



***European Spatial Data Research***

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Archiving and geoprocessing  
of historical aerial images:  
current status in Europe

Sébastien Giordano, Clément Mallet

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# GEOPROCESSING AND ARCHIVING OF HISTORICAL AERIAL IMAGES: CURRENT STATUS IN EUROPE

With 25 figures and 3 tables

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## Abstract

More and more countries have digitised or are currently digitising their archives of aerial images. They are a unique and relatively unexplored means to chronicle land-cover information over the past 100 years with very high spatial resolution. Such data provide a relatively dense temporal sampling of the territories. 3D information can even be retrieved since many surveys were performed under photogrammetric conditions. Therefore, many long-term environmental monitoring studies can be based on the analysis of these very rich time series of images.

We have noticed in the last years an increasing number of scientific papers processing archival airborne images. In a timely manner, it appears necessary to evaluate the current status of the archive digitisation process in Europe, up to the distribution policy. This document reports the outputs of a poll carried out by the French National Institute for Geographic and Forest Information (IGN-France) with the help of Swisstopo.

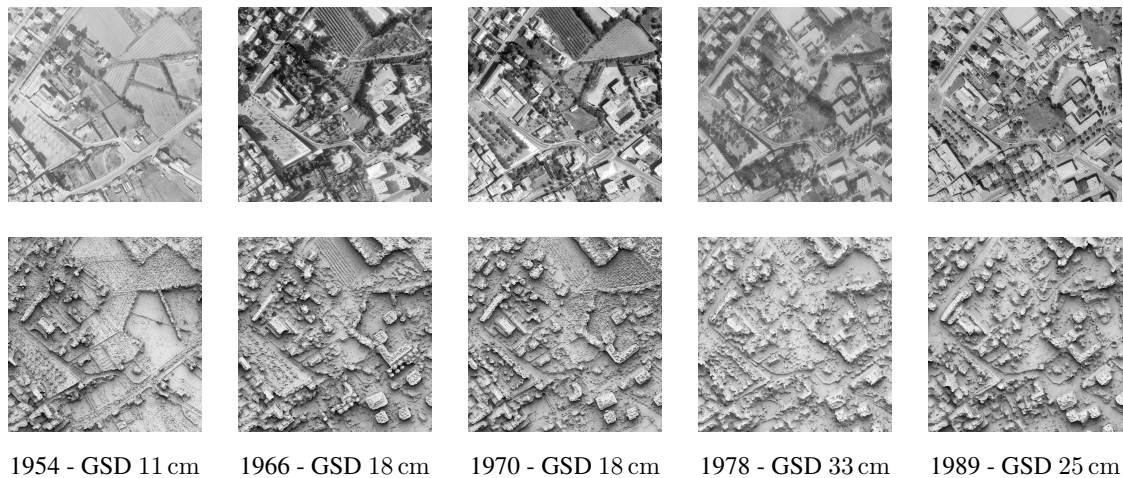


Figure 1: Archival images (France). An example of the inter-date discrepancies observed on 5 different epochs on a 350 m × 350 m area (43° 26' 01" North 6° 44' 23" East). 1st line: orthoimages (GSD=Ground Sampling Distance), 2nd line: Digital Surface Model computed from images (sky shaded view).

## 1. INTRODUCTION

### 1.1. Poll description

A survey called *"State of current practices concerning archival aerial images"* was set up by the French National Institute for Geographic and Forest Information (IGN-France) with the help of Swisstopo in the beginning of 2017. It was distributed through EuroSDR and Eurogeographics members in June 2017 in order to make a state of the art of the current practices concerning archival aerial images. The survey was open during the 2017 summer period. The questions are detailed

below but the full form can be found [here](#).

We are particularly interested in image processing methods for long-time time series of aerial images. In that case, two types of survey images can be part of the time series : (i) analogue aerial photographs (films or plates), that were used before digital photography, and (ii) digital aerial images, directly acquired with a digital camera. They used as a reference for a defined processing method.

| Poll # | Organisation                                                                  | Country             | Name              |
|--------|-------------------------------------------------------------------------------|---------------------|-------------------|
| 1      | Bundesamt für Eich und Vermessungswesen (BEV)                                 | Austria             | Norbert Rudolf    |
| 2      | Kartverket                                                                    | Norway              | Hardy Buller      |
| 3      | National Land Survey of Finland                                               | Finland             | Kimmo Nurminen    |
| 4      | Instituto Geográfico Nacional (IGN-Spain)                                     | Spain               | Jorge Martínez    |
| 5      | Geodetic Institute of Slovenia                                                | Slovenia            | Dalibor Radovan   |
| 6      | Department of Lands and Surveys                                               | Cyprus              | Georgia Papathoma |
| 7      | Land Survey Office of Czech Republic                                          | Czech Republic      | Petr Dušánek      |
| 8      | National Land Survey of Finland                                               | Finland             | Jurkka Tuokko     |
| 9      | Amt für Geoinformation, Vermessungs<br>- und Katasterwesen M-V                | Germany (Schwerin)  | Sven Baltrusch    |
| 10     | Bezirksregierung Köln Geobasis NRW                                            | Germany (Bonn)      | Ulrich Krause     |
| 11     | Landesamt für Geoinformation und Landentwicklung<br>Baden-Württemberg         | Germany (Karlsruhe) | Ulrich Widmann    |
| 12     | Landesamt für Digitalisierung, Breitband und Vermessung                       | Germany (Munich)    | Josef Dorsch      |
| 13     | Swisstopo                                                                     | Switzerland         | Stéphane Bovet    |
| 14     | Lantmäteriet                                                                  | Sweden              | Anders Ekholm     |
| 15     | Landesamt für Vermessung und Geoinformation Thüringen                         | Germany (Erfurt)    | Anett Seela       |
| 16     | Landesvermessung Land Brandenburg                                             | Germany (Potsdam)   | Thomas Opitz      |
| 17     | Main Office of Geodesy and Cartography Documentation                          | Poland              | Monika Michalak   |
| 18     | Institut National de l'Information Géographique et Forestière<br>(IGN-France) | France              | Nathalie Sillard  |
| 19     | Ordnance Survey                                                               | United Kingdom      | Jonathan Holmes   |

Table 1: Participants to the survey, listed by chronological order of responses.

This questionnaire is mainly focused on analogue survey images since it raises important methodological issues. However, some complementary information has also been asked on: (i) digital aerial images, in order to asses the entire time series that could be generated with all aerial images (analogue+digital), (ii) terrestrial (analogue or digital) images that could have been archived along with aerial images. The overall idea was to avoid biasing the survey to questions directly stemming for our analysis of the current status in France.

This form was prepared for the purpose of obtaining up-to-date information relating to supply and demand in the context of digitisation and provision of analogue survey images in Europe. At short-term, a first workshop on analogue image processing (with focus on the photogrammetry and remote sensing aspects) could be organised. In a more long term perspective, we aim to foster partnerships between National Mapping Agencies, research institutes, and other relevant

stakeholders.

The different replies are summarized in the following document, accompanied with the questions. This report covers different aspects: (1) introduction and presentation of the participants to the survey, (2) aerial surveys characteristics, (4) archive status information, (5) digital processing of analogue aerial images, (6) distribution policy of the analogue images as well as derived products, and eventually (7) current and future exploitation of aerial analogue images.

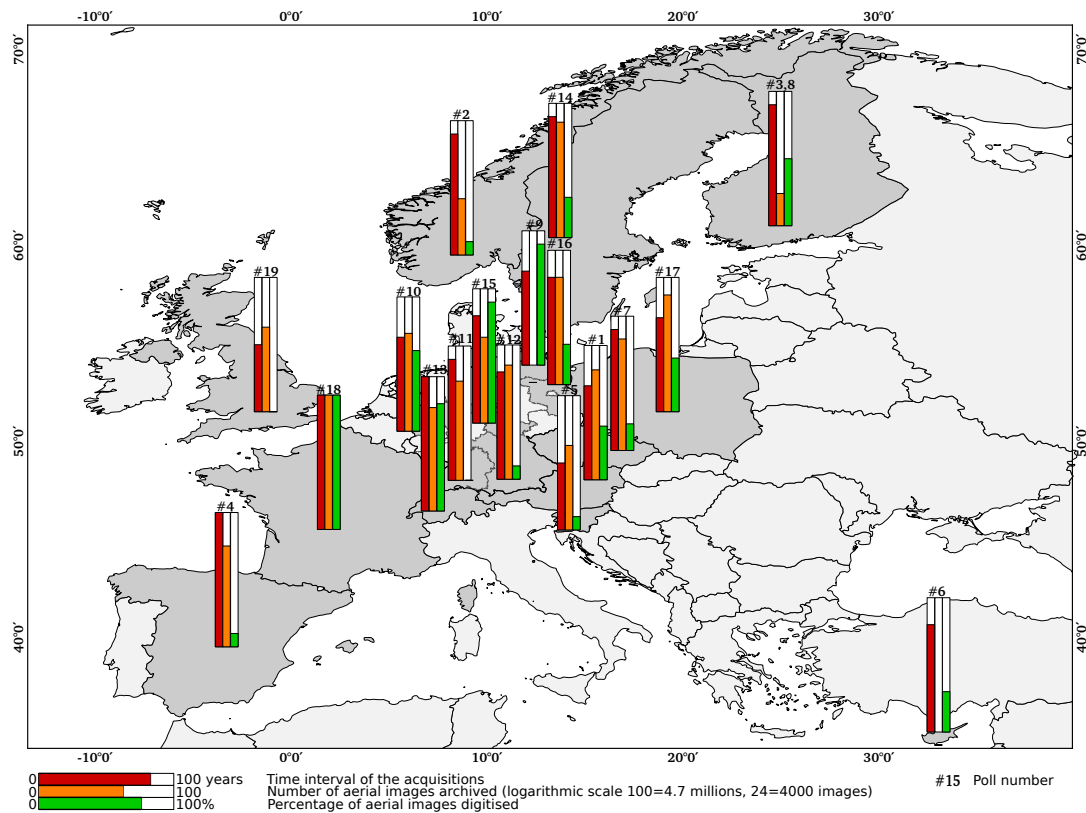


Figure 2: Participating countries to the survey accompanied with additional statistics: **time interval of the acquisition**, **number of images archived**, and **percentage of digitised images**.

