Heritage Science Austria

Interim Report

Project (no.)	Heritage_2020-014_INDIGO
Project (title)	INventory and DIsseminate Graffiti along the dOnaukanal
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Principal investigators	Geert J. Verhoeven (LBG) Norbert Pfeifer (TU Wien)
Host institutions	LBG - Ludwig Boltzmann Institute for Archaeological Prospection and Virtual Archaeology TU Wien - Department of Geodesy and Geoinformation

Report period	01-09-2021 until 15-09-2022 (September 2022 is partly included as most INDIGO output got generated this month)

A. Content Report

1. Conducted and current research

Pushing the boundaries of the status quo in inventorying and understanding extensive graffiti-scapes is a major goal of project INDIGO (IN-ventory and Disseminate G-raffiti along the d-O-naukanal). This two-year project, which launched in September 2021 through funding of the Heritage Science Austrian programme of the Austrian Academy of Sciences (ÖAW), aims to build the basis to systematically document, monitor, disseminate, and analyse a large part of the graffiti-scape along Vienna's central water channel *Donaukanal* (Eng. Danube Canal) in the next decade.

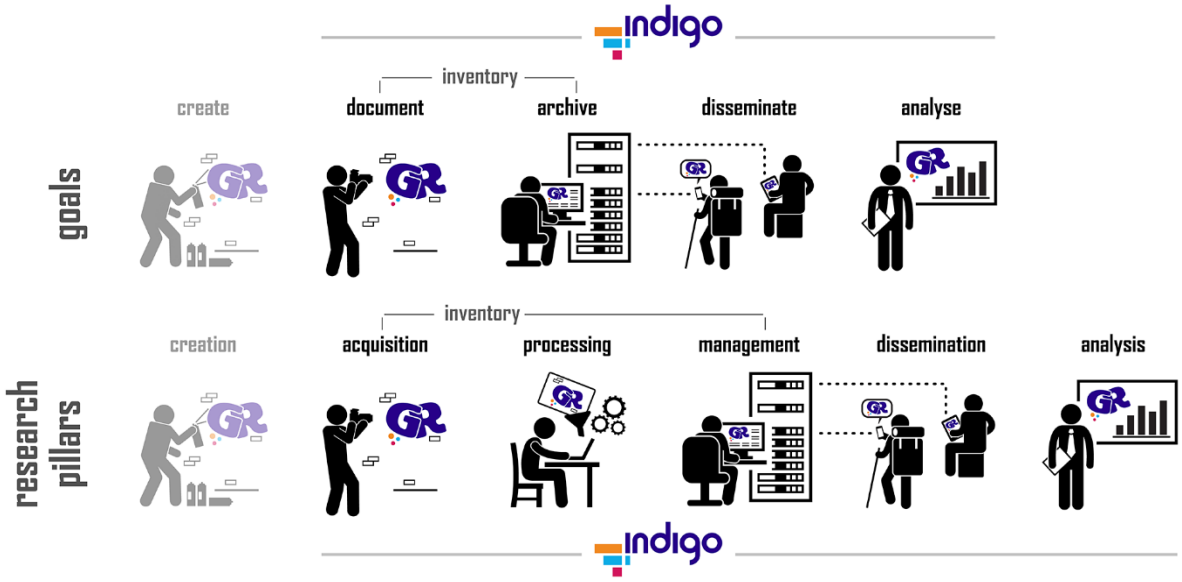


Figure 1 – A graphical overview of INDIGO's goals and research pillars. Although everything starts with producing a graffito, creating graffiti falls outside the scope of project INDIGO.

In doing so, INDIGO wants to digitally preserve this unique, complex, short-lived and socially relevant form of cultural heritage, as such leveraging its potential to disclose new socio-political-cultural research questions and graffiti-specific insights. To accomplish those aims, INDIGO is structured around five research pillars: 1) acquisition, 2) processing, 3) management, 4) dissemination and 5) analysis (graphical overview presented in Figure 1). Each of these pillars is covered by one or more Work Packages (WP). Since these 19 WPs form the actual management structure of project INDIGO, they are used below to detail last year's progress.

WP 1 – Management

Project INDIGO officially started with a kick-off meeting on the 9th (whole day) and 10th (half a day) of September 2021 (see Figure 2). After everybody introduced themselves in the morning session of the 9th, the team discussed the research and organisational challenges of the upcoming year. In the afternoon, all INDIGO staff (some with their family) participated in a guided tour along the graffiti of the Donaukanal. A graffiti spraying workshop the following morning ensured that all project members could start the project with at least a basic understanding and feeling for spraying graffiti.

Figure 2 – INDIGO's kick-off leaflet.

After the kick-off meeting, a tradition was established to have a team meeting at the end of every month. This practice will continue in the second project year. In addition, a status quo meeting is planned for October. The idea of this status quo meaning is two-fold: in the first part, INDIGO's past achievements will be presented. These first two hours of the meeting will also be streamed online, allowing any interested party to follow what has happened in the first project year. During the second part, the team will internally discuss the research plan for year two.

Lastly, this WP also contains daily management activities. Those are, however, detailed in Section A11.

WP 2 – Awareness

INDIGO deals with multi-coloured content, often created by people referring to themselves as artists. That is why the graphical work always received the necessary attention. INDIGO's logo was designed to express simplicity and harmony; the logo's four-colour palette (see Figure 3) is also applied in nearly every piece of graphical project work: the website, illustrations, maps, logos of software and symposium, business cards, and posters.

