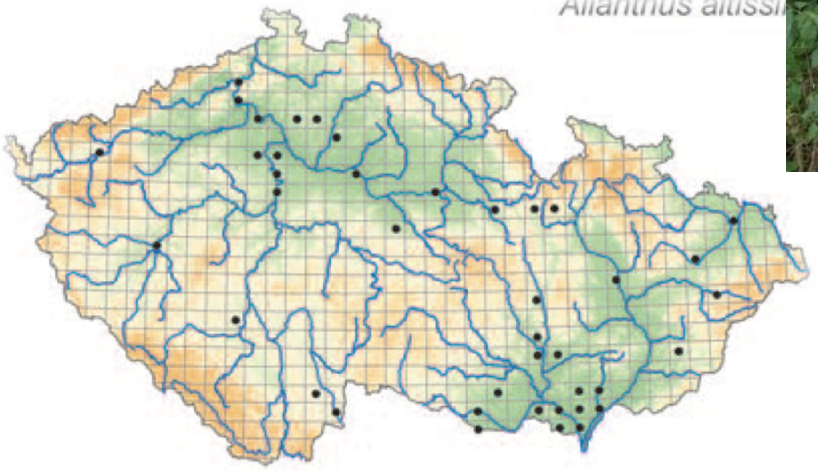
Ailanthus altissima



Pyšek et al. (2012): Plant invasions in the Czech Republic: current state, introduction dynamics, invasive species.. Preslia 84: 576–630.

Invasive species of interest

giant hogweed; knotweeds; tree of heaven; black locust

Robinia pseudoacacia

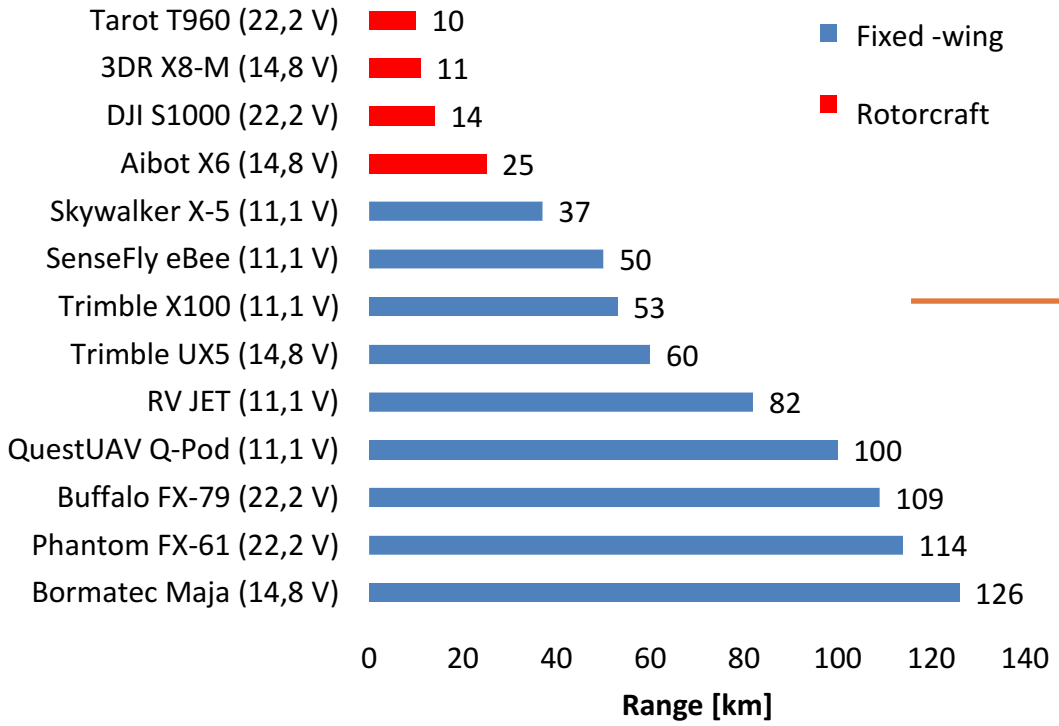
Pyšek et al. (2012): Plant invasions in the Czech Republic: current state, introduction dynamics, invasive species.. Preslia 84: 576–630.

Unmanned aircraft

Fundamental requirements

- map a site >= 80 ha in <1h
- GSD <= 7cm/px
- minimum pre-flight and post-flight procedures
- reliability
- low cost
- transportability – car + hand by one person for at least 1km

20km of flight (Canon S100, 80x80% overlap)



Fixed wing platform

Unmanned aircraft – development platforms

VUT 720

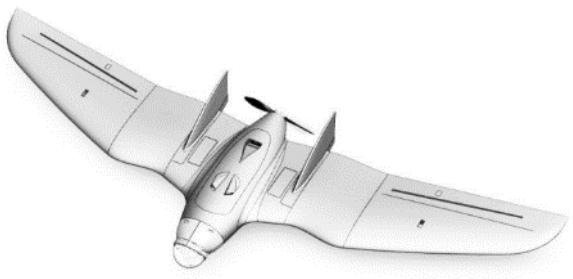
VUT 712

VUT 713

Unmanned aircraft – development platforms

VUT 720

VUT 712



VUT 713

	VUT 712 	VUT 713 	VUT 720 
Span	2.1 m	2.0m	2.6 m
Length	0.9 m	0.7m	1.3 m
m_{TOW}	3.1 kg	3kg	2.2 kg
v_C	17 m/s	18m/s	15 m/s
Endurance	0.9 hr	0.8hr	1 hr
Power	800 W	600 W	360 W
Payload	0.8 kg	0.9 kg	0.3 kg
Autopilot	Pixhawk autopilot	Pixhawk autopilot	APM2.5+ autopilot
Camera	2x Canon S100 stabilized	2x Sony A5100 + E20/2.8	1x Canon S100+ 1x GoPro
Based on	SkyWalker X8	RVJET	Multiplex Cularis

Unmanned aircraft – final platform: VUT 714

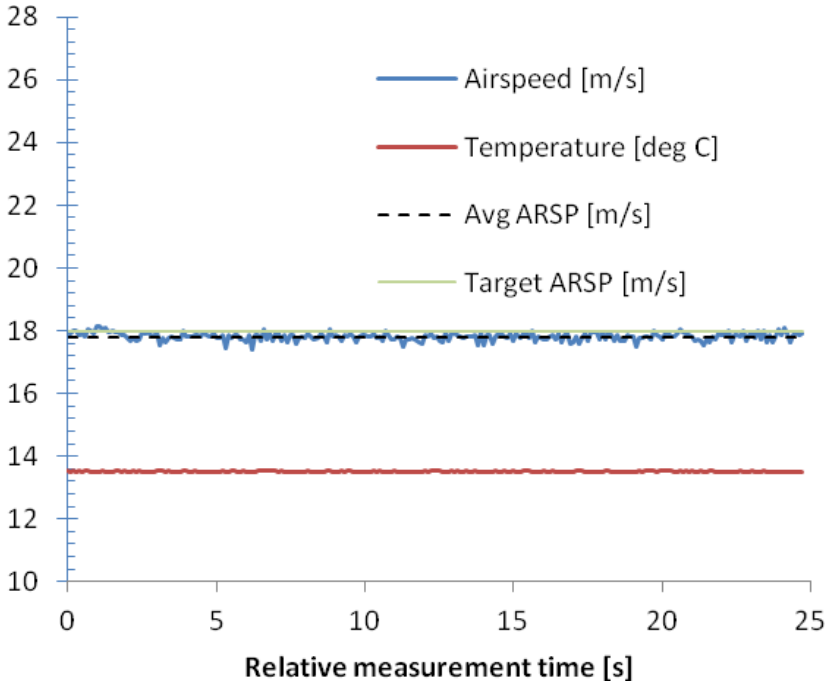
Why?