## 1.2. Participants

19 organisations from 13 countries replied to the survey. They are detailed in Table 1 and Figure 2. In particular, 6 entities from various Länder of Germany contributed to this survey, as well as two services of the National Land Survey of Finland. We also collected two answers from the National Land Survey of Finland, one focusing on the research activities (Finnish Geospatial Institute). All participants are the authoritative bodies in their respective country/Land related to mapping/cadastral/geodetic/survey purposes.

## 2. AERIAL SURVEYS

### 2.1. Purpose of the aerial image surveys

*For which purpose have these analogue aerial image surveys been carried out ?*

All the participating organisations have acquired in the past **both analogue and digital** aerial images. Figure 3 shows the purpose of these aerial surveys in both cases. Analogue and digital image aerial surveys were mainly dedicated to topographic map generation and update. Photogrammetric products such as orthoimages and Digital Terrain/Surface Models (DTM/DSM) are almost systematically derived from the digital images. However, the generation of these products have little been carried out in the analogue case. 5 organisations have derived analogue orthoimages, and only one organisation have computed Digital Terrain Models with analogue aerial image surveys.

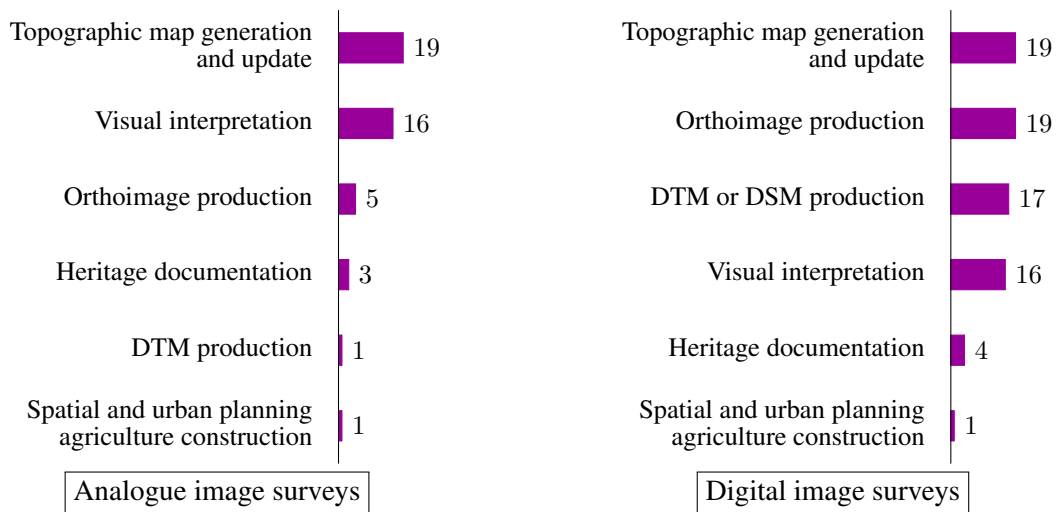
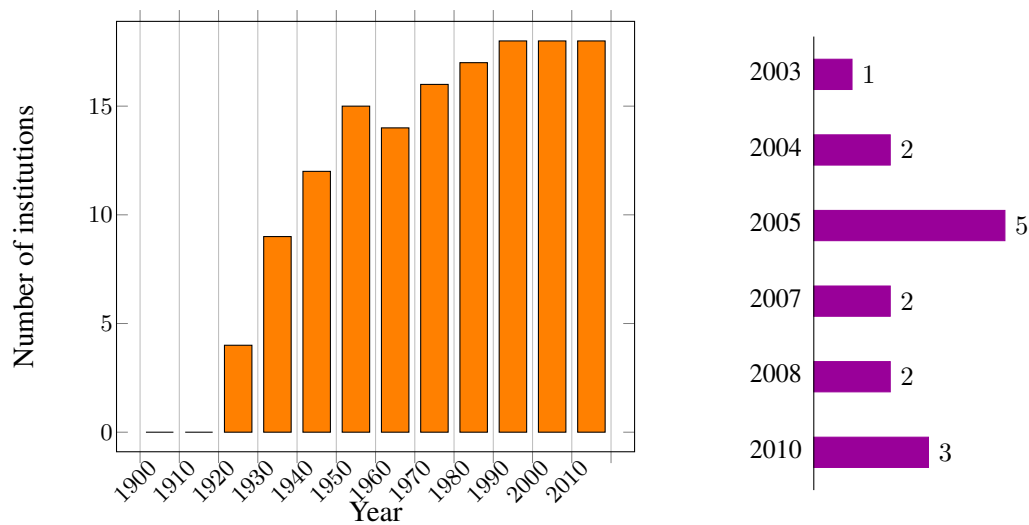


Figure 3: Main purpose of aerial survey acquisitions.

### 2.2. Temporal dimension of the archives: time interval of the acquisitions

*Can you give an estimation of the time interval of the acquisitions ?*

Figure 4 gives the number of organisations that have carried out aerial image surveys (analogue+digital) in the past 12 decades (Figure 4a). It also provides the years where aerial surveys acquisition switched from analogue to digital image acquisition (Figure 4b). Generally speaking, analogue image aerial surveys became a common practice from the 1950s. 79% of the participating organisations have already implemented this acquisition method. Less organisations have acquired images before the 1940s. The first organisations which have performed analogue aerial image surveys are: the National Land Survey of Finland, IGN Spain, Swisstopo, and IGN France (since 1920s), and Kartverket, Land Survey Office of Czech Republic, Landesamt für Geoinformation und Landentwicklung Baden-Württemberg and Lantmäteriet (since 1930s).



(a) Number of institutions having carried out aerial surveys (analogue or digital) in the past 12 decades.

(b) First digital aerial surveys.

Figure 4: Temporal behaviours of analog and digital surveys.

*Can you give an estimation of the total number of digital surveys that have been carried out ?*

The initial question appeared to be ambiguous. Participants either provided the number of aerial surveys / images and the amount of images acquired/archived/digitised. With additional questions we could represent on Figure 5 an estimation of the amount of aerial images acquired based on the answers of 16 organisations. Most of the organisations have hundreds of thousands images (10 organisations). 3 organisations have between 1 and 1.5 millions images (Landesamt für Digitalisierung, Breitband und Vermessung, Lantmäteriet and Main Office of Geodesy and Cartography Documentation). IGN-France has the highest number of image acquisitions (4.7 millions of images).

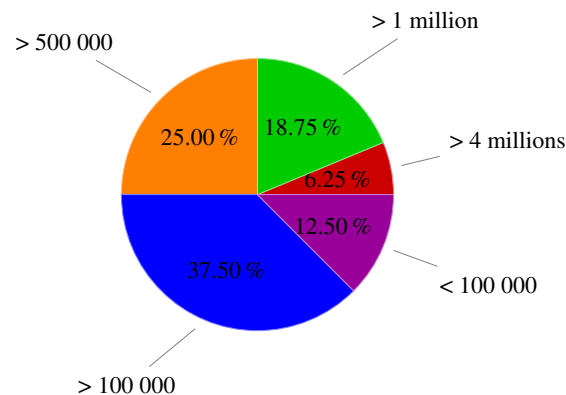


Figure 5: Number of aerial images acquired by the organisations.

### 2.3. Spectral dimension of the archives

*For analogue image surveys, what type of photo medium were used ?  
For digital image surveys, what type of radiometric channels are acquired?*

Figure 6 describes the photo medium that have been used for the **analogue** image surveys. The most common is panchromatic films. All the organisations have indeed acquired panchromatic analogue images. The natural colour images have also been usually acquired (79% of the organisations). Infrared and false colours (*color infrared*) images have only been acquired by approximately half of the organisations. Only 5 of them have first started with glass plates imagery. The result is highly correlated to the start of the aerial campaigns (see Figure 4a): The very first organisations to have performed aerial image surveys started with glass plates media. This statement on the spectral diversity in the type of analogue images is not valid in the digital case: 100% of the organisation (19) have acquires blue, green, red and infrared digital aerial images.