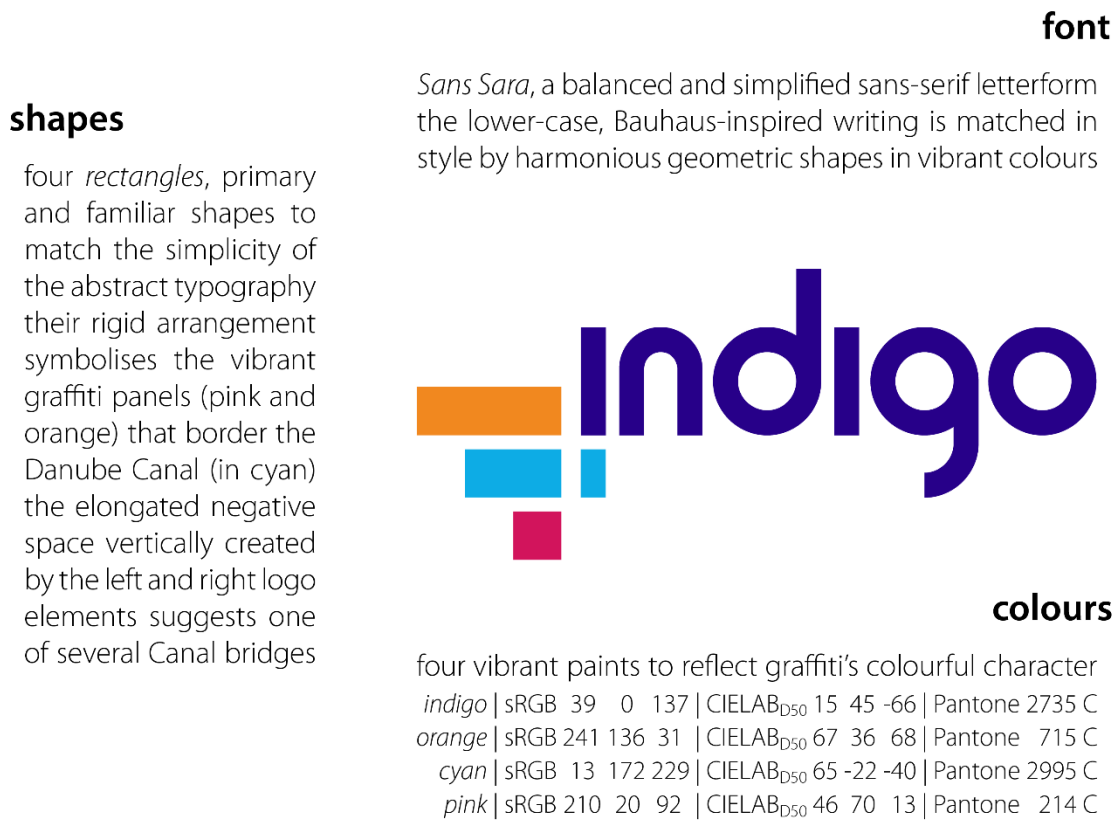


Figure 3 – The explanation of INDIGO's project logo and a technical description of the colour palette used.

Social media like Instagram and, to a lesser extent, Twitter are also important for INDIGO, because they establish the necessary local engagement with the local graffiti community. INDIGO's social media strategies are detailed in Section A9. In the second project year, these strategies will live on.

Besides the usual public dissemination like a website (see Section A9) and academic dissemination such as papers (Section A3), symposia (Section A6), and presentations (Section A7), INDIGO also spreads project awareness via the graffiti tours and workshops organised by Spraycity. Spraycity – in the person of Stefan Wogrin – not only establishes the necessary link between the academic and non-academic graffiti communities, but also organises graffiti tours and workshops as alternative team-building events or for

aspiring graffitists. During these events, Stefan raises awareness for project INDIGO. This results in a broader acceptance of project INDIGO in the local graffiti community, and sometimes even in surprising dissemination results. For instance, the Levin Statzer Foundation started to organise boat tours in September and October 2022 along the graffiti-scape of the Donaukanal. During these tours, project INDIGO and its goals are mentioned as well.

INDIGO also wanted to create flyers and spray QR codes along the Donaukanal. Both would link to an online form to report new graffiti. However, a meeting with a spokesperson of the City of Vienna (which prefers to be anonymous) clarified that the QR code idea would only be acceptable on the < 300 m of legal graffiti walls. However, the density of new graffiti appearing on these walls would mean that INDIGO's QR codes would likely be covered within a day. Combined with the limited stretch of surfaces on which these codes could find a place, the decision was taken to no longer pursue the QR idea. INDIGO-specific flyers were never created either. First, Stefan Wogrin's workshops are a very effective means to "spread the word". Second, the three project photographers that frequently visit the Donaukanal have business cards with personalised QR codes that link to the website and the online reporting form (Figure 4). These business cards have been considered a more compact replacement for the initial flyer idea.

Figure 4 – The front (on the left) and back (on the right) of Jona Schlegel's INDIGO business card. The QR codes are personalised and link to the general website and the online reporting form.

WP 3 – Hard- and software acquisition

During the first project months, considerable time has been invested into researching and purchasing the most appropriate hard- and software at the best possible price. In most cases, the intended products (i.e., those mentioned in the project proposal) were purchased. We only deviated in a few cases from the initial plan because more recent (or better value) solutions became available, or because the envisioned research strategy changed slightly. For instance, instead of two portable X-Rite Ci60 spectrophotometers, a more accurate Konica Minolta CM-26d was purchased. Initially, one of the intended instruments would have been sent to Spain, facilitating Adolfo Molada-Tebar to acquire the necessary data for his colourimetric developments. However, Adolfo could use a Spanish instrument which was at least as accurate as the X-Rite Ci60, so it made sense to purchase and operate a more accurate device in Vienna. This instrument will become very important during the second project year when INDIGO needs to assess the colourimetric workflow (see WP 8) and develop a graffiti-specific colour reference chart.

In the second project year, hard-and software purchases will drastically drop. Apart from a few hard drives and one or two licenses for Cesium Ion, nothing major has been foreseen. INDIGO has deliberately not spent the entire camera and lens budget. Relatively soon, it became apparent that only two cameras and lens sets were needed, because Jona Schlegel and Geert Verhoeven share the office and can easily exchange the camera gear. In addition, this money can be used to counter possible hardware failures or damage. Due to the intensity

of INDIGO's photographic activities, these are not unlikely. However, if INDIGO needs to buy a new lens or camera, the same model as those currently in use will be purchased. As such, no further research on purchasable hard- and software is needed.

WP 4 – Legislation

This WP looked at the complex problem of image copyright and all aspects concerning legal data sharing. Workshops on these – or related – topics were attended, and various people consulted. Many of them found it an interesting case, but in the end, nobody could help us further. We also invited Enrico Bonadio – lawyer and author of all major graffiti copyright books – to the goINDIGO 2022 symposium to discuss this issue. Mister Bonadio stressed the variability and regionality of the law on this topic. So, the matter seems to be highly complicated. After much research, INDIGO adopted the general and safe "In Copyright" statement for all photographs. This statement from rightsstatements.org clarifies that each photograph "is protected by copyright and/or related rights. You are free to use this Item in any way that is permitted by the copyright and related rights legislation that applies to your use. For other uses you need to obtain permission from the rights-holder(s)."

Because a photograph from a graffito has two copyrights (one held by the graffito creator and one by the photographer), the "In Copyright" statement is safe. Due to their general anonymity, INDIGO cannot contact every graffiti creator to clear their copyright. The "In Copyright" statement covers this situation because it notices that the user "may need to obtain other permissions for your intended use. For example, other rights such as publicity, privacy or moral rights may limit how you may use the material." The IPTC (International Press Telecommunications Council) image metadata of every INDIGO photograph mentions all this necessary rights info (see Table 1).

