LANTMÄTERIET

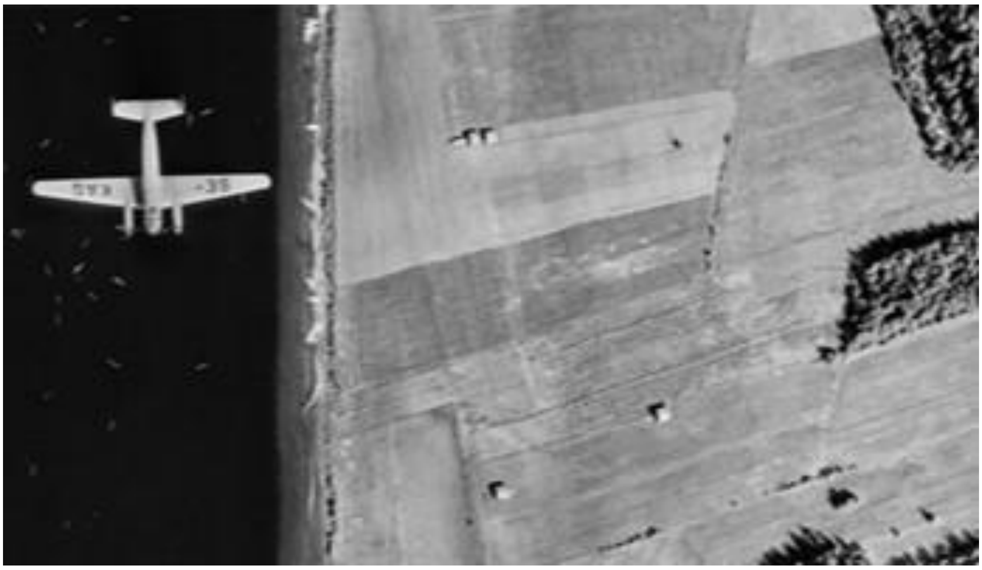
2021-11-01

PRODUCT DESCRIPTION

Scanned analogue aerial photographs (Skannade analoga flygbilder)

DOCUMENT VERSION: 1.2

Figure 1. Example scanned aerial photograph.



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1 General description

Aerial photography has been carried out in Sweden for a long time. The flight altitudes have varied depending on the type of camera used and the desired resolution of the photographs. During a long period, the photography was carried out with an analogue camera, but in recent years digital cameras have been used. In our analogue aerial photography archive, there are about 1,2 million negatives, from the late 1920’s to 2006. Digitalization of this archive is continuously ongoing, and we produce digitalized aerial photographs by scanning the old negatives.

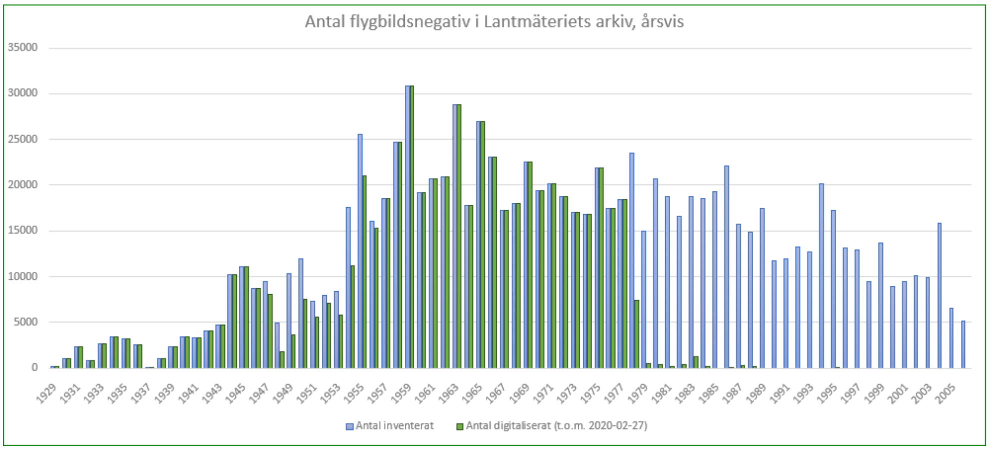
1.1 Contents

Most of the aerial photographs are in black-and-white, but there are also many in colour and IR. A large proportion of the photographs have a resolution of ~ 0,5 m and cover entire Sweden, but there are also photographs with other resolutions. Most of the images are photographed with overlap, which gives you the opportunity of interpreting and measuring in 3D / stereo.

