ZEMĚMĚŘICKÝ ÚŘAD

Historical aerial images of Czechia - archiving and applications in landscape studies

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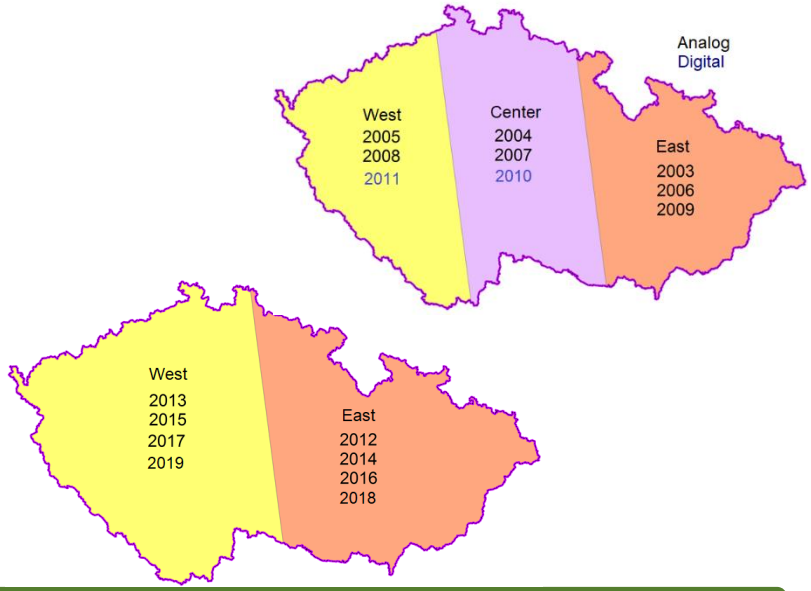
National Archive of Aerial Images

Aerial images in Czechia

- Military acquisitions 1936 – 1990
  - 1935 at area of Slovakia
  - 1936-1938: 46 500 km^2 of 78 666 km^2 (does not include Slovakia)
  - WWII: found 96 images of unknown origin
  - 1946 – 1991: Classified
    - Topographic mapping, Image Intelligence, coal pits monitoring, natural disasters documentation …
- 1991 – 2002
  - Declassification of images by the Order of the Ministry of Defense no. 26/1991
  - MoD
  - Private Companies
  - Civilian Public Sector (COSMC)
- After 2003 – public sector
  - MoD, COSMC, Ministry of Agriculture
  - Systematic Orthophoto production
  - Since 2010 digital aerial images
  - 2003 – 2011 1/3 of Czechia per year
  - Since 2012 ½ of Czechia per year



Participants

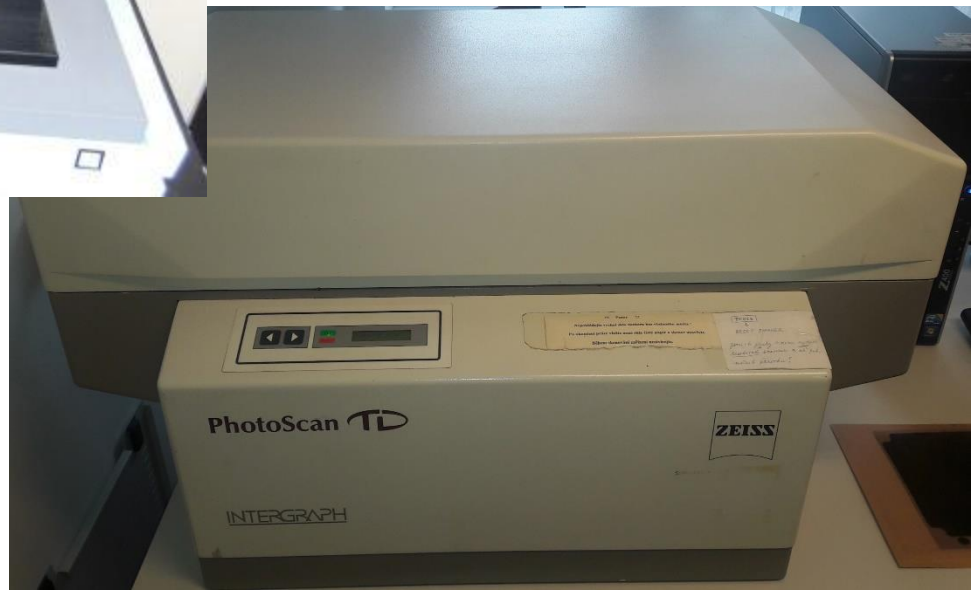
- Ministry of Defense (MoD)
  - Office of Military Geography and Hydrometeorology (OMGHM)
    - Owner of the Archive of analogue aerial images (including metadata)
    - Scanning of aerial images
    - Localization and metadata acquisition
    - Digitized aerial images and metadata backup
- Czech Office for Surveying, Mapping and Cadaster (COSMC)
  - Land Survey Office (LSO)
    - Scanning of aerial images (at OMGHM place)
    - Localization and metadata acquisition (at OMGHM place)
    - Management of development of the archiving system
    - Presentation and distribution

Scanning aerial images

- OMGHM in Dobruška
- Image by Image, no roll
- 4 employees (2x OMGHM, 2X LSO), 2 x eight-hours shift
- 3x UltraScan 5000 (1x OMGHM, 2x LSO)
  - 14 µm
  - 16 bit lossless TIFF
- 2x PhotoScan TD (LSO)
  - 14 µm
  - 08 bit lossless TIFF
- Radiometric corrections
  - Photoshop
  - 16 bit -> 8 bit lossless TIFF