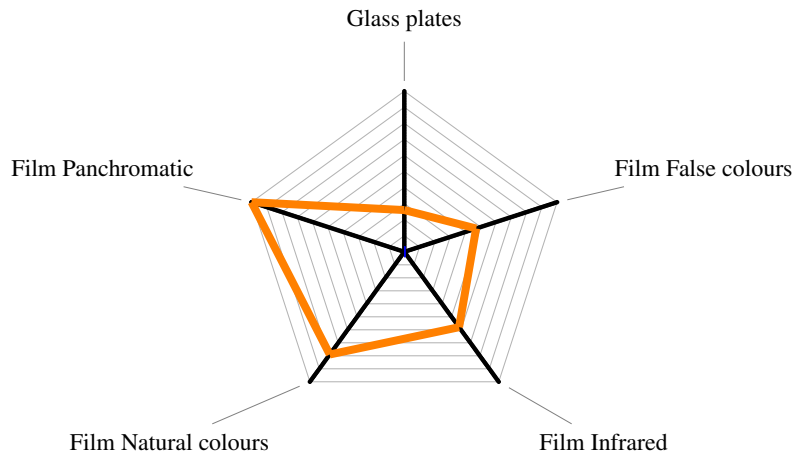
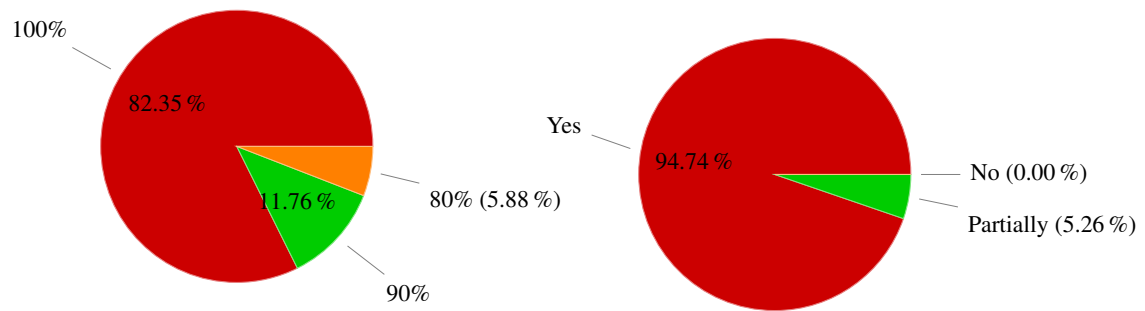


Figure 6: Percentage of organisations that acquired aerial images with the various media and spectral bands (middle: 0% → outside: 100%).

### 2.4. Photogrammetric approach

*Among all the analogue images acquired, what is the part (%) of nadir images (vertical) compared to oblique aerial images?  
Were the surveys carried with a photogrammetric approach ?*

On the one hand, most of the analogue image surveys acquired by the organisations consist of nadir (vertical) images (Figure 7a): 100% of the organisations have carried out such vertical image surveys. On the other few oblique images have been acquired. In Figure 7a, 82% of the organisations have only acquired vertical images, 12% have 90% of vertical images (along with 10% of oblique images), and 6% of the organisations have 80% of vertical images (along with 20% of oblique images). The analogue image surveys were predominantly carried out with photogrammetric approaches (sufficient conditions (overlapping) to produce 3D information).



(a) Distribution of the organisations according to the ratio "number of nadir/oblique" images. (b) Percentage of organisations that acquired data with a photogrammetric approach.

Figure 7: Photogrammetric approach for aerial surveys.

### 3. THE CHARACTERISTICS OF ANALOGUE AND DIGITAL PHOTOGRAMMETRIC SURVEYS

As shown in Figure 7b, almost all the organisations carried out analogue image aerial surveys with photogrammetric approaches. This section describes in details their main characteristics: overlapping conditions, spatial and spectral resolution, and temporal sampling.

#### 3.1. Overlapping conditions

*Was there a common parameter for forward/side overlap (overlap between photographs along the same/adjacent flight line)?*

Figure 8 shows that similar overlapping conditions were used by the different organisations. Concerning forward overlapping (overlap between photographs along the same flight line), 16 of the 18 organisations that have answered the poll used a 60% forward overlapping parameter. Swisstopo (Switzerland) (mostly 90% of forward overlapping) and the Main Office of Geodesy and Cartography Documentation (Poland) have acquired analogue images with very high forward overlapped conditions. Likewise, 20% or 30% side overlapping (overlap between photographs on adjacent flight line) have traditionally been used. Swisstopo (mostly 60% of side overlapping) and Landesvermessung Land Brandenburg are the organisations with the more important analogue image survey side overlapping.

The forward overlapping characteristics are roughly the same for the digital image surveys. Most frequently, 60% forward overlapping parameter is adopted (11 organisations). 5 organisations are using at least 80% forward overlap: namely, BEV, Geodetic Institute of Slovenia, Landesamt für Digitalisierung, Breitband und Vermessung, Ordnance Survey and Swisstopo. Side overlapping conditions are slightly greater for the digital case: 2 organisations with 20% side overlap, 11 organisations with 30%, 2 organisations with 40%, and 2 organisations with 50%. Landesamt für

Digitalisierung, Breitband und Vermessung, Swisstopo (50%) and BEV, Landesvermessung Land Brandenburg (40%) are the organisations with highest side overlapping conditions for digital image aerial surveys.

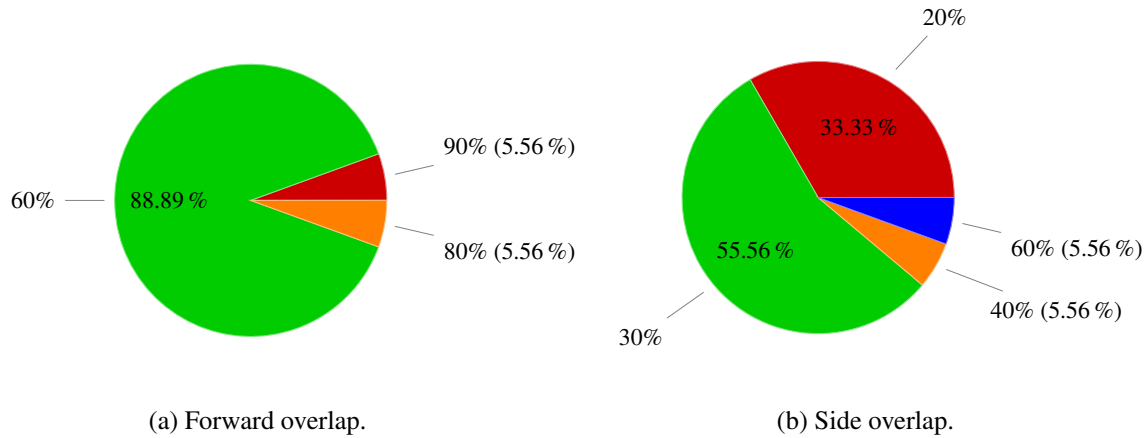


Figure 8: Analogue image survey overlapping characteristics. Distribution of the organisations according to the forward and side overlaps.

### 3.2. Assessment of the homogeneity between all the surveys (analogue+digital)

*Among all the analogue image surveys that have been acquired, can you give an estimation of the homogeneity of the following parameters: spatial resolution, spectral channels, and temporal sampling?*

The objective of the section is to assess if the aerial surveys (analogue+digital) of each participating organisation have homogeneous or heterogeneous characteristics. Among all the analogue image surveys that have been acquired, we asked the organisations to give an estimation of the homogeneity of the three main following parameters: spatial resolution, spectral channels, and temporal sampling. For example, with a spatial resolution ranging between 5 cm and 5 m depending on the application, homogeneity is considered as *very low*. If mostly panchromatic surveys were carried out (e.g., 85%), the spectral homogeneity can be rated as *high*. Depending on the area (e.g., urban areas), if aerial survey are carried out every 3 years or every 15 years, the temporal sampling homogeneity can be considered as *very low*. Results of such a categorization are provided in Figure 9.

Figure 9 shows that the analogue image time series can be considered as rather heterogeneous data considering the spatial, spectral and temporal dimensions. This kind of time series of images can genuinely be assimilated as multi-modal data acquisition. More than half of the organisations consider the spatial, spectral, and temporal homogeneity of their archives as *very low*, *low* or *intermediate*. Based on the *high* or *very high* answers, the spatial dimension tends to be in overall the less heterogeneous dimension, whereas the temporal sampling is considered as the

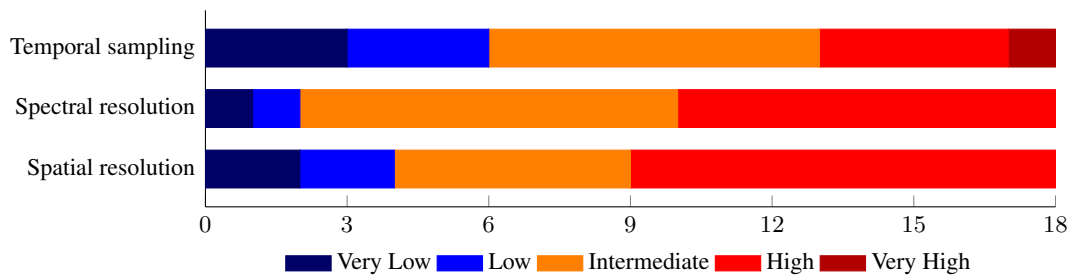


Figure 9: Assessment of the homogeneity of the spatial, spectral, and temporal characteristics of the analogue aerial surveys.

most heterogeneous characteristics of the archives. The following sections present in details the characteristics for the spatial and temporal dimensions, respectively.