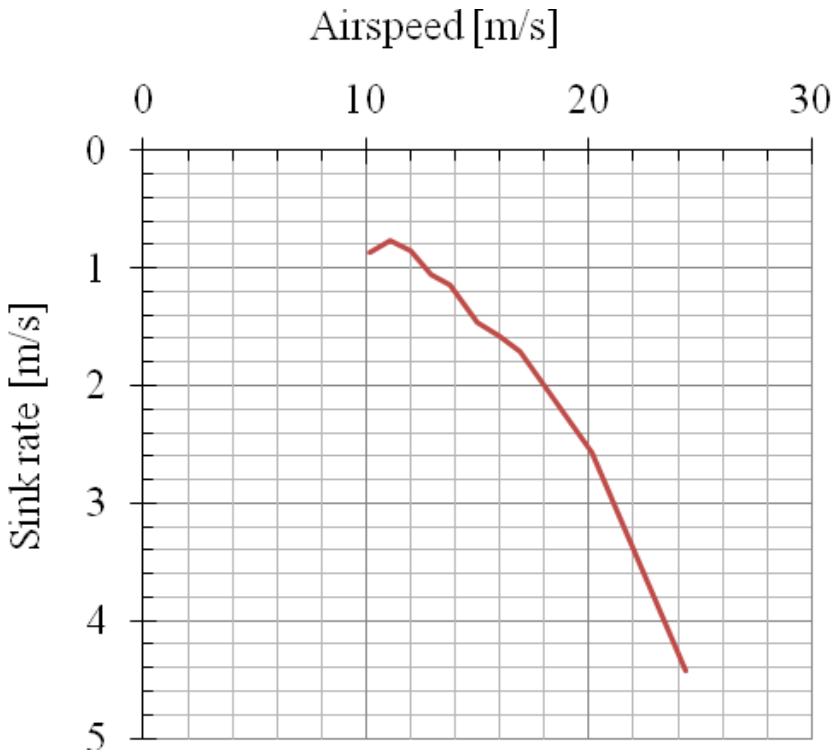
- Optimized performance
- Smaller size -> Better transportability
- No connectors, loose cables etc.
- Better payload accomodation
-
-
-
-
-
- We like to build new airplanes :-)

Unmanned aircraft – final platform: VUT 714

The approach:

- In-flight measurements





Unmanned aircraft – final platform: VUT 714

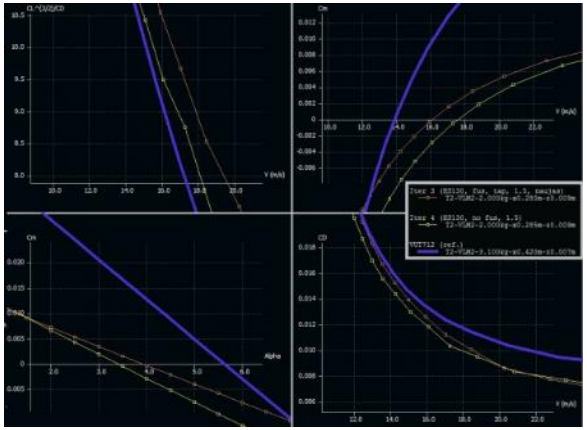
The approach:

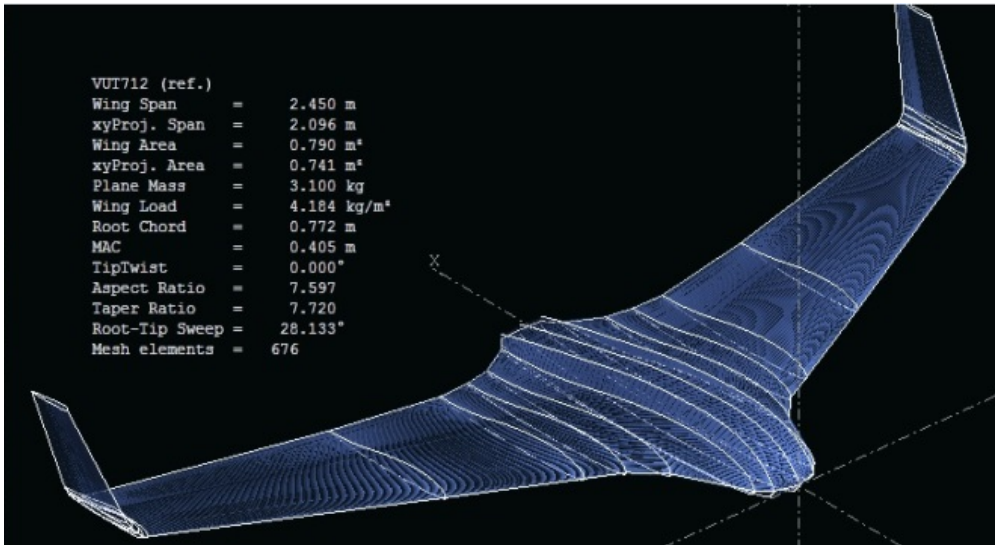
- Reverse engineering

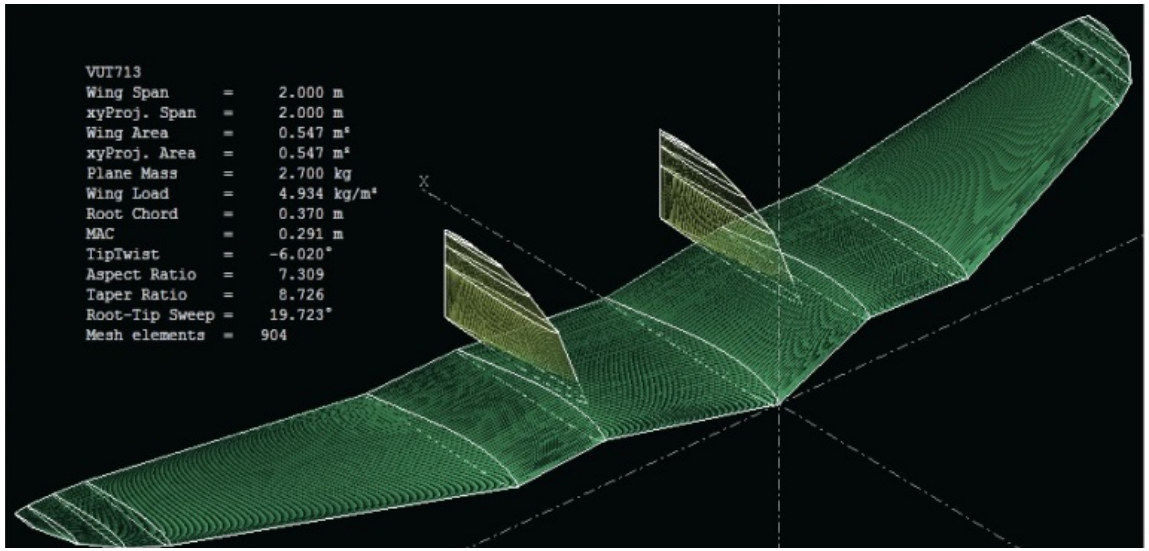
Unmanned aircraft – final platform: VUT 714

The approach:

- Simulations







Unmanned aircraft – final platform: VUT 714

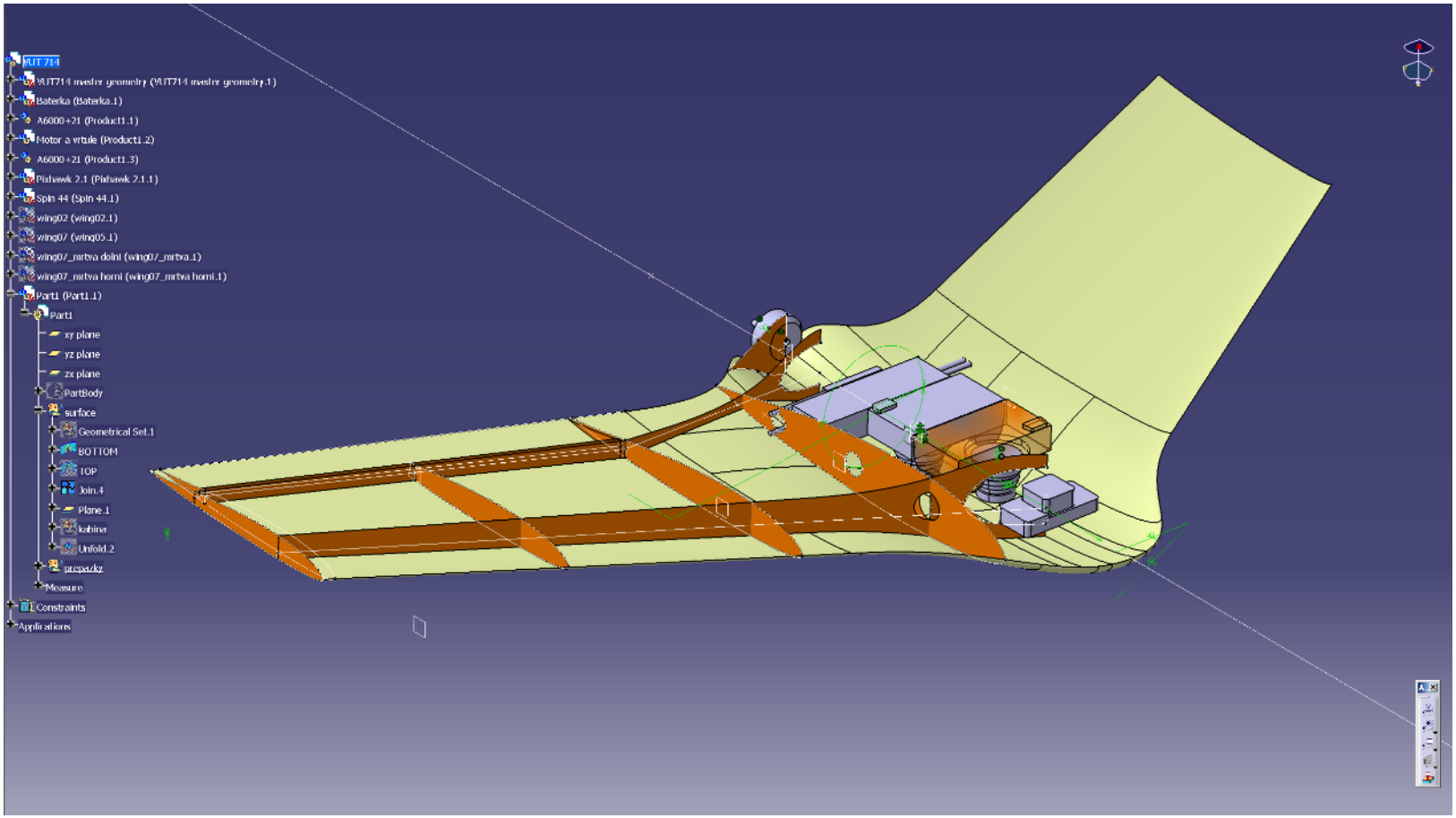
The approach:

- Design

Unmanned aircraft – final platform: VUT 714

The approach:

- Design



Unmanned aircraft – final platform: VUT 714

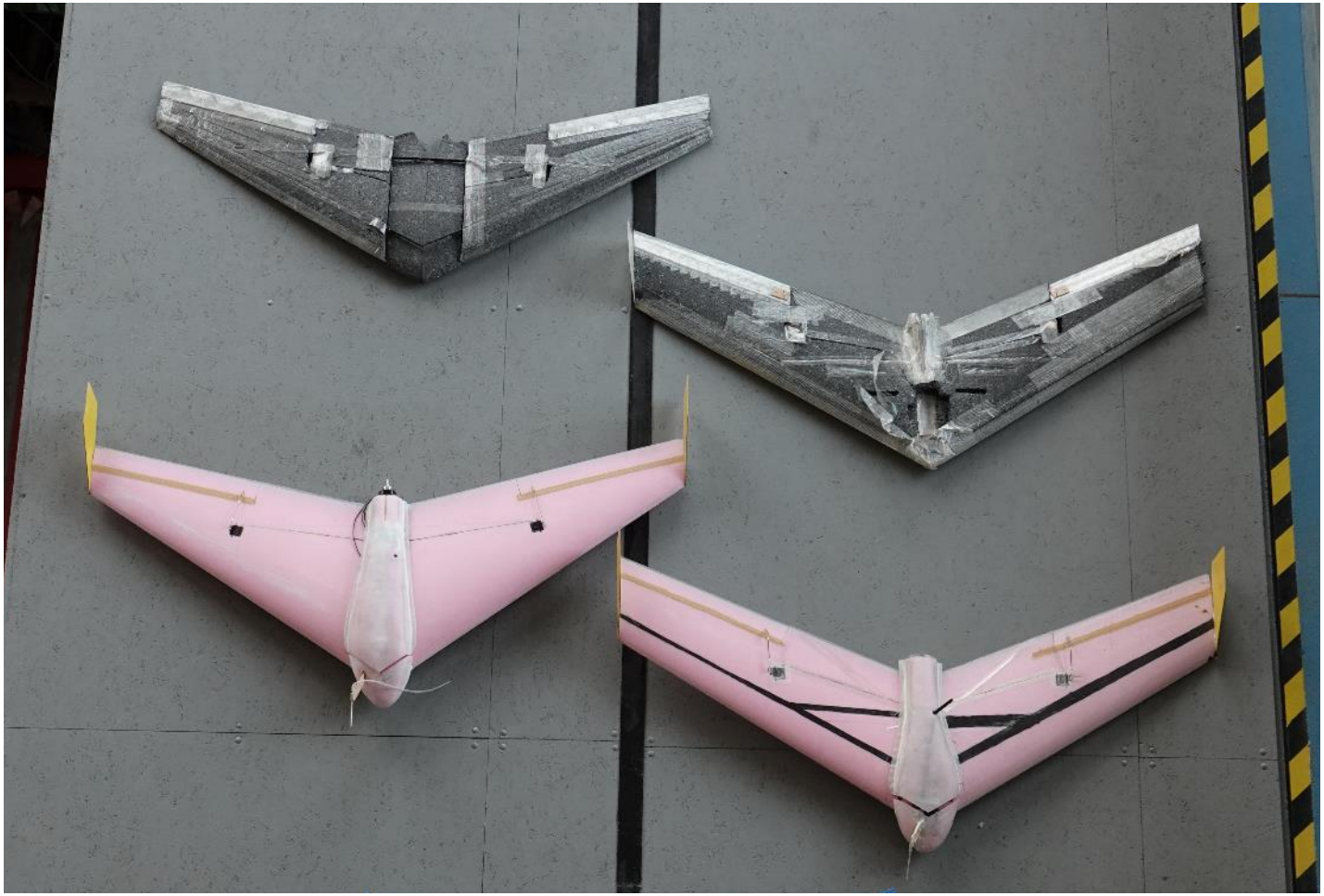
The approach:

- Prototyping

Unmanned aircraft – final platform: VUT 714

The approach:

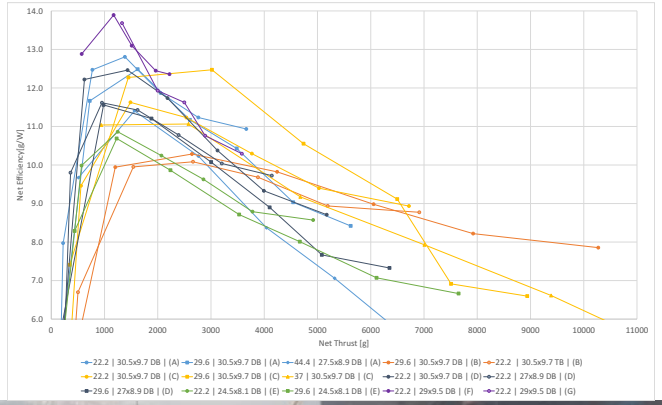
- Prototyping

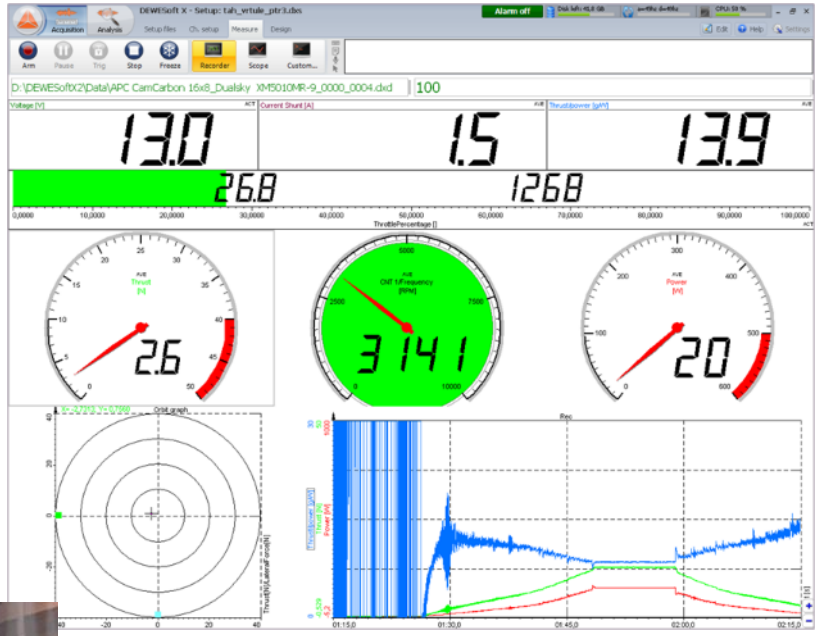


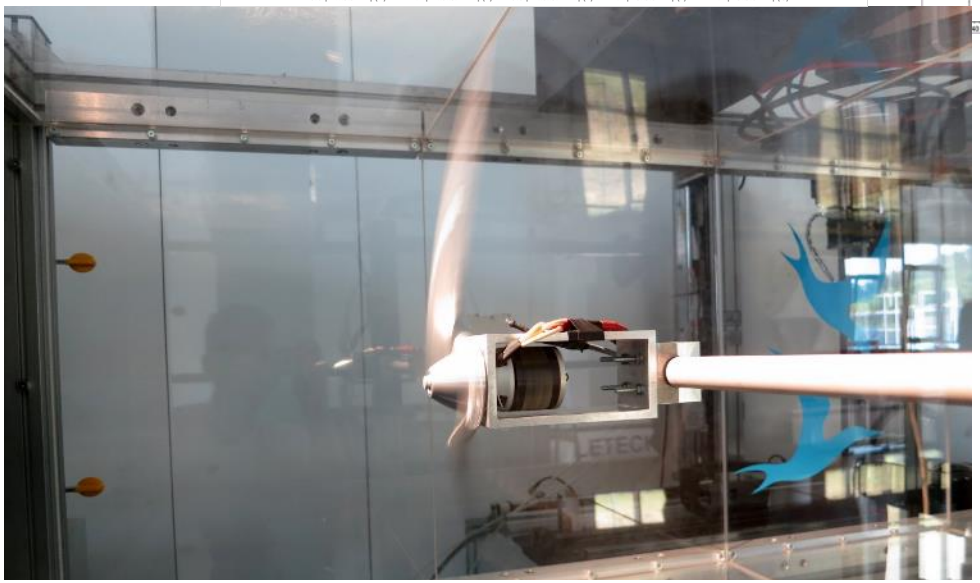
Unmanned aircraft – final platform: VUT 714

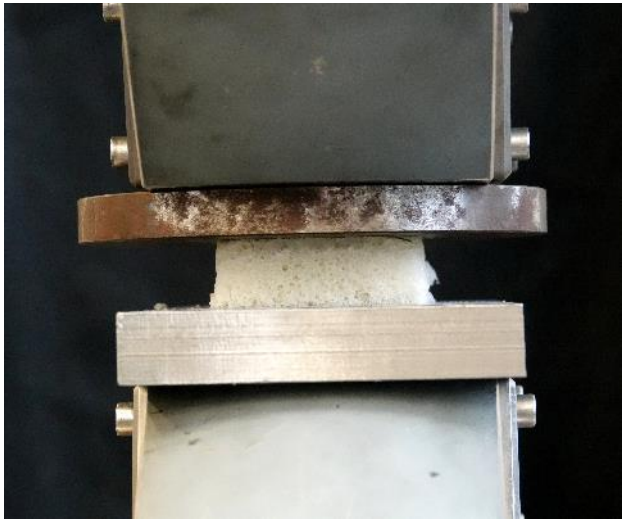
The approach:

- Material & component evaluation





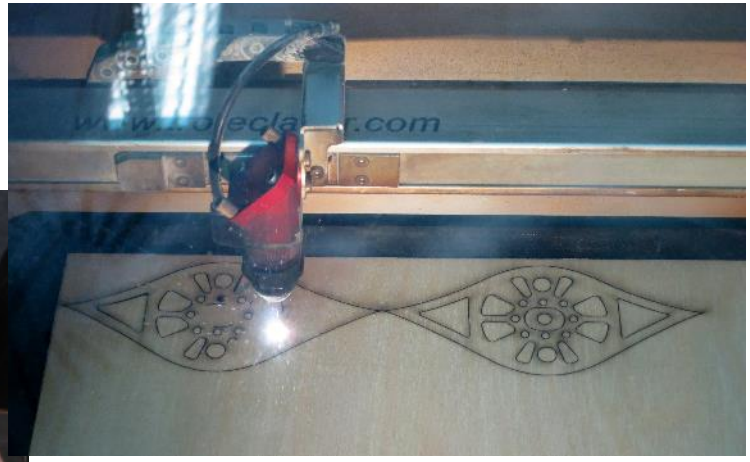


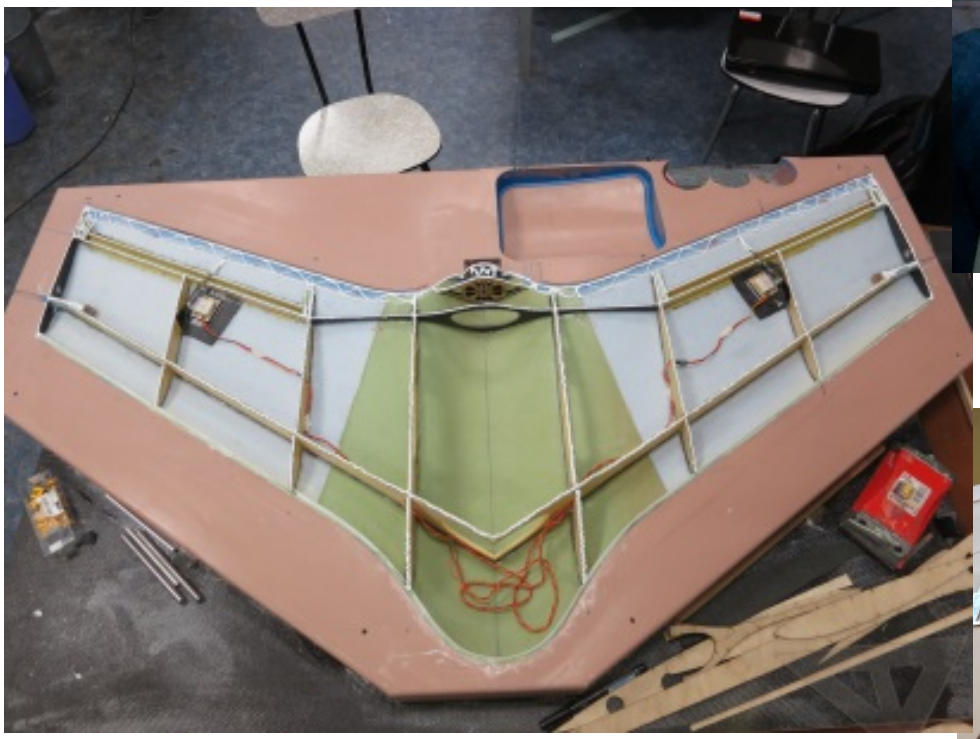


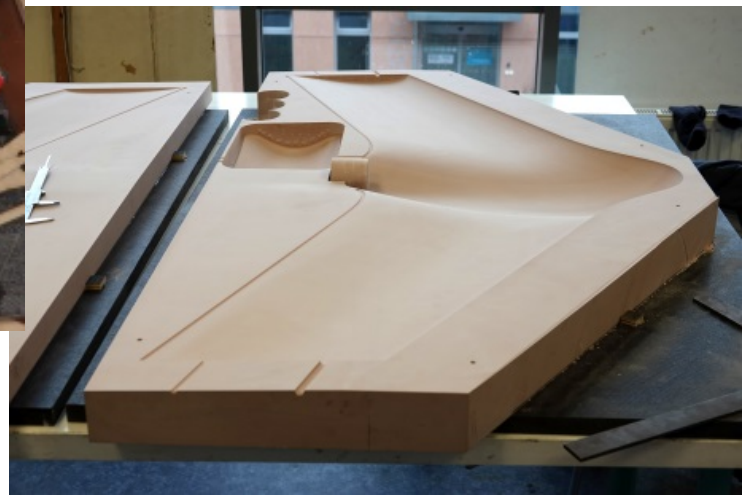
Unmanned aircraft – final platform: VUT 714

The approach:

- Manufacturing

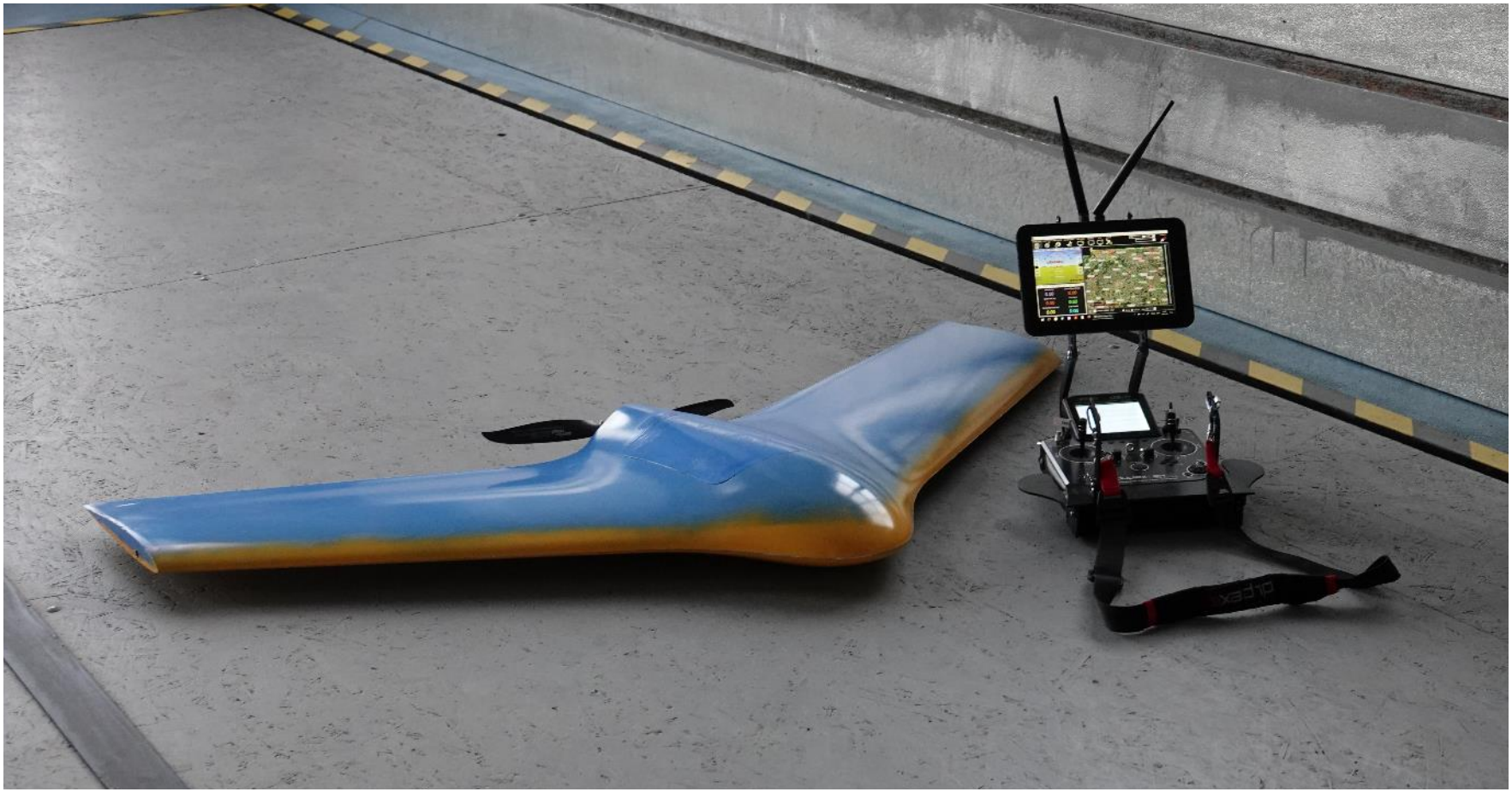






Unmanned aircraft – final platform: VUT 714

The result:

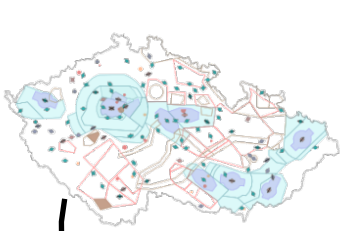


Manned aircraft

TL3000 Sirius

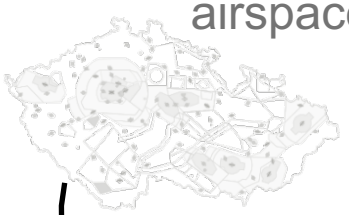
WT-9 Dynamic

Workflow



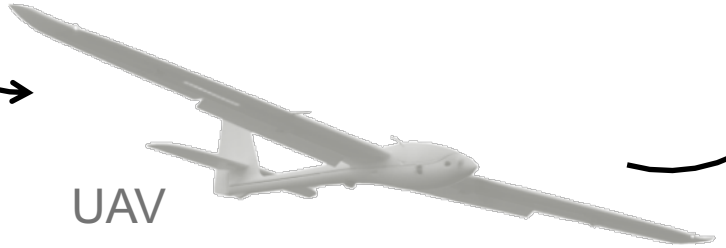
Workflow

airspaces

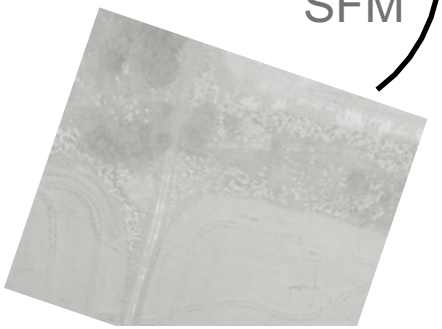


In-situ research, ground truthing

UAV



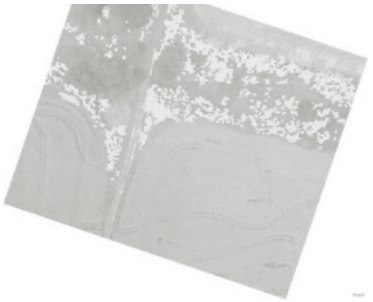
aerial imagery



SFM

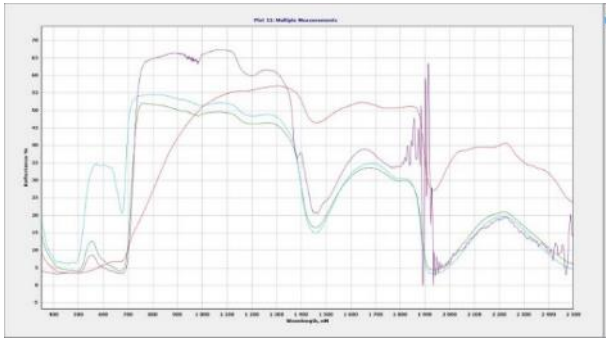
Orthomosaic, DSM, pointcloud, …

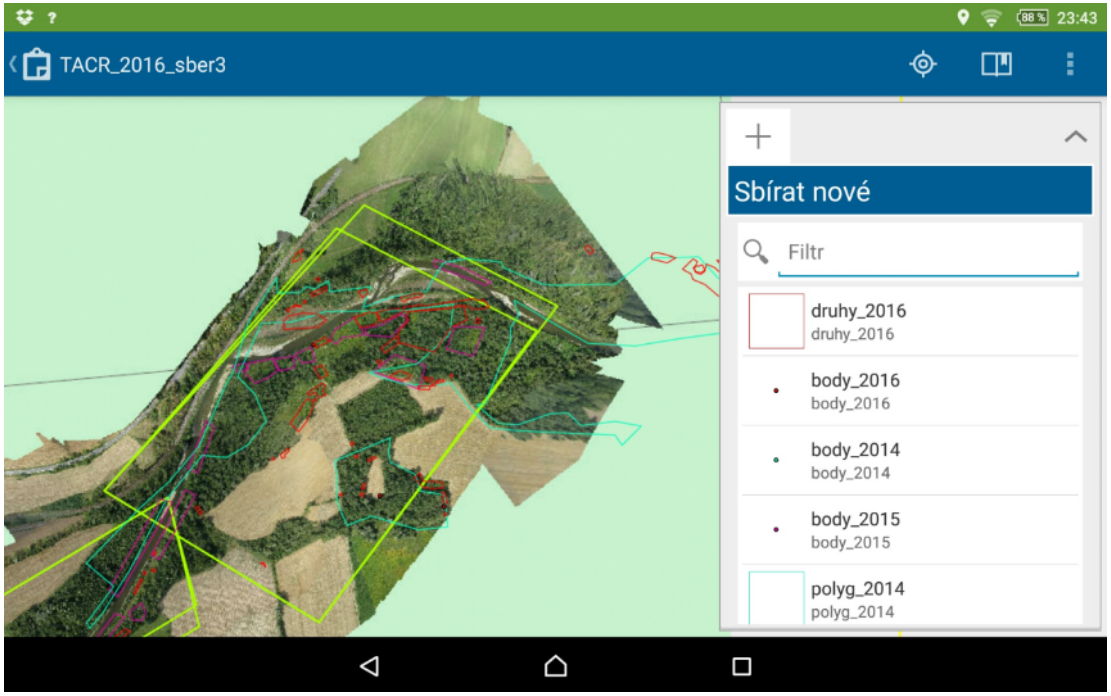
classification



A/ In-situ research/ ground truthing

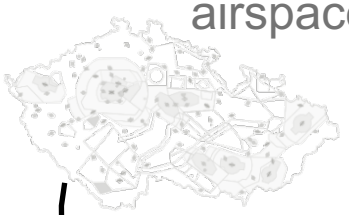
- RTK GPS
- Collector for ArcGIS
- Field spectrometer: Spectral evolution





