IPERION CH

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D.08.06 Two digital research resources available for open access on the web and one working resource

Lead Author: Marika Spring (NG)

With contributions from: Joseph Padfield, Marta Melchiorre, Joanna Russell, Cristina Giancristofaro, Jørgen Wadum, David Buti, Anna Vila, Johanne Nielsen, Astrid Grinder-Hansen, Nora Schlag, Heike Stege, Jeanine Walcher, Maite Jover de Celis, María Dolores Gayo García, Wim Fremout, Magdalena Iwanicka, Mikkel Scharff

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Abstract

This deliverable for task 4 in WP8, the Digital Documentation Research Work Package, is of the nature of a demonstrator. Therefore the main deliverables are the two digital research resources available for open access on the web (see URLs below) and one working resource for internal collaborative project use (see description below) rather than this document. The web resource should be accessed through a Google Chrome browser for the best experience. This document lays out the principles and some main points about the work carried out in constructing these research resources during the period since the last deliverable.

Digital resource 1: The database of preparation layers in sixteenth-century Italian paintings is now available at https://research.ng-london.org.uk/iperion/. Digital resource 2: a beta version of an extended database of preparation layers in paintings that includes northern European seventeenth-century paintings and Italian seventeenth-century paintings in addition to those from Italian sixteenth-century paintings is available at https://research.ng-london.org.uk/iperion-tmp/. A working resource for internal collaborative project use is also presented, as is its application for a digital sampling point system at the National Gallery, and for documenting points of interest for a technical examination at the British Museum.

It is intended to continue to use and to expand the content of these databases and resources in the future. The structures underlying the research resource are also re-usable, in that they can form a suitable template for research resources on completely different subjects. The intention is that after the end of IPERION-CH, some further work will be undertaken to make the code suitable for inclusion on GitHub and therefore accessible for use in the future.

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Authors (Partner)				
Responsible Author	**Name**	Marika Spring	**Email**	marika.spring@ng-london.org.uk
	Partner	National Gallery	**Phone**	00 44 20 7747 2827

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Introduction

The first deliverable in Work Package 8, Task 4, described the aims and the background to the development of the work in this task. This will not be repeated here, since this final deliverable is of the nature of a demonstrator rather than a report. Therefore the main deliverables are the two digital research resources available for open access on the web (see URLs below) and one working resource for internal collaborative project use (see description below). The web resource should be accessed through a Google Chrome browser for the best experience.

This document lays out the principles and some main points about the work carried out in constructing these research resources during the period since the last deliverable (as noted above, please see D8.03 for a more detailed discussion of content and database fields etc).

Digital resource 1: The database of preparation layers in sixteenth-century Italian paintings is now available at https://research.ng-london.org.uk/iperion/.

Digital resource 2: a beta version of an extended database of preparation layers in paintings that includes northern European seventeenth-century paintings and Italian seventeenth-century paintings in addition to those from Italian sixteenth-century paintings, available at https://research.ng-london.org.uk/iperion-tmp/.

Working resource for internal collaborative project use; a digital sampling point system. This was explored as a building block for future more extensive digital systems for documentation of paintings examination. It allows sample points to be recorded digitally on a full high-resolution image (with all the benefits that brings over current practices where they are marked on a print of a colour image), and then linked to digital images of the associated paint cross-sections together with text descriptions of them. In terms of functionality, automatic generation of a report is included. This system is now in day-to-day use inside the National Gallery. During IPERION-CH work has been carried out to investigate the process of installing it at a different institution. The code will eventually be made available through GitHub.

Some of the work for the two digital resources has already been presented at conferences, and it is intended that two papers will be published in the proceedings of the conference *Mobility Creates masters – discovering artists' grounds 1550-1700* (Copenhagen, 13–14 June 2019), Archetype Publications, expected 2020. In addition, the work of WP8 Task 4 has generated several further collaborations outside IPERION-CH, which will be pursued in the immediate future and are highly likely to see other international projects using the database developed in IPERION-CH as a repository for information being gathered in these external projects on the preparation layers of paintings. The National Gallery Scientific Department is also intending to expand the data in the database through gradually adding data from other periods and places. The overall hope is that the database should become the main research resource for preparatory layers in paintings over a wide time period and broad geographical area.

The structures underlying the research resource are also re-usable, in that they can form a suitable template for research resources on completely different subjects. The intention is that after the end of IPERION-CH, some further work will be undertaken to make the code suitable for inclusion on GitHub and therefore accessible for use in the future.

Digital resource 1: The database of preparation layers in sixteenth-century Italian paintings

Overview of structure and content

The rationale behind the development of the structure and content of the database was already described in the first deliverable for this task (D08.03). During the intervening period substantial work has been carried out developing the actual web interface and populating it with content. The results of this endeavour are on display in the database itself, so only a brief overview will be given here. It is also intended that this will be published in more detail in the postprints of the conference *Mobility Creates masters – discovering artists' grounds 1550-1700*, where the database was presented in June 2019.

This building of the research resource has been very much a collaborative effort – with a whole team at the National Gallery and with other IPERION-CH partners, especially CATS, Copenhagen, the Doerner Institut, Munich and the Prado Museum, Madrid. The individual collaborators are listed as co-authors on this document. Some external institutions – notably Gemäldegalerie, Dresden and Rijksmuseum, Amsterdam – have also contributed a small amount of data.

The development of painting on a coloured surface was possibly the most important and fundamental change in painting technique to have occurred during the sixteenth century in Italy, where it happened earlier than elsewhere in Europe. This was one motivation for choosing this subject for the pilot research resource. The second was that an extensive set of gathered data already existed to build on, in the form of tables describing the preparatory layers and their composition on just over 130 National Gallery paintings, published in the 1998 IIC Dublin Congress. This work has been updated during the course of the IPERION-CH project and gradually inserted into the online database. New data accumulated over the intervening years was also included. Another extremely valuable aspect of this pilot was the process of including data from other institutions, which also involved discussions as to the best way to structure and present it. Issues such as comparability and standard descriptions of data were also addressed.

The database is entered through a front page where registration and a login is required. Signing in takes the user to the webpage (see below), which offers the opportunity to enter directly into the database, and also through clicking on 'The Project' on the top bar, the opportunity to find out more about the project, both in terms of content of the database and about its development and the software tools that were used. This part of the database is currently only a holding page with the content structure, but will be populated with text and other information once the publications mentioned above have been prepared, as these will be used as a basis for this content.

On entering the resource the default view is a set of cards (see below), each corresponding to a painting, and showing on the front the main metadata of the painting, and in red the main preparation class designated for the preparatory layers. In the IIC Dublin Congress paper certain divisions were made between the results, divided according to a broad category of colour, the advantage of these being less dependence on very exact definitions of colour. They are also more likely to bring out general trends in terms of development of coloured grounds when searching by time and place.

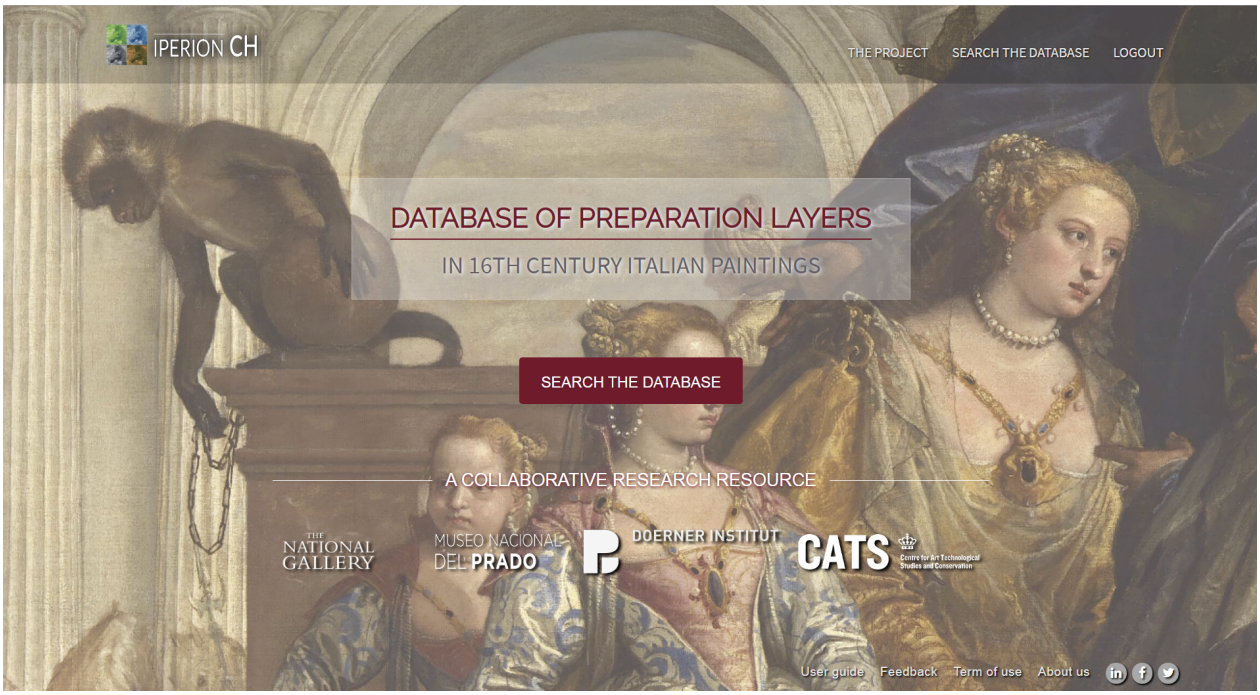


Fig.1. The front page of the research resource after the login.

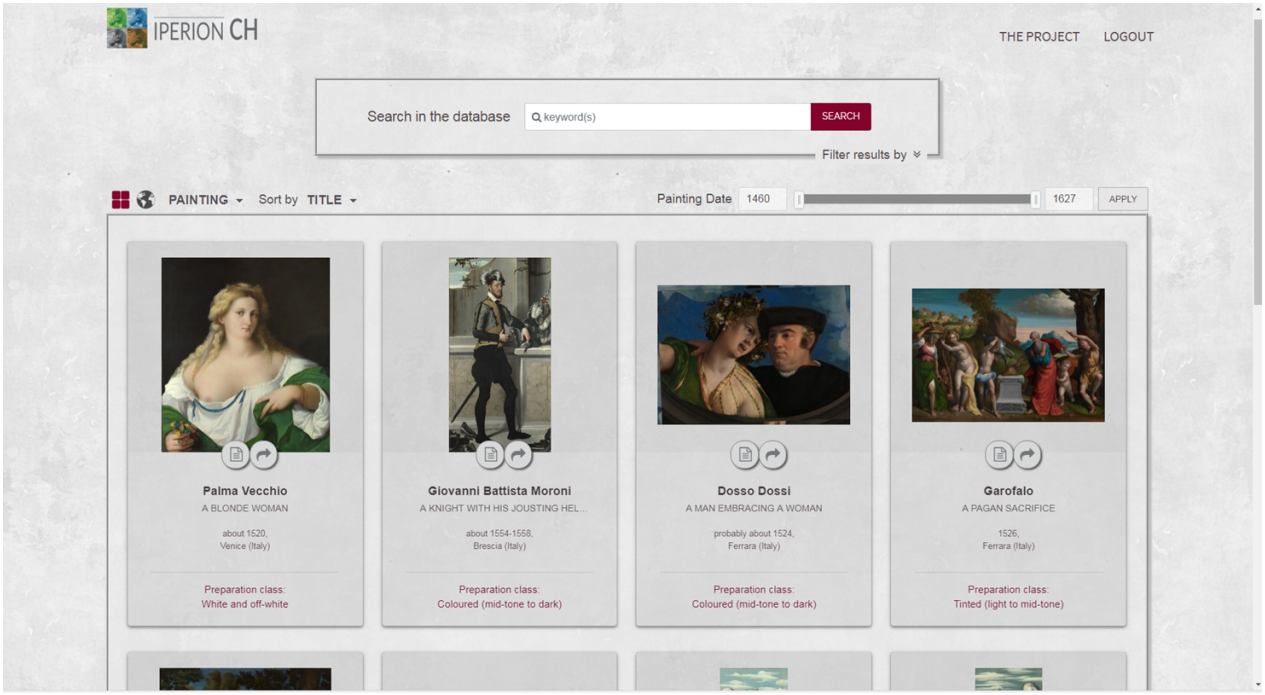


Fig. 2 Default view after entering the database, with a set of cards sorted by painting

The cards can be sorted by title, artist or date, this last option often being very useful. At the top right there is a slider showing the date range of the paintings displayed, which can be moved to show only paintings within a selected date range. A range of other filters are also available at the top of the page. Here, for example, the search can be limited to paintings within a colour category, or geographical area, or containing a certain pigment.

Turning the cards over shows a summary description of the ground layers of that painting (fig. 3).

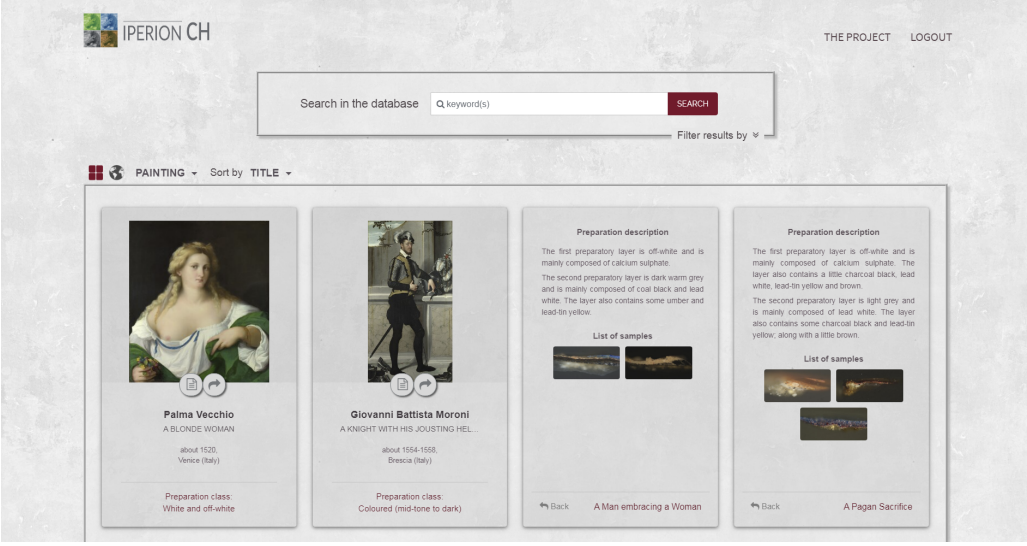


Fig. 3 The back of the painting cards showing the summary of the preparation layers

Following the same concept there is also a set of cards showing all the samples in the database, so that it is easy to compare the preparation layers directly.

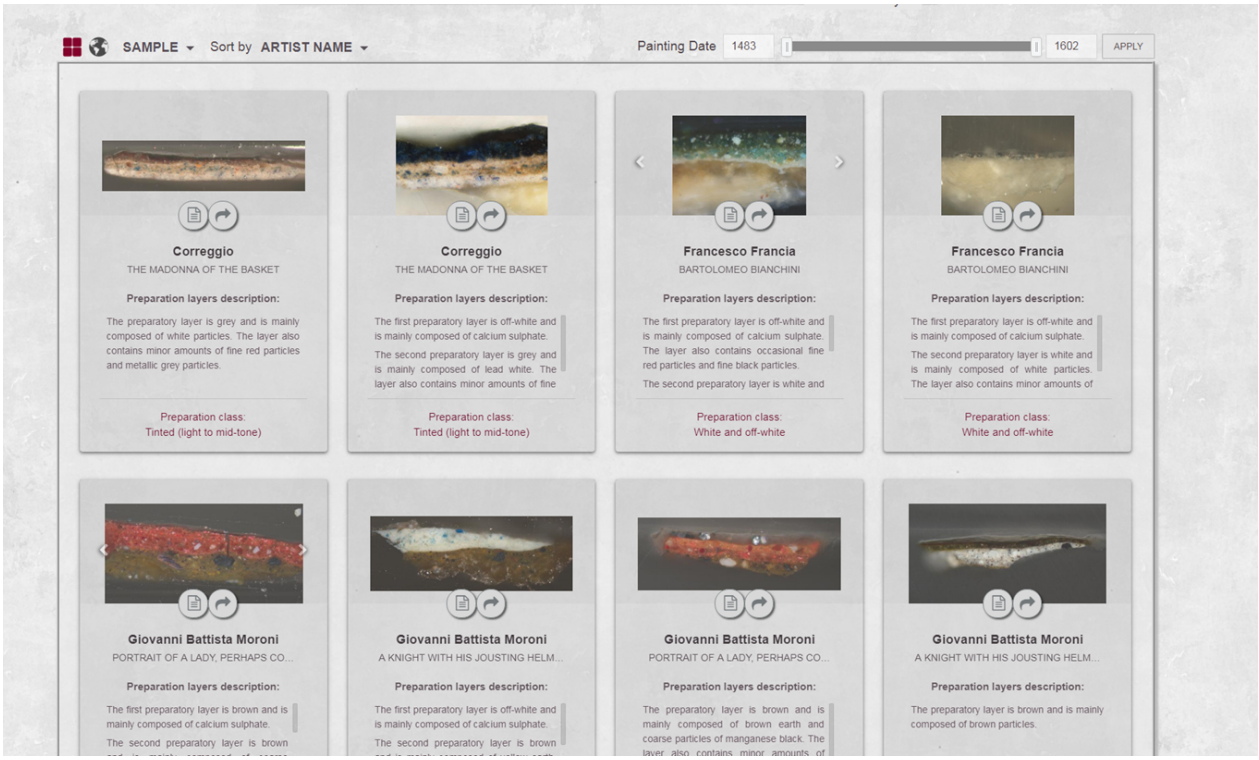
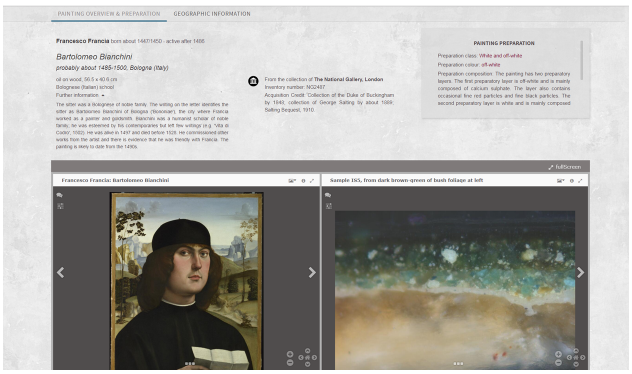


Fig. 4 The sample cards

Clicking on the painting image takes the user to the 'painting page' (figs 5 and 6), where there is the full detailed information on the paintings and the samples, as well as high resolution images together in a zoomable viewer based on the IIIF compliant Mirador software.