### 3.2.1. Spatial resolution of the analogue image surveys

*Can you give an estimation of the range of the resolutions of the analogue surveys ?*

We asked the different organisations to give a rough value of the range of the spatial resolutions of the aerial surveys. The estimation of the spatial resolution (Ground Sample Distance) takes into account the scale of the aerial survey and the digitisation resolution. In the analogue case, what has been estimated as *high spatial image survey* are more rigorously *large-scale image surveys*, where greater details are displayed on the photographs. We chose to present an estimation of the spatial resolution that can be better understood by non-experts. It is also more easily to compare with the characteristics of digital aerial image surveys.

It was found that organisations having declared homogeneous spatial characteristics (*high homogeneity* in Figure 9) have principally acquired high spatial resolution images. Here are example of complementary information given concerning spatial resolution: *20 cm to 25 cm, 25 cm, 10 to 30 cm*).

The organisations that have declared heterogeneous spatial characteristics (*intermediate to very low* in Figure 9) mainly have spatial resolution that vary between 10-20 cm to 1 m (values obtained in the poll: *10 cm to 1 m, 25 cm to 1 m, 25 cm to 1 m, 30 cm to 60 cm, 10 cm to 50 cm, 20 cm to 40 cm, 20 cm to 80 cm, 10 cm to 1.5 m and 20 cm to 1 m*). The only organisations that had carried out surveys with very high spatial resolutions (<5 cm) are IGN-France, Kartverket (Norway) and the Main Office of Geodesy and Cartography Documentation (Poland).

### 3.2.2. Temporal sampling of the analogue image surveys

*Can you give an estimation of the range of the temporal sampling of the analogue surveys ?*

The estimation of the homogeneity of the range of the temporal sampling of the surveys is rather different considering the different organisations. 8 of them have acquired the analogue and digital

image surveys with very regular temporal sampling. The temporal sampling for analogue surveys of the organisations are 4 years, 5 years (4 organisations), 6 years (2 organisations), and 10 years. Most frequently, there is an improvement of the temporal sampling when going from analogue to digital images surveys : most frequently a 3-year temporal sampling is now a common trend for the digital image surveys.

The other organisations declared not to have clear temporal acquisition pattern for the analogue image surveys. They insisted on the temporal heterogeneity. The temporal sampling can vary from 5 to 15-20 years depending on the area. Here are some of the analogue temporal sampling information given by the organisations: 3 to 5 years, 3 to 10 years, 5 to 20 years, 3 to 7 years, 5 to 10 years, 2 to 8 years. Again, the temporal sampling becomes much more regular with the use of digital image surveys.

### 3.3. National specifications

*Were the surveys lead by National specifications or on-purpose?  
Can you tell us if a standardisation of the acquisition parameters (spatial, spectral, temporal) have appeared at a certain date?*

Figure 10 shows that 89% of the organisations use national guidelines (spatial, spectral, and temporal resolutions) for their aerial image surveys. For most of the organisations, these guidelines have appeared along with switching from analogue to digital image survey or even very recently ( $\sim [2005 - 2015]$ ). Some organisations have initiated standardisation procedures in the era of analogue image surveys: since 1981 (Main Office of Geodesy and Cartography Documentation - Poland), since 1987 (Landesamt für Digitalisierung, Breitband und Vermessung) or since 1994 (Landesamt für Vermessung und Geoinformation Thüringen).

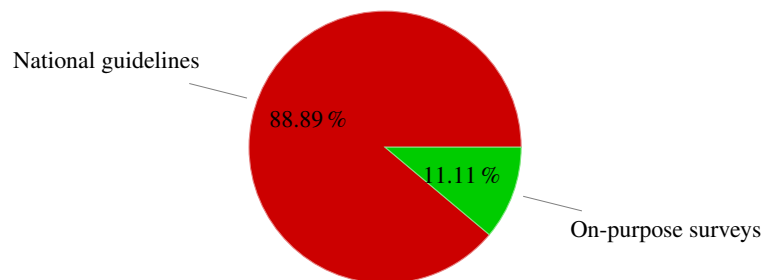


Figure 10: Specification design for the aerial surveys.

## 4. ARCHIVES STATUS INFORMATION : ANALOGUE AND DIGITAL SURVEYS

The previous sections describe the characteristics of the aerial image surveys. In this section, information is gathered in order to assess if the images and other relevant information that has been archived (storage of the physical support for analogue photographs, computer archiving for digital images).

#### 4.1. Physical support archiving: analogue images and relevant metadata

*Can you give an estimation of the percentage of analogue surveys archived ?  
Are the archives centralized by a unique national body or dispatched in several public/private bodies?*

It was found that 100% of the organisations (19) have archived both analogue and digital images. Figure 11a shows that for the analogue image surveys the archiving rate is rather complete. 72% of the organisations have archived all the analogue image surveys acquired, whereas the other 28% consider that more than 90% have been archived. Most frequently (Figure 11b), the archives are centralised by a unique national body (89% of the organisations). IGN-Spain and Ordnance survey (UK) have dispatched archives in several public/private bodies.

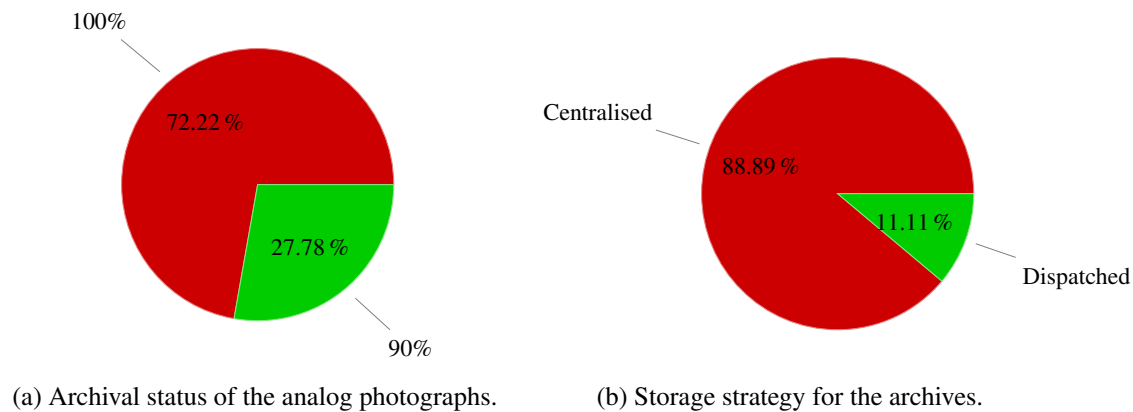


Figure 11: Status of the aerial analogue image survey archival process.

*What information concerning the analogue surveys have been archived ?  
Has your country started digitisation of the physical supports (films or plates) ?  
Can you give an estimation of the percentage of the analogue surveys that have been digitised (%)*

If the photographic films have been almost completely archived, this is not the case for metadata related to the aerial surveys. Figure 12 shows whether photographs, flight plans, image orientation, and camera calibration reports have been *not*, *partially* or *fully archived*. Flight plans and camera calibration certificates have been partially archived. In both cases, half of them have been fully archived. The rest is partially archived. The image orientation information appears to be a piece of information that has been more rarely archived.

#### 4.2. Digitisation of analogue images and metadata

*Has your organisation started digitalization of the physical supports (photographic films/plates)?  
Can you give an estimation of the percentage of the analogue surveys that have been digitised (%)*

Figure 13a shows that a large majority of organisations (89%) have started the digitisation of their physical supports (photographic films or plates). The two organisations that have not yet started

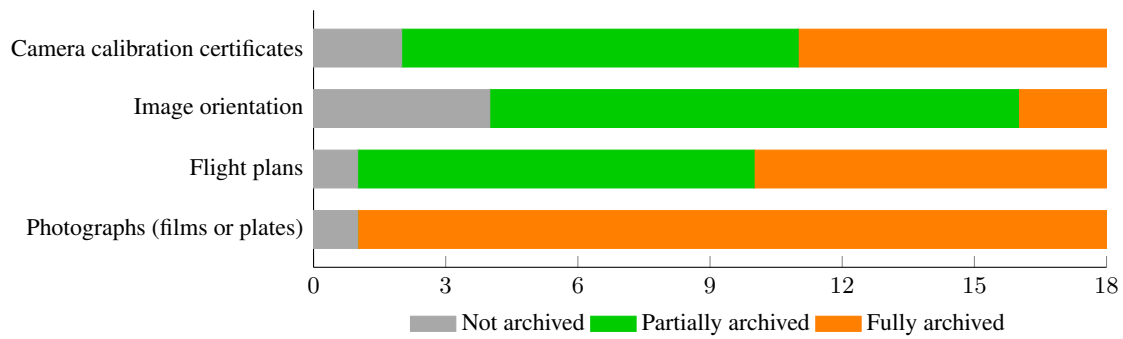


Figure 12: Data archived with the analogue surveys.