Workflow

airspaces



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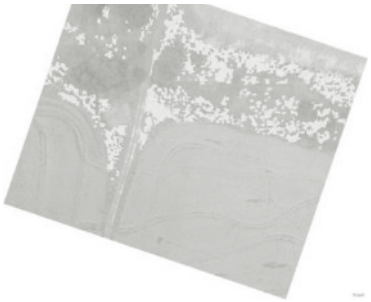
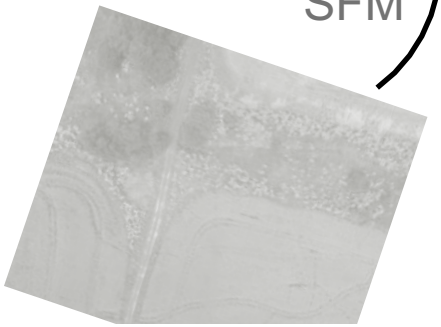


Orthomosaic, DSM, pointcloud, …

In-situ research, ground truthing

SFM



aerial imagery

UAV

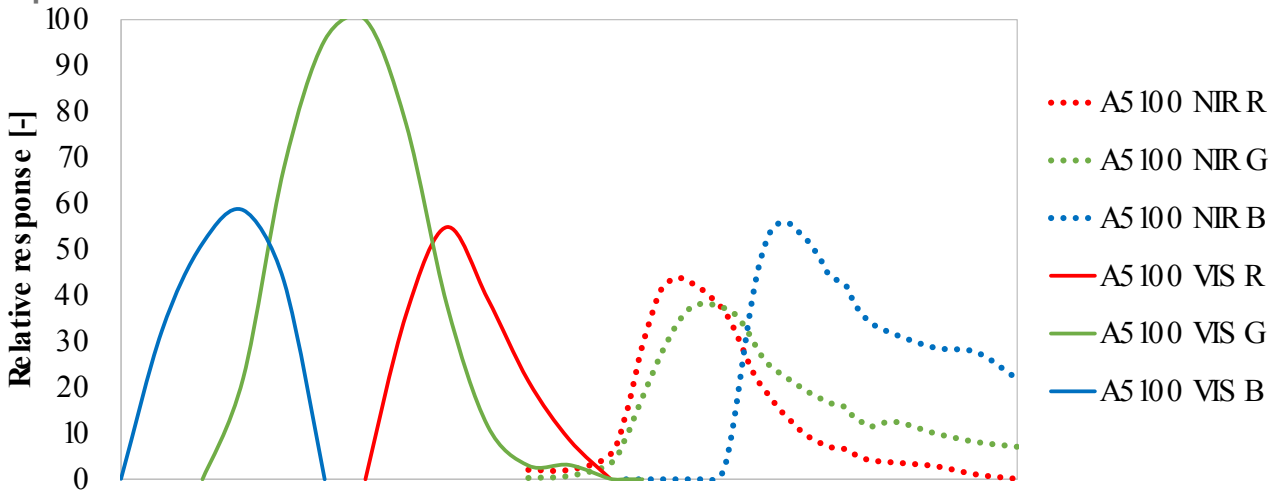
UAV data acquisition

UAV data acquisition - sensors

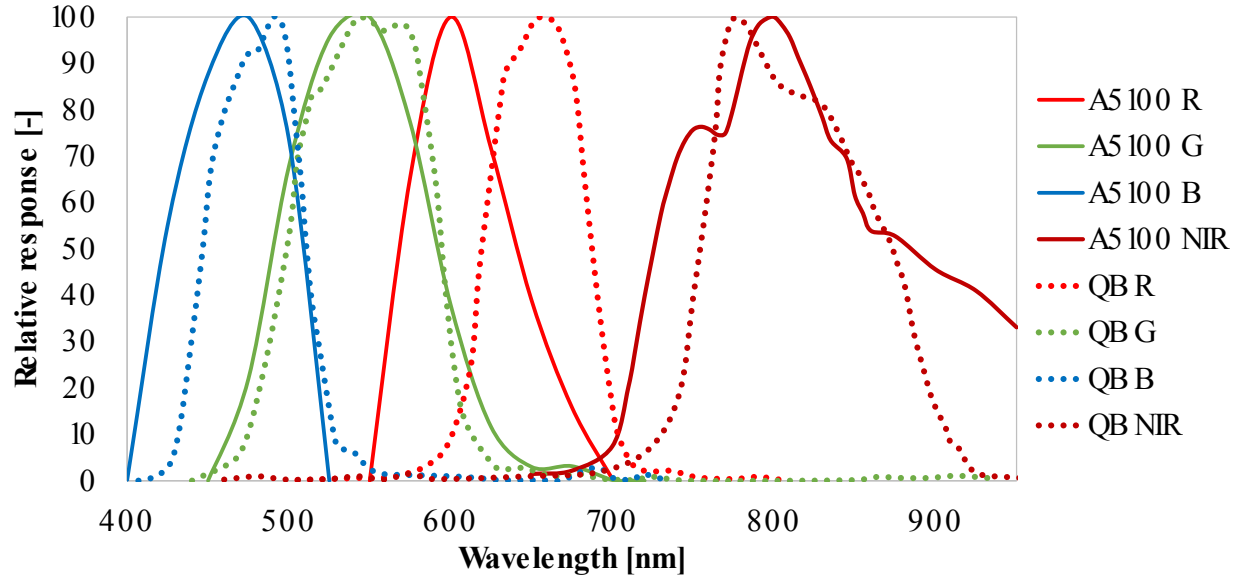
	IR)
Sensor	
Stabiliz	if t
Georef ng	og.
Trigger	
Total W	

UAV data acquisition - spectral resolution

Spectral response normalized to 100% Green ...

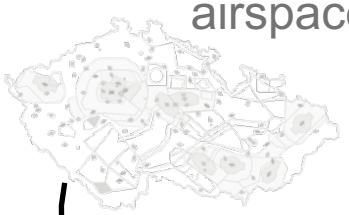


... compared to QuickBird (bands individually normalized)