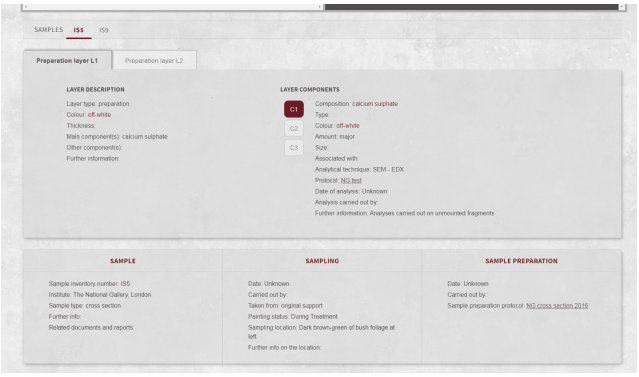


Fig 5, left – the top half of the 'painting page'; Fig 6 – right – the bottom half of the 'painting page'

Clicking on the 'globe' icon at the top left displays all the paintings, or a narrower group from a search result, on a map, with dots of different colour depending on the colour category. A bar at the left gives a list of the paintings that are displayed, which updates when zooming in to give only those that are visible (fig. 7, below).

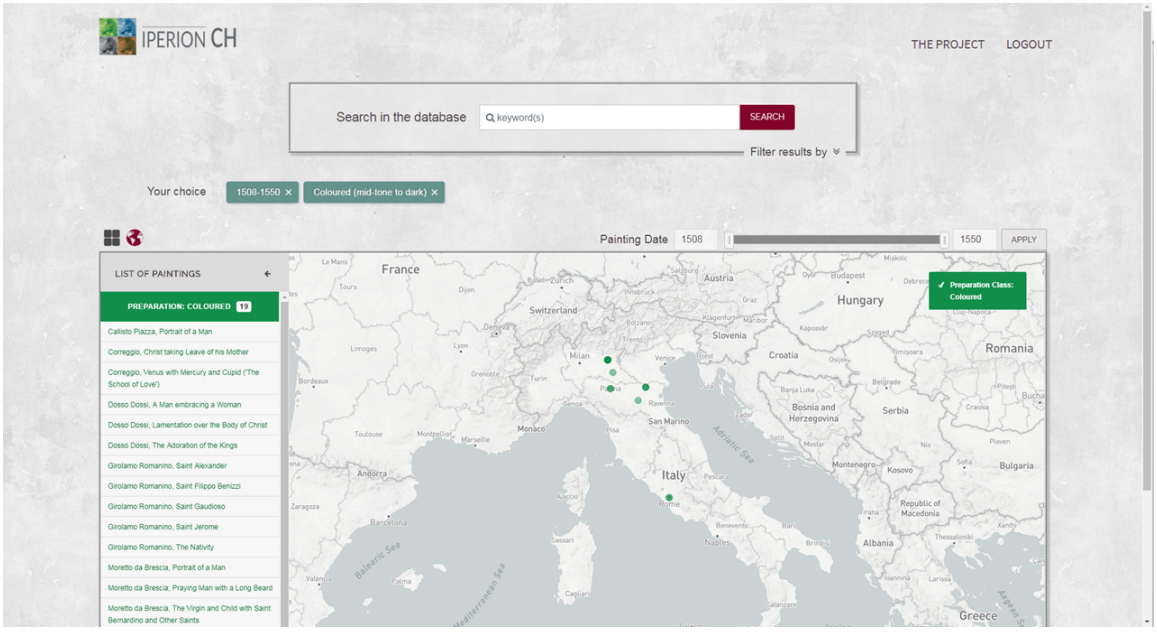


Fig. 7 visualisation of search results on a map

The above description gives an overview of the basic architecture of the database. A sense of the full capabilities and content can be gained from exploring the resource itself. Gradual improvements have been made as any issues have been noticed, and this will no doubt be a process that continues into the future.

143 sixteenth century Italian paintings so far are included in the database, of which 116 are from the National Gallery, 22 are from CATS, five from the Doerner Institut, four from the Gemaldegalerie, Dresden and two from the Museo del Prado.

Imaging protocols for cross-sections

As already described in the last deliverable, the construction of a database that includes images of cross-sections from different partners requires the images to be reasonably comparable in terms of colour.

In order to improve this aspect, a round robin exercise was started, asking the partners to take images of the same three samples and to record their imaging protocols in a template form which describes the sample preparation procedure, the imaging system and the day-to day protocol used for taking the photographs, including any regularly used software corrections. The protocols recorded by the first 5 partners (NG, CATS, PRADO, DI-BS, KIK-IRPA) who participated to this exercise are reported in Appendix 1.

Since the last deliverable was submitted, two additional partners (NCU and KADK) participated in the exercise, with results confirming that the most important factors for obtaining comparable images are the white balance step and the adjustment of the exposure settings. The protocol recorded by NCU is also reported in Appendix 1.

A second round of photography was carried out by two partners (NG and CATS), after adjusting their protocols to make the images consistent with those made by other institutions. The updated protocols of these two institutions are reported in Appendix 2.

The principal adjustment made to the method used at the NG was to change the type of surface used for the white balance, by replacing the white opaque glass slide with a X-rite Color Checker Gray Balance photographic card. This decision was made after comparing the images of a white spectralon (Labsphere 99% reflectance) taken under the same conditions (maximum light intensity, fixed frame dimension, fixed exposure settings, no colour off-set, brightness -0.51, contrast 1.02, gamma 0.45), but using different surfaces for white balancing: the X-rite Color Checker Gray Balance photographic card; the white opaque glass slide; the white spectralon itself. As shown in the images below (Fig. 8), the photograph taken after performing the white balance on the X-rite card is closer to white than that taken after performing the white balance on the opaque glass slide, making the Color Checker card a better choice for 'white balancing'. In addition to this visual evaluation, Nip2 was used to measure the average colour of the images of the white Spectralon, using the procedure described in the *Colour measurement experiments* section of the previous deliverable. The values measured on the image taken after white balancing on the white opaque glass were: L* 85, a* 3.1, and b* 6.7. The values measured on the image taken after white balancing on the X-rite card were: L*87, a*0.9, b* 0.8. In the latter result both a* and b* values are closer to zero, the point that would correspond to a neutral grey.

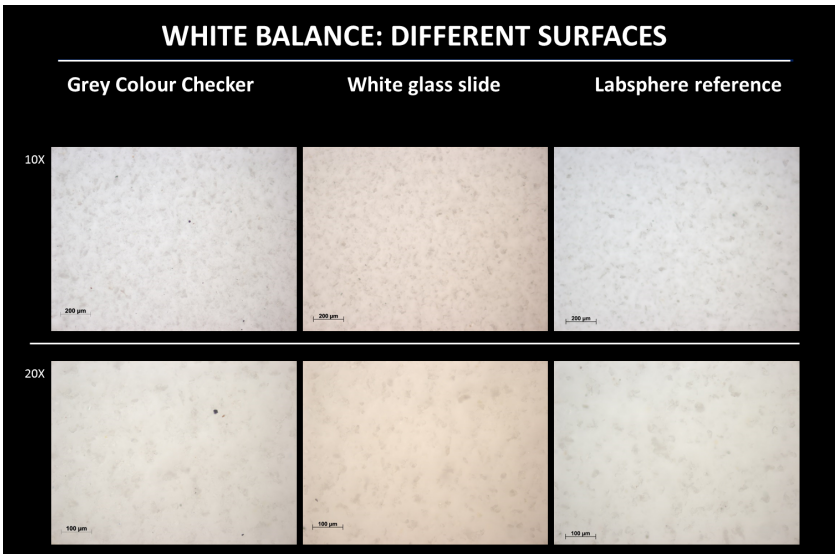


Fig. 8

A number of standard camera software settings were also identified as the most appropriate for taking consistent images that replicate closely what viewed down the microscope eyepieces. These changes in method were not large and the images taken before and after adjusting the protocol are similar, as seen in the image below (Fig. 9). More important was the fact that an approach was defined that could be used by anyone carrying out cross section photography at the NG.

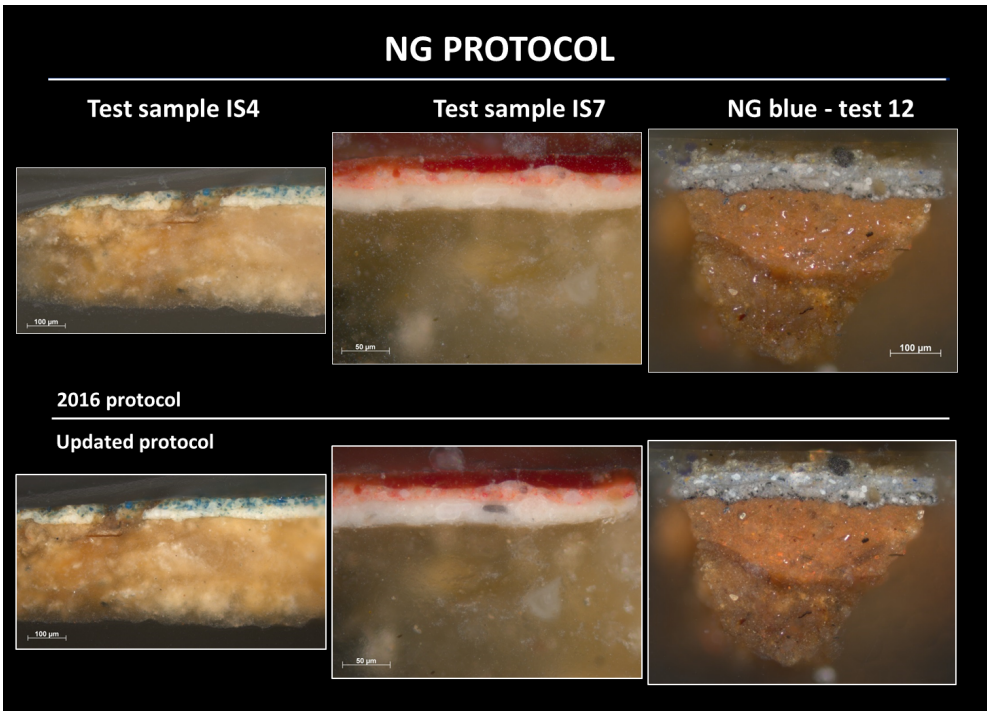


Fig. 9

For most of the samples, images taken using the standard settings defined in this exercise replicate closely what viewed down the microscope eyepieces, although small manual adjustments of these parameters are sometimes required to produce images with as much information as possible (for example, images of a sample containing very dark and very light layers might require a manual adjustment of gamma). As these adjustments are carried out looking at

the images on the screen of computer attached to the microscope, a procedure was introduced to regularly calibrate the colour of this screen using a Hewlett-Packard GretagMacbeth device, with i1Match software.

The main change made to the imaging method used at CATS was the introduction of a white balance step (carried out on a white Spectralon), which greatly improved the comparability of the images with those taken by other partners.

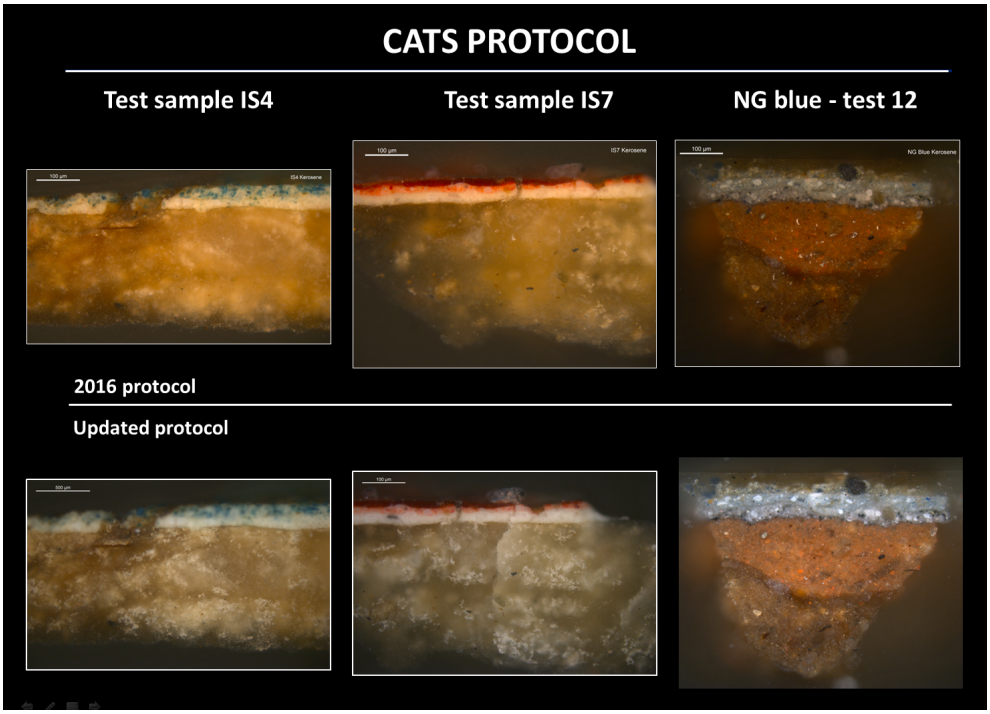


Fig. 10

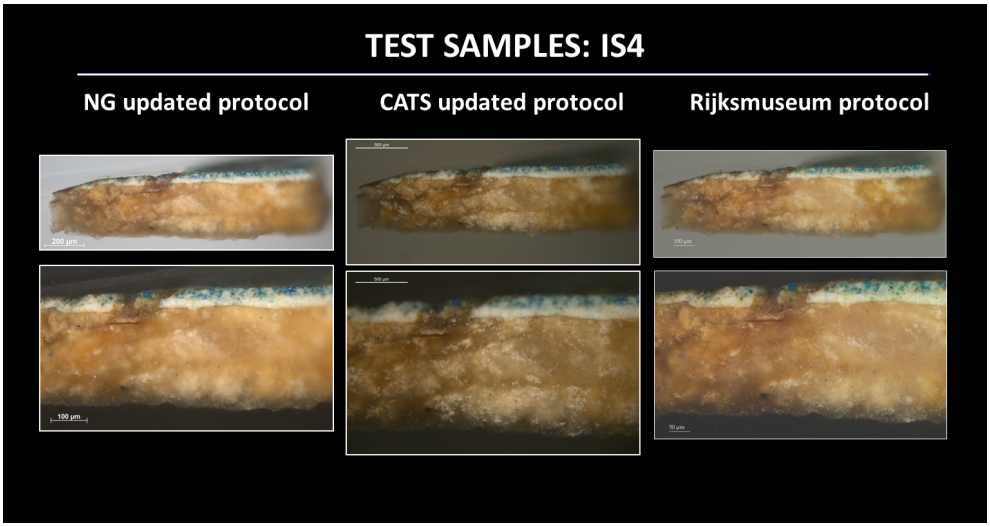


Fig. 11

In total, seven partners plus one external institution participated in this exercise (NG, CATS and KADK, PRADO, DI-BS, KIK-IRPA, NCU, Rijksmuseum), which has proved very valuable for improving our methodology more generally and not only for the database.

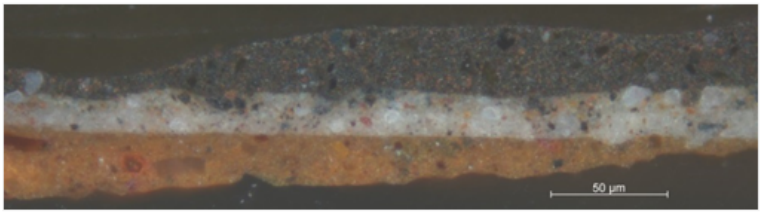
Colour measurement experiments

As reported on in the last deliverable, a new Nip2 imaging processing function was developed and explored as a means of measuring and numerically defining the colour of preparatory layers in images of paint cross-section.

Following on the preliminary tests described in the last deliverable, the new colour averaging procedure was used on images of cross-sections from a larger selection of paintings, providing a valuable method to define colour systematically using L*a*b* values. The results confirmed that the method is helpful in deciding how to group paintings according to the colour of their preparatory layers, and in reviewing the naming of these colours, which can otherwise be variable and subjective.

The method was also used to average the colour of preparatory layers seen in photomicrographs, to gain a better under understanding of the relationship between the colour seen in a cross-section layer and the appearance of the layer on the painting surface. The results showed that in general, the colour averaged from the preparatory layer in the cross-section image did give a good approximation of the bulk colour of the preparation. The lightness of the measured colours appeared to be the most significant difference between colours measured from cross-sections and those seen on the surface, particularly for dark coloured grounds.

A test was carried out on a Dutch seventeenth-century painting with a double ground consisting of a grey over a brownish red layer (with a view to considering the extension of the second digital research resource). The colours of the two preparatory layers in the cross-section image (see below, Fig. 12a) were measured both together and separately, and were also compared to the bulk colour observed in a photomicrograph of the surface of the painting, where the preparatory layers are exposed at the edge of a paint loss (see below, Fig.12b). The results showed that the bulk colour measured from the photomicrograph (was very similar to that measured from the combined preparatory layers in the cross-section, but slightly shifted towards the uppermost layer colour, being slightly lighter and less red.



(a)

(b)

Colour averaged from the lower preparatory layer in cross-section image			Colour averaged from the upper preparatory layer in cross-section image			Colour averaged from equal areas of both preparatory layer in cross-section image			Colour averaged from the upper layer in the photomicrograph		
L*	a*	b*	L*	a*	b*	L*	a*	b*	L*	a*	b*
45.3	10.6	20.2	56.8	0.2	4.3	50.9	4.6	12.1	54.1	3.1	12.0

Fig. 12

The colour averaging procedure was not directly incorporated into the database, but has been a useful exercise in testing and confirming that paintings are being described and grouped in an appropriate way. The colour averaging results could also be used more directly to group paintings according to their numerical colour values.