Scanning aerial images

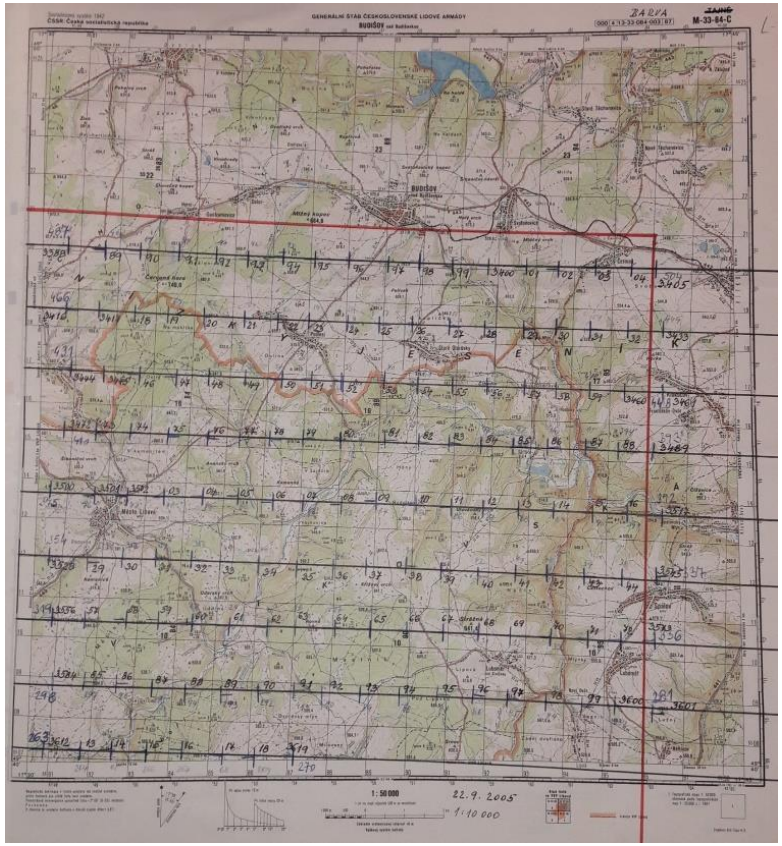
UltraScan 5000



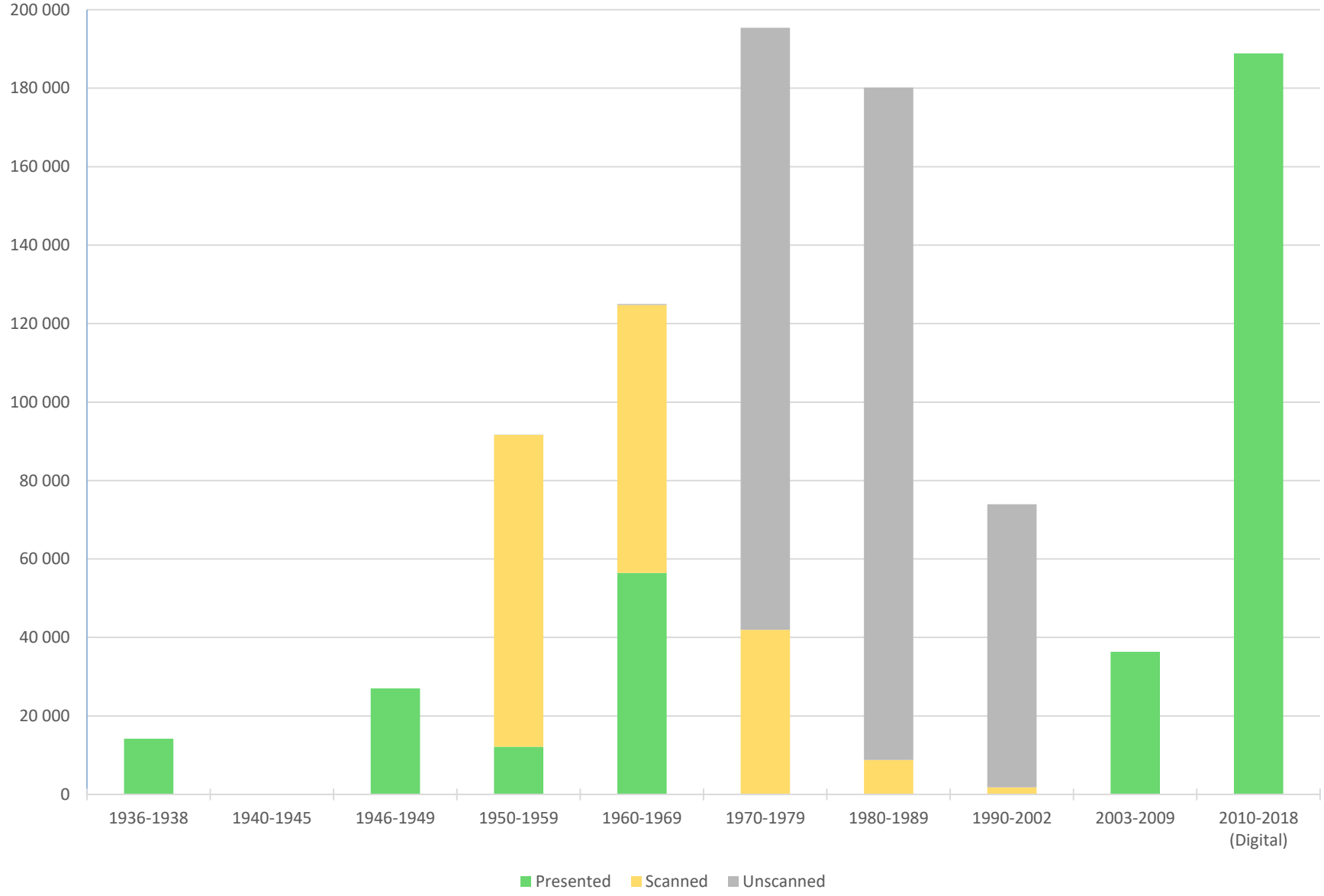
PhotoScan TD

Approximate georeferencing of aerial images

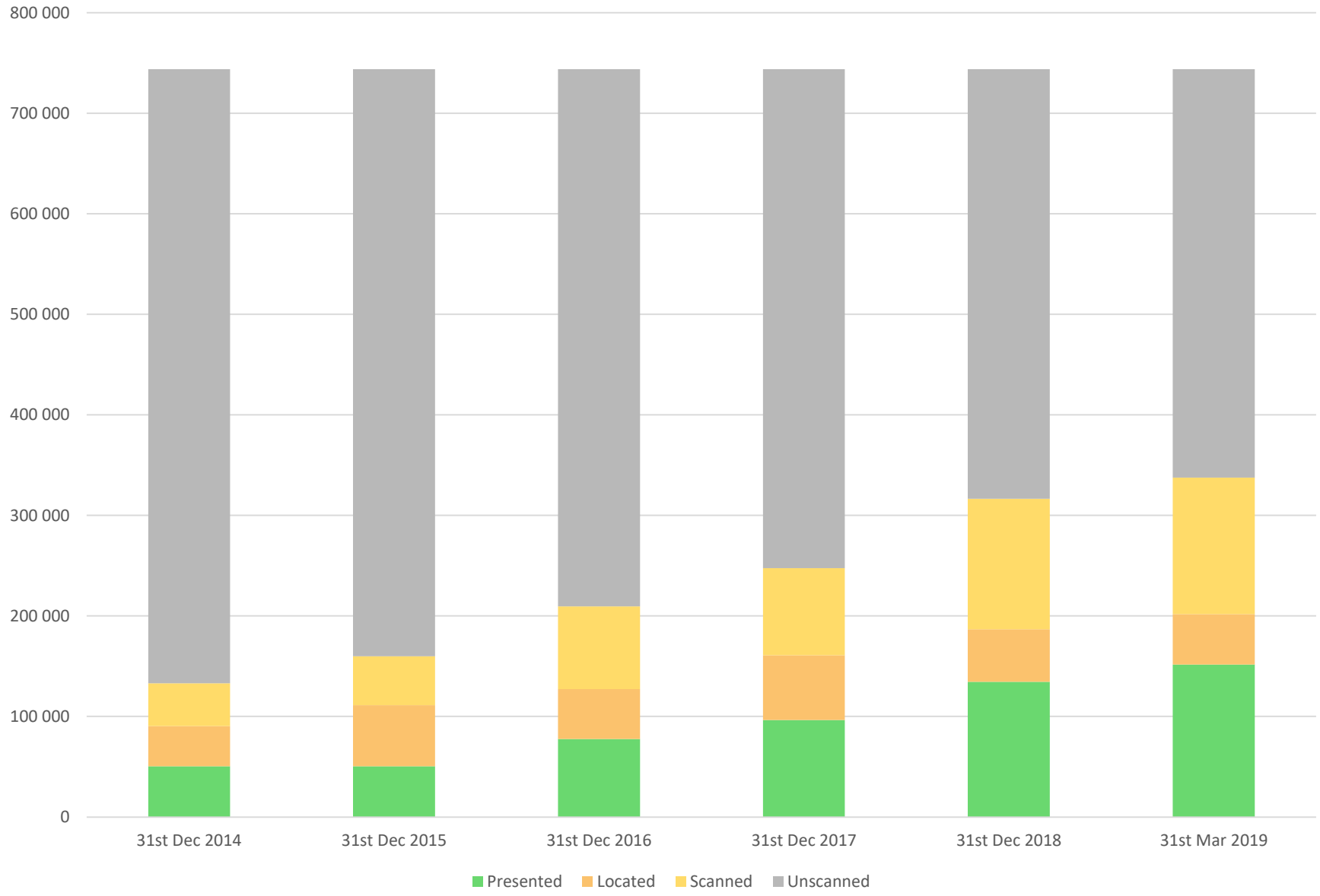
- OMGHM in Dobruška
- Approximate position drawn in the Atlas of Topographic maps 1: 50 000
- Digitization of the corners and the center
  - WGS84/UTM33,
  - Orthophoto,
  - Topographic maps 1:50 000,
  - Historical orthophoto
- Focal length read from the aerial images
- Estimation of the kappa angle
- Automatic fill of the aerial image size and date
- Automatic generating footprints
  - By the corners, center and the size
- 2 employees/8 hours shift



Amount of aerial images by periods



Digitization progress (Total No.)