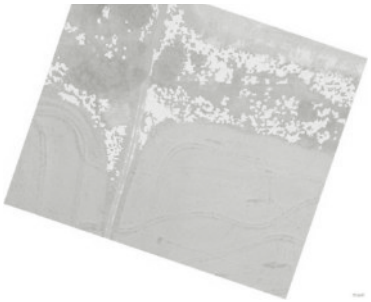


Workflow

airspaces



classification

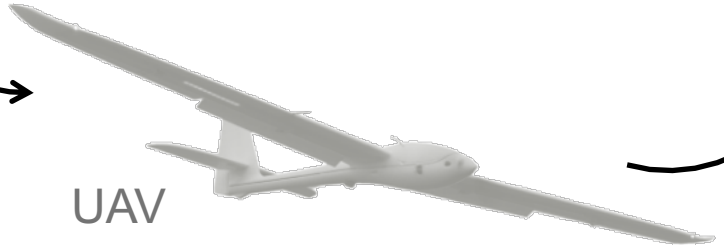


Orthomosaic, DSM, pointcloud, …

In-situ research, ground truthing

SFM

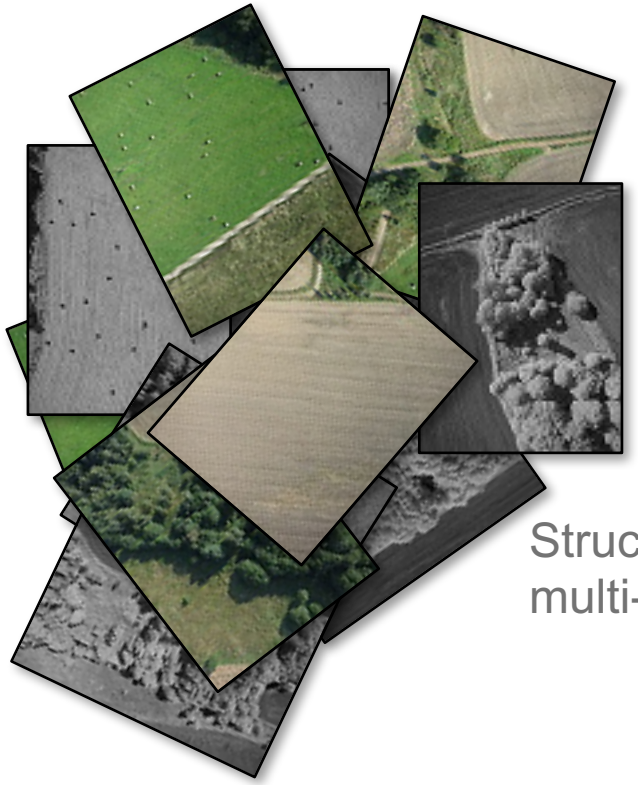
aerial imagery



UAV

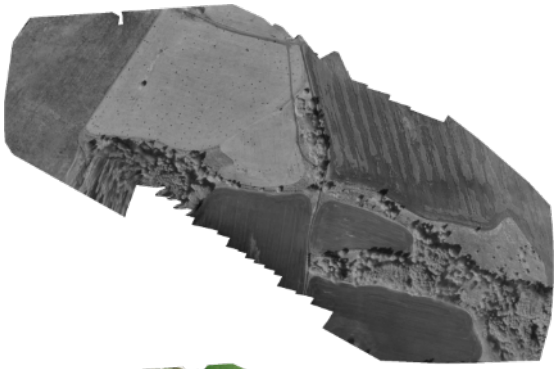
SFM - Mosaicking

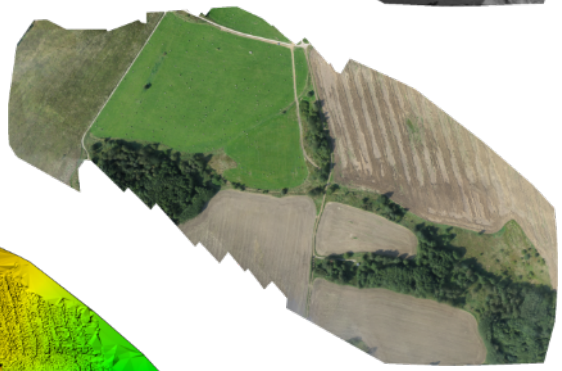
Approximately 800 VIS + 800 NIR images for a single mission

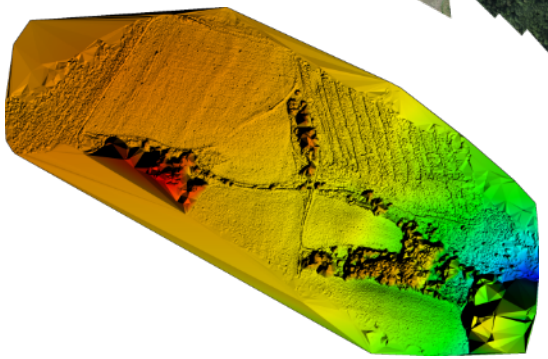


Agisoft

Structure from motion …
multi-stereo photogrammetry

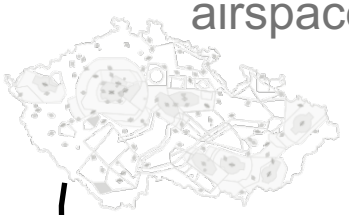




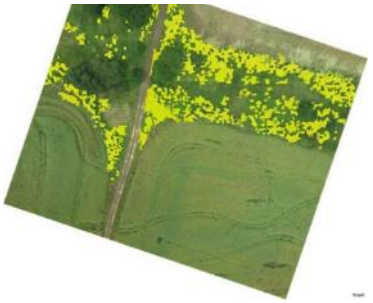


Workflow

airspaces



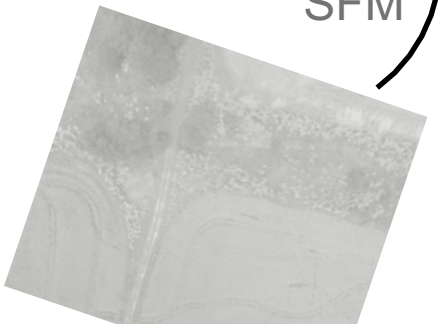
classification



Orthomosaic, DSM, pointcloud, …

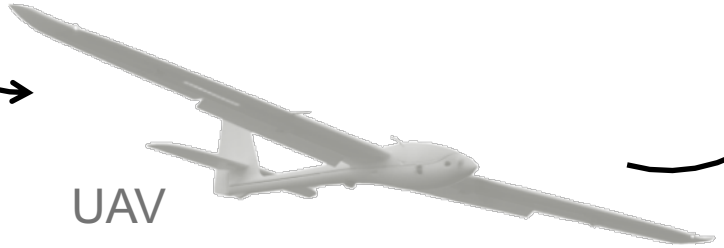
In-situ research, ground truthing

SFM



aerial imagery

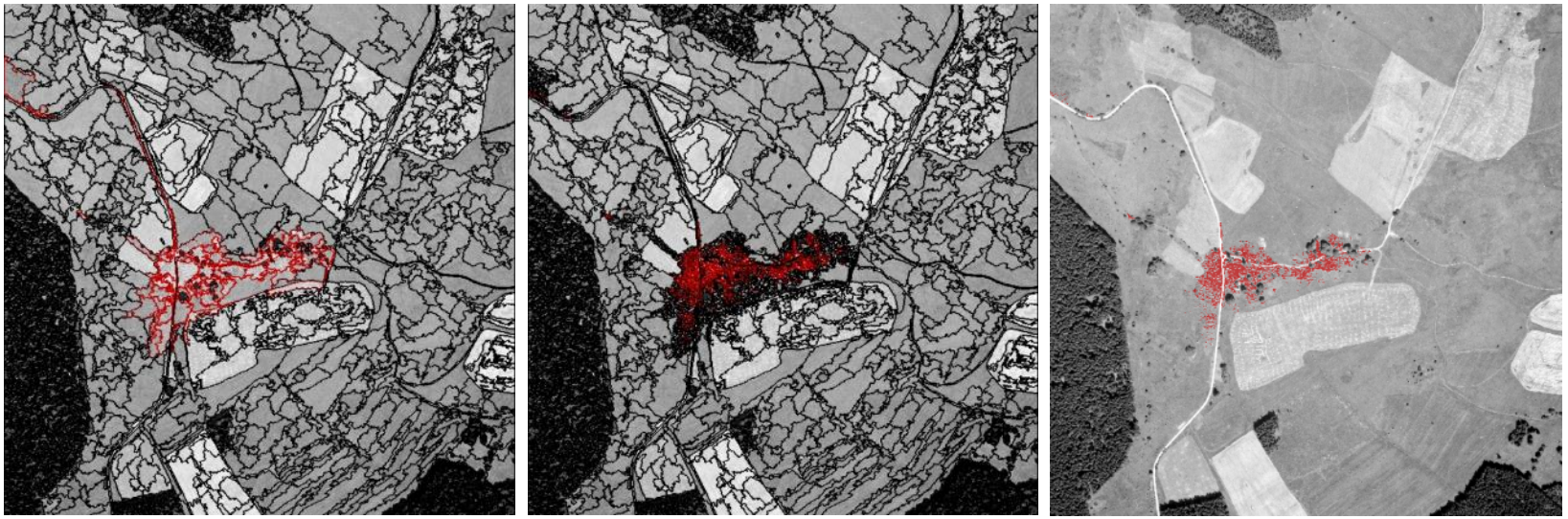
UAV



Classification - approaches

- spatial resolution higher than the plant size, distinct shape/texture → object-based (rule-based, hierarchical)