These experiments and the work carried out to develop a more standard imaging protocols were presented at the conference *Mobility Creates masters – discovering artists' grounds 1550-1700* (Copenhagen, 13–14 June 2019), and will be published in the conference postprints (J. Russell, M. Melchiorre Di Crescenzo, J. Padfield, M. Spring, 'Experiments using image processing software (Nip2) to define the colour of preparatory layers in sixteenth century Italian paintings', in *Mobility create Masters – discovering artists' grounds 1550-1700*, Archetype Publications, forthcoming Spring 2020).

Building the database

The construction of the database has involved a huge amount of work on the relational database design and structure (described in Appendix 3, for reference as documentation of the database).

The software that was used in development of the database can be found in Appendix 4.

Digital resource 2: a beta version of an extended database of preparation layers in paintings that includes northern European seventeenth-century paintings and Italian seventeenth-century paintings

Several IPERION partners were strongly interested in extending the remit of the database of preparation layers in paintings to include a wider range in terms of time and geography. In particular there was a desire to incorporate seventeenth-century Northern European paintings, partly because of the nature of the collections of the partners and partly because of plans that were being made for future research projects that might use the database for documentation (including with collaborators not in IPERION-CH). This was the motivation for the second digital resource made ready to be available online. This has been labelled as a 'beta' version because the additional data (beyond what is present in Digital Resource 1) is not yet extensive. Nevertheless it is this that may well become the resource that becomes a general repository for this type of data in the future.

As of June 2019, this database included 187 paintings dating from 1460 to 1673.

The above colour measurement experiments on a seventeenth-century Dutch painting were made with this extended database in mind. A useful learning outcome from the work done for this second digital resource, is the testing of the structure designed for sixteenth-century Italian paintings to see if it was still suitable when used for later works, which have different types of preparation layer structures and therefore required different descriptors and some adjustments. Nevertheless this approach worked very well, and it is clear that the constructed database will work for this purpose, without too many modifications for other paintings.

A working resource for internal collaborative project use; SAOI ("Simple Area Of Interest") - a digital annotation system and an example of application for a digital sampling point system

Saoi – Irish, literally translates to "wise one"[1]

Complete Conservation and Heritage Science documentation can be a very complex issue, requiring very detailed workflows, permissions, data & file formatting, controlled lists, customised user interfaces and much more. However, for many applications much of the captured information/knowledge resolves around annotated images. This might include simply highlighting damages, areas of conservation, the location of analytical examinations and sample points, discussing subject matter or even marking up images to order further imaging work.

Part of the work carried out within this work-package has concentrated on creating a simple IIIF[2] and Mirador[3] based tool to begin capturing this core image-based data, developing a standards-based system for annotating images and highlighting generic areas of interest to provide a tool for users to begin. In order to maximise the availability and potential use of this system, it has developed using open freely available software components.

The development of the system, demonstrated with screen shots in this document, of the current internal working system, was initially focussed on creating a digital sample point annotation system within the National Gallery, to record and share related records; internally and with future ArchLab[4] and other collaborative projects. However, subsequent development has focussed on creating a more generic system to allow anyone to record different types of areas of interest, specifically concentrating on use cases provided internally, by the British Museum and through discussions with other project partners.

System components

The SAOI system is being developed using the following software and systems:

- Apache HTTP Server (http://httpd.apache.org) has been used as the primary web server.
- MySQL (https://www.mysql.com) has been used as the primary database to store all the data gather and used by the system.
- PHP (https://www.php.net) has been used to actually create all of the webpages and organise the interactions with the MySQL database.
- JavaScript – (https://www.javascript.com) has been used as the primary client side scripting language to control and arrange the website content.
- IIIF (https://iiif.io) has been used as the standard for organising, describing and sharing the images and annotations used in the system.
- Mirador (https://projectmirador.org) has been used as the IIIF compliant image and annotation viewer.

[1] https://en.wikipedia.org/wiki/Saoi
[2] International Image Interoperability Framework – standard framework for sharing and re-using digital images across the web - http://iiif.io
[3] IIIF compliant *"Open-source, web based, multi-window image viewing platform with the ability to zoom, display, compare and annotate images from around the world."* - https://projectmirador.org
[4] *"Access to specialised knowledge and organized scientific information … in datasets largely unpublished from archives of prestigious European museums, galleries and research institutions"* - http://www.e-rihs.eu/access

- Bootstrap 4 (https://getbootstrap.com) has been used as the front-end component library, an open source toolkit for developing with HTML, CSS, and JS.
- JQuery (https://jquery.com) has been used to simplify and enrich the JavaScript processes used.
- tinymce (https://www.tiny.cloud) has been used to provide rich text editor functionality
- Catch-A (https://github.com/annotationsatharvard/catcha) – was used and the initial annotation server – current development is looking at replacing this with a simple MySQL based data store to align the functionality with the other databases used for the system
- NG Code – Additional PHP and JavaScript code has been developed to bring everything together and create the required functionality and user interfaces.

Use Case: National Gallery – Digital Sampling Point System

As noted, the first use case of SAOI was to create a simple digital sampling point system within the National Gallery. Figure 1 shows a flow diagram highlighting the internal sources of data that were re-used to create the system. The intention was to remove the need for any duplication of data entry, so the following existing machine-readable data sources where combined to form and internal API[5]:

- All painting details are pulled directly from the current National Gallery collection management system, TMS[6].
- Painting images come directly from existing internal IIIF systems.
- Sample details and images were also provided from internal systems.
- User authentication was achieved via an LDAP[7] system, so no new usernames and passwords.

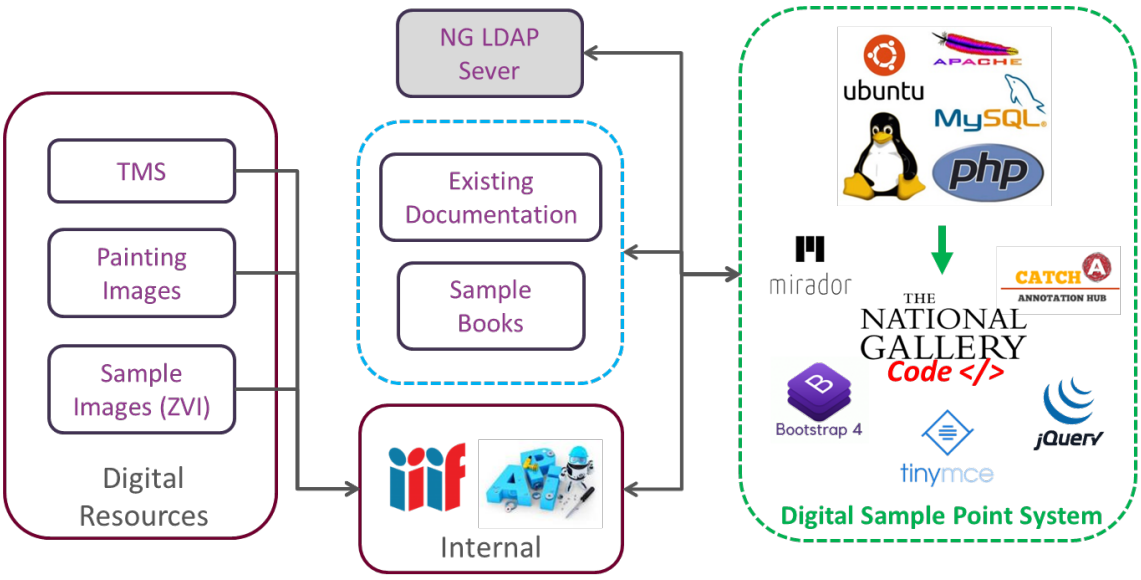


Figure 1: Schematic diagram highlighting the main sources of data and software tools used in the development of the first working version of SAOI.

[5] https://en.wikipedia.org/wiki/Application_programming_interface
[6] https://www.gallerysystems.com/products-and-services/tms-suite/tms
[7] https://en.wikipedia.org/wiki/Lightweight_Directory_Access_Protocol

The National gallery system has been set up to provide the following functionality:

- A secure LDAP based login system.
- A simple painting search engine.
- An IIIF Mirador image viewer connected to a set of defined web forms.
- The ability to create new sample sites, and then move, edit and delete them as required.
- Associate one or more samples to a single sample site.
- To produce automated reports for each painting.

National Gallery system screenshots

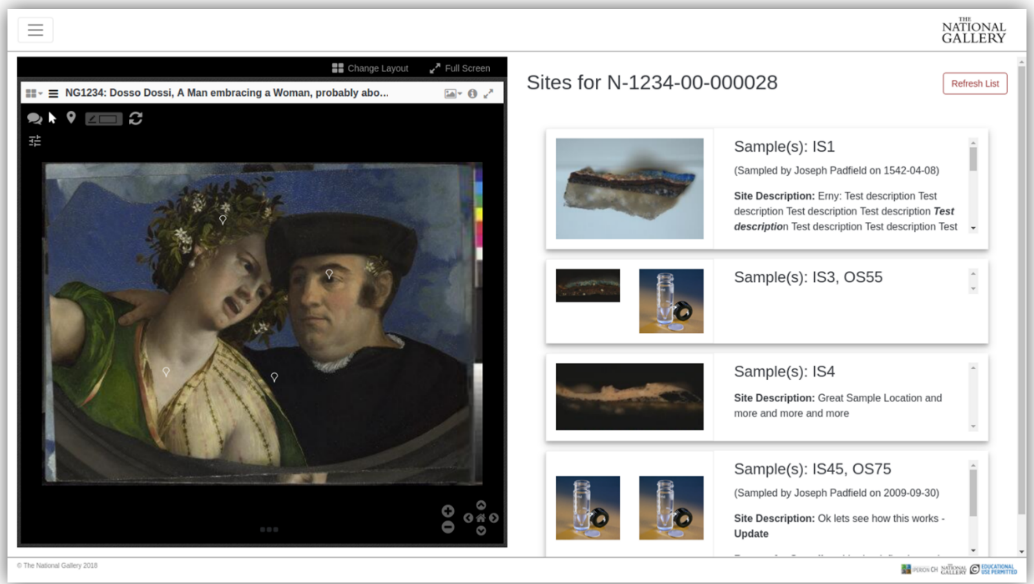


Figure 2: Default painting page showing the Mirador viewer on the left and the sample details on the right. Sample site and sample details can be accessed and edited by clicking on the sample cards on the right.

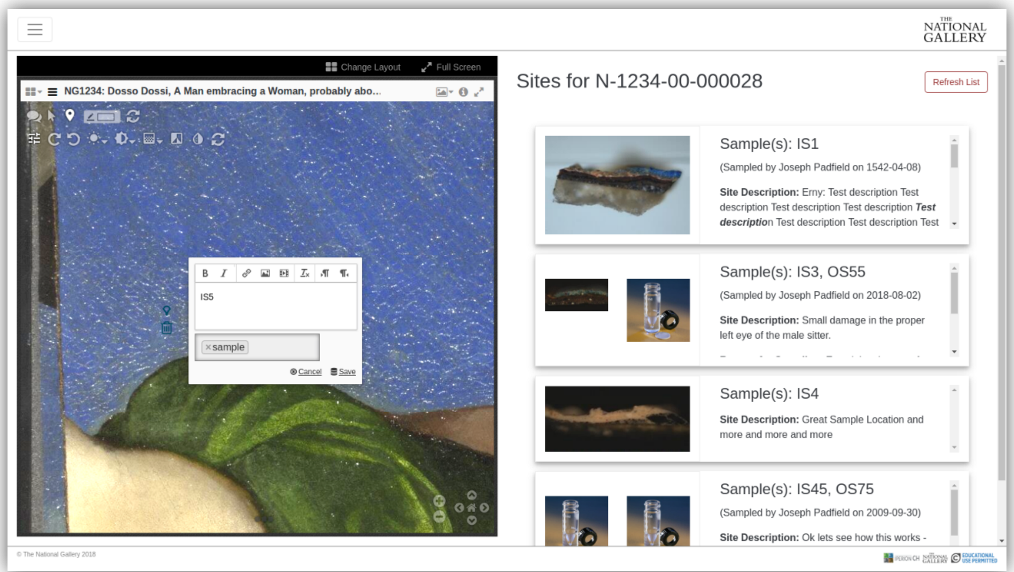


Figure 3: New annotations can be added to the images using the standard Mirador functionality. The system can then automatically associate sample site to samples based on a standardised sample naming protocol.

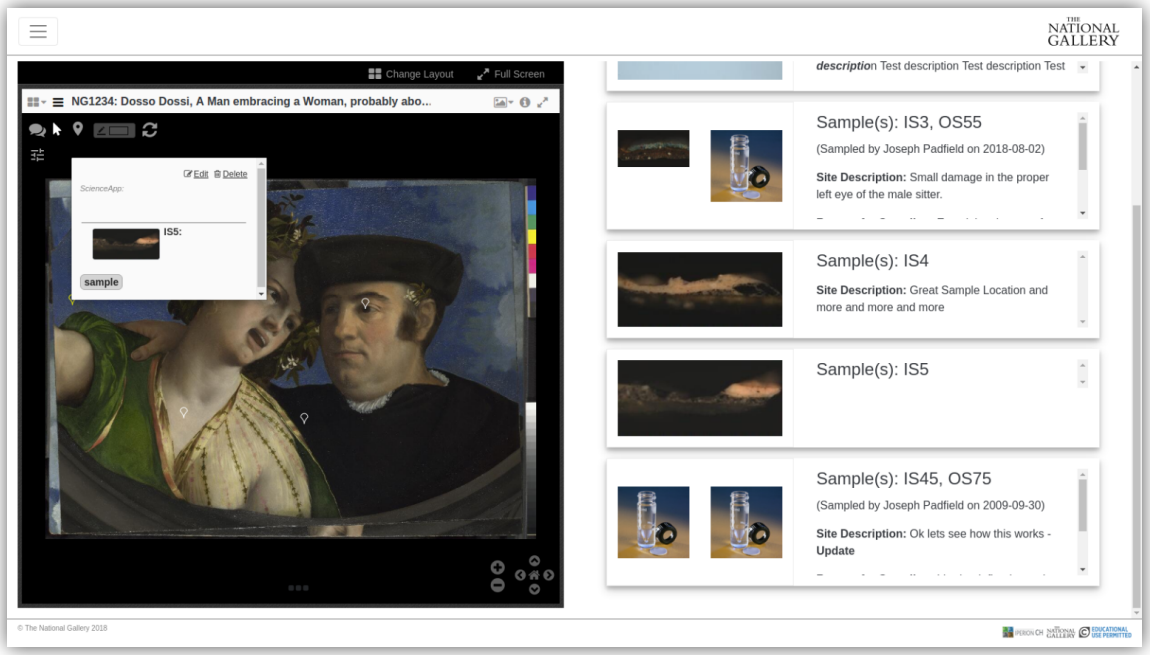


Figure 4: Once a new caption has been entered as a simple comma separated list of sample numbers the system will automatically create to sample records and add a clickable sample image to the annotation.

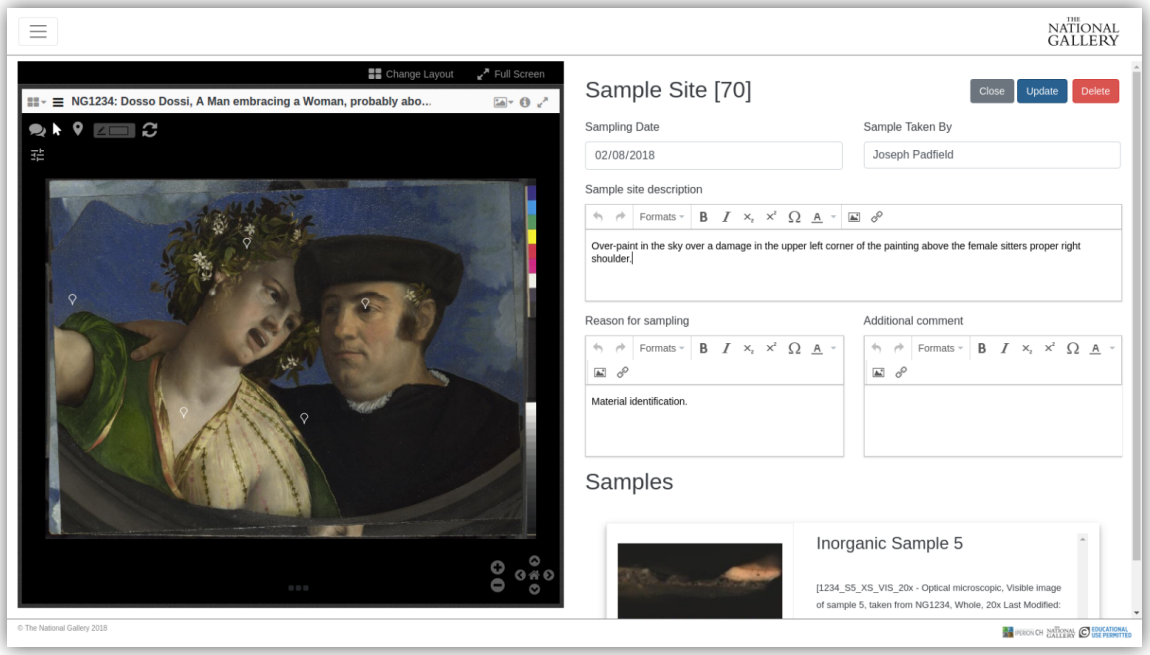


Figure 5: Sample and Sample site details can be added and edited using the forms provided. These descriptions can then also be automatically added to the annotations.

If a more traditional report is required, to present all the information stored for a painting, particularly for printing or external dissemination, the system can automatically combine all the details together to form a printable report. The reports, including all the custom annotated images are automatically generated from the stored information without the need for any additional work. If new information has been added to the system, the report can simply be refreshed as needed.