Scanned analogue aerial photographs from all years can be ordered with optional requirements regarding image cropping. If the photographs are not already available digitally, they will be scanned after ordering.

There are also orientation data available for many of the aerial photographs and we can on order produce orientation data for images that don’t have it.

Figure 2. Number of analogue negatives (blue bars) and digitalized aerial photographs (green bars) in Lantmäteriets archive, annually.



1.2 Geographic coverage

The aerial photographs cover Sweden’s entire territory, limited by country and territorial borders. Additional information about the aerial images’ coverage area can be found in the GeoLex web service.

1.3 Geographic cut-out

The size of the surface that an aerial photograph covers on the ground depends on the type of camera used and flight altitude. In table 2 below there are some examples of the most common combinations of flight altitudes and camera constants and the surface coverages and pixel sizes on the ground that are obtained after the digitalization.

Table 1. Relation between flight altitude, pixel size and surface coverage.

Flight altitude (m)	Total number of flight lines	Camera dimension/ Film size (cm)	Camera constant (cm)	Pixel size on the ground (cm)	Image surface coverage on the ground (km)
800	2000	23x23	15,2	10x10	1x1
2000	3000	23x23	15,2	20x20	3x3
3000	1500	18x18	24,7	20x20	2x2
3900	3500	30x30	20	30x30	6x6
4600	12000	23x23	15,2	50x50	7x7
9200	1500	23x23	15,2	100x100	14x14
13200	300	23x23	8,8	225x225	35x35

The metadata above can be obtained from flight line overviews and calibration protocols. Surface coverage and pixel size on the ground can then be calculated from these metadata. The surface coverage can be obtained from the formula: Side of the surface on the ground = Film size (cm) * Flight altitude (m) / Camera constant (cm).

1.4 Coordinate system

The orientation data of the aerial photograph is used to place the image in a coordination system. Orientation data is produced in connection with the block triangulation of the aerial photograph and can be delivered in SWEREF 99 TM and local zones (horizontal) and RH 2000 (vertical).

2 Quality description

In Table 3 quality, including quality themes and quality parameters as described in the standard SS-EN ISO 19157:2013 Geografisk information – Datakvalitet, is presented. More detailed description of lineage and quality can be found in the text below.

Table 2. Quality themes and quality parameters for Scanned analogue aerial photographs.

Quality theme	Quality parameter	Quality
Positional accuracy	• Absolute positional accuracy • Positional accuracy of raster data	At the orientation the accuracy may vary rather much, depending on the image quality and the support/reference material used, also see chapter 2.4.1 Positional accuracy.

2.1 Purpose and utility

An aerial photograph is a central projection, where no corrections have been made for variations in the terrain or the cameras angle of inclination, hence the scale varies in the photograph.

Common areas of application are monitoring of changes in built-up areas in cities and communities, localisation of old deposits of environmentally hazardous goods around industries etc. The IR-information can be used for interpreting vegetation and make different kinds of forest analyses.

Most of the photographs are taken with overlap, about 60% within the flight line and 30% between the flight lines, which makes interpreting and measuring in 3D / stereo possible.

2.2 Data capture

2.2.1 LINEAGE

The aerial photography has mainly been carried out from a flight altitude of 4 600 m, with monochromatic film, adapted to the reference system of that time, RT 90 2,5 gon V. Other flight altitudes have also occurred, from a few hundred metres up to 13 200 m.

The aerial photos have been scanned with 14-16 micrometres resolution, which results in a resolution on the ground of approx. 0,5 m. The older aerial photographs, from the years 1930-1948, have been copied to microfilm as a first step, which causes these earliest images to have approx. 3-5 times lower resolution on the ground. These photographs do not cover the entire country and the quality is not so good compared to the other aerial photographs.