Table 1 – The rights values embedded in every INDIGO photo via the IPTC Image Rights Statements metadata fields.

IPTC field	Value
Copyright	In Copyright
Credit	project INDIGO (image) and [graffiti creator/s] (content)
Source	project INDIGO
Copyright URL	https://rightsstatements.org/page/InC/1.0/
Rights Usage Terms	This Item is protected by copyright and/or related rights. You are free to use this Item in any way that is permitted by the copyright and related rights legislation that applies to your use. For other uses you need to obtain permission from the rights-holder(s). NOTICES - Unless expressly stated otherwise, the organisation that has made this Item available makes no warranties about the Item and cannot guarantee the accuracy of this Rights Statement. You are responsible for your own use. - You may find additional information about the copyright status of the Item on the website of the organisation that has made the Item available. - You may need to obtain other permissions for your intended use. For example, other rights such as publicity, privacy or moral rights may limit how you may use the material.

Since the beginning of INDIGO, it became clear that it would be crucial to consider and address moral and ethical questions (e.g., how to deal with hateful, subversive, potentially illegal or other sensitive content). As a result, WP 4 got extended to "legislation and ethics" in the first project months. INDIGO consulted TU Vienna's research ethics coordination for counselling. Initial discussions led to a meeting between INDIGO project members with the Pilot Research Ethics Committee (Pilot REC). In this meeting, the project's ethical dimensions and potential strategies to tackle them were confidentially discussed. The conclusions drawn from this gathering serve as a basis to address ethical responsibilities throughout the project. The entire statement can be found here: https://projectindigo.eu/wp-content/uploads/2022/05/INDIGO_ethicsStatement.pdf

Once INDIGO starts classifying graffiti and putting content online, more specific ethical questions are expected to arise. However, the Pilot REC has agreed to provide further counselling if needed. Overall, this WP can be considered finished.

WP 5 – Photography

Taking photographs is INDIGO's main activity. The original project plan mentioned four so-called 'total coverage' surveys besides weekly or bi-weekly follow-up photography tours. Let us start with the latter.

At least once per week, one of the three photographers goes out to document new graffiti. These photographers have a pool of various hardware available: two identical imaging systems, two ColorChecker Passport Photo 2 colour reference targets by X-Rite (now produced by Calibrite), two Solmeta GMAX GNSS (Global Navigation Satellite System) receivers, two Sekonic C-7000 SPECTROMASTER spectrometers and two Samsung Galaxy Tab A7 Lite tablets (see Figure 5). All devices of the same type are labelled "A" and "B" to distinguish them. Device B is always set up identically to device A. For example, the tablets run the same apps, and all settings of both spectrometers are identical.

INDIGO relies on two Nikon NIKKOR Z 20mm f/1.8 S lenses paired with a full-frame mirrorless Nikon Z7 II camera generating 45-megapixel photos. The Solmeta GNSS receiver is attached to the camera's hot shoe and directly writes geographical coordinates into the photo's Exif metadata. Both cameras feature the same settings. This not only enforces identical results (from a technical point of view) across imaging systems; it also ensures that the camera-related photo properties are appropriate for INDIGO's colourimetric and geometric processing pipelines (detailed in WPs 8 and 9, respectively).

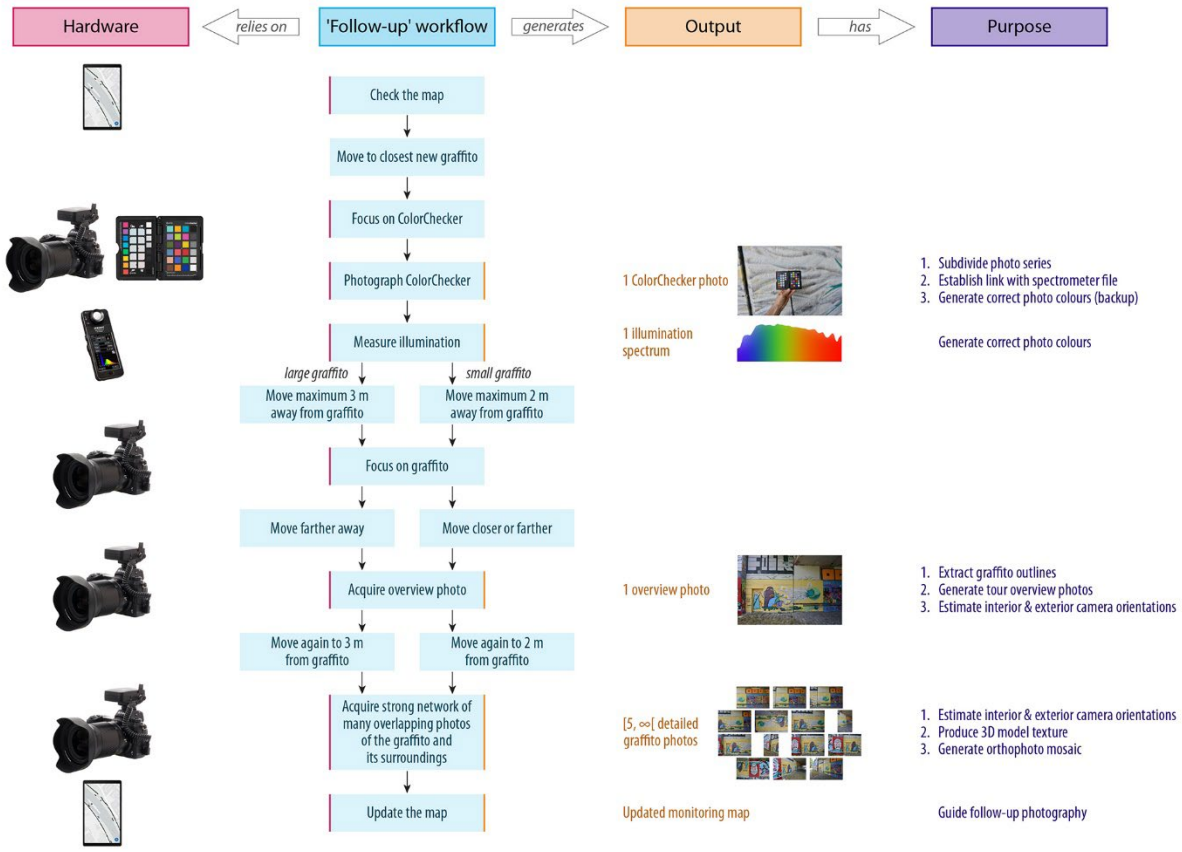
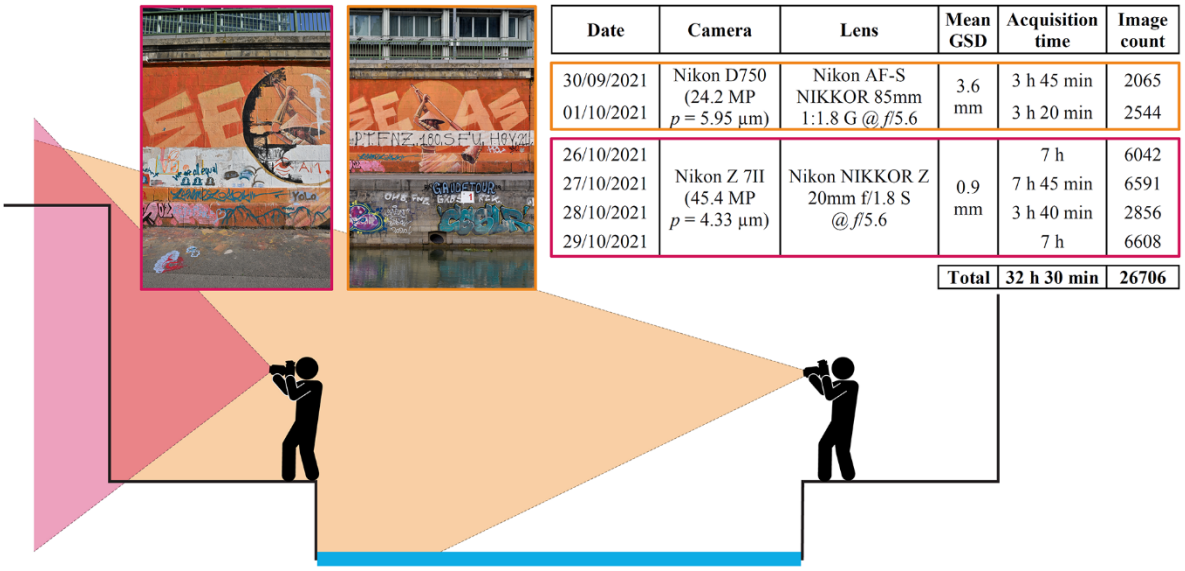