Archiving Data

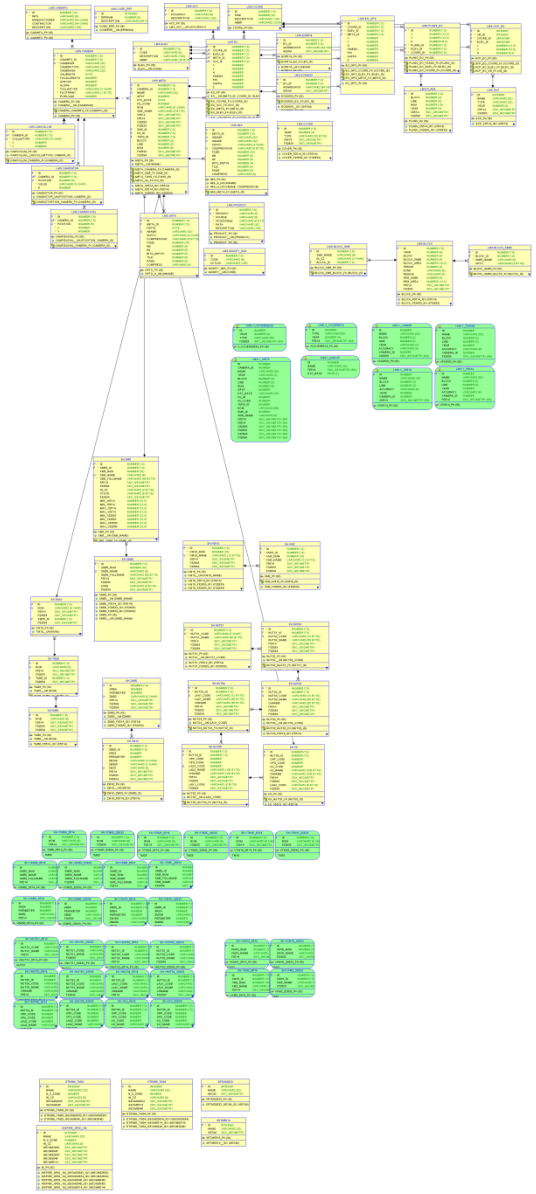
- Data compression
  - ERDAS Imagine 2015 (ERDAS IMAGINE since version 2016 inserts Alpha channel)
  - Lossless JPEG 2000
  - Batch exportjp2.exe
    - -tile 4096 -precinct 256 -ratio Lossless -progression RPCL -res 6 -qual 1 -geojp2 0 -gmljp2 0
- Rename to unique Archive name
- Data compression for Web presentation
  - TIFF with JPEG compression 8 bit
  - gdal_translate
    - -ot Byte -scale 0 255 1 254 -co PROFILE=BASELINE --config GDAL_PAM_ENABLED NO
  - gdaladdo
    - 2 4 8 16 32 64 128 256 512 1024 --config COMPRESS_OVERVIEW JPEG --config JPEG_QUALITY_OVERVIEW 80

Archiving metadata

- Prepare a new camera if needed
  - for historical images only focal length
- Import metadata to Oracle Spatial
  - Center coordinates
  - Footprint
  - Date
  - kappa
- Footprint corners sorted by the kappa angle
- Centers and footprints transformed
  - From WGS84/UTM33
    - ETRS89-TM33, ETRS89-TM34 and S-JTSK
- World file parameters calculated by footprint
- Recalculation of centers height
  - Footprint, focal length, DTM
- Fill DB by image metadata
  - Format, size, volume, bit depth, compression

Metadata DB

- External Orientation
  - GNSS/INS and AT (since 2003)
  - Digitized (before 2003)
- Geometry of centers
- Geometry of footprints
- Code of EO accuracy
  - GNSS/IMU
  - AT
  - Digitize on map
- Date-time (UTC)
  - Since 2006 derived from GPS time of IMU
  - Before 2003 time set to noon of day
  - Before 1948 date set to 1st July
- Metadata about the product
  - Bit depth, size…
- Cameras
  - Distortions, Fiducial Marks (not before 2003)
  - Links to a pdf calibration protocol (since 2010)
- Links to Blocks, Map Sheets etc.
- 200x200 m DTM for computations
- Flight plans (since 2012)
- Planned: GCPs with links to pdf



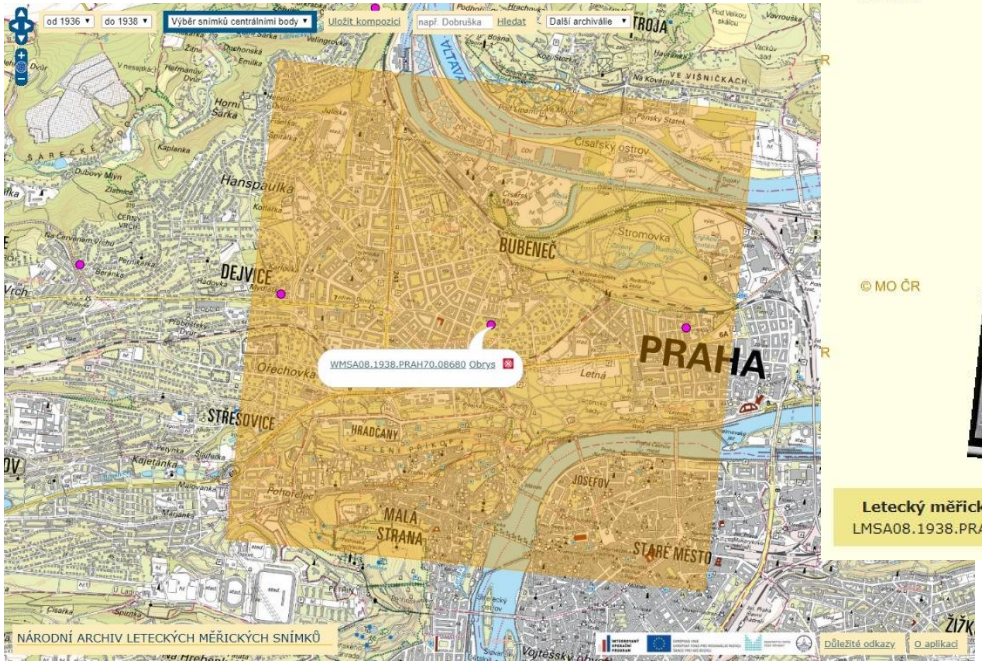
Data in Archive (23th May 2019)