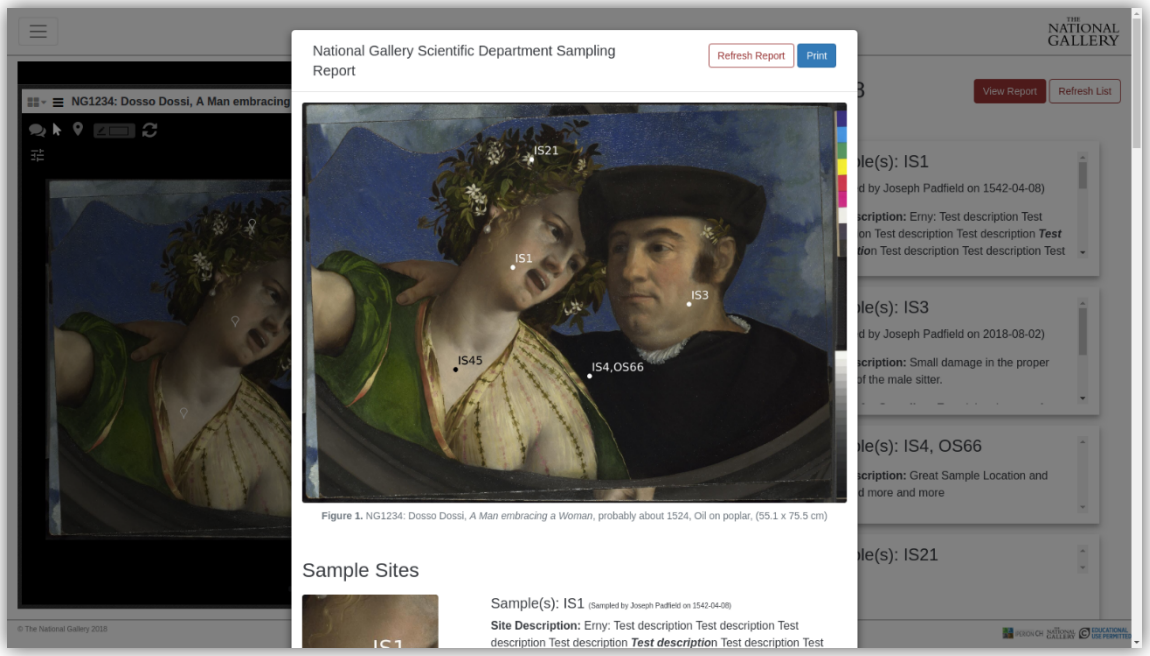


Figure 6: The system automatically creates a printable report including a full painting image and cropped details with the annotation numbers already added to the images.

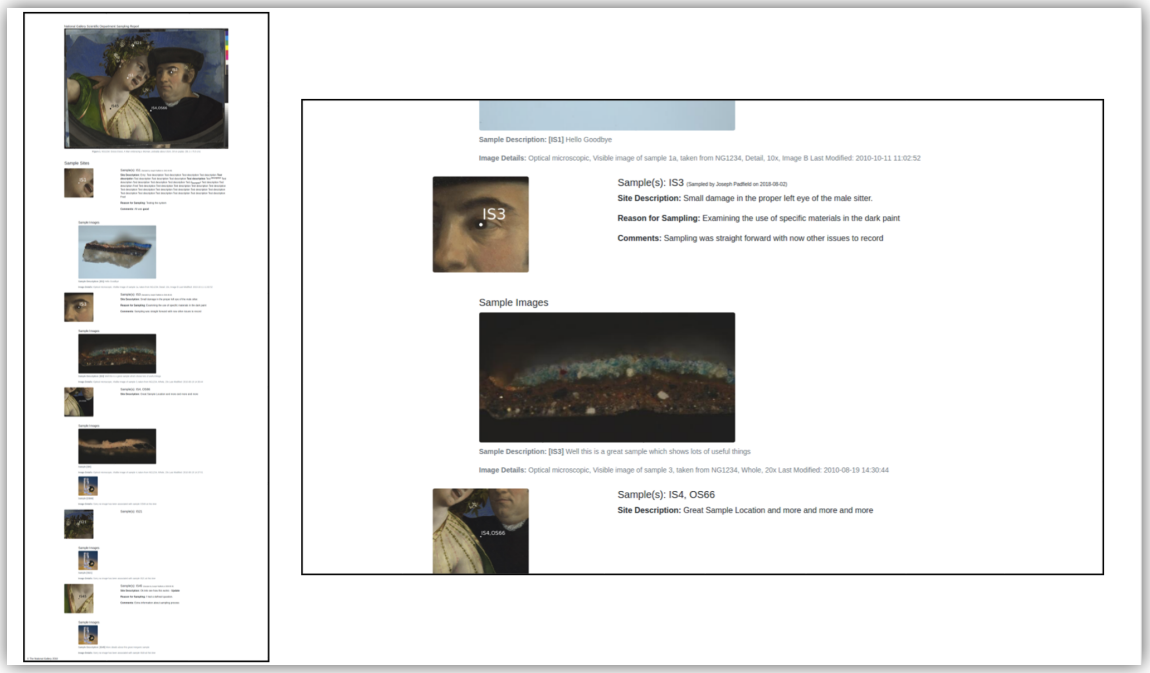


Figure 7: The specific layout for the report can be arranged with a template, but this requires additional coding rather than any adjustments in the user interface.

Use Case: British Museum – recording areas of interest and examination

Looking beyond the initial development of an example digital sample point system the work within this work-package has continued to gather more generic uses cases for the SAOI system in order to inform future development work.
Rather than working with removed samples the British Museum wanted to use this system to record the location of areas of additional examination, simple microscopic details or the location of more complex analysis and display these across multiple registered overall images taken using different imaging techniques. This additional use case has been discussed in detail between the partners and all the required functionality has been added to the development plan for the system
As the initial SAOI system was built in connected to several other National Gallery systems additional work has been required to separate out all the functionality and to make the system more generic. It has been possible to complete this separation process but adding the required additional functionality and to finalise an additional implementation of the system has been beyond the scope of this project. However, the development of the SAOI system will continue, as discussed below, and a full working example of the British Museum use case will be created.

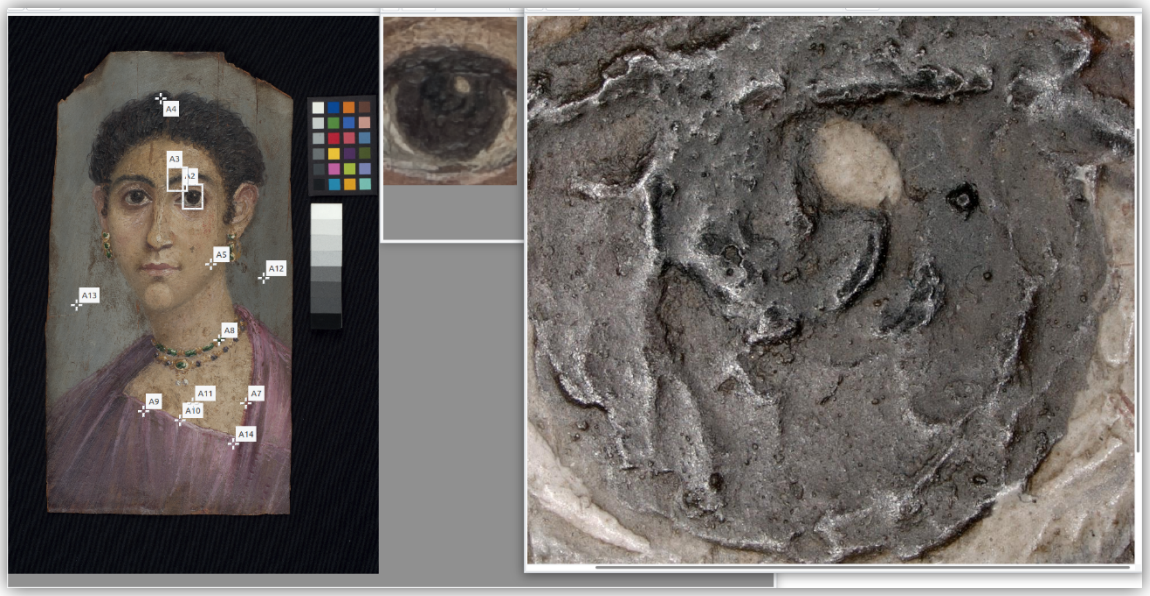


Figure 8: Example image showing defined annotations on a "Portrait of a Woman" (inv. no. EA74706) provided by the British Museum, along with an associated photomicrograph.

Dissemination and future development

With the IPERION-CH project it has been possible to develop the SAOI system beyond a simple planned worked example, into a system that has become part of the day to day activities within the National Gallery Scientific Department. The National Gallery are continuing to use and develop this system for internal activities, along with planning additional development work and longer-term collaborations to expand its scope and allow it to be used by other institutions.

In order to make the future discussion of and collaborative development of the SAOI system easier it is planned that the source code and documentation will be uploaded to Github[8] specifically to the page: https://github.com/jpadfield/saoi

Conclusions

Several main achievements have emerged from the work in Task 4 of the WP8 work package described in this deliverable:

- A rich and attractively presented research resource on the database of preparation layers in sixteenth-century Italian paintings, has been developed and is now available online.
- The structure has proved to work for an extended range of paintings in terms of time and date, and demonstrated by the second research resource that is now available online.
- There has been interest from both IPERION-CH partners and other collaborators in continuing to use the databases for documentation of preparatory layers in paintings, for future projects.
- The framework and structure of the database is also potentially re-usable for other resources; future work is intended to make this available on GitHub.
- In terms of sustainability, the databases are currently hosted on a National Gallery server. There is commitment to maintain it over the next few years.
- Further development is envisaged, as the first digital resource will be used as a dataset in the SSHOC project to explore how to make data FAIR.
- The database has been reviewed by partners and others outside IPERION-CH, with some useful feedback having been received, which has identified some improvements that could be instigated in the future.
- A working resource for internal collaborative project use, SAOI ("Simple Area Of Interest") - a digital annotation system, has been described and its use for a digital sampling point system at the National Gallery and for recording areas of interest and technical examination of an object at the British Museum have been explored. This digital sampling point system is already in day-to-day use at the National Gallery, a practical outcome of the work in this task. It is intended that the code will be made available in GitHub for future use by others.

[8] https://github.com/

Appendices

Appendix 1: Imaging protocols

SYSTEMS and PROTOCOLS for TAKING CROSS SECTION IMAGES

NATIONAL GALLERY SCIENTIFIC DEPARTMENT (draft 2016)

1) INSTRUMENT details

Microscope: Leica, DM4000 M

Light source: tungsten halogen lamp (12V, 100W)

Objectives: 5x, 10x, 20x, 50x, 100x (also 20x, short working distance -1.15 mm-, but rarely used)

Working modes: dark field, bright field

Filters and polirizers: not used

Fluorescence light set-up (source and filter cube): Leica EL6000, mercury metal halide bulb, filter cube A (excitation filter BP340-380, dichromatic mirror 400, suppression filter LP 430).

Camera: AxioCam HRc Zeiss (resolution: up to 13 Mpixels in each colour channel; 3 x 14 bit colour depth)

Computer screen: HP DreamColor LP2480ZX.

2) SOFTWARE details

Camera software: AxioVisionRel.4.8

Additional editing software: NIP used to add consistent scale bars to a batch of cross-section images, but only when they are going to be published.

3) PROTOCOL

Sample preparation

Samples embedded in polyester resin (in 2016: Tiranti).
Polished using silicon carbide grinding paper (320 and 1200) and finished with micromesh cloth (4000, 6000, 8000 and 12000).
Cross-section placed on white slide with plasticine (pale blue colour) and levelled.
Before taking dark field and UV fluorescence images the sample is wetted with some odourless kerosene.
Working in bright field (less frequent) the sample is imaged as it is.

Vis light, dark field image

Images are taken so that the sample on the screen looks as similar as possible to the sample as seen through the microscope eyepieces.

Light intensity: set to the maximum level (microscope source set-up 20).

White balance (performed on white opaque glass slide): select the lowest magnification that will be used (usually 10x objective), focus on the plate, adjust exposure (automatic adjustment

performed using the software 'measure' function), fine focus (if required), white balance (performed the software 'automatic' function). The white balance is considered OK if the R, G, B curves in the histogram overlap.

Taking the image (after performing the white balance): select the magnification; focus on the sample; frame the image; adjust exposure (automatic adjustment using the software 'measure' function); control that colours on the screen resemble what you see through the eyepieces; fine focus adjustment (looking at the screen); control the camera settings (these should be: RGB; 4164x3120 scanned colour – highest resolution; High Quality Readout speed-12.5MHz); take the shot.
Although it is preferable not to use the software controls, if the image on the screen does not resemble what is seen through the eyepieces, the image is sometimes adjusted using software functions before taking the shot.
Available software functions: exposure (manual adjustment, used often); colour saturation (default value: 1.0; rarely used); colour temperature (default value of the colour offset: 0.00; rarely used); gamma (default value: 0.45, used often, especially for samples that have dark and bright layers); brightness; contrast.

Additional camera functions that might be used: extended focus.

Processing the image: the scale bar is added and fused to the image.
If the image on the screen does not resemble what is seen through the eyepieces, it is adjusted using the camera software functions: gamma, brightness and contrast
It is possible to adjust gamma, brightness and contrast before taking the image or during the post-processing procedure (users prefer to apply corrections before taking the image).

UV fluorescence image
Every shot taken under Vis light is also taken under UV light: change the light source, adjust the exposure (sometimes it is better to do it manually as the automatic adjustment can result in a very dark image), adjust the focus and take the shot.

4) FILE DETAILS

Format of file capture with camera: AxioVis40.Image .zvi

Format of the exported file: standard JPEG Images (8bit).

Resolution of the exported file: 4164x3120 pixels

Naming: NGNr_Sample Nr_Type of sample_Light_Field_Mag_Tag_comment
NG number: National Gallery registration number
Sample Nr: beginning with IS (inorganic sample)
Type of sample: XS (cross section)
Light: Vis or UV
Field: BF (bright field), DF (dark field) -optional-
Tag: this denotes how many images have been taken of the current sample using the same conditions (a,b,c,d,…)
Comment: free text –optional-
Example: NG1230_IS1_XS_Vis_DF_20X_a

CATS-SMK LABORATORY (Johanne Nielsen, draft 2016)

1) INSTRUMENT details

Microscope: Leica DM4000M

Light source: tungsten halogen lamp (12V, 100W)

Objectives: 5x, 10x, 20x, 50x. Also 40x, but rarely used to take Vis images (Does not work with Dark Field)

Working modes: Dark field, Bright field, Differential Interference Contrast

Filters: Not used

Fluorescence light source: Mercury short arc HBO, 103W/2. Filter A and I3.

Camera: Leica DFC490 (8 Mp sensor. RGB colour depth 36 bits).

2) SOFTWARE details

Camera software: Leica LAS V4.1 (Leica Application Suite)

Additional editing software: No additional software used. (All editing done in LAS, such as crop and scalebar)

3) PROTOCOL

Sample preparation

Samples embedded in EasySections using Technovit 2000 LC (light curing) resin (Heraeus Kulzer) and cured in the Technotray (also Heraeus Kulzer).
Polished using silicon carbide grinding paper 500 (stopped before the sample is reached in most cases) and finished with micromesh cloth (1500, 1800, 3200, 3600, 4000, 6000, 8000 and 12000)
Cross-section placed on slide with plasticine and levelled.
Before taking dark field and UV fluorescence images the sample is not wetted (If the cross-section is old and scratchy odourless kerosene is used)
Before the sample is embedded the sample is photographed, for documentation and to determine the orientation for the embedding.

Vis light, dark field image

Images are taken so that the sample on the screen looks as similar as possible to the sample as seen through the microscope eyepieces.

Light intensity (microscope source set-up): usually set to 18-20 (20 is the maximum level).

White balance : not performed for every sample as the light level is not changed. There is a white balance function within the software that works selecting an area that is known to be white.

Taking the image: select the magnification; focus on the sample; adjust exposure. Frame the image; control that colours on the screen resemble what you see through the eyepieces (pre-settings, adjusting brightness, gain, contrast and colour temperature, have been made to uniform the images and help speed up this process); fine focus adjustment (looking at the screen). To avoid over or under exposed the function “spot exposure” is used to adjust the brightness of the image, selecting the area of the image which is over or under exposed. The

highest resolution is used, which is Interlaced Large HQ 3264 x 2448 px. The image is captured in the darkness, to avoid ambient light in the pictures.

Processing the image: The scale bar and sample identification are added and fused to the image.

UV fluorescence image
Every shot taken under Vis light is also taken under UV light: change the light source, adjust the exposure, also here a pre-setting are used to make sure the image is the same as on the screen.

4) FILE DETAILS

Format of file capture with camera: TIFF

Format of the exported file:
Before saving the TIFF file, the scale bar is added and fused to the image.

Naming: Accession number, sample number, magnification, light (Dark field, bright field, UV filter A, UV filter I3)
Example: KMS10_552a_x10_DF

DOERNER INSTITUT (Heike Stege and Jeanine Walcher, draft 2016)

1) INSTRUMENT details

Microscope: Zeiss Axioskop 20
Light source: Zeiss halogen lamp, 12 V, 100 W
Objectives: 5x, 10x, 20x, 50x (ocular: 10x)
Working modes: dark field and sometimes bright field
Filters and polarizers: polarizer DIC

Fluorescence light set up (source and filter cube: LQ-HXP 120-3/010.26B of Leistungselektronik Jena; filter no. 02 (excitation: G 365; beam splitter: FT 395; emission: LP 420)

Camera: AxioCAM MRc5 (2/3“CCD-sensor ICX 282; resolution: 2584 x 1936 = 5 Mpixels; spectral sensitivity: ca. 400 nm bis 710 nm, BG 40 IR blocking filter)

Computer screen: Fujitsu LCD display; calibration done July 2016 (hardware: „eye-one“, GretagMacbeth; software: i1 Profiler, version 1.6.3)

2) SOFTWARE details

Camera software: AxioVision SE64 Rel. 4.9
Additional editing software: DI chose RGB; 2584 x 1936 quality standard.
Di also used consistent scale bars.