Coarse segmentation | Fine segmentation | Classification results



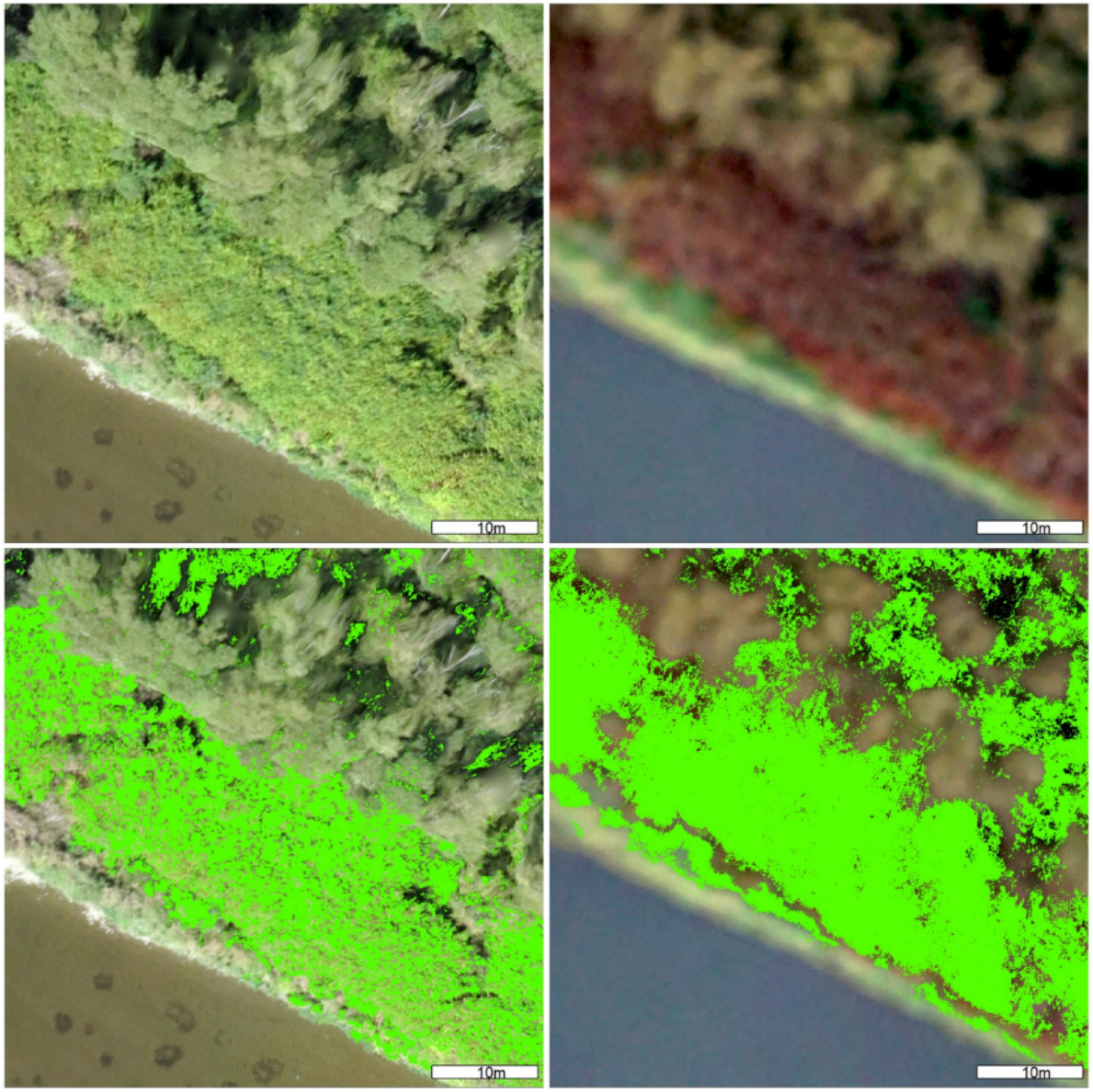
- lower spatial & higher spectral resolution, less distinct → pixel-based

- problematic → hybrid approach

Classification – UAV data, black locust

Classification – UAV data, black locust

Classification – timing is important



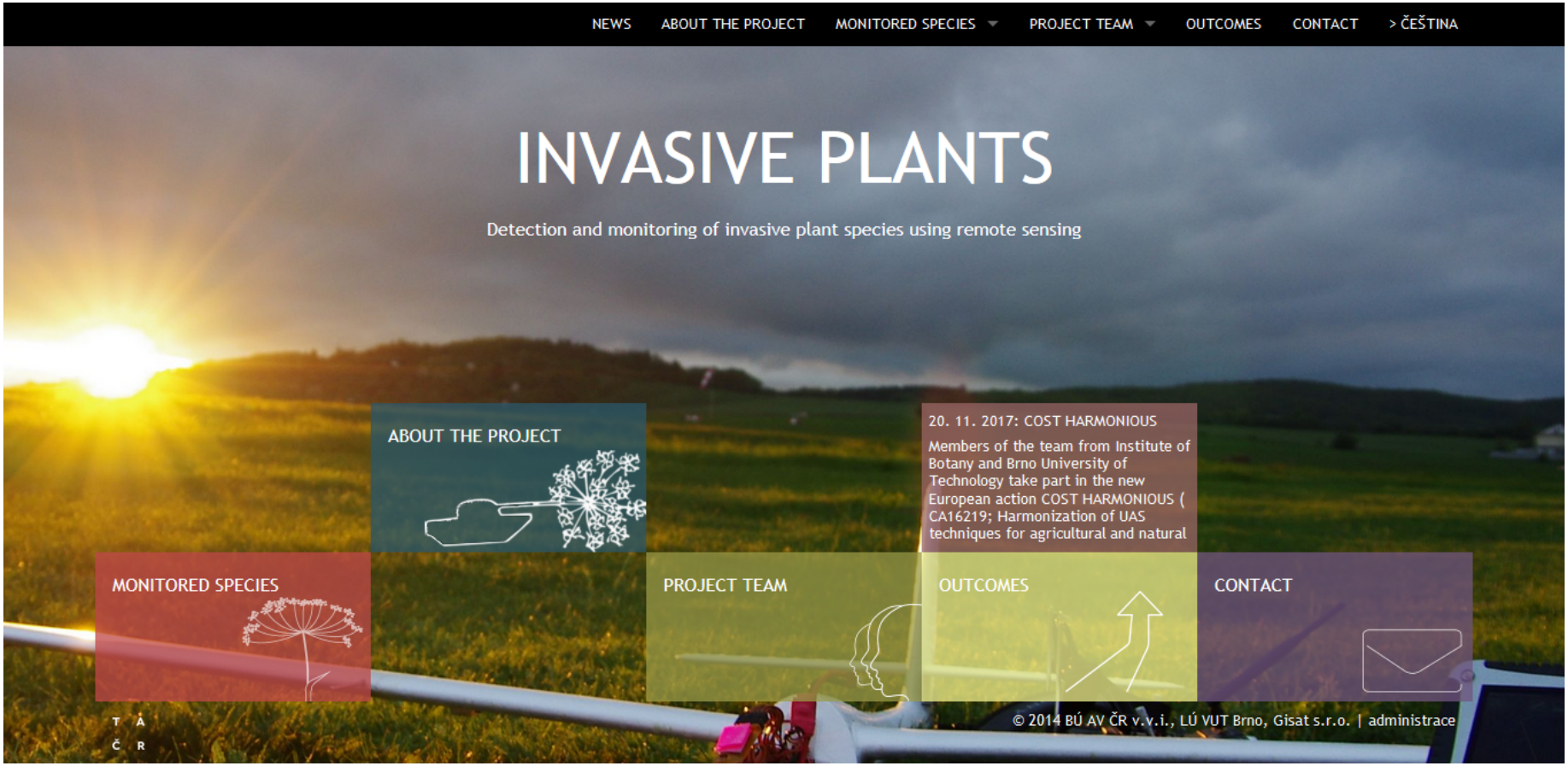
Conclusions

- Worse satellite spatial resolution is outweighed by better spectral resolution compared to low-cost UAV sensors
- Crucial advantage of UAVs is in their flexibility – precise timing of the data acquisition according to the phenology of the plant of interest
- Legal constraints of UAV deployment might be very limiting
- Classification method depends on the target species characteristics

Further work

- Open – source SFM implementation
- RTK workflow implementation
- Multispectral sensor (MicaSense RedEdge)

Further information



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Thank you