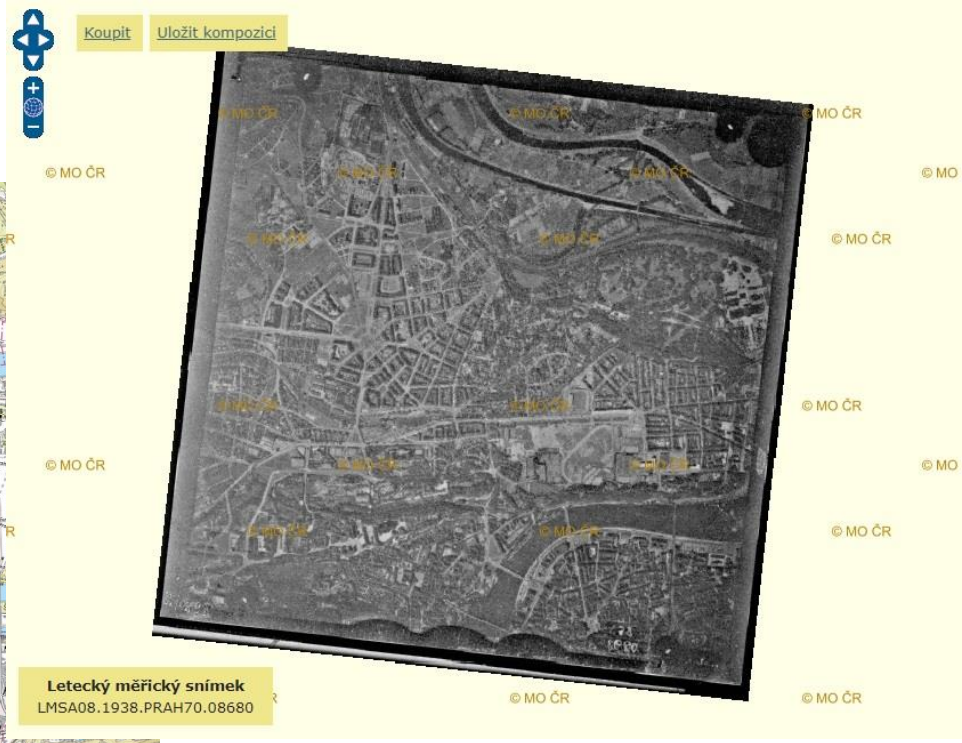
Directory	Product	Volume [TB]
LMSA08	Scanned PAN 8 Bit AI **	7.83
LMSA24	Scanned RGB 8 Bit AI **	6.88
LMSD48	Digital RGB 16 Bit AI **	151.67
NIRD16	Digital NIR 16 Bit AI **	60.01
ORTI24*	CIR 8 Bit Orthophoto in SM5 Sheets **	3.84
ORTO08	Grey 8 Bit Orthophoto in SM5 Sheets **	0.32
ORTO24	RGB 8 Bit Orthophoto in SM5 Sheets **	8.52
WMSA08	Scanned PAN 8 Bit AI ***	3.33
WMSA24	Scanned RGB 8 Bit AI ***	1.10
WMSD24	Digital RGB 8 Bit LMS ***	9.46

* Produced by Forest Management Institute
** Lossless jp2
*** Tif + jpeg Compression

Data publication and distribution

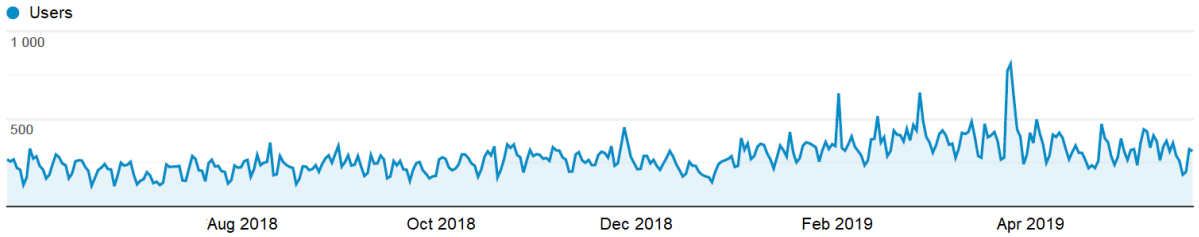
- Geoportal COSMC
  - https://lms.cuzk.cz/lms/lms_prehl_05.html
  - Searching and viewing aerial images, adding to an e-shop basket



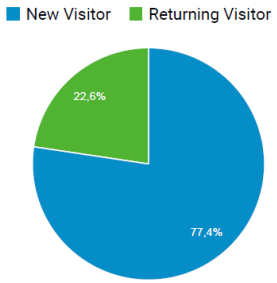


Data publication and distribution

- Geoportal visits (21st May 2018 – 21st May 2019)



Users	New Users	Visits
57 041	56 008	124 287
Sessions / User	**Pageviews**	**Pages / Session**
2,18	503 282	4,05
Avg. Session Duration	**Bounce Rate**	
00:06:21	41,09 %	



- E-Shop (110th Jun 2015 – 21st May 2019)

	Paid	Free of charge	Total
No. Orders	224	11	237
No. Images	1679	469	2148
Images / Order	7.5	42.6	9.1
Price: 1 AI for 500 CZK (~ 19.20 Euro)			