3) PROTOCOL

Sample preparation
Samples embedded in TECHNOVIT 2000LC resin.
Polished using SiC-grinding paper (800 and 1200 with aqua), micromesh cloth (2400, 4000, 6000, 8000 and 12000) and polishing paper.
Cross-section placed on slide with plasticine (light grey colour) and levelled.
Is the sample wetted? no
Use of cover slips? no

Taking the image Vis light, dark field image
Light intensity: set to the maximum level (light source set-up:12).

Before using the microscope camera: Check resolution of the camera and the available software functions (colour temperature (colour offset: 0.00); colour saturation (default value: 0.7); gamma (default value: 0.45).

White balance: DI works with x-rite color checker classic, light gray plate (acquired in June 2016) for VIS and with barium sulphate p.a. for VIS and UV.
Select the lowest magnification that will be used (usually 10x), focus on the light gray plate of the color checker or on BaSO4, adjust exposure (automatic adjustment and manual readjust if necessary (check with marking overexposure)), white balance (performed with the ‘automatic’ or ‘interactive’ software function).
The white balance is considered OK if the RGB curves in the histogram overlap.

Taking the image (after performing the white balance): focus on the sample, frame the image, adjust exposure (automatic adjustment and manual readjust if necessary (check with marking overexposure)), fine focus adjustment (looking at the screen), take the shot.

Processing the image the scale bar is added and fused to the image; no software functions are used.

UV fluorescence images
Every shot taken under Vis light is also taken under UV light: change the light source and the filters, performing the white balance under UV light (only one shot!), adjust the exposure (automatic adjustment and manual readjust if necessary (check with marking overexposure)), adjust the focus and take the shot.

4) FILE DETAILS

Format of file capture with camera: .zvi

Format of the exported file: .*jpg (JPG komprimiert)
% compression factor: 5

Resolution of the exported file: 150 dpi; 2584 x 1936 pixels

Naming: DI stores the image in file folder. The naming of the images is not standardized.

Naming of folder: TemporaryProjectNumber_Comment
TemporaryProjectNumber: is the specific consecutive examination number for every object (combination of a letter and a 2-digit number)
Comment: free text, e. g. name of the artist or short title of the object.

Naming of image (most used): Nr_MagnificationLocationField
Nr: number of sample
Location: rechts/ re (right); links/ li (left)
Field: DIC (bright field), UV-02 (UV-light and filter no.)

Example: folder: R47_Campendonk; image: 1_200rechtsDIC

PRADO SCIENTIFIC DEPARTMENT

(Maite Jover and María Dolores Gayo García, draft 2016)

1) INSTRUMENT details

Microscope: Leica DMRX
Light source: tungsten halogen lamp (12v, 100w)
Objectives: 5x, 10x, 20x, 50x. Also 40x, but rarely used to take Vis images (a cover slip on the cross section is needed) or to take UV images.
Working modes: dark field, bright field
Filters: Not used

Fluorescence light source: Mercury short arc HBO, 103W/2. Filter A.

Camera: Leica DFC420 C (5 Mp sensor, resolution up to 12,5 Mp. RGB colour depth 36 bits).

2) SOFTWARE details

Camera software: Leica Application Suite v.2.8.1 Build 1554

Additional editing software: Adobe PhotoShop CS5. This is used for every image, to enhance colour and light, seeking higher similarity with the real sample image observed through the microscope. It is also used to crop the image (to select the sample, eliminating part of the non-informative surrounding background.

3) PROTOCOL

Sample preparation
Samples embedded in methacrylate resin Technovit 4004 (Heraeus Kulzer).
Polished using silicon carbide grinding paper (320, 1200 and 2500) and finished with micromesh cloth (4000, 6000, 8000 and 12000).
Cross-section placed on slide with plasticine and levelled.
The sample is wetted only if the surface is not even (i.e. if methacrylate bubbles have remained in the sample). Then the sample is slightly moistured and observed putting a glass cover to avoid quick evaporation.

Vis light, dark field image
Images are taken so that the sample on the screen looks as similar as possible to the sample as seen through the microscope eyepieces.

Light intensity (microscope source set-up): light level set to 10.5 (12 is the maximum value). The light is adjusted for every individual sample using the microscope aperture diaphragm.

White balance: not performed for every sample as the light level is not changed. There is a white balance function within the software that works selecting an area that is known to be white.

Taking the image: select the magnification; focus on the sample (looking through the eyepiece); adjust the light intensity using the diaphragm apertures; check that the colours resemble what you see through the eyepieces; fine focus adjustment (looking at the screen); take the shot.

Although it is preferable not to use the software controls, if colours do not resemble what you see through the eyepieces, before taking the shot, colours are adjusted using software functions (colour wheel and gamma). These are used only to adjust the colour and the contrast (all other corrections can be done using the editing software).
In the saving process, the enlargement number is selected and stored as metadata, so the bar scale can be added afterwards.
The system allows taking images with 5 levels of resolution, being the highest 2592 x 1944 pixels. We usually work with the next level ("Interlaced medium HQ" 1728 x 1296)

Processing the image: after saving the JPEG file, the image can be processed using the camera software. In this moment the scale bar is added and fused with the image, overwriting the original image. Scale bars are expressed in 50 or 100 µm.

UV fluorescence image
Taken only if working at 20x or 40x.
Procedure: change the source of light, remove the polarizer and analyser to avoid damages in the plates, rotate the reflector turret to the UV filter position. In this case, aperture diaphragm has to be completely open and light adjusted using the software "exposure time" control.
Using 40x, the glass cover is used to prevent heat damages to the sample.
Adjust the focus and take the shot.

4) FILE DETAILS

Format of file capture with camera: JPEG Images (also TIFF and BMP is possible).

Format of the exported file: JPEG Images. Two files (XLM and LAN) are generated at the same time, containing metadata information of the image.

Resolution of the exported file: 1728 x 1296 RGB.

Naming: Technique-Painter-painting&sample_magnification&UV&tag
Technique: analytical technique used to investigate the sample: PM (polarized microscopy)
Painter: letter referring to the artist (e.g. V for Velázquez)
Painting: laboratory code related to a catalogue number in a separate database. Paintings of the same artist are ordered alphabetically, from A to Z and then AA, AB, etc…
Sample: number of the sample (1, 2, 3…)
Magnification: 5, 10, 20, 40 or 50
UV: only for UV images, "UV" is added after the magnification number (e.g. PM-V-AY1_40UV)
Tag: used to denote how many images have been taken of the current sample using the same conditions ("a" is added to the second image, "b" to the third, etc…)

Example: PM-V-AY1_50a
Polarizing microscope visible light image taken of sample number 1 from a Velázquez painting whose code is AY, enlargement 50X. In this case, there should be more than one photograph taken under the same conditions.

ROYAL INSTITUTE FOR CULTURAL HERITAGE LABORATORY DEPARTMENT (draft 2016)

1) INSTRUMENT details

Microscope: Zeiss, AxioImager.M1

Light source: tungsten halogen 12V 100W

Objectives: 5x, 10x, 20x, 50x (apochromat), 100x

Working modes: bright field, dark field, polarisation

Filters and polarizers: polariser/analyser

Fluorescence light set up (source and filter cube: Mercury short arc (HXP120W), Zeiss filter set 02 (excitation: G365, beam splitter: FT395, emission: LP420) used for general "blue" fluorescence microscopy,
Zeiss filter set 69 (excitation: BP470/35, beam splitter FT499, emission: BP560/100) used for "green" fluorescence of Sypro Ruby stain.

Camera: InfinityX-32 (resolution up to 31Mpixels, 24bit RGB, dynamical rage >66dB)

Computer screen: AG Neovo X-W22, not calibrated (although planned)

2) SOFTWARE details

Camera software: Deltapix Insight 4.0.10
Additional editing software:

3) PROTOCOL

Sample preparation
Samples embedded between two PMMA cubes with fast curing prepolymerised PMMA/PMA resin (Spofacryl).
Polished using silicon carbide grinding paper with increasing mesh (220 to 4000) and aided by running water as long as the sample is not exposed; afterwards using only slightly wetted grinding papers. (If necessary) further polished dry with micromesh cloth (up to 12000 mesh)
Cross-section placed on transparent glass slide with white plasticine and levelled.
Samples are never wetted, because of possibility to dissolve some paint layers (especially modern paints!) or extracting components. As such, no cover slips are used. Imaging of surface reflection and scratches are reduced by using crossed polarisers. Regular bright and dark field are seldom used.
Working with crossed polarisers or UV/filter set 02, no further sample preparation is used.

Taking Vis cross polarised light images
Light intensity (microscope source set-up): most often set to maximum level

White balance / colour calibration procedure: no standardised protocol; every operator uses his own method/tricks. As there is no colour card and no calibrated screen, this is very subjective and arbitrary anyway. General steps:

- Adjusting exposure time and camera gain
- Performing a white balance correction on a white or grey area in the cross section, or recalling settings from a previously recorded image as a rough starting point

- Comparison and adjusting the image as seen through the eyepieces and on the screen. Fine-tuning of the colours involves adjusting the three colour gain sliders (red, green, blue; often used), the hue slider (rarely), gamma (particularly when both dark and light layers are present) and the saturation (rarely), contrast and brightness sliders.

This is done for every sample/objective lens/filter set combination after focussing. Swapping objective lenses (magnification) or operating modes, drastically changes colours.

Taking the image: Magnification and focussing are done before adjusting the colours (screen vs eyepieces, see above). Images are usually recorded at 18Mpixel (4848x3648) RGB. Extended focus and extended exposure are often used, for bigger samples such as mortar samples, extended area (stitching) is used.

A scale bar is added and fused to the image.

Taking UV fluorescence images

After each image taken with crossed polarisers, a picture of exactly the same area is also taken with UV light source, without changing the objective lens or focus. This involves changing the filter set from POL to filter set 02, retracting the analyser and switching the light source.

White balance / colour calibration procedure: the same approach is followed as for polarised light microscopy. The image on the screen is adjusted to what is observed in the eyepieces. This involves increasing exposure time and/or camera gain and fine-tuning the colours

Taking the image: as for polarised light microscopy.

Processing the images

Usually no further post-processing is performed after the image has been taken. None of our monitors is calibrated, optimising colours or contrast/brightness on one computer will likely degrade the image when viewed on other computers and will deteriorate the image after multiple interventions (since jpeg is used).

4) FILE DETAILS

Format of file capture with camera

The DeltaPix software package doesn't create raw file formats. Images can be saved in jpeg, jpeg2000, bmp and tiff formats. Annotations (e.g. scale bar) and camera/software parameters are stored respectively in .ann (binary) and .xml files with the same prefix. Annotations are not fused this way. We generally don't save files this way.

Format of the exported file

DeltaPix also presents a "realize" function, which is comparable to export functions in other software packages. This function creates a jpeg, jpeg2000, bmp or tiff file, but with the annotations fused into the image itself. The camera and software parameters are automatically stored within the EXIF data. At KIK/IRPA microscopy images are stored in jpeg format, 24 BPP and "QFactor" 2 (quality option available in DeltaPix; this seems to correspond with a jpeg quality setting 95%). Usually images are recorded at 18Mpixel (4848x3648) RGB.

Naming

There are no strict naming conventions. Since the foundation of the KIK/IRPA, all paint cross sections are attributed a unique code based on their storage location (e.g. C12.123). All

images taken from those cross sections start with this number, although unfortunately not always in a consistent way (C12.123, C12_123, C12-123, 12_123…). This is usually followed by the instrumental parameters (e.g. 200x POL, 500x UV), software features that might have been used (e.g. EE for extended exposure, EF for extended focus…) and eventual other comments.
Example: C12.123 200x POL EF.jpg

Nicolaus Copernicus University, Toruń, Poland, DEPARTMENT OF CONSERVATION OF PAINTINGS AND POLYCHROME SCULPTURE

(Magdalena Iwanicka, 2018 draft)

1) INSTRUMENT details

Microscope: Nikon Eclipse 600

Light source: Halogen lamp: Schott KL 1500 LCD, 3200 kelvins

Objectives: 4x, 10x, 20x

Working modes: bright field

Filters and polarizers: not used

Fluorescence light set-up (source and filter cube): Nikon HB-10104AF Super High Pressure Mercury Lamp (100W), filter cube UV-2A (excitation filter EX 330-380, dichromatic mirror DM 400, suppression filter BA 420).

Camera: Canon EOS 600 D, resolution: up to 18 Mpixels, (for technical specifications: https://www.digicamdb.com/specs/canon_eos-600d/)

2) SOFTWARE details

Camera software: EOS Utility

Additional editing software:
Picolay – free software for focus stacking (www.picolay.de)
Corel Draw used to add scale bars to cross-section images, but only when they are going to be published.

3) PROTOCOL

Sample preparation
Samples embedded in acrylic resin (Duracryl Plus, Spofa Dental).
Polished using silicon carbide grinding papers (320, 500, 1000, 4000)
Cross-section placed on white slide with plasticine (light grey colour) and levelled.
Before taking UV fluorescence images the sample is sometimes wetted with immersion oil (RAL)
Working in bright field the sample is sometimes wetted with immersion oil (RAL).

Vis light
Images are taken so that the sample on the screen looks as similar as possible to the sample as seen through the microscope eyepieces.

Light intensity: set to the maximum level.

White balance: Images are taken with the automatic white balance, which is sometimes manually adjusted so that the colours on the screen resemble what is seen through the eyepieces.

Taking the image (after performing the white balance): select the magnification; focus on the sample; frame the image; adjust exposure manually; control that colours on the screen resemble what you see through the eyepieces; fine focus adjustment (looking at the screen); take the shot. I take series of shots (usually between 2-6) with different focus to perform focus stacking afterwards (especially useful for magnification 20x).

Processing the image: the scale bar is added and to the image if needed, contrast is enhanced in some cases.

UV fluorescence image
Every shot taken under Vis light is also taken under UV light: change the light source, adjust the exposure (sometimes it is better to do it manually as the automatic adjustment can result in a very dark image), adjust the focus and take the shot.

4) FILE DETAILS

Format of file capture with camera: we do not collect RAW files due to data size, number of samples photographed (over 100 samples every year) and insufficient manpower to postprocess

Format of the exported file: standard JPEG Images (24 bit, sRGB).

Resolution of the exported file: 5184x3456 px

Naming: Object no_Sample Nr_Magnification_wetted/dry_Light_info on White Balance offset (if applied)_info on focus stacking
Object no: NCU Conservation Department registration number
Sample Nr: consistent with the research documentation written by students
Light: Vis or UV
info on focus stacking: if stacked or not
Example: 1567_1_x20_wetted_WB_A6_G1_VIS_stacked

Appendix 2: Updated imaging protocols

SYSTEMS and UPDATED PROTOCOLS for TAKING CROSS SECTION IMAGES

NATIONAL GALLERY SCIENTIFIC DEPARTMENT (Marta Melchiorre, 2019)

1) INSTRUMENT details

Microscope: Leica, DM4000 M

Light source: tungsten halogen lamp (12V, 100W)

Objectives: 5x, 10x, 20x, 50x, 100x (also 20x, short working distance -1.15 mm-, but rarely used)

Working modes: dark field, bright field

Filters and polirizers: not used

Fluorescence light set-up (source and filter cube): Leica EL6000, mercury metal halide bulb, filter cube A (excitation filter BP340-380, dichromatic mirror 400, emission filter LP 430).

Camera: AxioCam HRc Zeiss (resolution: up to 13 Mpixels in each colour channel; 3 x 14 bit colour depth).

Computer screen: HP DreamColor LP2480ZX, calibrated with Hewlett-Packard GretagMacbeth device.

2) SOFTWARE details

Camera software: AxioVisionRel.4.8

Additional editing software: NIP used to add consistent scale bars to a batch of cross-section images, but only when they are going to be published.

Screen calibration:i1Match software.

3) PROTOCOL

3.1 Preparation of cross-sections

Samples embedded in polyester resin (in 2016: Tiranti).
Polished using silicon carbide grinding paper (320 and 1200) and finished with micromesh cloth (4000, 6000, 8000 and 12000).

Cross-section placed on white slide with plasticine (pale blue colour) and levelled.
Before taking dark field and UV fluorescence images the sample is wetted with some odourless kerosene. Working in bright field (less frequent) the sample is imaged as it is.

3.2. Vis light and UV induced fluorescence, dark field image of cross-section

Light intensity: set to the maximum level (microscope source set-up 20).

White balance (performed on a X-rite® ColorChecker Gray Balance photographic card): select the lowest magnification that will be used (usually 20x objective), focus on the plate, adjust exposure (automatic adjustment performed using the software ‘measure’ function), fine focus

(if required), white balance (performed using the software 'automatic' function). The white balance is considered OK if the R, G, B curves in the histogram overlap.

Image acquisition (Vis) (after performing the white balance): check the camera settings (these should be: RGB; 4164x3120 scanned colour – highest resolution; High Quality Readout speed-12.5MHz) and the values of the software functions (default values should be: colour saturation 1.0; colour temperature colour offset 0.0; gamma value 0.45; brightness value -0.51; contrast value 1.02); select the magnification; focus on the sample; frame the image to crop out excess areas of blank space; adjust exposure using the 'measure' function in the software and then, if required, refine the exposure manually (to get rid of over-exposed areas as identified using the software tool, or to improve the visibility of details in darker layers); fine focus adjustment (looking at the screen); take the shot.

For most of the samples, images taken using these standard settings replicate closely what viewed down the microscope eyepieces, although small manual adjustments of these parameters are sometimes required to produce images with as much information as possible, for example images of a sample containing very dark and very light layers might require a manual adjustment of gamma. Software adjustments of gamma, brightness and contrast can be applied in post-processing.

Additional camera functions that might be used: extended focus.

Image acquisition (UV fluorescence)
Every shot taken under Vis light is also taken under UV light: change the light source, adjust the exposure (sometimes it is better to do it manually as the automatic adjustment can result in a very dark image), adjust the focus and take the shot.

3.3 Processing the image: the scale bar is added and fused to the image.
When required, gamma, brightness and contrast are changed to produce images with as much information as possible.

4) FILE DETAILS

Format of file captured with camera: AxioVis40.Image .zvi

Format of the exported file: standard JPEG Images (8bit), or TIFF.