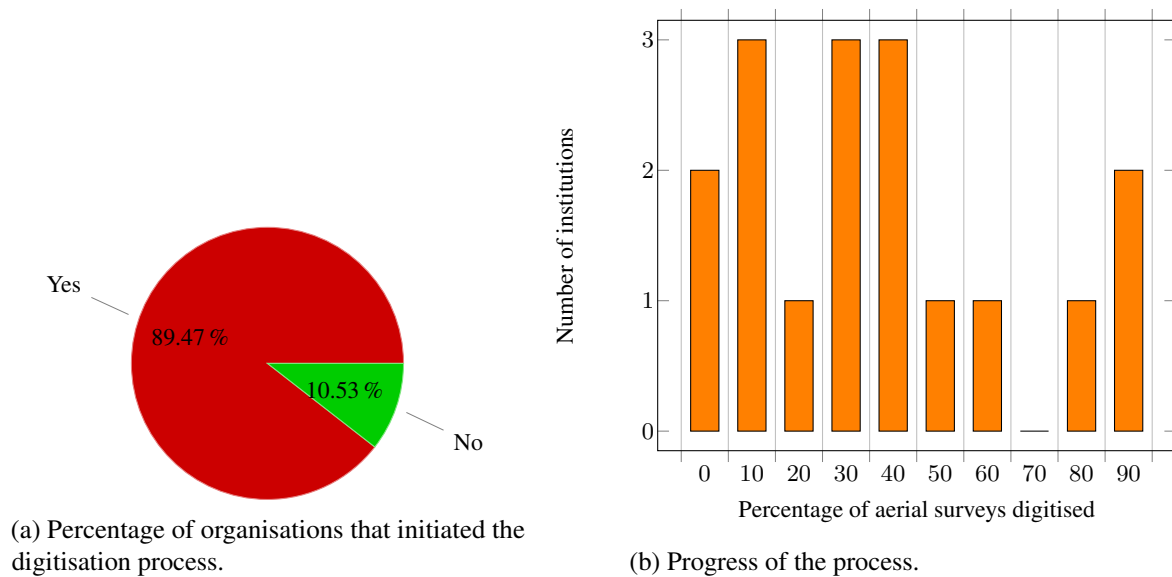


Figure 13: Status of the digitisation process.

are the Ordnance Survey (UK) and the Landesamt für Geoinformation und Landentwicklung Baden-Württemberg. Figure 13b exhibits that this digitisation process is most frequently not yet complete. A large majority of organisations have processed less than 50% of their archives of analogue images (Figure 13b). The digitisation rate is highly heterogeneous between the organisations. The most advanced organisations are IGN-France, Landesamt für Vermessung und Geoinformation, Amt für Geoinformation, Vermessungs- und Katasterwesen M-V, and Swisstopo.

*Do you intend to digitise these analogue surveys?  
Within which time frame do you intend to digitise your analogue surveys?*

89% of the organisation target to digitise their analogue images (Figure 14), whereas 2 organisations have no intention to do full digitisation: the Department of Lands and Surveys (Cyprus) and the

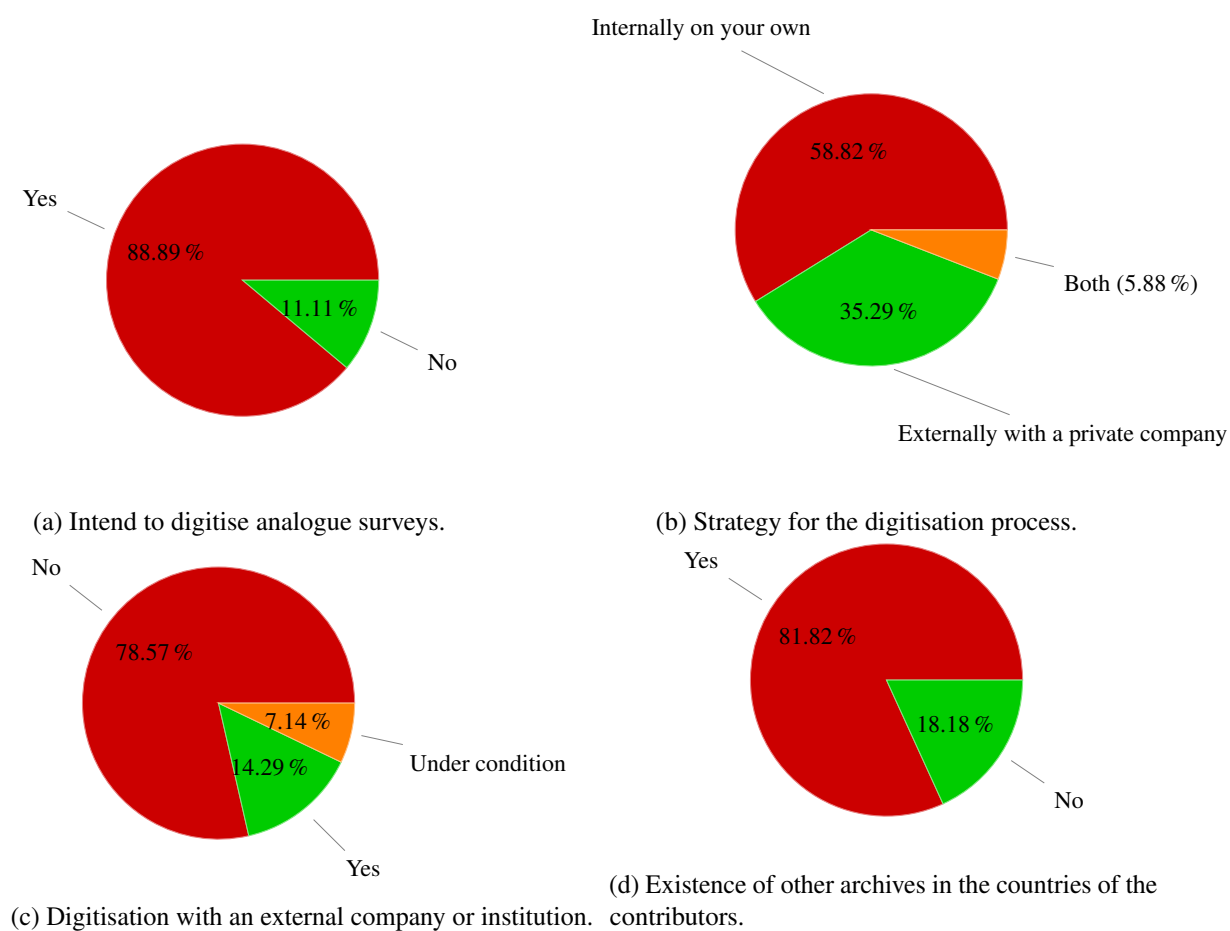


Figure 14: Status and strategy on the digitisation process.

Ordnance Survey (UK). The Lands and Surveys department does not have a full digitalization program and has rather opted for on-demand digitisation. Many organisations think they will succeed in full achievement. The target date for completion of the digitisation is planned, depending on the organisations, between 2020 and 2030. However, other contributors think full digitalisation might not be possible and have some limitations. These limits concern: (i) the availability (maintenance) of the photogrammetric scanning techniques, (ii) the available budget.

*How do you digitise your analogue surveys ?*  
*How and why do you digitise your analogue surveys on your own?*  
*Why do you digitise your analogue surveys via an external provider ?*  
*Can you envisage having your original analogue surveys digitised by an external provider at another location abroad ?*

Most often, the digitisation is performed internally by the organisations (Figure 14b). This can be easily explained: many of these organisations hold high precision digital photogrammetric scanners (often a Leica DSW 700/DSW600, Zeiss/Leica Photoscan), accompanied by the relevant know-how and staff. The organisations insist on the use of photogrammetric scanner. The high scanning precision (12.5-14 $\mu$ m) is mandatory to be able to produce orthoimages. Another reason for internal digitisation is to avoid too much manipulation of old films and plates. The degradation process is a major concern for all contributors. Some organisations had to use an external provider. This stems from the fact that they do not own photogrammetric scanners or since they want to speed up the process. There is however no will to perform the digitisation abroad (Figure 14c).

*The digitisation process deals with which kind of data ?*

Figure 15 shows the type of data that is planned to be digitised. Obviously, all the organisations that express the intention to digitise their analogue image survey, digitise the photographs (films or plates). Flight plans and camera calibration certificates, even if they have been partially archived (Figure 12), are intended to be kept by a majority of organisations. The image orientation files are less often planned. However, 7 organisations have archived this information and/or plan to digitise them in the future.



Figure 15: Data involved in the digitisation process (for 17 institutions).

#### 4.3. Digital image archives status

*Can you give an estimation of the percentage of digital aerial surveys archived ?  
Are the archives centralised by a unique national body or dispatched in several public/private bodies?*

*What information concerning the digital aerial surveys have been archived ?*

The digital aerial image surveys have been massively archived (Figure 16a). The computer archiving is mostly centralised by a unique national body. As opposed to the analogue image data, relevant metadata (flight plans, camera calibration certificates and image orientation files) are fully archived in the digital image case (Figure 17).

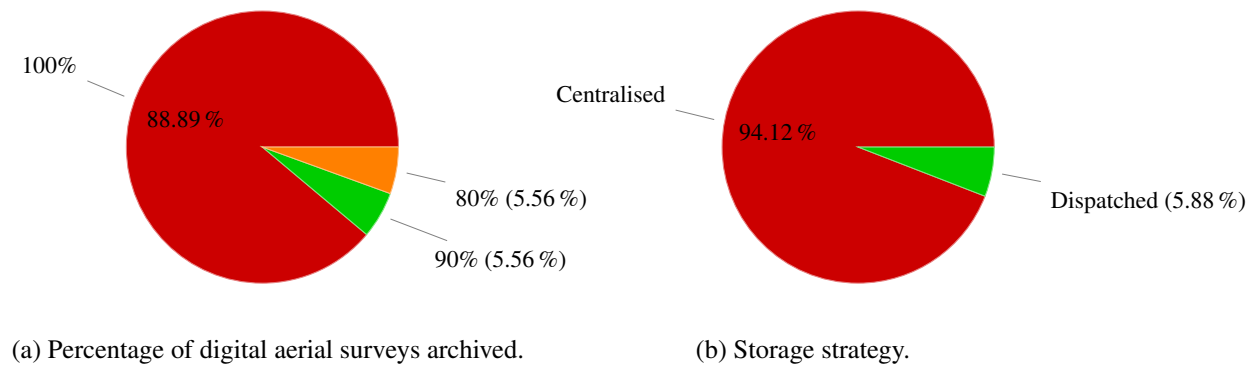


Figure 16: Status of digital image archives.