The following georeferencing of the digital photos are partly done with other methods than for new aerial photos, due to the lack of GPS data. The centre coordinate for the aerial photos are taken from old analogue flight line overviews. Inner orientation is mainly done by searching for the photos collimating marks and measuring these. Old camera calibration protocols are used to achieve coordinates for collimating marks, to be able to make corrections for the camera’s distortion error.

GEOMETRIC RESOLUTION

Flight altitude and the type of camera used in the photography determines the geometric resolution of the images, see table 2 Relation between flight altitude, pixel size and surface coverage. The resolution can be calculated by the formula: Pixel size on the ground (m) = Scanner resolution (cm) * Flight altitude (m) / Camera constant (cm).

Photography has mostly been carried out from an altitude of 4 600 metres with a negative scale of approx. 1:30 000, which results in a resolution in the aerial photographs of 0,5 m/pixel.

The geometric precision at digitalization via scanning is better than 2 µm (RMS) for 23 x 23 cm negatives and 3 µm (RMS) for 30 x 30 cm negatives. The scanned aerial photographs are stored with a depth of 8 bits.

The processes that follows do not usually lead to completely white or black pixels (i.e. pixel values of 255 or 0), but in rare cases there might occur light reflexes in the image that obtain maximum pixel values. The aim is that the statistics for the scanned image, the histogram, should be similar for every object type, i.e. that built-up areas, forests and other land covers will look similar in different images when other conditions are the same. But the time of photography as well as the conditions on the ground and in the atmosphere at the time of photography also affect how good the result can be. The time of season also affects to a large extent, due to more or less developed vegetation, for example before or after leafing.

2.3 Maintenance

2.3.1 MAINTENANCE FREQUENCY

Digitalization of the aerial photography archive is continuously ongoing. The analogue images are scanned in order to preserve a historical layer. More information regarding the aerial photographs that are available can be found in GeoLex.

2.4 Data quality

2.4.1 POSITIONAL ACCURACY

At the orientation the accuracy may vary rather much, depending on the image quality and the support/reference material used.

2.5 Metadata

All aerial photographs can on request be delivered with information about camera, time of photography, flight line- and image number.

The file name of each aerial photograph, i.e. the identity of the image, normally contains information about year of photography, flight line number and image number, for instance Y_58_203_06. Images from further back in time might have somewhat different image identities, since the naming principles have changed over the years.

The orientation file (ori-file) contains image number, camera position and camera orientation (rotation matrix).

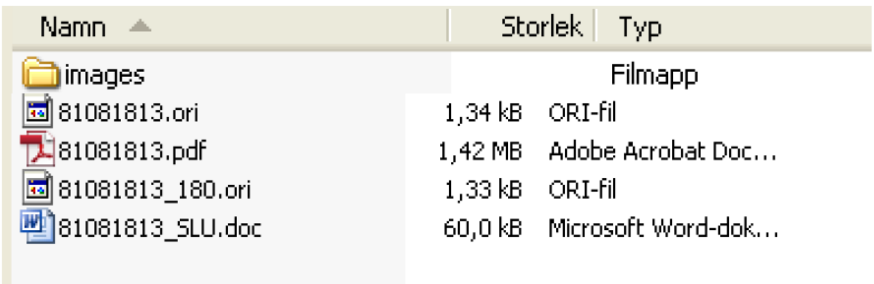
Detailed information about every aerial photograph, for instance time of photography, can also be obtained from our webservice GeoLex.

3 Contents of the delivery

3.1 Folder structure at delivery

An example of a delivery of scanned aerial photographs can be seen here below.

Figure 1. Folder structure at delivery.



3.2 Delivery format

Scanned analogue aerial photographs are delivered in uncompressed TIFF-format.

Orientation data is delivered in PatB-format (.ori-file) and as a project file for Match-AT (.prj-file). You can instead of these files obtain refined orientation data for the ESPA-system or for the Summit-project, or ready-to-use model files for these.