Order content

- Aerial images
  - Lossless 8 bit scanline TIFF
  - Since 2010 RGB + NIR
  - On request 16 bit
  - World file
- ASCII file with EO
  - S-JTSK + Baltic height (on request ETRS89-TM33 or ETRS89-TM34 with GRS80 height)
  - Image name, X, Y, H, omega, phi, kappa, Date-time, Camera ID, EO precision
- ASCII file with IO
  - Export from DB
- PDF calibration protocol
  - If exists
- GCP
  - On request, if exist
  - Pdf with a situation photo
  - ASCII with coordinates
- Inpho Project

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Applications of historical aerial photos in landscape studies

On examples of projects utilising historical aerial imagery:

- Heritage of „lost“ landscapes: identification, reconstruction and presentation
- Change of rural architecture with emphasis on developments in the 19th and 20th century

Heritage of lost landscapes: identification, reconstruction and presentation

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- Project goals
  - to identify, document, reconstruct and present the heritage of landscapes which function have considerably changed during the period of dynamic societal changes since the end of the 18th century, with emphasis on:
    1. utilization of historical sources and modern technologies,
    2. presenting diversity of cultural landscape heritage and contributing to its systematic protection, presentation and inclusion in education and regional development.
- Data sources
  - cadastral maps,
  - historical and current aerial (ortho)images,
  - digital terrain models, soil characteristics, land use database, database of protected natural areas, database of cultural heritage sites, historical photographs, …
- Historical aerial images used for
  - creating orthoimages and photorealistic 3D models to document changes and development of selected areas
  - only documentation and visualisation purposes
- 40 model areas
  - Different development (post-mining, military areas, mountainous agriculture, dams, …)
  - Different size(800 ha – 6 000 ha)
  - Processing of historical images in 2 time periods (1930‘s, 1980‘s or 1990‘s)

Project No. DG18P02OVV008 of the Ministry of Culture of Czechia (2018-2022)

http://zaniklekrajiny.cz/

Heritage of lost landscapes: identification, reconstruction and presentation

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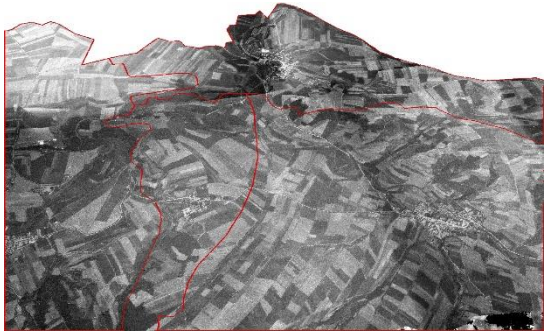
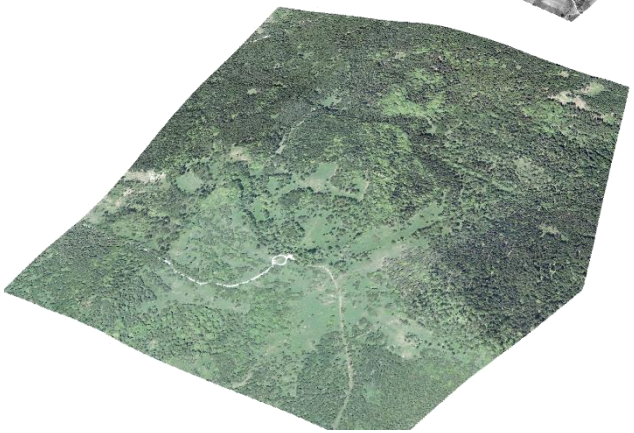
- Output: Digital atlas of „lost“ landscapes (http://www.zaniklekrajiny.cz/atlas/)

Aerial images © ČÚZK





1: Military area Boletice 1947 and 2018

2: Agriculture landscape
Podbořany 1938 and 2018

Change of rural architecture with emphasis on developments in the 19th and 20th century

- Project goals: art-historical research of the urban development of 39 selected villages in order to point out neglected historical and art values of rural architecture
- Data sources
  - cadastral maps,
  - ground plans of rural architecture,
  - historical aerial images (3 test villages in different terrain types).
- Processing: orthorectification of historical aerial images
  - three periods around the years: 1938 + 1970 + 1985,
  - main emphasis on a built-up area of the villages,
  - required orthophoto accuracy within 3 m.

Project No. DG16P02H023 of the Ministry of Culture of Czechia (2016 - 2022) http://venkov.fsv.cvut.cz/projekt/

Common problems related to utilisation of a standard photogrammetric processing workflow on historical images

- Lack of calibration data
- Quality of images
- Size of the area to be processed (stereo or single photo coverage & connected costs) $\rightarrow$ number of images
- Possibility of finding suitable ground control points (based on other data sources, e.g. cadastral maps, current orthoimages, nation-wide orthoimage layer from 1950‘s)
- Availability and quality of a DTM and/or automated generation of DTM