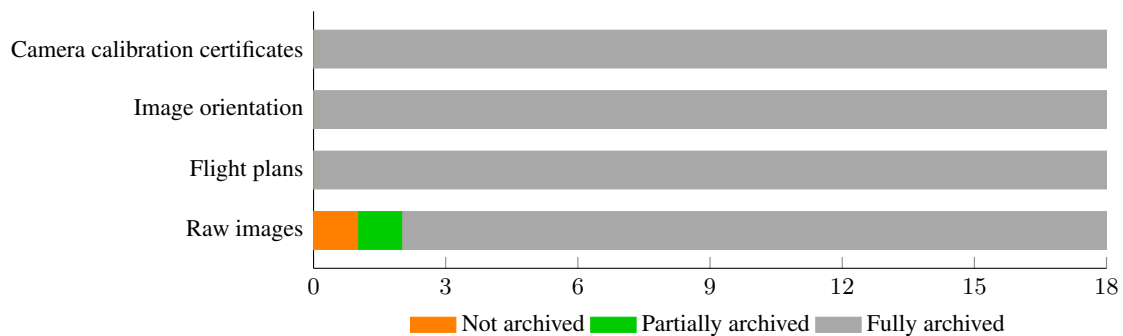


Figure 17: Information stored with the digital surveys.

#### 4.4. Terrestrial surveys

*What type of terrestrial surveys were carried out in your country ?  
For which purpose have these analogue terrestrial image surveys been carried out ?*

The aim of this section was to find out if aerial image archives (analogue or digital) are accompanied with terrestrial images. It was found that a majority of organisations (60%) have not

performed terrestrial image surveys (Figure 18). 7 organisations have acquired terrestrial images. It mainly concerns analogue images: BEV, Department of Lands and Surveys Cyprus, Geodetic Institute of Slovenia, IGN-France, IGN-Spain, Kartverket, Swisstopo. These images have mostly been acquired for topographic map generation and update.

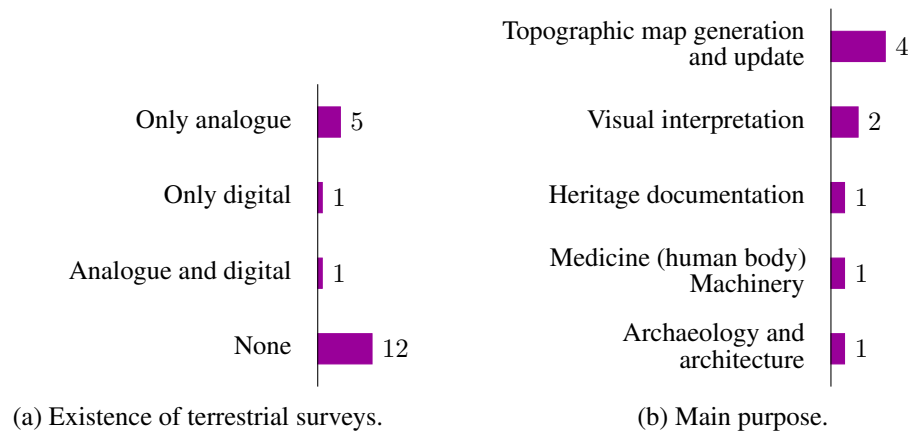


Figure 18: Nature and purpose of surveys of terrestrial images.

*Can you give an estimation of the time interval of the acquisitions ?*

We can notice that the time interval of the acquisition of terrestrial images is very long. This type of data source, similarly to aerial images, has been used since the 1920s (Figure 19). This is genuinely complementary to airborne surveys.

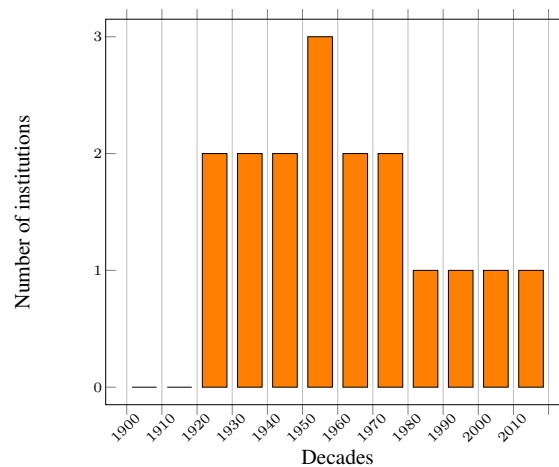


Figure 19: Histogram of time interval for terrestrial acquisitions.

The number of terrestrial images contained in the archives is usually very low (<500). Only Swisstopo has a very large number of terrestrial images in their archives (~80,000). This highlights a systematic use with airborne images.

## 5. DIGITAL PROCESSING OF ANALOGUE AERIAL IMAGES

As opposed to aerial digital image surveys, generating photogrammetric or remote sensing products (i.e., orthoimages, Digital Surface Models, land cover maps, ...) from aerial analogue images is very challenging. The objective of this section is to assess whether initiatives have been taken by the contributors so as to derive such products from the aerial analogue images.

### 5.1. Photogrammetric products (orthoimages, Digital Surface Models)

*Are you aware of initiatives on analogue aerial image processing?  
Can you give information of the tools that have been used for data processing?  
Does a database of permanent Ground Control Points is available for archival image orientation ?*

All the organisations (Figure 20) have taken initiatives to produce orthoimages with analogue aerial images. The method seems to be based on photogrammetric approaches as 15 of 18 organisations have also performed image orientation on analogue aerial images. Only half of the organisations have heard about initiatives to produce Digital Surface Models (DSM) with analogue aerial images. For that purpose, mainly commercial softwares are used, but no unique solution: Photo Modeller, Erdas Imagine, Adam stations, Orima, Trimble Inpho, Match-AT, Ortho-Box, Match-T-DSM, SURE, PCI Geomatics, Hexgon/Z/I Imaging, Image Station, DTMaster Stereo, Erdas, Dephos, Vexcel UltraMap, Integrgraph ISAT, BAE Systems SOCET SET. To perform the image orientation task, 63% of the organisations have set up a permanent Ground Control Points database.

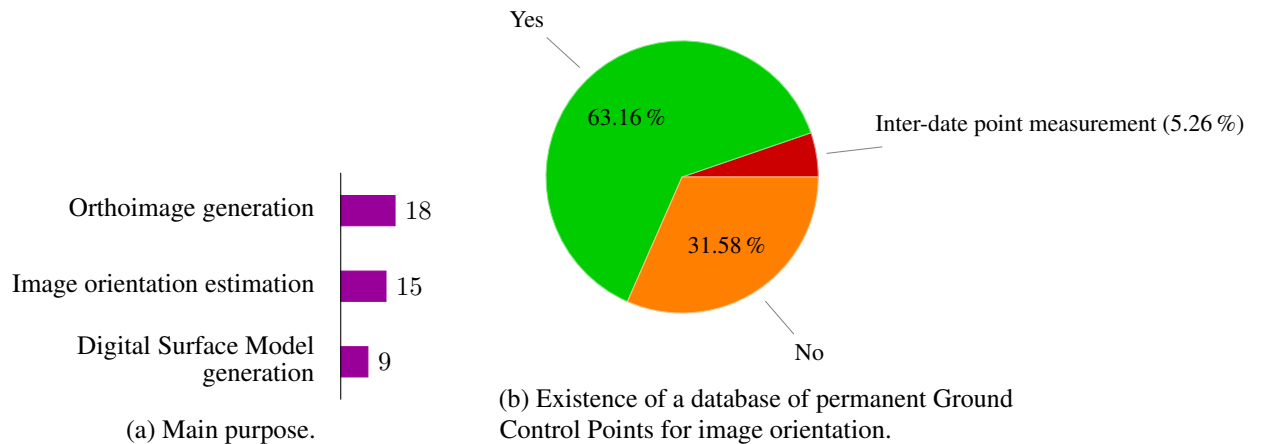


Figure 20: Photogrammetric exploitation of archival aerial images.