3.3 File sets

The aerial photograph is delivered as an uncompressed TIFF file.

The orientation file (ori-file) contains image number, camera position and camera orientation (rotation matrix). The project file for Match-AT (.prj-file) also contains, apart from orientation, camera settings and inner orientation for the images. Several systems support import of the formats. In appendix 1 there is a more detailed description of an ori-file.

In the delivery the files above can, if preferred, be replaced with refined orientation data for the ESPA-system or for the Summit-project, or ready-to-use model files for these.

An additional ori-file (_180.ori), which is rotated 180 degrees compared to the flight direction, is also included in the delivery.

Included in the delivery are also a text document (.doc) with information regarding the delivery, as well as an additional overview document (.pdf), containing a map with the image exposure position in order to find the location more easily.

Calibration protocols for each of the cameras can be found on Lantmäteriets website.

Appendix 1: Description of an ori-file

The orientation information in an ori-file consists of three rows for each image:

image nr	**Camera constant**	E_{PC}	N_{PC}	H_{PC}
k_1	k_2	k_3	k_4	k_5
k_6	k_7	k_8	k_9	

Example:

1705	120.00000000	567498.92018	6240003.14745	5036.79739
0.003487293108	0.999993910667	0.000131970599	0.999987383107	0.003486793127
0.003616061336	0.003615579163	0.000144579200	0.999993453321	

Description of the information:

Row 1: **image nr** is a unique image number within the actual block.

Camera constant, presented in mm.

E_{PC}, N_{PC}, H_{PC} is a position indication for the projection centre (PC) of the image, in the current plane coordination system, for instance SWEREF 99 TM, and the current height coordination system, for instance RH2000, presented in metres.

Since the geodetical plane and height system does not represent a right-angled three-dimensional system and the horizontal coordinates contain the errors of the map projection, the position information is adjusted in order to achieve the best adaptation on the ground. The value HPC is therefore adjusted for the scale factor of the map projection, which mainly depends on the distance from the central meridian.

Rad 2 och 3: coefficients in a 3x3 rotation matrix **R**, which describes the rotation from **image to ground**

$$\mathbf{R} = \begin{pmatrix} k_1 & k_2 & k_3 \\ k_4 & k_5 & k_6 \\ k_7 & k_8 & k_9 \end{pmatrix}$$

With the assumption that the geodetical plane and height system locally can be approximated with a right-angled three-dimensional system, the equation for the relation between the image coordinates for a certain point (**x**’, **y**’) and the coordinates for the ground (**E**, **N**, **H**) can be written as follows:

$$\begin{pmatrix} \mathbf{E} \\ \mathbf{N} \\ \mathbf{H} \end{pmatrix} = \begin{pmatrix} \mathbf{E}_{\mathrm{PC}} \\ \mathbf{N}_{\mathrm{PC}} \\ \mathbf{H}_{\mathrm{PC}} \end{pmatrix} + \mathbf{mR} \begin{pmatrix} \mathbf{x'} \\ \mathbf{y'} \\ -\mathbf{c} \end{pmatrix}$$

where **m** is the scale factor for the image in the current point.

Rotation angles (in radians) can be derived from the coefficients for the rotation matrix, as follows:

omega = $-\arctan(k_8 / k_9)$

fi = $\arcsin(k_7)$

kappa = $-\arctan(k_4 / k_1) + \pi$

The rotation angles are defined in a right-angled three-axis coordination system, with origo in the projection centre (PC) and the axes parallel with the geodetic system.

omega represents rotation around the E-axis of the coordinate system.

fi represents rotation around the N-axis of the coordinate system.

kappa represents rotation around the H-axis of the coordinate system.

The rotation direction is defined as clockwise positive in positive axis direction.

The rotation order is defined as: omega primary, fi secondary and kappa tertiary.

The ori-file is normally the result of a block triangulation, where the equalisation calculation is carried out with the following settings:

- correction for the rounding of the earth is applied.
- correction for atmosphere refraction is applied.