Figure 5 – Follow-up photography workflow for a new graffito. The illustration indicates the hardware needed and the purpose(s) of the generated outputs.

During the first year, the entire data acquisition and graffiti monitoring workflows (explained in Figure 5) witnessed several significant and minor changes. For example, no spectrometer was available at the beginning, and the order of acquiring specific photos (like the overview photo or the photo of the ColorChecker target) was different. Even though there currently is a well-defined data acquisition workflow, minor mistakes still occur now and then. Photographing two or more hours in a strict regime while juggling various hardware makes it easy to lose focus. Working on days with extreme temperatures or when in a rush does not help either. Besides thin gloves on frigid days, there is little potential improvement for these matters. Nevertheless, INDIGO still sees room for serious advancement in acquiring accurate coordinates for the camera stations. That is the focus of WP 6.

In addition to this follow-up photography, four moments for a total photographic coverage had been scheduled (September/October 2021 and 2022, March/April 2022 and 2023). The first of those coverages took place in October 2021. Spread over six days, a zone slightly exceeding INDIGO's entire research area (containing 13 km of graffitied surfaces – Figure 7) has been photographed in detail. In the first two days, the channel's embankments were photographed at a time when the water level was shallow. Photos from the left bank's wall were captured from the channel's right bank and vice versa (everything related to this acquisition is depicted in orange in Figure 6). During the last four days, all other surfaces were photographed (indicated with pink in Figure 6), generating 26.7k photographs altogether.



Date	Camera	Lens	Mean GSD	Acquisition time	Image count
30/09/2021	Nikon D750 (24.2 MP p = 5.95 µm)	Nikon AF-S NIKKOR 85mm 1:1.8 G @ f/5.6	3.6 mm	3 h 45 min	2065
01/10/2021				3 h 20 min	2544
26/10/2021	Nikon Z 7II (45.4 MP p = 4.33 µm)	Nikon NIKKOR Z 20mm f/1.8 S @ f/5.6	0.9 mm	7 h	6042
27/10/2021				7 h 45 min	6591
28/10/2021				3 h 40 min	2856
29/10/2021				7 h	6608
			Total	**32 h 30 min**	**26706**

Figure 6 – The total coverage photographic survey took place during two and four consecutive days at the start and end of October 2021, respectively. Both survey moments also utilised a different camera setup and acquisition strategy. This illustration uses orange (for the first two days) and pink (for the last four days) to indicate all the relevant data, the photographer's position and a sample photo of both photographic campaigns.

These photographs serve three essential purposes:

- First, a digital 3D model that encodes the geometry of all solid surfaces along the Donaukanal can be computed from them (see WP 7).
- Second, these photos create a graffiti status quo. They constitute a complete record of the graffiti-scape at a particular moment, thus effectively establishing INDIGO's starting point for tracking change in the graffiti-scape via follow-up photography.
- Third, those data enable the efficient processing of new graffiti photographs. Within INDIGO, all graffiti photos acquired during the follow-up photography are processed into two end-products: geometrically corrected orthophotos and textures for a 3D surface model. The production of both

products can be considerably sped up with knowledge about the camera's exact location and angular rotation when acquiring each of these total coverage photos. This process – and the necessary technical lingo – will be detailed in WP 7.

The initially planned four total coverage surveys aimed to record changes in the entire graffiti-scape that went unnoticed before. However, since WP 11 (change detection) did not yield the expected results so far, the second total coverage survey was omitted. Nevertheless, a new total coverage survey will take place at the beginning of October 2022. This will serve two primary purposes: 1) provide additional photographs to create a complete 3D surface model of the Donaukanal (see WP 7), and 2) establish a new status quo for the second project year. Although INDIGO hopes WP 11 will yield the sought-after results by March 2023, a third total coverage survey is not planned because of how the change detection approach will be implemented (see WP 11 for more details). In contrast, the (bi)weekly follow-up photography will continue in year two with the same intensity as the first year.