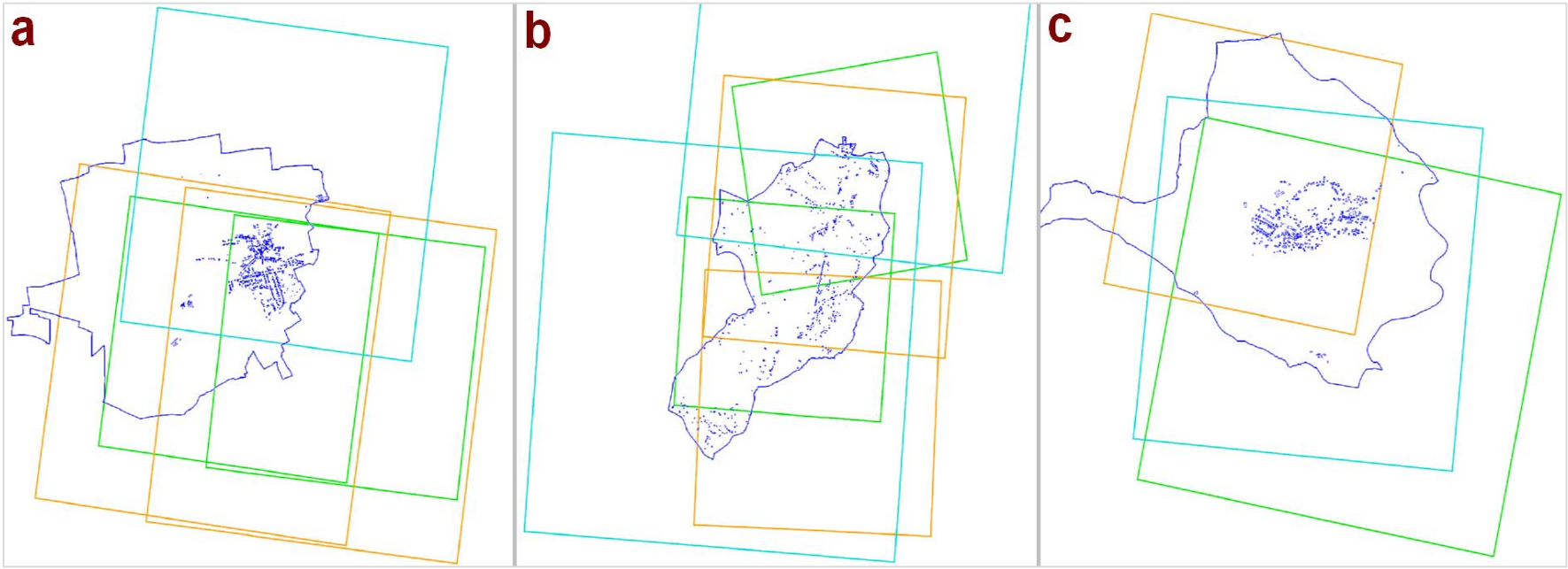
Image quality

Image quality of historical aerial images (© VGHMUr) – Ropice village

Hodač & Zemánková (2018)

Hodač, J.; Zemánková, A. (2018): Historical orthophotos created on base of single photos – specifics of processing, *The Civil Engineering Journal* 2018(3), 425-438. ISSN 1805-2576, DOI 10.14311/CEJ.2018.03.0034.