Resolution of the exported file: 4164x3120 pixels

Naming: NGNr_Sample Nr_Type of sample_Light_Field_Mag_Tag_comment
NG number: National Gallery registration number
Sample Nr: beginning with IS (inorganic sample)
Type of sample: XS (cross section)
Light: Vis or UV
Field: BF (bright field), DF (dark field) -optional-
Tag: this denotes how many images have been taken of the current sample using the same conditions (a,b,c,d,…)
Comment: free text –optional. This can be used to record changes to any software setting.
Example: NG1230_IS1_XS_Vis_DF_20X_a

CATS-SMK LABORATORY (Astrid Grinder-Hansen and Nora Schlag 2019)

1) INSTRUMENT details

Microscope: Leica DM4000M

Light source: Tungsten halogen lamp (12V, 100W)

Objectives: 5x, 10x, 20x, 50x.

Working mode: Dark field.

Filters and polarizers: not used

Fluorescence light set-up (source and filter cubes): Mercury short arc HBO light bulb, 103W/2; metal Lamp housing 106Z-Hg 100W (4-lens). Filter A (excitation filter BP340-380, dichromatic mirror RICP 400, suppression filter LP430) and I3 (ex. Filter BP450-490, dichr. Mirror 510, sup. Filter LP515)

Camera: Leica DFC490 (8 Mpixel CCD 1; shot resolution: 1088x 816; progressive scan preview with up to 15 fps. Colour depth: 36 bits RGB).

Computer screen: EIZO ColorEdge CG247 (self-calibrating screen).

2) SOFTWARE details

Camera software: Leica LAS Software (Leica DFC Twain, Leica Image Manager).
Additional editing software: no additional software used (all editing, such as crop and scale bar is carried out in Leica Application Suite, LAS V4.9).
Screen calibration: ColorNavigation software

3) PROTOCOL

Samples are documented before embedding (using mainly Dark field, DF). Images of the unembedded samples are captured using multifocus.

3.1. Preparation of cross-sections

The samples are transferred to EasySections and embedded in Technovit 2000 LC resin liquid. Technovit 2000 varnish is applied to the samples during the process of curing. Silicon carbide grinding paper is used for the coarse grinding of the samples (grain 320-500), after which they are polished with micromesh cloths (grain 1500, 1800, 2400, 3200, 3600, 4000, 6000, 8000 and 12000).

3.1.2 Former embedding materials:

Date	x-section number	Used material(s)
<1965 - ~1989	≤127	Acrylic resin
1991 - 2007	130 – 278	Serifix® (polyester)*
2007 - 2012	279 – 477	Easy section (acrylic resin) with Serifix® (polyester)*
> Dec. 2012	478 – now	Easy section with Technovit® (acrylic resin)**

*Product information about Serifix®: https://www.yumpu.com/en/document/view/26816014/serifix-resin-m1201017-2008-04-22-struers
**Product information about Technovit®: http://kulzer-technik.de/media/webmedia_local/kulzer_technique/media_4/downloads_4/sicherheitsdatenblaetter/metallo_1/MSDS40876_-_Technovit_2000_LC_GB_3.pdf
http://kulzer-technik.de/media/webmedia_local/kulzer_technique/media_4/downloads_4/sicherheitsdatenblaetter/metallo_1/MSDS1348_-_Technovit_2000_LC_varnish_GB_3.pdf

3.2

3.3 Vis light and UV fluorescence, dark field image of cross-sections

Before documentation each cross section is placed on a transparent glass slide with Blu-Tack® and levelled. The sample is wetted with a thin layer of odourless kerosene for images at 5x, 10x, 20x and 50x magnification. For the latter the kerosene can be removed from the surface to get the best results.

Images are taken so that the sample on the screen looks as similar as possible to the sample as seen through the microscope eyepieces. The cross-sections are normally documented at different magnifications.

Light intensity (microscope source set-up) is set to the maximum level (INT = 20).

White balance: The DF configuration (see below) is selected. White balance is performed on a white standard (Spectralon® white standard), under maximum light level (INT = 20).The lowest magnification that will be used (normally 5x or 10x objective) is selected, the focus is adjusted, and the white balance is performed using the "automatic white balance" software function. The white balance is considered to be all right if the R. G. B. curves in the histogram overlap. The white balance is performed every time the image settings ("Current Configuration") is changed or the program is reset.

Image acquisition (Vis): The software setting for Dark Field is selected (Exposure time: 1,1 sec; Gain: 1,4 x; Saturation: 1,30; Gamma: 0,51). After the white balance has been performed on the white standard, the light intensity is left to the maximum level on the microscope. The preferred magnification is selected and the focus as well as the exposure time is adjusted. Selecting an area with "region of interest" will crop the image to focus on the sample. The highest resolution is used, which is Interlaced Large HQ 3264 x 2448 px. The image is captured in a room devoid of external light sources, to avoid ambient light in the pictures.

Image acquisition (UV fluorescence): Every image acquired in Vis light is also taken under UV radiation, making sure the captured area is identical to the selection during Vis lighting, and taken following the same procedure as mentioned above (see Image acquisition (Vis)). However, the light source is switched to the Mercury bulb and the filter UV-A or UV-I3 is chosen. Corresponding to the chosen filter the software setting is selected. For UV-A configuration: Exposure time: 1,4 s; Gain: 2,2 x; Saturation: 1,85; Gamma: 0,57. For UV-I3 configuration: Exposure time: 350,8 ms; Gain: 2,4x; Saturation: 1,90; Gamma: 0,40. Only focus and exposure time is adjusted manually.
No white balance is needed for the UV fluorescence image; however, if switching back to the Vis settings the white balance needs to be performed again.

3.3 Processing the image

After saving a non-edited copy, the scale bar is added and merged with the image, and sometimes along with a line of information about the image (sample name_type of sample_magnification_mode_extra comments). The images are normally not adjusted after capture.

4) FILE DETAILS

Format of file captured with camera: TIFF

Format of the exported file: TIFF

Naming:
KMSNr[1]_Sample nr.[2]_Magnification[3]_Field[4]_IP[5]_tag/comment[6]

1. Internal or external registration number.
2. The individual number for each cross section.
3. Magnification (objective).
4. Field: DF, UVA or UVI3.

5. IP = IPERION-CH (only for images taken following this protocol).
6. Comment, free text. Optional. (e.g. Type of sample, ex. Ground, inorganic etc.)

Eks. KMS412 513a_10x_DF_IP_no kerosene

Appendix 3;
Ground/bronzes relational database design and structure

WP 8 JRA3 – Developing of digital documentation and data
Task Number 8.4: Sharing in practice: developing research-led digital resources from existing archives/data

Partner: National Gallery
Author: Cristina Giancristofaro (Cristina.Giancristofaro@ng-london.org.uk)
Date: 24.10.2016
Last review: 06.06.2017

This document describes content and structure of the National Gallery ground database developed as a relational database that uses SQL (Structured Query Language) language for querying managing data.
The same information and data will be elaborated with RDF store or triplestore, a purpose-built database for the storage and retrieval of triples through semantic queries.

This relational data model contains all our needed logical design choices and it's the result of several steps to decide what information we want to record, how to divide that information into appropriate tables and columns, and how those tables relate to each other.

The design process consisted of the following steps:

- Determine the purpose of the database
- Find the information required
- Gather and organize all the information we want to record in the database (spreadsheets)
- Divide the information into tables
- Decide what information we want to store in each table. Each item becomes a field and is displayed as a column in the table
- Specify primary keys. The primary key is a column that is used to uniquely identify each row
- Set up the table relationships
- Look at each table and decide how the data in one table is related to the data in other tables. Depending on the type of relationship we add specific fields to the tables or create new relational tables that clarify the relationships[9]
- Refine the design
- Analyse the design for errors. Create the tables and add a few records of sample data. See if we can get the results we want from our tables. Make adjustments to the design, as needed.
- Apply the normalization rules to see if the tables are structured correctly. Make adjustments to the tables, as needed.

Database ER Diagram

The Entity-relationship diagram below provides a visual overview of the NG ground database and the relations between the tables created to store all the gathered information.

[9] Relationships are a logical connection between different tables. In a Relational database there are several types of database relationships, such as One-to-One, One-to-Many, Many-to-Many and Self Referencing relationships.

Figure 1 Logical structure of the NG ground database defined by an Entity-relationship diagram (ER Diagram). This diagram shows a graphical representation of the information we want to record (entities) and the relationship between them.

Table Overview

This section is the overview of all the tables created in the relational ground database. Each table is defined by a specific name, attributes (columns name) and constrains that specify rules for the data in the table. Each row is uniquely identified by a primary key which helps to find a particular record (row) in a table more easily and quickly.

PERSON TABLE

This table includes information about people or corporate bodies.
The list contains known and unknown artists, responsible for the design and creation of works of art. It also may contain information about curators, owners, commissioners, authors, restorers, conservation scientists, specialists and any other person important to the record of an object.
The table includes the following columns:

- **PERSON_ID**: unsigned integer that uniquely identifies each row/record in the table (*PRIMARY KEY* constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **PERSON_NAME**: full name by which an individual or corporate body is known
- **PERSON_OTHER_NAME**: other name, appellation, pseudonym, nickname, or other identifying phrase by which an individual or corporate body is known instead of his/her real name
- **PERSON_PREFIX_ID:** FOREIGN KEY[10] linked to the primary key of the "person_prefix" table to represent a one-to-many relationship[11] between "person" and "person_prefix". The field is used when the person identity is uncertain and we want to assign a prefix qualifier of an anonymous individual in reference to a known person (e.g. circle of Caravaggio).
- **PERSON_PARENT_ID**: Self Referencing relationship[12] to the person_id of a known person named to define an unknown subject (e.g., person_parent_id for a person identified as "circle of Caravaggio" is the person_id assigned to "Caravaggio")
- **PERSON_TITLE**: person's title or qualification
- **PERSON_CONTACT**: email or other personal contact details
- **ULAN_LINK**: external link to the Getty Vocabulary ULAN (Union List of Artist Names)[13] page.
- **PERSON_COMMENT**: comment/ description or any other relevant information, insert as free text

PERSON_PREFIX TABLE

This table includes a list of prefix used to qualify an unknown person in reference to a known person (attribution qualifier as *assistant of, studio of, follower of, school of, in the manner of, circle of, after, stile of, etc*.).

[10] The Foreign key is a field (or collection of fields) in one table that uniquely identifies a row of another table, pointing to the corresponding primary key. Practically when a primary key migrates to another table, it becomes a foreign key in the other table. The FK value can be null.
[11] a one-to-many relationship is a type of cardinality that refers to the relationship between two entities A and B in which an element of A may be linked to many elements of B, but a member of B is linked to only one element of A. Relational database
[12] The Self Referencing relationship is used when a table needs to have a relationship with itself. A table bears this type of relationship to itself when a given record in the table is related to other records within the table.
[13] ULAN (Union List of Artist Names) is a structured vocabulary, including names, biographies, related people, and other metadata about artists, architects, firms, studios, museums, patrons, sitters, and other people and groups involved in the creation and study of art and architecture.

The table includes the following columns:

- **PERSON_PREFIX_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **PERSON_PREFIX_NAME**: prefix name
- **AAT_LINK**: external link to the "attribution qualifier" list in the Getty Vocabulary AAT (Artist & Architecture Thesaurus)[14]
- **PERSON_PREFIX_COMMENT**: comment/ description or any other relevant information, insert as free text

ROLE TABLE

The role or activity performed by a person. E.g. *artist, creator, designer, draftsman, painter, sculptor, architect, carpenter, framer, curator, restorer, conservator scientist, specialist, assistant, author, owner, art historian*, etc.

The table includes the following columns:

- **ROLE_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **ROLE_NAME**: role name
- **ROLE_TYPE**: role categories or groups
- **AAT_LINK**: external link to the Getty Vocabulary AAT (Artist & Architecture Thesaurus)
- **ROLE_COMMENT**: comment/ description or any other relevant information, insert as free text

PERSONxROLE

Junction table that establishes a many-to-many relationship[15] between persons and roles.

The table includes the following columns:

- **PERSONXROLE_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **PERSON_ID**: FOREIGN KEY that matches the primary key column of the "person" table
- **ROLE_ID**: FOREIGN KEY that matches the primary key column of the "role" table
- **INSTITUTION_ID**: FOREIGN KEY that matches the primary key column of the "institution" table

INFLUENCE TABLE

The term or terms identifying an historical period, style, school, group or art movement whose characteristics can be associated with a person or an event related to the work of art.

The table includes the following columns:

[14] AAT (Artist & Architecture Thesaurus) is a structured vocabulary, including terms, descriptions, and other metadata for generic concepts related to art, architecture, conservation, archaeology, and other cultural heritage. Included are work types, styles, materials, techniques, and others.

[15] a many-to-many relationship is a type of cardinality that refers to the relationship between two entities A and B in which an element of A may be linked to many elements of B and vice versa

- **INFLUENCE_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **INFLUENCE_NAME**: term identifying an historical period, style, school, group or art movement (e.g. *Baroque, Renaissance, Mannerist, etc.*)
- **INFLUENCE_TYPE**: a term identifying the type represented in the influence_name (e.g. *historical period, style, school, group, movement*)
- **PARENT_INFLUENCE_ID**: Self Referencing relationship to the influence_id of the higher hierarchical level influence period/style/school/movement
- **AAT_LINK**: external link to the Getty Vocabulary AAT (Artist & Architecture Thesaurus)
- **INFLUENCE_COMMENT**: comment/ description or any other relevant information, insert as free text

PERSONxINFLUENCE TABLE

Junction table that establishes a many-to-many relationship between a person and a stylistic or period term assigned to or associated with that person.
The table includes the following columns:

- **PERSONXINFLUENCE_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **PERSON_ID**: FOREIGN KEY that matches the primary key column of the "person" table
- **INFLUENCE_ID**: FOREIGN KEY that matches the primary key column of the "influence" table

EVENT TABLE

This table defines all the type of event associated with a work of art. Terminology can also refer to a critical event, activity, status, or situation that took place in the life of a person related to the work of art. Each event must be accompanied by a date or a geographic place.
The table includes the following columns:

- **EVENT_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **EVENT_NAME**: identification of the event involving the work of art
- **EVENT_TYPE**: a term identifying the type represented in the event_name
- **TIMESPAN_ID**: FOREIGN KEY that matches the primary key column of the "timespan" table. This value defines a description of the date or range of dates when the event took place or the state, status, or situation was in effect (e.g., *1740-1756, from 1888*)
- **TIMESPAN_DESCRIPTOR**: descriptor to be used when the timespan is uncertain or approximate (e.g., *about, after, before, early, mid, late*)
- **TIMESPAN_CONFIDENCE**: level of confidence/accuracy for the defined timespan (e.g., *standard, automatic, probably, possibly*)
- **PLACE_ID**: FOREIGN KEY that matches the primary key column of the "place" table and defines the geographic place where the event took place (e.g., London (England); Florence (Tuscany, Italy))
- **PLACE_CONFIDENCE**: level of confidence for the defined place (e.g. *standard, automatic, probably, possibly*)

- **PROTOCOL_ID**: FOREIGN KEY that matches the primary key column of the "protocol" table, useful when the guidelines of an event are provided by a specific protocol (e.g., examination)
- **OBJECT_STATUS**: status of the object involved in the event (e.g., *Gallery condition, before cleaning, after cleaning*, etc.)
- **EVENT_COMMENT**: comment/ description or any other relevant information, insert as free text

• EVENT FOR A PERSON	• EVENT FOR AN OBJECT
• general historical event	• general historical event
• birth	• commission
• activity	• production / creation
• education	• design
• lived	• start of production
• final years	• completion of production
• death	• modelled
• documented	• cast
•	• wrought
•	• forged
•	• coating
•	• laminating
•	• reworked
•	• component alteration
•	• discovery
•	• destruction
•	• loss
•	• discovery
•	• acquisition - purchase
•	• cataloguing
•	• movement
•	• loan
•	• restoration
•	• maintenance
•	• exhibition
•	• sampling
•	• analysis
•	• cross section preparation
•	• image acquisition

PERSONxEVENT TABLE

Junction table that establishes a many-to-many relationship between a person and an associated event.
The table includes the following columns:

- **PERSONXEVENT_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **PERSON_ID**: FOREIGN KEY that matches the primary key column of the "person" table
- **EVENT_ID**: FOREIGN KEY that matches the primary key column of the "event" table
- **ROLE_ID**: FOREIGN KEY that matches the primary key column of the "role" table
- **ROLE_CONFIDENCE**: level of confidence/ accuracy of the role attribution (e.g. *attribute, formerly attributed, probably, possibly*)
- **PERSONXEVENT_ORDER**: number that defines an order to organize the event-person values.