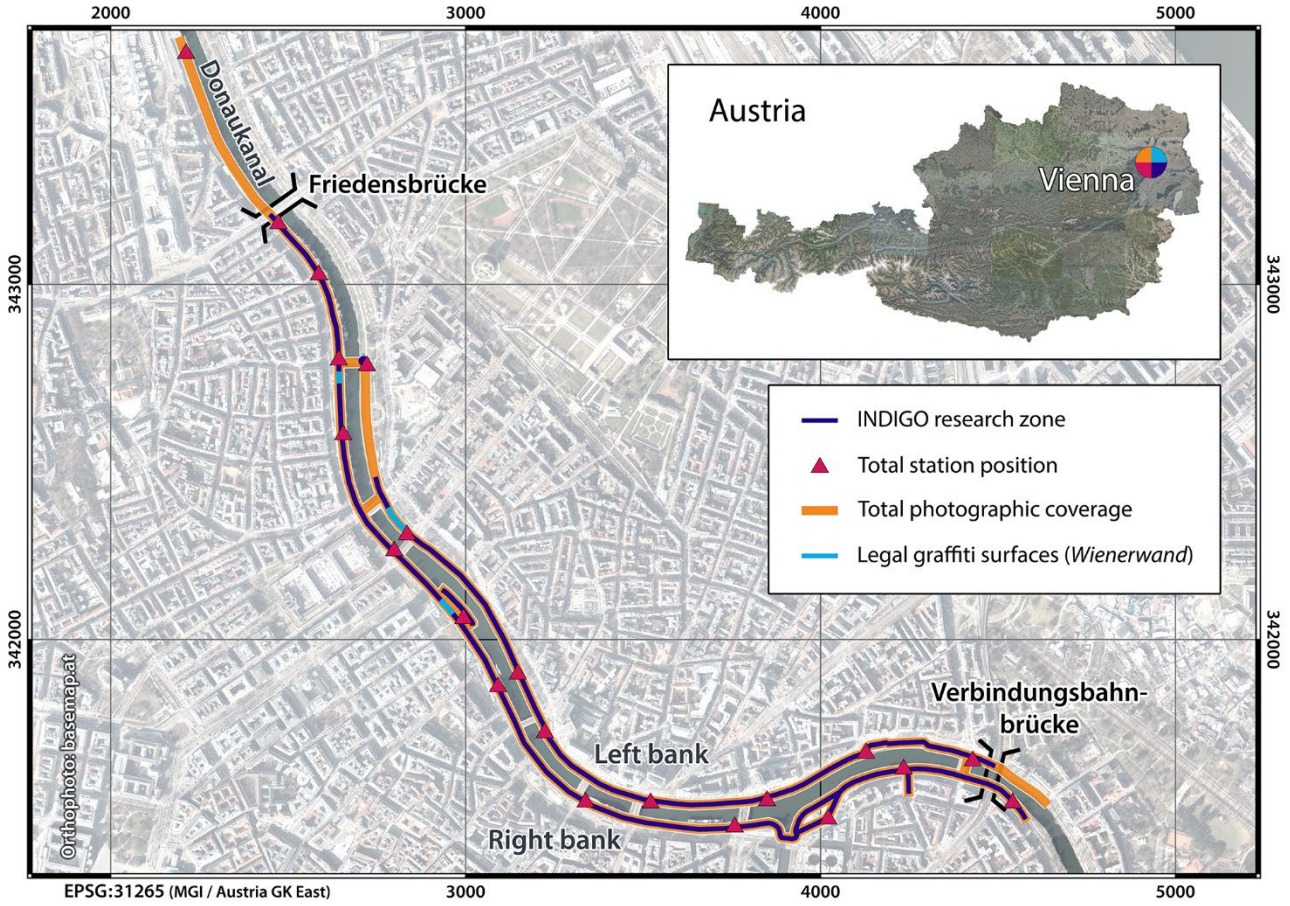


Figure 7 – All urban surfaces covered by project INDIGO (and the limited number of legal graffiti surfaces in this area). The illustration also depicts INDIGO's 2021 total coverage zone and the positions from where graffiti-scape points were measured (see WP 7).

WP 6 – GNSS/IMU

Currently, a Solmeta Geotagger GMAX is mounted on the camera. This unit uses the American GPS and Chinese Beidou satellite constellation to compute the camera's location with a precision of about 2.5 metres (at one standard deviation). This precision can be reached in ideal scenarios because the unit uses the correction signals broadcasted by the satellite-based augmentation system EGNOS (European Geostationary Navigation Overlay Service). The estimated geographical latitude, longitude, and altitude values are written into the Exif metadata of the RAW and JPEG files. These values are leveraged in the orthorectification workflow (see WP 9) for computational speed improvements. However, acquiring more accurate coordinates for every camera station would be helpful.

The INDIGO team has developed a device to record the camera's exterior orientation. Built from commercially available but cost-effective components housed in a 3D printed case, this device also connects to the hot shoe on top of the camera. It receives a Real-Time Kinematic (RTK) GNSS correction from the Austrian EPOSA service (Echtzeit-Positionierung-Austria), for which the settings get wirelessly controlled from the tablet or any smartphone (Figure 8). Although a thorough assessment of this device and its integration with INDIGO's geometric photo processing workflow are planned for October 2022, first tests have indicated the potential to obtain centimetre-accurate coordinates and sufficiently correct rotation angles for each camera station.

INDIGO is very proud of this truly unique device. No other hardware solution offers this functionality out of the box. The most similar device on the market is the 3D ImageVector from REDcatch. However, handling the REDcatch device is more cumbersome due to its long cable and attached data logger. At the same time, the obtained camera rotation angles are much more inaccurate than those from INDIGO's device. Because of the Russian invasion of Ukraine and all the related supply chain issues, WP 6 had to deal with considerable delays. Specific electronic components arrived much later than expected; in one case, the needed piece became unavailable. This explains why the € 10k foreseen for this WP remains unpaid. Martin Wieser, who is developing and assembling these devices, could only finish the first copy of this device in August (and payment occurs when a second copy is ready and received). This clarification is also given in Section B1.

In project year two, two months are foreseen (see Figure 18) to intensively test the device, write a user manual and programme a small script to store the positional and rotational values as metadata, either in the image or in a separate file.

Figure 8 – The new RTK-enabled GNSS-IMU logging device (left and middle) with the interface controlling its settings (right).

WP 7 – 3D Geometric backbone

INDIGO aims to document the majority of new graffiti created along a large part of the Donaukanal via thousands of photographs that digitally encode the stratified graffiti-scape. Highly processed versions of these photographs will end up in a spatial database that feeds an online platform where users can freely and virtually visualise and query all graffiti records. To provide clean and relevant data for the spatial database and online platform, i) three-dimensional (3D) surface geometry of the Donaukanal, ii) photographs of the graffiti, and iii) auxiliary data must be acquired. The 3D digital surface is vital to remove the geometrical photo deformations (see WP 9). It is also the backbone onto which graffiti images will be mapped for display online.