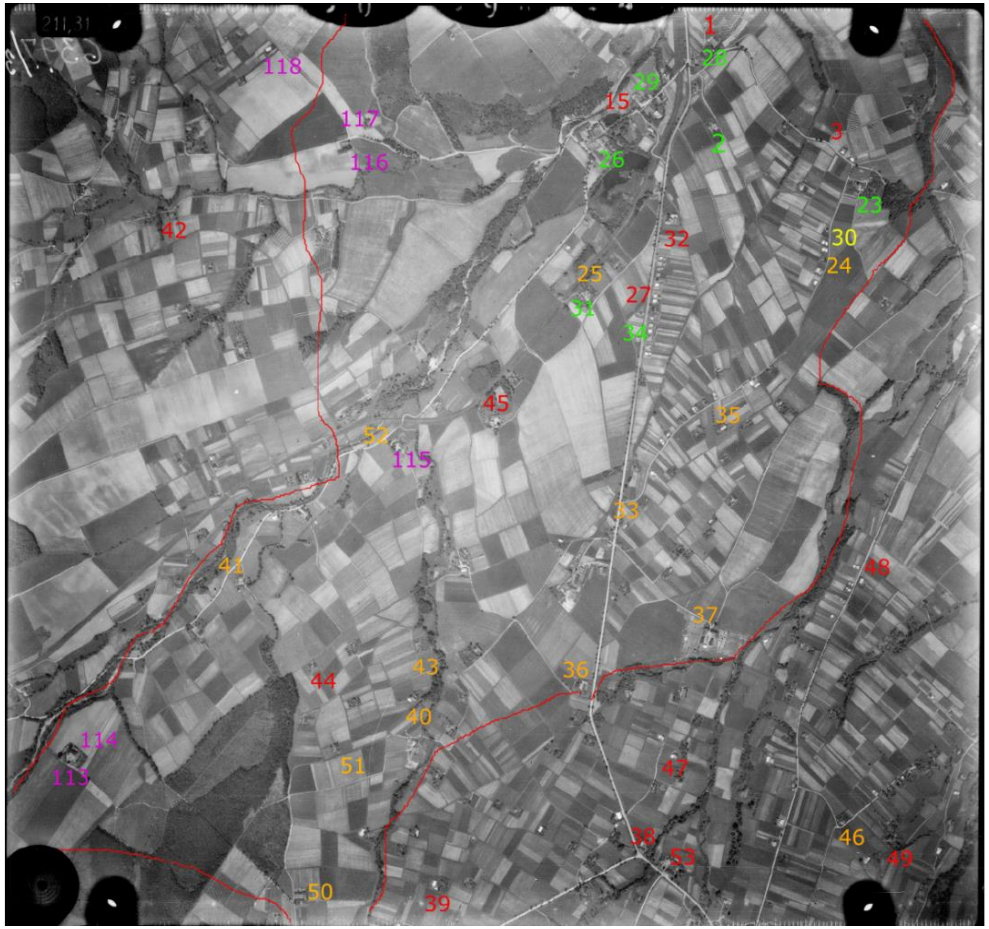
Image cover

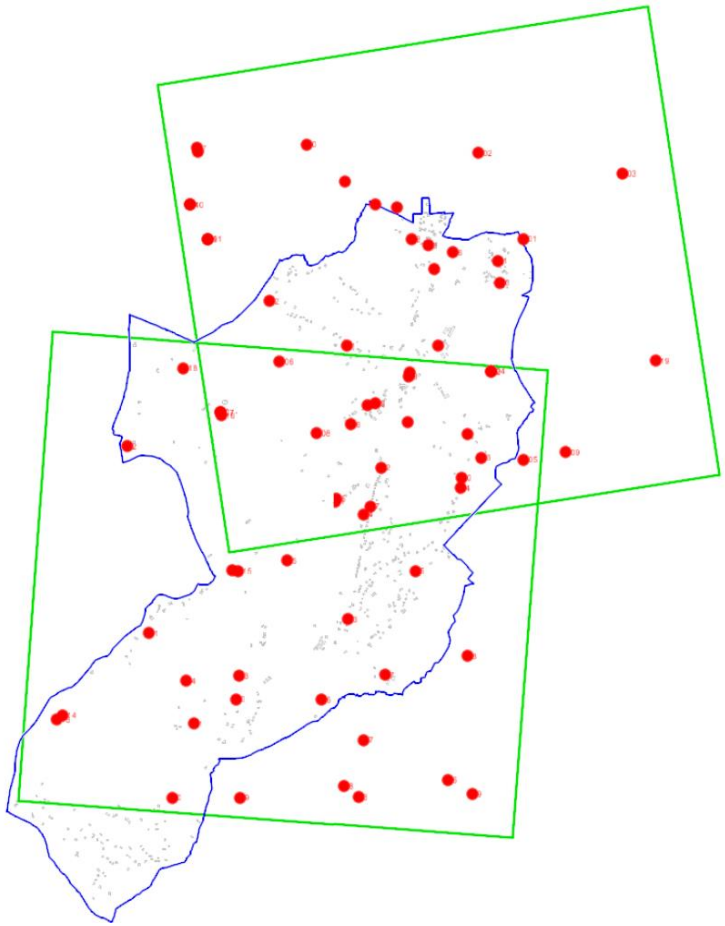


Covering of cadastral districts by historical aerial images (a-Hostouň, b-Ropice, c-Držkov). Years – green = 1938+37+38, orange = 1969+72+71, blue = 1983+86+88

Hodač & Zemánková (2018)

Ground control points





GCP source: ***cadastral map and current orthoimage*** *($\Delta_P \leq 1m$),* ***cadastral map****,* ***orthoimage 1950's****,* ***cadastral map and current orthoimage*** *($\Delta_P > 1m$);* ***difficult identification in the historical image***

Hodač & Zemánková (2018)

Results of image orientation and orthorectification

	rms X *[m]*	rms Y *[m]*	rms Z *[m]*	MDZ *[m]*	IQ	S	DAOV *[°]*
Ropice							
1937_PH2	0,5	**0,5**	0,3	*100*	*good*	*20 500*	*53*
1972_PH2	0,5	**0,6**	0,5		*weak*	*23 400*	*91*
1986_PH1	0,7	**0,9**	0,8		*very good*	*29 600*	*91*
Držkov							
1938_PH1	1,0	**1,7**	0,7	*150*	*very good*	*19 700*	*59*
1971_PH1	**1,8**	1,4	0,8		*very good*	*13 700*	*58*
1988_PH1	1,9	**3,5**	2,0		*very good*	*13 700*	*91*
Hostouň							
1969_PH1	0,6	**0,8**	0,4	*50*	*good*	*24 500*	*95*

legend: **1937_PH2** - year of recording + photo number; **S** - scale; **DAOV** - diagonal angle of view; **MDZ -** maximum difference of Z coordinate of used GCP; **IQ** - image quality

initial assumptions:
- distribution of GCP is equable on each used HAP
- one typical result of EO is presented for each year
- number of used GCP is 15-25 per photo

EO based on spatial resection

Orthoimage accuracy

method	1 photo		stereo v1		stereo v2	
CPN	ΔY *[m]*	ΔX *[m]*	ΔY *[m]*	ΔX *[m]*	ΔY *[m]*	ΔX *[m]*
1	-1,30	-0,58	-0,48	-0,31	***4,12***	-1,18
2	-0,08	-0,40	-0,51	-0,23	-0,36	1,03
3	1,52	-1,75	-0,55	***2,17***	0,35	0,53
4	0,84	1,34	0,56	1,99	0,01	***3,45***
5	***2,23***	-0,65	***2,08***	0,23	1,82	0,55
6	-0,02	***-2,28***	0,38	-0,67	-1,13	-2,68
7	-0,01	-0,84	-0,14	-0,07	-0,70	0,38
8	0,35	-1,51	-0,03	-0,98	-1,12	-1,29
9	-0,63	-0,04	-0,88	0,11	-1,21	0,69
10	1,74	-0,69	1,80	0,43	-0,01	-2,17
∅	**0,46**	**-0,74**	**0,22**	**0,27**	**0,18**	**-0,07**

legend: **CPN** - control point number

1 photo - exterior ori. calculated on base of 1 photo only

stereo v1 - exterior ori. calculated on base of stereo + purchased DMR

stereo v2 - exterior ori. calculated on base of stereo + DMR created by us

Hodač & Zemánková (2018)

Future steps towards quality and efficiency improvement

- Estimation of parameters of inner orientation
- Recommendations for estimation of EO parameters in case of small projects (single or a few images)
- Creating GCP database and automated GCP search in time series of images
- DTM from historical images – automated procedures applied on low quality images (?)

Thank you for your attention

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