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 km² of 78 666 km² (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

- 1936-1938: 0
- 1940-1945: 0
- 1946-1949: 20,000
- 1950-1959: 40,000
- 1960-1969: 60,000
- 1970-1979: 80,000
- 1980-1989: 100,000
- 1990-2002: 120,000
- 2003-2009: 140,000
- 2010-2018: 160,000
- (Digital): 180,000

Legend:
- Green: Presented
- Yellow: Scanned
- Gray: Unscanned
Digitization progress (Total No.)

- Presented
- Located
- Scanned
- Unscanned

31st Dec 2014
31st Dec 2015
31st Dec 2016
31st Dec 2017
31st Dec 2018
31st Mar 2019

Digitization progress (Total No.) chart showing the progress of digitization from 31st Dec 2014 to 31st Mar 2019.
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 (23\textsuperscript{th} May 2019)

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<thead>
<tr>
<th>Directory</th>
<th>Product</th>
<th>Volume [TB]</th>
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<td>Scanned PAN 8 Bit AI **</td>
<td>7.83</td>
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<td>LMSA24</td>
<td>Scanned RGB 8 Bit AI **</td>
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<td>CIR 8 Bit Orthophoto in SM5 Sheets **</td>
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<tr>
<td>WMSD24</td>
<td>Digital RGB 8 Bit LMS ***</td>
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* 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](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)

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

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<th>Paid</th>
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<td>237</td>
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<td>42.6</td>
<td>9.1</td>
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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
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

- **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

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

1: Military area Boletice 1947 and 2018

2: Agriculture landscape Podbořany 1938 and 2018

Aerial images © ČÚZK
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.

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) → 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 of historical aerial images (© VGHMUr) – Ropice village

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

<table>
<thead>
<tr>
<th></th>
<th>rms X [m]</th>
<th>rms Y [m]</th>
<th>rms Z [m]</th>
<th>MDZ [m]</th>
<th>IQ</th>
<th>S</th>
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<tr>
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<tr>
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<td>good</td>
<td>24 500</td>
<td>95</td>
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</table>

**Orthoimage accuracy**

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

**Initial assumptions:**
- distribution of GCP is equitable 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

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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