## 5.2. Remote sensing products

*Are you aware of thematic exploitation of these products? Which applications?*  
*Do some of these studies use automatic remote sensing methods?*  
*Can you give information of the existing tools for remote sensing exploitation of the digitised analogue images ?*

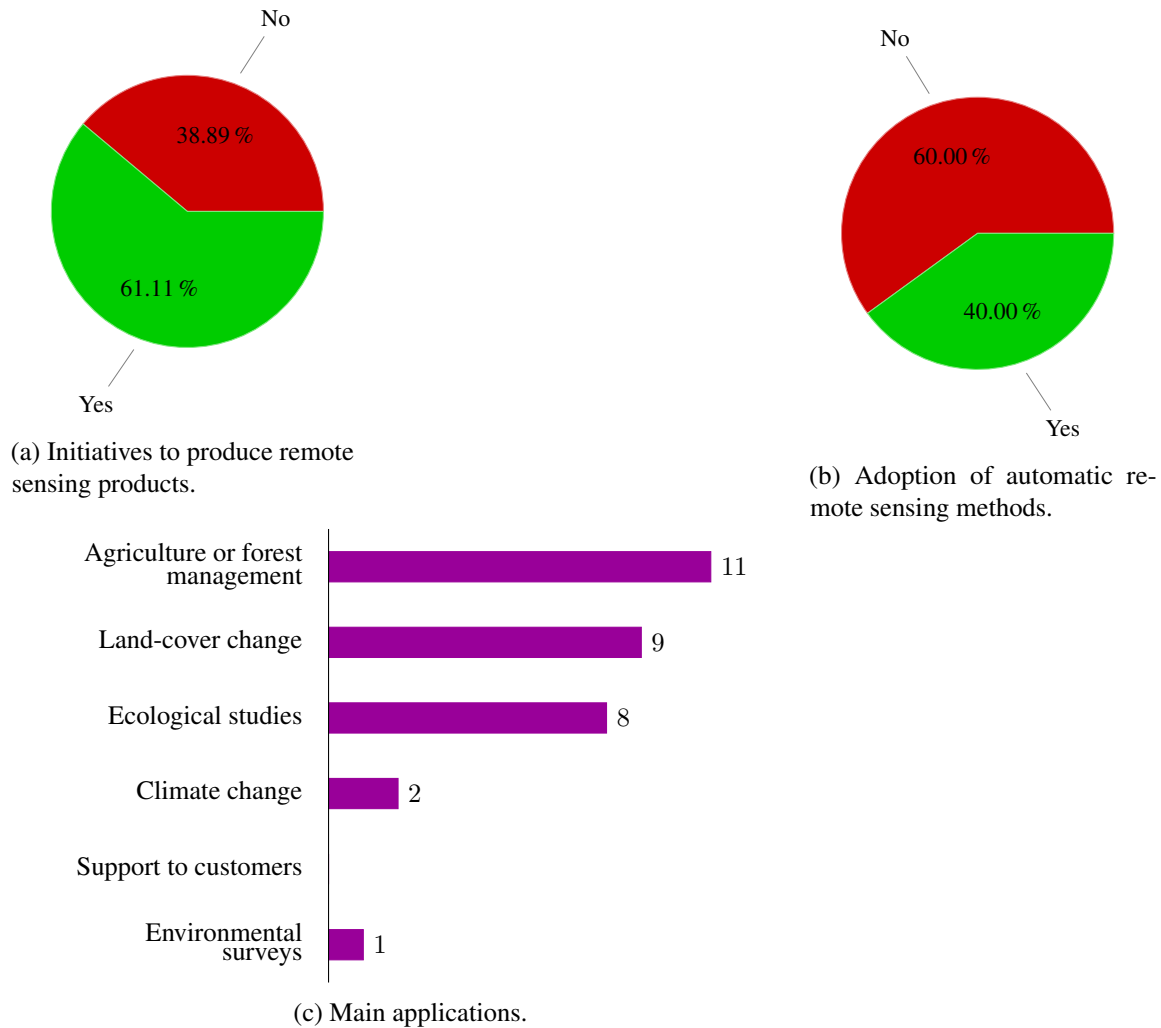


Figure 21: Status of the derivation of remote sensing products from archival data.

Such as for the generation of photogrammetric products, a majority of the organisations have experienced the production of thematic products with the aerial analogue image surveys (Figure 21a). However, this work has mainly been carried out with visual interpretation techniques (Figure 21b).

The organisations that have experienced automatic remote sensing product generation are: National Land Survey of Finland, Geodetic Institute of Slovenia, Land Survey Office of Czech Republic, Amt für Geoinformation, Vermessungs- und Katasterwesen M-V, Landesamt für Geoinformation und Landentwicklung Baden-Württemberg. For that purpose, both remote sensing and photogrammetric tools were used: Photo Modeller, Erdas Imagine, Adam stations, photomod, ArcGIS, ZI-imaging, TRIMBLE Inpho, ERDAS Geosystems. Again, no consensus emerges from the poll. These remote sensing products have mainly been produced for agriculture or forest management, land cover change detection, and ecological studies (Figure 21c).

## 6. DISTRIBUTION OF THE IMAGES, ORTHOIMAGES AND DSM GENERATED WITH ANALOGUE PHOTOGRAPHS

The aim of this section is to assess the distribution policy of the scanned analogue images and their derived products. It both concerns the visualisation (Section 6.1) and the distribution policy (Section 6.2).

### 6.1. Visualisation platforms

*Does a visualization platform exist for these products generated with analogue photographs?  
Can you name and link such platforms if they exist ?*

Figure 22 shows which kind of data is proposed for visualisation. This is mostly orthoimages (14 organisations). 11 organisations propose to visualise also the analogue images. The survey metadata are rarely proposed for visualisation (4 organisations). Table 2 lists all the links to the organisation visualisation platforms.

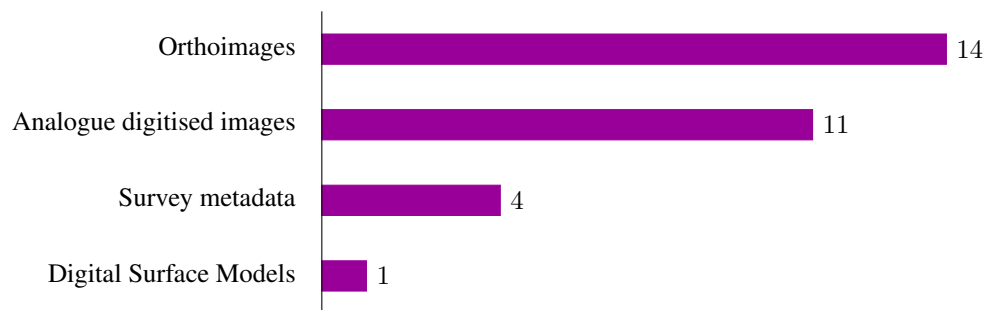


Figure 22: Existence of a visualization platform, categorized according to the various potential metadata.

### 6.2. Distribution policy

*What is the condition of access for the products generated with analogue photographs ?*

Figure 23 provides information about what type of products generated with analogue photographs can be distributed and under which condition (we defined the following categories: *free*,

| Poll # | Area           | First year   | Link                                                                                                                                     |
|--------|----------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------|
| 2      | Norway         | 1937         | <a href="http://www.norgeibilder.no">www.norgeibilder.no</a>                                                                             |
| 4      | Spain          | 1929<br>2004 | <a href="http://fototeca.cnig.es">fototeca.cnig.es</a><br><a href="http://www.ign.es">www.ign.es</a>                                     |
| 6      | Cyprus         | 1963         | <a href="http://eservices.dls.moi.gov.cy">eservices.dls.moi.gov.cy</a><br><a href="http://www.geoportal.gov.cy">www.geoportal.gov.cy</a> |
| 7      | Czech Republic | 1937         | <a href="http://lms.cuzk.cz">lms.cuzk.cz</a>                                                                                             |
| 8      | Finland        | —            | Human customer service (internal use)                                                                                                    |
| 10     | Germany (Bonn) | 1996         | <a href="http://www.tim-online.nrw.de">www.tim-online.nrw.de</a>                                                                         |
| 13     | Switzerland    | 1979<br>1926 | <a href="http://map.geo.admin.ch">map.geo.admin.ch</a><br><a href="http://www.swisstopo.admin.ch">www.swisstopo.admin.ch</a>             |
| 14     | Sweden         | 1960         | <a href="http://geolex.etjanster.lantmateriet.se">geolex.etjanster.lantmateriet.se</a>                                                   |
| 18     | France         | 1919<br>1950 | <a href="http://remonterletemps.ign.fr">remonterletemps.ign.fr</a><br><a href="http://www.geoportail.gouv.fr">www.geoportail.gouv.fr</a> |

Table 2: Link to visualisation platforms. *First year* indicates the date of the first images that can be viewed.

*partially charged, charged*). Approximately 80% of the organisations distribute orthoimages and analogue digitised images. This service is most of the time charged. Metadata are by contrast more often free for distribution. Very few organisations propose services to distribute Digital Surface Models. We list the Geodetic Institute of Slovenia (Human customer Service) and the Main Office of Geodesy and Cartography Documentation of Poland.

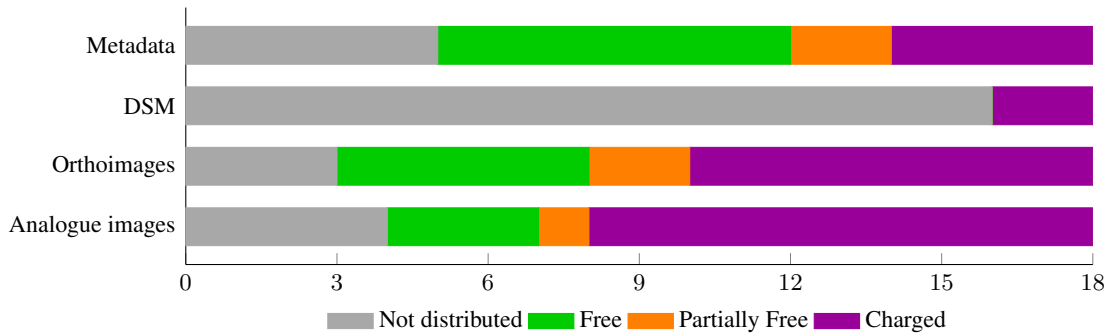


Figure 23: Condition of access for the products generated with analogue photographs.