INFLUENCExEVENT TABLE

Junction table that establishes a many-to-many relationship between event and influence (historical period, style, school, group or art movement) and defines related timespan and place.
The table includes the following columns:

- **INFLUENCEXEVENT_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **INFLUENCE_ID**: FOREIGN KEY that matches the primary key column of the "influence" table
- **EVENT_ID**: FOREIGN KEY that matches the primary key column of the "event" table

EVENTxTHING TABLE

Junction table that establishes a many-to-many relationship between an object, sample, or component (overall defined as *thing*) with a specific associated event.
The table includes the following columns:

- **EVENTXTHING_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **THING_ID**: primary key of a specific subject (e.g., *object_id, object_part_id, place_id, institution_id, sample_id, component_id*). This value corresponds with the id in the related table (e.g. for *object_id* = 2, in the object table, we will have *thing_id* = 2, *thing_type* = object)
- **THING_TYPE**: a term identifying the type of subject/thing (e.g., *object, sample, component*)
- **EVENT_ID**: FOREIGN KEY that matches the primary key column of the "event" table

TIMESPAN TABLE

This table defines date or range of dates.
The table includes the following columns:

- **TIMESPAN_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **TIMESPAN_NAME**: timespan name (e.g. *Late 18th Century*)
- **TIMESPAN_START**: earliest date of the timespan (YYYY-MM-DD)
- **TIMESPAN_END**: latest date of the timespan (YYYY-MM-DD)

- **TIMESPAN_CLASS**: a term identifying the type of timespan (*year, year-range, cent, cent-range, dec*)
- **TIMESPAN_GROUP**: timespan qualifier (*early, earlier, before, after, about, mid, late, later, second half of the, etc.*)
- **TIMESPAN_COMMENT**: comment/ description or any other relevant information, insert as free text

TIMESPAN_EXTRA TABLE

This table defines further information on a specific timespan.
The table includes the following columns:

- **TIMESPAN_EXTRA_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **TIMESPAN_ID**: FOREIGN KEY that matches the primary key column of the "timespan" table
- **TIMESPAN_EXTRA_NAME**: timespan name (e.g.*15th Century*)
- **TIMESPAN_EXTRA_RELATION**: (*within, overlaps, contains*)
- **TIMESPAN_EXTRA_GROUP**: timespan qualifier (*decade, century*)
- **TIMESPAN_EXTRA_COMMENT**: comment/ description or any other relevant information, insert as free text

PLACE TABLE

Information about current or historical geographic places related to a work of art.
The table includes the following columns:

- **PLACE_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **PLACE_NAME**: proper names, appellations, nicknames, or other identifying phrases by which a place is known
- **PLACE_TYPE**: term that characterizes significant aspects of the place, including its role, function, political anatomy, size, or physical characteristics (e.g., *locality, region, province, island group, country, administrative area, point of interest*)
- **HISTORICAL_FLAG**: flag indicating the historical status of the name (e.g., *current, historical*)
- **TIMESPAN_ID**: a description of the date or range of dates when a particular name was in use for the place
- **LATITUDE**: latitude geographic coordinate (a set of numbers used to define points on the earth's surface that correspond to the physical location of the place)
- **LONGITUDE**: longitude geographic coordinate (a set of numbers used to define points on the earth's surface that correspond to the physical location of the place)
- **THE_GEOM**: reference geographic coordinate system (e.g. *WGS84*)
- **PARENT_PLACE_ID**: Self Referencing relationship to the place_id of the higher hierarchical level place type
- **TGN_LINK**: external link to the Getty Vocabulary TGN (Thesaurus of Geographic Names)[16]
- **PLACE_COMMENT**: comment/ description or any other relevant information, insert as free text

[16] TGN (Thesaurus of Geographic Names) is a structured vocabulary, including names, descriptions, and other metadata for extant and historical cities, empires, archaeological sites, and physical features important to research of art and architecture. TGN may be linked to GIS, maps, and other geographic resources.

INSTITUTION TABLE

The table includes a list of institution (Museum, Gallery, University, Centre of research, etc.) that can be correlated to persons, objects and events.
The table includes the following columns:

- **INSTITUTION_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **INSTITUTION_NAME**: name of the institution
- **INSTITUTION_ACRONYM**: acronym by which the institution is also known
- **INSTITUTION_TYPE**: type of institution (e.g. *museum, gallery, university, centre of research,* etc.)
- **PLACE_ID**: FOREIGN KEY that matches the primary key column of the "place" table and defines the geographic location of the institute
- **WEBPAGE**: URL address of the institution official website
- **INSTITUTION_CURRENT_FLAG**: flag indicating the historical status of the institution (e.g., *current, historical*)
- **INSTITUTION_COMMENT**: comment/ description or any other relevant information, insert as free text

REFERENCE TABLE

The table includes bibliographic sources, report or unpublished documents that provide all the information recorded for person, object and related events.
The table includes the following columns:

- **REFERENCE_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **REFERENCE_TITLE**: reference title
- **REFERENCE_TYPE**: type of reference (e.g., *archive, book, journal, newspaper,* etc.)
- **REFERENCE_LOCATION**: volume, editor and any other cataloguing information essential to find the reference
- **REFERENCE_LINK**: link to the related file
- **REFERENCE_COMMENT**: comment/ description or any other relevant information, insert as free text

REFERENCExTHING TABLE

Junction table that establishes a many-to-many relationship between an object, sample, or component (overall defined as *thing*) and a reference to a bibliographic source, unpublished document, or opinion that provides the information recorded in this category.
The table includes the following columns:

- **REFERENCEXTHING_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **REFERENCE_ID**: FOREIGN KEY that matches the primary key column of the "reference" table

- **THING_ID**: primary key of a specific subject (e.g., *object_id, sample_id, component_id*)
- **THING_TYPE**: a term identifying the type of subject/thing (e.g., *object, sample, component*)
- **TIMESPAN_ID**: FOREIGN KEY that matches the primary key column of the "timespan" table
- **CLASSIFICATION**: reference's class

CLASSIFICATION TABLE

Hierarchical classification scheme that includes type classes gather together on the basis of similar characteristics. The table includes the following columns:

- **CLASSIFICATION_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **CLASSIFICATION_NAME:** class name
- **CLASSIFICATION_PARENT_ID**: Self Referencing relationship to the classification_id of the higher hierarchical level type
- **AAT_LINK**: external link to the Getty Vocabulary AAT (Artist & Architecture Thesaurus)
- **CLASSIFICATION_COMMENT**: comment/description or any other relevant information, insert as free text

CLASSIFICATION (Hierarchy levels)		
Level 1	Level 2	Level 3
object type	altarpiece	diptych
		triptych
		polyptych
	painting	
	sculpture	
	pot	
	architecture	
	wall painting	
	tapestry	
layer type	preparatory layer	
	local preparation	
	underdrawing	
	paint layer	
	metal leaf	
	intermediate unpigmented organic layer	
	varnish	
	non original	
colour preparation category	white, off-white	
	tinted	

	• coloured	•
• chemical_class	• organic	•
	• inorganic	•
	• organic-inorganic mixture	•
	• undefined	•

The MySQL table may look like this:

classification_id	classification_name	classification_parent_id
1	object type	
2	altarpiece	1
3	sculpture	1
4	pot	1
6	diptych	2
7	triptych	2
8	polyptych	2

CLASSIFICATIONxTHING TABLE

Junction table that establishes a many-to-many relationship between an object, sample, or component (overall defined as *thing*) with a specific associated type class.

The table includes the following columns:

- **CLASSIFICATIONXTHING_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **THING_ID**: primary key of a specific subject (e.g., *object_id, sample_id, component_id*). This value corresponds with the id in the related table (e.g. for *object_id* = 2, in the object table, we will have *thing_id* = 2, *thing_type* = object)
- **THING_TYPE**: a term identifying the type of subject/thing (e.g., *object, sample, component*)
- **CLASSIFICATION_ID**: FOREIGN KEY that matches the primary key column of the "classification" table
- **CLASSIFICATIONXTHING_ORDER**: number that defines an order for the thing-classification values.

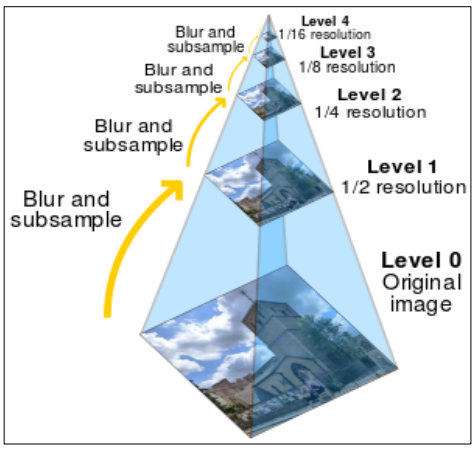
This table must contain the following relationship:

- between the *object* table and the classification type related to the *object type*
- between the *preparation* table and the classification type related to the *colour preparation category*
- between the *preparation* table and the classification type related to the *layer type*
- between the *sample layer* table and the classification type related to the *layer type*
- between the *sample layer* table and the classification type related to the *colour preparation category*
- between the *material* table and the classification type related to the *chemical class*
- between the *chemical compound* table and the classification type related to the *chemical class*

IMAGE TABLE

This table includes all the information about a single image that depicts or is associated to a work of art. The table includes the following columns:

- **IMAGE_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **IMAGE_NAME**: image name
- **IMAGE_FILE**: image file name
- **EVENT_ID**: FOREIGN KEY that matches the primary key column of the "event" table and defines date, place and protocol of the image record
- **IMAGE_WIDTH**: image width (in pixel)
- **IMAGE_HEIGHT**: image height (in pixel)
- **IMAGE_FORMAT**: file format
- **IMAGE_LEVEL**: number of image pyramid levels
- **IMAGE_PPMM**: pixel per millimetre (pixel/mm)
- **IMAGE_TILE**: number of square bitmap graphics displayed in a grid arrangement to show the image (e.g., 256×256 pixel images). An image pyramid is a collection of images - all arising from a single original image - that are successively downsampled until some desired stopping point is reached.



Visual representation of an image pyramid with 5 levels

- **IMAGE_PUBLIC**: Boolean data type (yes/no) that defines the image public domain
- **IMAGE_CAPTION**: image caption
- **IMAGE_DETAIL_TYPE**: image type (*whole, detail*)
- **IMAGE_LIGHTSOURCE**: lightsource of the image acquisition system (e.g., *visible light, visible, ultra-violet, X-ray,* etc.)
- **IMAGE_OPTICAL_SPEC**: optical specifications (e.g. *dark field, bright field,trasmitted light*, etc.)
- **IMAGE_ASPECT**: description of the aspect (position, angle, orientation) of the work as depicted in the image (e.g., *front, back*)
- **IMAGE_FILEDATE**: image file date
- **IMAGE_COPYRIGHT_HOLDER**: copyright statement naming the copyright holder (e.g., *The National Gallery, London*)
- **IMAGE_LICENSE**: summary of any restrictions on the use or dissemination of the image
- **IMAGE_PHOTOREFERENCE**: reference related to the physical photographic negative (internal documentation of the Gallery)
- **IMAGE_CLASSIFICATION**: a term identifying the type represented (e.g., *Picture, Sample*, etc.)
- **PATH_ID**: FOREIGN KEY that matches the primary key column of the "path" table
- **SERVER_ID**: FOREIGN KEY that matches the primary key column of the "server" table
- **IMAGE_COMMENT**: comment/ description or any other relevant information, insert as free text

The *image_purpose* can be deduced by the other image data (e.g. preparation visible on surface, sampling location, technical image).

3D MODEL TABLE

This table collects all the Three-dimensional models acquired for a single artefact.
The table includes the following columns:

- **3DMODEL_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **POINT_CLOUD_NAME**: point cloud file name
- **MESH_NAME**: 3D mesh file name
- **EVENT_ID**: FOREIGN KEY that matches the primary key column of the "event" table and defines date, place and protocol of the image record
- **3DMODEL_CAPTION**: 3D model caption
- **3DMODEL_TYPE**: 3D model type (*whole*, *detail*)
- **3DMODEL_TEXTURE** Boolean data type (yes/no) that defines the texture presence
- **3DMODEL_FILEDATE**: 3D model file date
- **3DMODEL_COPYRIGHT**: copyright statement naming the copyright holder (e.g., *The National Gallery, London*)
- **3DMODEL_LICENSE**: summary of any restrictions on the use or dissemination of the model
- **PATH_ID**: FOREIGN KEY that matches the primary key column of the "path" table
- **SERVER_ID**: FOREIGN KEY that matches the primary key column of the "server" table
- **3DMODEL_COMMENT**: comment/ description or any other relevant information, insert as free text

POINT LOCATION TABLE

Method for expressing a point location in an image or 3D model and localise specific areas or points of interest (e.g., area of interest, test area, detail, sampling point, acquisition point, etc.). A system of spatial coordinates is used to specify the point location and the size, shape, and placement of an area.
The table includes the following columns:

- **POINT_LOCATION_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **POINT_LOCATION_NAME**: location name
- **POINT_LOCATION_DESCRIPTION**: brief description that identifies the selected area/point
- **POINT_LOCATION_CATEGORY**: area or point type (e.g., *area of interest, detail, photomicrograph, sample*, etc.)
- **OBJECT_SIDE**: side of the object where the defined point is located
- **IMAGE_ID**: FOREIGN KEY that matches the primary key column of the "image" table
- **IMAGE_LOCATION_X**: image x-coordinate
- **IMAGE_LOCATION_Y**: image y-coordinate
- **IMAGE_LOCATION_W**: image w-coordinate
- **IMAGE_LOCATION_H**: image h-coordinate
- **3DMODEL_ID**: FOREIGN KEY that matches the primary key column of the "3D model" table
- **3DMODEL_LOCATION_X**: x-point-coordinate on the 3D model
- **3DMODEL_LOCATION_Y**: y-point-coordinate on the 3D model

- **3DMODEL_LOCATION_Z**: z-point-coordinate on the 3D model
- **POINT_LOCATION_COMMENT**: comment/ description or any other relevant information, insert as free text

MEDIAxTHING TABLE

Junction table that establishes a many-to-many relationship between a person, object, sample, or component (overall defined as *thing*) with an image.
The table includes the following columns:

- **MEDIAXTHING_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **THING_ID**: primary key of a specific subject (e.g., *object_id, object_part_id, sample_id*). This value corresponds with the id in the related table (e.g. for *object_id* = 2, in the object table, we will have *thing_id* = 2, *thing_type* = object)
- **THING_TYPE**: a term identifying the type of subject/thing (e.g., *object, object_part*)
- **MEDIA_ID**: FOREIGN KEY that matches the primary key column of the "image" table
- **MEDIA_TYPE**: a term identifying the type of media (e.g., *image, 3D model*)
- **IMAGE_ORDER**: number that defines the order of the images
- **3DMODEL_ORDER**: number that defines the order of the 3D models

SERVER TABLE

This table contains a list of web server address where the images can be stored.
The table includes the following columns:

- **SERVER_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **SERVER_NAME**: server address

PATH TABLE

The table lists virtual file paths through the server's directory structure that define the stored image locations.
The table includes the following columns:

- **PATH_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **PATH_NAME**: file path
- **PATH_ORIGINAL**
- **PATH_PUBLIC**: Boolean data type (yes/no) that defines the path public domain

OBJECT TABLE

This table considers a work of art (painting, sculpture, drawing, architecture, etc.) as a generic object.
The table includes the following columns:

- **OBJECT_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **OBJECT_INVENTORY_NUMBER**: catalogue number by which the object is identified within a collection
- **ALPHA_CODE**: object_internal_numbers redefines as a list of alphabetical order codes
- **TITLE_ID**: FOREIGN KEY that matches the primary key column of the "title" table and assigns the object title
- **OBJECT_HEIGHT**: object height
- **OBJECT_WIDTH**: object width
- **OBJECT_DEPTH**: object depth
- **OBJECT_DIAMETER**: object diameter
- **EXECUTION_TECHNIQUE**: brief description of the execution technique
- **MANIFACTURING_PROCESS**: brief description of the manufacturing process
- **CONDITION**: brief description of the current condition of the object
- **OBJECT_CREDITLINE**: further information
- **OBJECT_COMMENT**: comment/ description or any other relevant information, insert as free text

OBJECT PART TABLE

This table lists all the object components by identifying each of them like a single object part.
The table includes the following columns:

- **OBJECT_PART_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **OBJECT_ID**: FOREIGN KEY that matches the primary key column of the "object" table
- **OBJECT_PART_NAME**: name or brief description of the object part
- **OBJECT_PART_NUMBER**: arbitrary number assigned to the object part
- **OBJECT_PART_TYPE**: type of object part (e.g., *original support, addition, filler, repair)*
- **OBJECT_PART_OBSERVATION**: define how the part was identified (e.g., *naked-eye observation, analysis identification*)
- **OBJECT_PART_COMMENT**: comment/ description or any other relevant information, insert as free text

OBJECTxTHING TABLE

Junction table that establishes a many-to-many relationship between an object and a person, place or institution when there isn't any kind of event correlating the two entities (e.g., object and artist are correlated through the "creation" event). The table includes the following columns:

- **OBJECTXTHING_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **THING_ID**: primary key of a specific subject (e.g., *person_id, place_id, institution_id,*)
- **THING_TYPE**: a term identifying the type of subject/thing (e.g., *person, place, institution*)
- **ROLE_ID**: FOREIGN KEY that matches the primary key column of the "role" table (e.g., *owner* for a person, location or place, *painter, creator, designer, draftsman, etc*. for a person, *permanent location, temporary location, research centre* for a place or istitution*)*
- **ROLE_CONFIDENCE**: level of confidence/ accuracy of the role attribution (e.g. *attribute, formerly attributed, probably, possibly*)
- **OBJECTXTHING_COMMENT**: comment/ description or any other relevant information, insert as free text

TITLE TABLE

The table includes the title or name given to an object.
The table includes the following columns:

- **TITLE_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **TITLE_NAME**: full title or name of the object
- **TITLE_SHORT**: title abbreviation
- **TITLE_COMMENT**: comment/ description or any other relevant information, insert as free text

MEDIUM TABLE

The table reports information about painting medium and indirectly about the artistic technique.
The table includes the following columns:

- **MEDIUM_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **OBJECT_ID**: FOREIGN KEY that matches the primary key column of the "object" table
- **MEDIUM_NAME**: medium name
- **MATERIAL_ID**: : FOREIGN KEY that matches the primary key column of the "material" table and defines the medium chemical composition
- **MEDIUM_AMOUNT**: medium amount
- **MEDIUM_ORDER**: number that defines an order for the media values.
- **MEDIUM_COMMENT**: comment/ description or any other relevant information, insert as free text

SUPPORT TABLE

The table reports information about the object support.
The table includes the following columns:

- **SUPPORT_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **OBJECT_ID**: FOREIGN KEY that matches the primary key column of the "object" table
- **SUPPORT_NAME**: support name
- **MATERIAL_ID**: FOREIGN KEY that matches the primary key column of the "material" table, name of the matter, material, or substance used to create the support
- **SUPPORT_COMMENT**: comment/ description or any other relevant information, insert as free text

PREPARATION TABLE

The table defines the characteristics of the object preparation.
The table includes the following columns:

- **PREPARATION_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **OBJECT_ID:** FOREIGN KEY that matches the primary key column of the "object" table
- **SURFACE_VISIBILITY**: Boolean data type (yes/no) that defines the layer surface visibility
- **COLOUR_ MAIN_ID**: FOREIGN KEY that matches the primary key column of the "colour main" table
- **COLOUR_MODIFIER_ID**: FOREIGN KEY that matches the primary key column of the "colour modifier" table
- **COLOUR_DESCRIPTOR_ID**: FOREIGN KEY that matches the primary key column of the "colour descriptor" table
- **APPLICATION_TECNIQUE**: name of the means, method, process, or technique by which a material was used in the layer creation
- **PREPARATION_COMMENT**: comment/ description or any other relevant information, insert as free text