As mentioned in WP 5, a zone slightly exceeding INDIGO's research area (Figure 7) was photographed for six days in October 2021. Using techniques from the photogrammetric and computer vision fields (more specifically, Structure from Motion or SfM), it was possible to determine the camera's position and angular rotation for all 26.7k acquired photos (see Figure 9). In addition to these so-called exterior camera orientations, the SfM algorithm also produces the camera's interior orientation parameters: a handful of variables that describe the camera's internal geometry (see Figure 9 for an example).

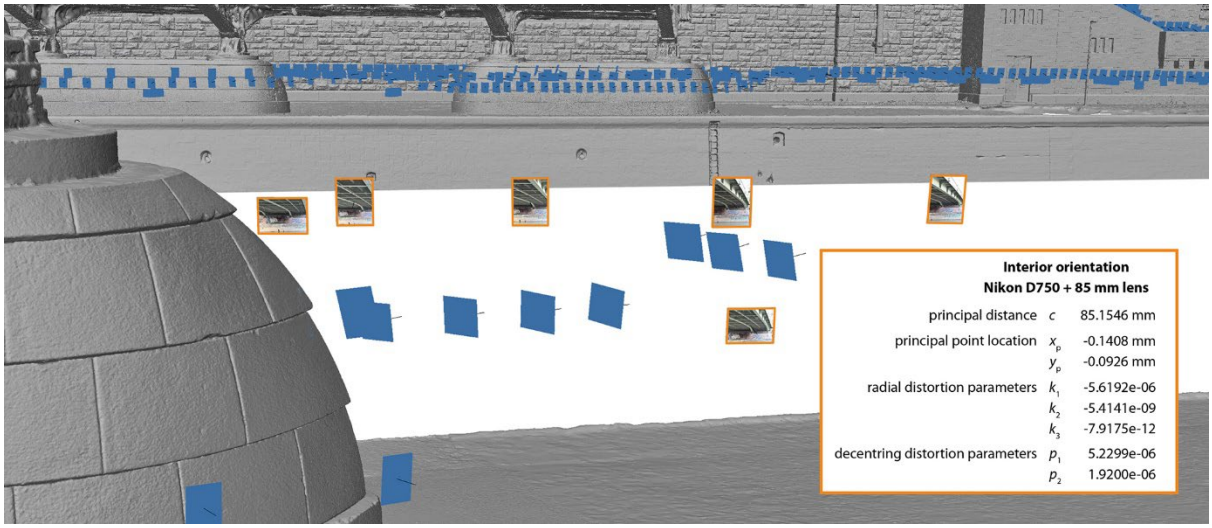


Figure 9 – A portion of the polymesh that digitally represents the solid surfaces along the Danaukanal. The blue rectangles visually represent the exterior orientations of the camera stations. At the camera stations featuring an orange outline, a photo was captured from the opposite bank with a Nikon D750 camera plus an 85 mm lens. Those photos are shown inside the orange strokes, while the lower right inset provides the parameters describing the interior orientation of this camera-lens combination.

However, there is one problem with the approach mentioned above: the output of an SfM algorithm is expressed in an arbitrary coordinate reference system, meaning that the estimated positions and rotations of the circa 27k camera stations are only equivalent to their real-world values up to a global scaling, rotation and translation factor. The SfM output was embedded in a real-world coordinate reference system via a dense network of over 600 Graffiti-scape Points (GPs), measured during a multi-day total station surveying campaign (Figure 10). These GPs are object/scene points that are well-identifiable in many photos (even when potentially sprayed over) and whose long-term positional stability can be assumed (Figure 10, inset). Their coordinates were determined from one of the 21 total station locations that INDIGO established along the Donaukanal (see Figure 7). After indicating these 100s of GPs points in many thousands of photos, the SfM output could be accurately expressed in the MGI/Austria GK East coordinate reference system (EPSG:31256).

Figure 10 – Benjamin Wild operating the Leica Viva TS16 total station. The inset on the lower right displays three typical GPs.

As soon as all cameras are correctly oriented, it is possible to generate a continuous, digital 3D model that encodes the geometry of all solid surfaces along the Donaukanal. This is achievable via Multi-View Stereo (MVS), another photogrammetric computer vision technique. When given a set of detailed photos for which the image overlap is substantial, an MVS algorithm can produce a hole-free digital 3D surface representing fine geometrical features. Since this case meets both requirements, the well-known SfM-MVS software package Agisoft Metashape Professional could generate a preliminary, continuous 3D surface as a polymesh (Figure 9). Since INDIGO's envisioned online platform should offer virtual walks along the Donaukanal, this digital 3D surface model will form its geometric backbone.

Ideally, the 3D backbone would not only be created from digital photos, but also from the dense point clouds collected via laser-scanner through Vienna's "Wien gibt Raum" initiative. These points would be needed to model the bridges' and horizontal walking surfaces better. So far, only a portion of the entire Donaukanal dataset became available, so the final 3D model could not be produced yet (and just the preliminary mesh mentioned before). The second total coverage survey in October 2022 will add an extra day to photograph these weakly covered surfaces exhaustively. In that way, creating a final 3D surface model becomes possible even without the City of Vienna's point cloud data. Suppose the latter data would become available. In that case, it can still be integrated into the total coverage photo networks for an even more complete 3D surface.

Creating this final 3D surface mesh will be a work-intensive task for which circa three months are scheduled. The problem lies in the number of photographs that need to be processed, making every operation very time intensive. In addition, the final 3D mesh will be too large for usage online, so it needs to be simplified and segmented. Although the INDIGO team is familiar with these operations, a workflow must be found to deal with the expected gigantic size of the generated 3D mesh. To considerably speed up all these processing steps, a high-end computer was purchased in July 2022.

WP 8 – Colourimetry

Colour is a powerful communication element in most forms of cultural heritage. This importance of colour notwithstanding, the documentation of cultural heritage typically focuses on the geometrical aspects and seldom the spectral dimensions of an artefact. This is partly because colour and the science of colour (called colourimetry) are non-trivial. In addition, capturing accurate colour data with standard digital cameras remains challenging due to the operating principle of standard imaging sensors and the need for a stable, non-variant illumination source. Despite these limitations, INDIGO made it one of its central aims to generate colour-accurate photos from graffiti captured with standard digital cameras in varying outdoor illumination conditions. To enable this, one of the main intended deliverables was an open-source toolbox. Despite the contract problems (and resulting delays) with the University of Valencia (see Section B1), this software was finished and made freely available at the end of August 2022. INDIGO's COlour Operations Library for Processing Images (COOLPI) is available from its GitHub repository. At the same time, an extensive user manual is available at https://graffitiprojectindigo.github.io/coolpi.