The distribution is either made with human customer services or with dedicated platforms. Table 3 shows the type of the distribution performed by the organisations and the link toward the distribution platforms when they exist.

| Poll # | Area             | First year | Link                                                                     |
|--------|------------------|------------|--------------------------------------------------------------------------|
| 1      | Austria          | 1949       | <a href="http://www.bev.gv.at">www.bev.gv.at</a>                         |
| 4      | Spain            | 1956       | <a href="http://centrodedescargas.cnig.es">centrodedescargas.cnig.es</a> |
| 5      | Slovenia         | —          | Human customer service                                                   |
| 6      | Cyprus           | 2014       | <a href="http://eservices.dls.moi.goc.cy">eservices.dls.moi.goc.cy</a>   |
| 8      | Finland          | —          | Human customer service (internal use)                                    |
| 13     | Switzerland      | 1926       | <a href="http://www.swisstopo.admin.ch">www.swisstopo.admin.ch</a>       |
| 14     | Sweden           | 1930       | Human customer service                                                   |
| 15     | Germany (Erfurt) | 1943       | <a href="http://www.geoportal-th.de">www.geoportal-th.de</a>             |
| 18     | France           | 1919       | <a href="http://remonterletemps.ign.fr">remonterletemps.ign.fr</a>       |

Table 3: Link to distribution platforms. *First year* indicates the date of the first images that can be downloaded.

*Existence of web/on-line services for data processing?  
Name and link to the webservice ?*

Some organisations have set-up web/on-line services for users dedicated to analogue data processing (Figure 24). These services are mainly interactive. The Department of Lands and Surveys (Cyprus) ([dlsportal](http://dlsportal), [geoportal](http://geoportal)) and the Landesvermessung Land Brandenburg have developed services to interactively produce orthoimages. The Landesamt für Geoinformation und Landentwicklung Baden-Württemberg and the Landesvermessung Land Brandenburg ([GeobrokerBrandenburg](http://GeobrokerBrandenburg)) also propose tools in order to interactively generate DSM, and Kartverket and Landesvermessung Land Brandenburg ([GeobrokerBrandenburg](http://GeobrokerBrandenburg)) for interactive land cover mapping. BEV ([www.bev.gv.at](http://www.bev.gv.at)) is the only organisation working on fully automatic services for orthoimage generation.

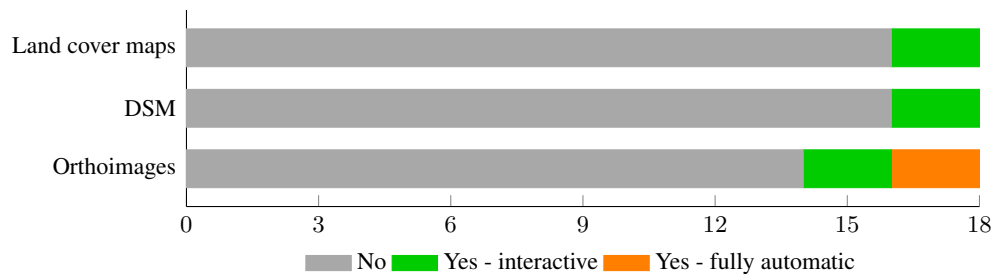


Figure 24: Existence of on-line data processing services.

## 7. CURRENT AND FUTURE EXPLOITATION OF AERIAL ANALOGUE IMAGES

### 7.1. Current and future use of analogue aerial surveys

*Is there any current use of these analogue aerial survey ?*

Figure 25a shows that there are already multiple outreach possibilities with archival airborne images. These answers are in line with the main thematic applications mentioned in the literature (see Section 9). Exploitation cases can be roughly categorized into three main themes: (1) general public applications (communication and education); (2) ecological studies; (3) change detection, that can take on great importance for authoritative bodies (public policy assessment and legal affairs in real estate are cited).

Same topics are cited for the forthcoming use of archival images. They do not represent the full range of conceivable thematic applications. They are bound to be extended when a larger number of images will be digitised and made available to research teams, end-users, and other practitioners. A literature review shows that cultural heritage, archaeology, geomorphology, land-cover, and in particular shoreline and river changes are currently the main topics at stake (see Section 9).

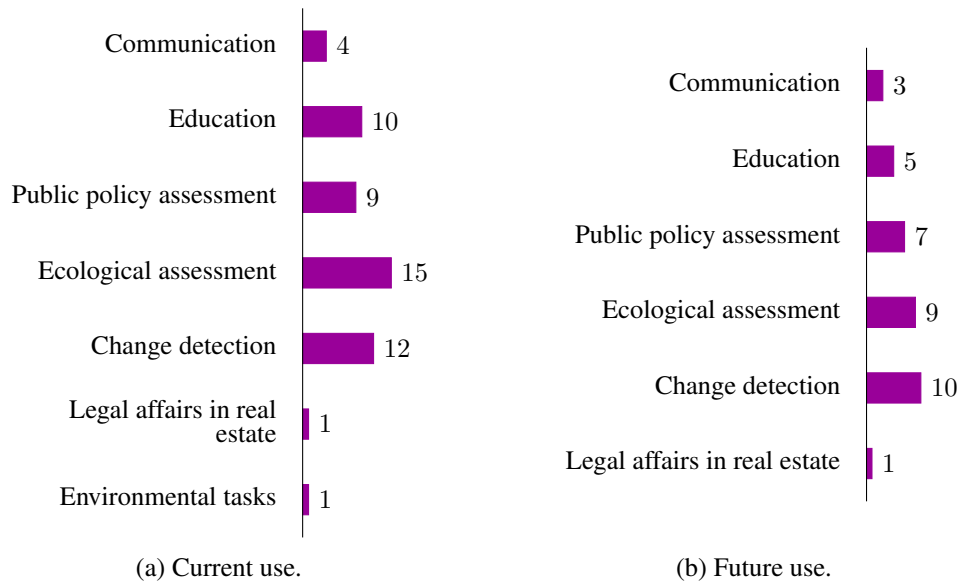


Figure 25: Outreach activity of archival images.

### 7.2. Current bottlenecks

*What do you think are the biggest issues using these analogue aerial images to produce photogrammetric/remote sensing products ? What is missing to develop such workflows ?*

It was asked to the organisations to identify the main bottlenecks today when using these analogue aerial images in order to produce photogrammetric/remote sensing products.

First, the most common problem raised by the organisations is the **production of orthoimages** with analogue aerial images (7 organisations). Three different difficulties were noticed : (i) **missing metadata** information (camera calibration), (ii) the availability of **Ground Control Points (GCPs)**, and (iii) the **lack of automatic methods** for the generation of orthoimages. Missing camera calibration files make the use of autocalibration techniques compulsory. This can introduce some problems in the image orientation step. Finding GCPs on old analogue images is noticed as difficult and very time consuming. It requires a lot of manual work for orthoimage production. As a result, the process is described as very time demanding and costly. Moreover, there is a lack of efficient workflows and commercial software for historical aerial photo process. All contributors consider it fundamental to quickly generate orthoimages. The fact that orthoimages are not available is obviously a limitation for the use of such kind of remote sensing data source.

Another main issue is raised by the organisations: the **digitisation** process at itself. The fact that for many organisations digitisation is incomplete is an obstacle to start producing photogrammetric/remote sensing products. In some cases, scanning techniques are described as not precise enough to generate such products. Therefore, again, no solution has been set up so far to cope with remaining spatial discrepancies and propose a fully automatic pipeline for 2D and 3D data registration.

Finally, it has been noticed that even if there is arising awareness for archival aerial images, clear and beneficial use cases are missing. Moreover, there are not enough users/customers for this type of information, despite an obvious attractiveness from the general public. As a result, the development of rapid/cost reasonable methods to produce photogrammetric/remote sensing products is slowed down.

## 8. CONCLUSION

This report is a first step towards the identification of the main contributors in the digitisation and diffusion process of archival airborne images in Europe. The survey shows that many initiatives have been taken so far. Data, including orthoimages and Digital Surface Models, can be provided to thematic end-users. The impact of archival data is really high: historical data is indeed an invaluable input for a large number of applications in many environments. However, generating such by-products remains a tedious task since no fully automatic photogrammetric pipeline has been developed so far both by research teams and industrial companies. Solutions exist but they are consistent only for limited geographical extents and/or require a significant amount of human input. In order to foster the adoption of archival aerial data for the automatic chronicling of territory dynamics at large scales, main efforts should now be put on:

- Making explicit the main common issues towards the definition of an automatic and fast photogrammetric pipeline, and in particular orthoimages;
- Generating in-between first datasets over the largest period of time in order to stimulate first thematic use-cases;

- Organizing workshops in order to gather people interested in methodological and thematic developments;
- Refining such survey with additional institutions and questions dedicated to practitioners. Important questions and bottlenecks related for instance to the scanning process and subsequent artifacts are missing. Eventually, remaining errors and inaccuracies will be corrected and solved.

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Currently, there is no state-of-the-art related to the status and methodological challenges related to the automatic processing of archival aerial images: georeferencing process, orthoimage generation, Digital Surface Model generation, radiometric correction, land-cover mapping, time series image analysis. Similarly, no overview paper about the existing and potential thematic exploitation of such datasets has been proposed so far. Thus, here, we list some relevant papers related to the subtopics mentioned above. The aim is not to provide a comprehensive overview of the literature.

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