SAMPLE TABLE

Information about specimens that are normally examined to provide a specific piece of information for the restorer working on the object conservation and at the same time to collect all possible data about materials and technique.
The table includes the following columns:

- **SAMPLE_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **SAMPLE_NUMBER**: number assigned to the sample during analysis
- **OBJECT_ID:** FOREIGN KEY that matches the primary key column of the "object" table
- **OBJECT_PART_ID:** FOREIGN KEY that matches the primary key column of the "object_part" table
- **SAMPLE_TYPE**: cross section, fragment, etc.
- **POINT_LOCATION_ID**: FOREIGN KEY that matches the primary key column of the "point location" table and defines the sampling location
- **SAMPLE_COMMENT**: comment/ description or any other relevant information, insert as free text

SAMPLE LAYER TABLE

Data collected on a sample layer.
The table includes the following columns:

- **SAMPLE_LAYER_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **SAMPLE_LAYER_NUMBER**: recorded or arbitrary layer number
- **SAMPLE_ID**: FOREIGN KEY that matches the primary key column of the "sample" table
- **OBJECT_LAYER_NUMBER**: object layer number
- **COLOUR_ MAIN_ID**: FOREIGN KEY that matches the primary key column of the "colour main" table
- **COLOUR_MODIFIER_ID**: FOREIGN KEY that matches the primary key column of the "colour modifier" table

• THICKNESS RANGE
• less than 0.5 μm
• 0.5 - 5 μm
• 5 - 10 μm
• 10 - 20 μm
• 20 - 50 μm
• 50-100 μm
• 100 μm +

- **COLOUR_DESCRIPTOR_ID**: FOREIGN KEY that matches the primary key column of the "colour descriptor" table
- **SAMPLE_LAYER_THICKNESS**: layer thickness (μm)
- **SAMPLE_LAYER_COMMENT**: comment/ description or any other relevant information, insert as free text

SAMPLE COMPONENT TABLE

Data collected on a single component identified in a sample examination.
The table includes the following columns:

- **SAMPLE_COMPONENT_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **SAMPLE_COMPONENT_NUMBER**: arbitrary component number
- **SAMPLE_LAYER_ID**: FOREIGN KEY that matches the primary key column of the "sample layer" table
- **SAMPLE_COMPONENT_AMOUNT**: component amount
- **SAMPLE_COMPONENT_SIZE**: component size
- **COLOUR_ MAIN_ID**: FOREIGN KEY that matches the primary key column of the "colour main" table
- **COLOUR_DESCRIPTOR_ID**: FOREIGN KEY that matches the primary key column of the "colour descriptor" table
- **MATERIAL_ID**: FOREIGN KEY that matches the primary key column of the "material" table and defines the component chemical composition
- **PARENT_COMPONENT_ID**: Self Referencing relationship to the sample_component_id used to define the component associations

- **SAMPLE_COMPONENT_COMMENT**: comment/ description or any other relevant information, insert as free text

• Component amount	• Component size
• major	• tinted/none
• minor	• fine
• trace	• fine and medium
•	• fine and coarse
•	• medium
•	• coarse
•	• coarse and medium
•	• coarse, medium, and fine

COLOUR MAIN TABLE

The table defines a list of colours used to categorize the main colour of an object/element/layer/compound. The table includes the following columns:

- **COLOUR_MAIN_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **COLOUR_MAIN_NAME**: colour name
- **COLOUR_MAIN_COMMENT**: comment/ description or any other relevant information, insert as free text

COLOUR MODIFIER TABLE

The table defines a list of colours used to categorize the modifier of the main colour of an object/element/layer/compound. The table includes the following columns:

- **COLOUR_MODIFIER_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **COLOUR_MODIFIER_NAME**: colour name
- **COLOUR_MODIFIER_COMMENT**: comment/ description or any other relevant information, insert as free text

• Colour of the preparation			• Colour of the sample layer			• Colour of the component	
• **main**	• modifier	• descriptor	• main	• modifier	• descriptor	• main	• descriptor
• off-white	• grey	• light	• off-white	• grey	• light	• white	• transparent
• white	• pink	• mid	• white	• pink	• mid	• black	• light
• grey	• brown	• dark	• grey	• brown	• dark	• brown	• mid
• pink	• yellow	•	• pink	• yellow	•	• yellow	• dark
• brown	• red	•	• brown	• red	•	• orange	• metallic
• yellow	• orange	•	• yellow	• orange	•	• red	•
• red	• warm	•	• red	• warm	•	• grey	•
• black	• cool	•	• black	• colol	•	• colourless	•
• main	•	•	• unpigmented	•	•	•	•
•	•	•	• yellowed	•	•	•	•
•	•	•	• orange	•	•	•	•
•	•	•	• green	•	•	•	•
•	•	•	• blue	•	•	•	•
•	•	•	• violet	•	•	•	•

COLOUR DESCRIPTOR TABLE

The table defines a list of colour descriptors.

The table includes the following columns:

- **COLOUR_DESCRIPTOR_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **COLOUR_DESCRIPTOR_NAME**: descriptor name

- **COLOUR_DESCRIPTOR_COMMENT**: comment/ description or any other relevant information, insert as free text

MATERIAL TABLE

The table defines a list of materials that can be related to the properties and history of an object in terms of raw materials used, manufacturing process, dating, preservation. The table also includes a list of chemical compounds and element essential to characterize and describe chemical and physical analyses carried out on sample/microsamples taken from the object.
The table includes the following columns:

- **MATERIAL_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **MATERIAL_NAME**: material name (e.g. *linseed oil*)
- **MATERIAL_TYPE**: type of material (e.g. *chemical compound, chemical element*)
- **MATERIAL_CLASS**: the class a material belongs to (e.g. *polymer, metal, ceramic, composite*)
- **MATERIAL_SUBCLASS**: subclass of a material class (e.g. *drying oil*)
- **LINK**: external link
- **MATERIAL_COMMENT**: comment/ description or any other relevant information, insert as free text

TECHNIQUE TABLE

The table defines the characteristic of analytical techniques and instrumentation which can be used in a wide range of diagnostic, conservative and research applications.
The table includes the following columns:

- **TECHNIQUE_ID:** unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **TECHNIQUE_NAME**: specific name by which an analytical technique is known
- **TECHNIQUE_FULL_NAME**: full name of the technique required when the common name is defined as an acronym
- **TECHNIQUE_LINK**: link to a web page that describes the technique
- **TECHNIQUE_COMMENT**: comment/ description or any other relevant information, insert as free text

PROTOCOL TABLE

Protocols, documents and reports describing the specific procedure and setting used in a wide range of activities, such as object sampling, analysis, data reporting and elaboration.
The table includes the following columns:

- **PROTOCOL_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **PROTOCOL_NAME**: protocol title

- **PROTOCOL_TYPE**: protocol type (e.g. *image acquisition, image calibration, SEM acquisition*, etc.)
- **TECHNIQUE_ID**: FOREIGN KEY that matches the primary key column of the "technique" table
- **INSTITUTION_ID**: FOREIGN KEY that matches the primary key column of the "institution" table, the institution where the protocol was written, approved and applied.
- **TIMESPAN_ID**: FOREIGN KEY that matches the primary key column of the "timespan" table, date of the protocol
- **PROTOCOL_FILE**: protocol's file name
- **PROTOCOL_ORDER**: number that defines the order of the protocol
- **PROTOCOL_KEYWORDS**: list of key words defining the main features of the protocol
- **PROTOCOL_COMMENT**: comment/ description or any other relevant information, insert as free text

MEASUREMENT TABLE

This table defines the properties of a single measurement carried out in a specific analytical procedure.
The "measurement" relates to the whole process of obtaining a quantity value. The description of how the measurement is performed involves the "event = acquisition", where is possible to specify "time", "place" and "acquisition protocol".
The table includes:

- **MEASUREMENT_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **MEASUREMENT_NUMBER**: arbitrary number assigned to the measurement during the analysis
- **EVENT_ID:** FOREIGN KEY that matches the primary key column of the "event" table
- **POINT_LOCATION_ID:** FOREIGN KEY that matches the primary key column of the "point location" table
- **MEASUREMENT_COMMENT**: comment/ description or any other relevant information, insert as free text

MEASUREMENTxCOMPOSITION TABLE

Junction table that establishes a many-to-many relationship between a point measurement and a detected material, chemical element or chemical compound (all of them are listed in the "material" table). A quantity value can be attributed to the measurand together with any other available relevant information.
The table includes the following columns:

- **MEASUREMENTXCOMPOSITION_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **MEASUREMENT_ID:** FOREIGN KEY that matches the primary key column of the "measurement" table
- **MATERIAL_ID:** FOREIGN KEY that matches the primary key column of the "material" table
- **MATERIAL_VALUE(COUNTS):** quantity value, in counts, attributed to the material
- **MATERIAL_VALUE%:** percentage value attributed to the material
- **RESULT_CONFIDENCE:** level of confidence/ accuracy of the measurement result (e.g., *possibly, probably*)

- **MEASUREMENTXCOMPOSITION_COMMENT**: comment/ description or any other relevant information, insert as free text

RESULT TABLE

This table reports brief descriptions of results that can be obtained through several analytical procedures.
The table includes the following columns:

- **RESULT_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **EVENT_ID**: FOREIGN KEY that matches the primary key column of the "event" table
- **RESULT_DESCRIPTION**: brief description of the result
- **RESULT_COMMENT**: comment/ description or any other relevant information, insert as free text

RESULTxTHING TABLE

Junction table that establishes a many-to-many relationship between an object, object part, sample, component, etc. (overall defined as *thing*) with a specific associated result.
The table includes the following columns:

- **RESULTXTHING_ID**: unsigned integer that uniquely identifies each row/record in the table (PRIMARY KEY constraint). It must contain unique values, not null, and it is created automatically every time a new record is inserted into the table (auto-increment field)
- **THING_ID**: primary key of a specific subject (e.g., *object_id, object_part_id, sample_id, component_id*). This value corresponds with the id in the related table (e.g. for *object_id* = 2, in the object table, we will have *thing_id* = 2, *thing_type* = object)
- **THING_TYPE**: a term identifying the type of subject/thing (e.g., *object, sample, component*)
- **RESULT_ID**: FOREIGN KEY that matches the primary key column of the "result" table

Appendix 4;

IPERION-CH DATABASE DEVELOPMENT:
LIST OF SOFTWARE, TOOLS AND LIBRARIES EXPLORED AND USED TO BUILD THE DATABASE AND THE WEB INTERFACE

Author: Cristina Giancristofaro
Date: 21/03/2018

1. DATA GATHERING

- Excel Spreadsheet: used to collect data from all the Iperion partners involved in the project
- NG painting information: imported from NG API / TMS
- The geographic information related to the artist life has been collected consulting:
  - NG website and intranet
  - NG Completed Illustrated Catalogue
  - Getty ULAN: http://www.getty.edu/research/tools/vocabularies/ulan/
  - TRECCANI Italian Encyclopedia (with references): http://www.treccani.it/enciclopedia/tiziano-vecellio/
  - Wikipedia (with references)

The images of the artists have been collected consulting the following resources:

- Vasari, Le vite de' più eccellenti pittori, scultori e architettori (1568): https://it.wikisource.org/wiki/Le_vite_de%27_più_eccellenti_pittori,_scultori_e_architettori_(1568)
- Fondazione Zeri, Photo Online catalogue: http://catalogo.fondazionezeri.unibo.it/form_ricerca.jsp?percorso_ricerca=OA&locale=en&decorator=layout_resp&apply=true
- Europeana collection: https://www.europeana.eu/portal/it
- Musee du Louvre: http://cartelen.louvre.fr/cartelen/visite?srv=crt_frm_rs&langue=fr&initCritere=true
- Prado museum online collection
- Wellcome collection: https://wellcomecollection.org/works
- National Galleries Scotland online collection: https://www.nationalgalleries.org/

Software to define sample location points or areas: NIP2

2. DATABASE DESIGN AND DEVELOPMENT:

- yEdGraph
- phpMyAdmin

3. WEBSITE MOCK-UP AND DESIGN:

- Balsamiq Mockups 3
- Adobe Photoshop CC
- Adobe Illustrator CC

Icon online free databases:
- Font-awesome https://fontawesome.com/v4.7.0/icons/
- Google icon https://material.io/icons/
- Noun project https://thenounproject.com/

4. TEXT EDITOR FOR CODING (HTML, CSS, PHP, JAVASCRIPT):

- Geany (tested)
- Brackets (tested)
- Visual Studio Code (tested)
- PhpStorm JetBrains 2.4 (final choice. It supports multiple code languages and provides the best code completion, smart code navigation, refactoring, on-the-fly error prevention, easy debugging and testing)

5. TOOLS AND LIBRARIES USED FOR THE WEBSITE IMPLEMENTATION:

- Bootstrap 4.0.0. alpha: open source toolkit for developing with HTML, CSS, and JS. https://getbootstrap.com/
  The website has been built using the Bootstrap framework:

  - the grid system layout: several options for laying a project, including wrapping containers, a powerful flexbox grid system, a flexible media object, and responsive utility classes.
  - several bootstrap components: alerts, badges, buttons, button groups, card, carousel, collapse, dropdowns, forms, input group, list group, modal, navs, navbar, pagination

- jQuery plugins to improve the usability of dropdown menu
  - https://www.jqueryscript.net/demo/jQuery-Plugin-For-Filterable-Bootstrap-Dropdown-Select-Bootstrap-Select/
  - http://select2.github.io/select2/index.html
  - https://fk.github.io/select2-bootstrap-css/index.html

Only these plugins have been explored so far, but a further recommendation would be to use something similar to improve the filter dropdown usability (e.g. including autocomplete search bar for long list)

- plugins to build a range slider (for the date filter):
  - bootstrap-slider.js http://www.html.it/wp-content/uploads/script/demo/f/52201/demo.html, https://github.com/seiyria/bootstrap-slider (explored)
  - jQuery.nstSlider.js https://github.com/lokku/jquery-nstslider (explored)
  - jQuery Slider plugin http://egorkhmelev.github.io/jslider/ (explored)
  - jQRangeSlider http://ghusse.github.io/jQRangeSlider/index.html (explored)
  - noUiSlider.11.0.3 https://refreshless.com/nouislider/ (final choice; a jQuery plugin to make double range sliders. Every slider can have two handles to select a range, a fixed minimum or maximum can be set to select a limit, or two handles can be used, to simply pick some points. Supports Google Chrome, Firefox, Opera, Safari and Internet Explorer 7 to 10. It also supports touch on capable devices, such as iPhone, iPad and Android phones and tablets.)

6. IMAGE VIEWER:

- IIIF International Image Interoperability Framework
  - IIIF API 2.1.1 http://iiif.io/api/presentation/2.1/
  - IIIF Image API 2.1.1 http://iiif.io/api/image/2.1/ - introduction

- Mirador 2.6.1 https://github.com/ProjectMirador/mirador

7. BUILDING MAPS AND TIMELINES:

Explored tools, libraries and online resources:

- TimeMaps http://www.timemaps.com/history/world-1215ad/
  Timeline.js https://timeline.knightlab.com/
  an open-source tool that enables anyone to build visually rich, interactive timelines.
- OldMapsOnline indexes over 400.000 old maps. http://www.oldmapsonline.org/
- SepiaTown is a cultural history project whose goal is to provide both a window to the past by merging photography, geography, and technology, as well as a forum for institutions and individuals to share and map historical images http://www.sepiatown.com/index
- Recogito Pelagios Commons provides online resources and a community forum for using open data methods to link and explore historical places
  http://commons.pelagios.org/
  https://recogito.pelagios.org/
- David Rumsey - Map Collection Database https://www.davidrumsey.com/home
- Georeferencer: an online tool that assigns geographical location to any image.
  https://www.georeferencer.com/
- Axis Maps https://www.axismaps.com/, http://axismaps.github.io/eshhad/public/
- Periodo: a public domain gazetteer of scholarly definitions of historical, art-historical, and archaeological periods. It eases the task of linking among datasets that define periods differently. It also helps to see where period definitions overlap or diverge.
  http://perio.do/
- GeoNames geographical database: http://www.geonames.org/

The maps currently available in the website have been developed using:

- OpenCage Geocoder: API to convert coordinates to and from places
  https://geocoder.opencagedata.com/
- GeoJson file validation and visualisation: http://geojson.io/ - map=6/45.745/10.239
- Mapbox GL JS v0.44.1: a JavaScript library that uses WebGL to render interactive maps from vector tiles and Mapbox styles.
  (Mapbox API documentation https://www.mapbox.com/mapbox-gl-js/api/)

Mapbox functionalities used in the Iperion website:

- Display a map: https://www.mapbox.com/mapbox-gl-js/example/simple-map/
- Add custom icons with Markers: https://www.mapbox.com/mapbox-gl-js/example/custom-marker-icons/
- Display a popup on click: https://www.mapbox.com/mapbox-gl-js/example/popup-on-click/
- Attach a popup to a marker instance: https://www.mapbox.com/mapbox-gl-js/example/set-popup/
- Custom styles: https://www.mapbox.com/designer-maps/
- Filter symbols by toggling a list: https://www.mapbox.com/mapbox-gl-js/example/filter-markers/
- Filter features within map view: https://www.mapbox.com/mapbox-gl-js/example/filter-features-within-map-view/
- Fit a map to a bounding box: https://www.mapbox.com/mapbox-gl-js/example/fitbounds/
- View a fullscreen map: https://www.mapbox.com/mapbox-gl-js/example/fullscreen/
- Display map navigation controls: https://www.mapbox.com/mapbox-gl-js/example/navigation/

Features of mapbox and other libraries explored that might be implemented in the future:

- Create and style clusters: https://www.mapbox.com/mapbox-gl-js/example/cluster/
- Fly to a location based on scroll position: https://www.mapbox.com/mapbox-gl-js/example/scroll-fly-to/
- Change a map's style: https://www.mapbox.com/mapbox-gl-js/example/setstyle/
- Limit geocoder results to a named region: https://www.mapbox.com/mapbox-gl-js/example/mapbox-gl-geocoder-limit-region/
- Create a time slider: https://www.mapbox.com/mapbox-gl-js/example/timeline-animation/

- Leaflet_1.3.1: open-source JavaScript library for mobile-friendly interactive maps