COOLPI was created by Adolfo Molada Tebar from the Polytechnic University of Valencia, Spain. Although Adolfo had initially planned to be in Vienna during the second project year to continue working on colourimetric problems – via a Margarita Salas grant that he won in the first months of project INDIGO – he was offered a job by the TIDOP research group at the University of Salamanca in mid-September 2022. Although the colourimetry WP is 90 % finished, a few more weeks are needed to evaluate the software and combine its functionality with the geometrical processing pipeline (see WP 9 and WP 12).

In addition, a small research item is added to this WP: creating a graffiti-specific colour reference chart. Instead of photographing a ColorChecker target, higher colour fidelity can be obtained when the colour reference

target features graffiti-specific colours. Throughout the first project year, colour swatch books of all major spraycan brands were bought. These samples support the creation of a novel graffiti-specific reference target. The spectral reflectivity of every colour sample will be determined with INDIGO's Konica Minolta CM-26d spectrophotometer. Collecting all these spectral signatures yields, in turn, a spectral database specific for graffiti spray paint. Such a database does not exist yet. However, making it freely available could open up new pathways for other researchers interested in the automated detection of graffiti (colours).

WP 9 – Orthorectification and texturing

Because INDIGO aims to create an extensive digital 3D model with colour-accurate textures of the Donaukanal's graffiti-scape, spatially- and temporally varying textures must be generated from the thousands of photographs acquired during the follow-up tours. This textured 3D model of INDIGO's envisioned online platform will allow users to view every graffito in its correct urban setting, both spatially and temporally. Suppose one also wants to study a graffito's dimensional, stylistic or semantic aspects. In that case, a highly detailed 2D orthophotograph can be viewed alongside the 3D model. Because the 3D textures and 2D orthophotographs will be queryable via an underlying database, the platform can support *intra-* and *inter-*graffito visualisations and analyses, thus providing as much context as is technically feasible.

To deal with massive amounts of photos and create textures for the 3D mesh along with orthophotos, the team has developed the python-based software AUTOGRAF (AUTomated Orthorectification of GRAFfiti photos). AUTOGRAF is distributed via INDIGO's GitHub. This free tool is an add-on for the popular software Agisoft Metashape Professional. It leverages the SfM and MVS functionality of Metashape. Still, it adds much automation and a few new functions so that graffiti photos can automatically be transformed into distortion-free graffiti orthophotos and mesh textures. Apart from a few optimisation tweaks to AUTOGRAF, this WP is finished and only needs to be implemented in WP 12.

WP 10 – Segmentation and annotation

WPs 10, 12, 13, 14, 15 and 16 are highly interrelated, and this relationship has proven technically and logistically challenging. Although progress has been made in all of them, none has reached the advancement anticipated at this stage. Let us start with WP 10 and sketch the challenge.

The result of every photographed graffito should be:

- a 3D polygon that marks the border of the graffito
- a 2D orthophotograph
- a texture patch for the 3D mesh
- a database record storing all metadata about the processing stages and the graffito itself.

To create the second and third products, it is necessary to define the outer boundary of each graffito in real-world coordinates. The resulting 3D polygon is then the spatial entity that represents the graffito. In other words, all metadata are linked to this polygon. At the moment, this polygon is defined via an overview photo of the graffito (enabled via AUTOGRAF), but a more flexible and automated solution is needed. Flexible means that the processing pipeline should allow this segmentation to occur at any stage. For instance, after downloading all photos acquired during a follow-up tour, it is not unimaginable that 30 minutes are spent segmenting every new graffito from its environment in the overview photos. However, this means that the processing pipeline should store this 2D polygon and use it after the orthorectification stage to extract its 3D coordinates. Another possibility could be to segment automatically after the orthorectification stage. Suppose the latest orthophoto can be compared with an earlier orthophoto. In that case, a change detection procedure might yield this polygon in an automated way. Although graffito segmentation is thus currently possible, its exact implementation will also depend on the change detection procedure developed in WP 11.

A similar problem concerns metadata annotation. The 3D texture patch and 2D orthophoto will have metadata about their processing parameters. In contrast, the final polygon (and the corresponding entry in the spatial database) must also store info on content, stylistic characteristics and temporality. Like the segmentation step, the exact stage of metadata entry is still undefined. Much information could be added to the images using photo cataloguing software such as Camera Bits' Photo Mechanic Plus or Photools' IMatch (both available in project INDIGO). These solutions would embed the necessary metadata in the image or a sidecar file (likely via an INDIGO-specific XMP namespace). This XMP metadata could then be read by OpenAtlas (INDIGO's database solution – see WP 14), but such functionality must be programmed. One could also add this information at a later stage directly in the database. The latter workflow has the advantage that no extra functions are needed, and that at the time of ingestion (typically a few days or weeks after photo acquisition), info on temporality (like the period a graffito was visible) might be known. However, any workflow is currently waiting for progress in WP 13: the thesaurus.

Graffiti research is notorious for using a wide variety of unstandardised terms, which prevents analysis on a larger-than-local scale. For example, suppose database A labels a creation 'graffito', while database B considers the same work as 'street art'. In that case, cross-database queries would lead to partial results and conflicts. And even if multiple people enter data into OpenAtlas, the fact that they might be using different personal definitions for the same terms could render that database unusable. To avoid the inaccurate, biased or even impossible analysis that stems from too much terminological elasticity, project INDIGO decided to create a broad, graffiti-centric thesaurus of well-defined terms. These terms will be used during metadata annotation. Although much time has been invested in this thesaurus (WP 13), it is still unfinished. And as long as the primary terms are not defined, it does not make sense to start annotating metadata. However, one could say that the workflows mentioned above could be tested without using the final terminology. Although the initial project plan did indeed assume this possibility, the specific semantic implementation of the thesaurus also determines how (and if) OpenAtlas can leverage it. And as long as OpenAtlas does not contain any data, data ingestion in ARCHE can not start, and the Online platform cannot query OpenAtlas. So long story short: a first implementation of the thesaurus is needed.

Although the project proposal has highlighted the challenges related to this complex interaction, it is mainly due to delays of (and the work put into) the thesaurus that other WPs are slightly behind schedule. In addition, Benjamin Wild was planned to work on the segmentation and annotation part. Although he has facilitated basic segmentation in AUTOGRAF, Benjamin could not work an entire year for 100 % in INDIGO (see B1 for the explanation). However, this means that INDIGO still has the necessary staff to work on a better technical implementation of this WP and WP 11. The status quo and road ahead of the other related work packages are detailed below.

To end this section on a positive note: project INDIGO has established connections to some of the most authoritative people in the fields covered by these interrelated WPs. For instance, to ensure that storing and reading image metadata would follow all established standards (which almost no software is currently capable of), connections were made with the developers of the photo management tools mentioned above and David Riecks. Mister Riecks is a metadata evangelist, founder of ControlledVocabulary.com and co-lead of the IPTC Photo Metadata Working Group. Although collaborating with these experts has lengthened the entire metadata annotation development – because it revealed several new issues (which are also barely covered in the scientific literature) – these delays are considered a necessary evil. INDIGO wants to raise the bar in cultural heritage documentation, dissemination and digital preservation by improving some of the current approaches in digital humanities. As such, at least INDIGO's primary data (i.e., many 10,000s of photographs) should feature maximum metadata compatibility and adhere to complex standards. This is also envisioned to happen by the end of 2022.

WP 11 – Change detection

The initial idea of image change detection was related to the total coverage tours, of which the last three should help detect previously undocumented graffiti via automated change detection. So far, the idea has proven more straightforward than its execution. In addition, the INDIGO photographers realised that the monitoring strategy (finding new creations via Instagram or relying on visual memory when walking/biking along the channel) is insufficient to spot minor graffiti. That is why a new monitoring approach, based on image change detection, was born. The envisioned workflow goes like this. Two GoPro HERO10 action cameras are mounted on a camera bar. The bar connects to a handgrip, allowing the dual-camera construction to be handheld. Because the camera lenses point in approximately opposite directions, one can photograph nearly every surface above and below the walking/biking path by biking once on each side of the channel (see Figure 11).

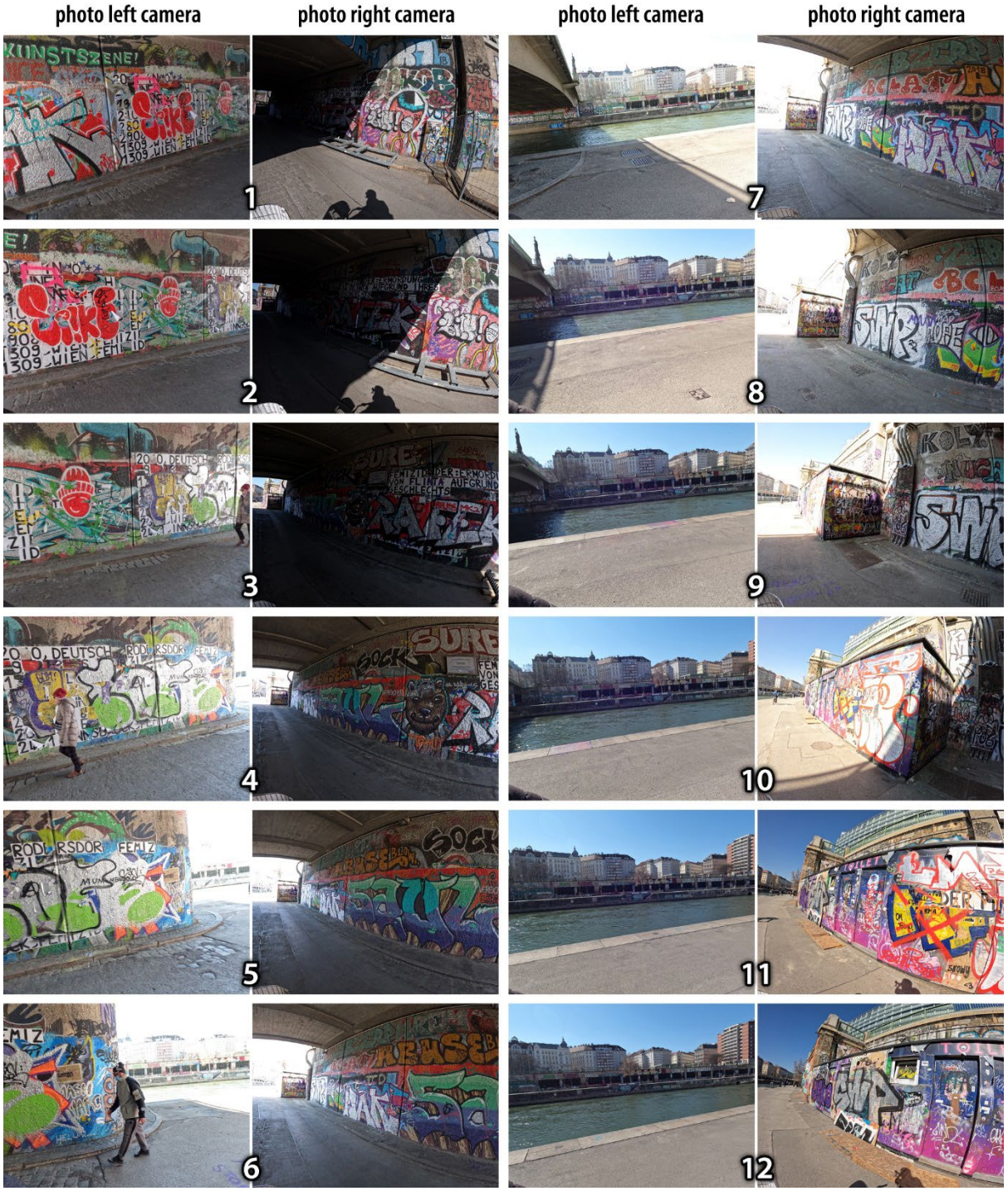


Figure 11 – A sequence of twelve left-right photographs acquired from the Donaukanal's left bank.

Using the previously mentioned SfM approach, the exact exterior orientation of each camera station is retrievable. Imagine a GoPro photo series acquired during a one-hour biking tour on Monday morning and correctly processed with SfM by Tuesday afternoon. At that point, one can compute a meshed 3D surface of these images using an MVS algorithm (Figure 12A). Once the mesh is ready, it can be textured with the photographs (Figure 12B). After a rainy night, a new GoPro photo series is collected on Wednesday morning. Because an incremental SfM approach can leverage the network of oriented Monday photos (i.e., the dark blue rectangles in Figure 12C), the position and rotation of the newest camera stations (symbolised by the light blue rectangles in Figure 12C) are estimated by Wednesday evening.

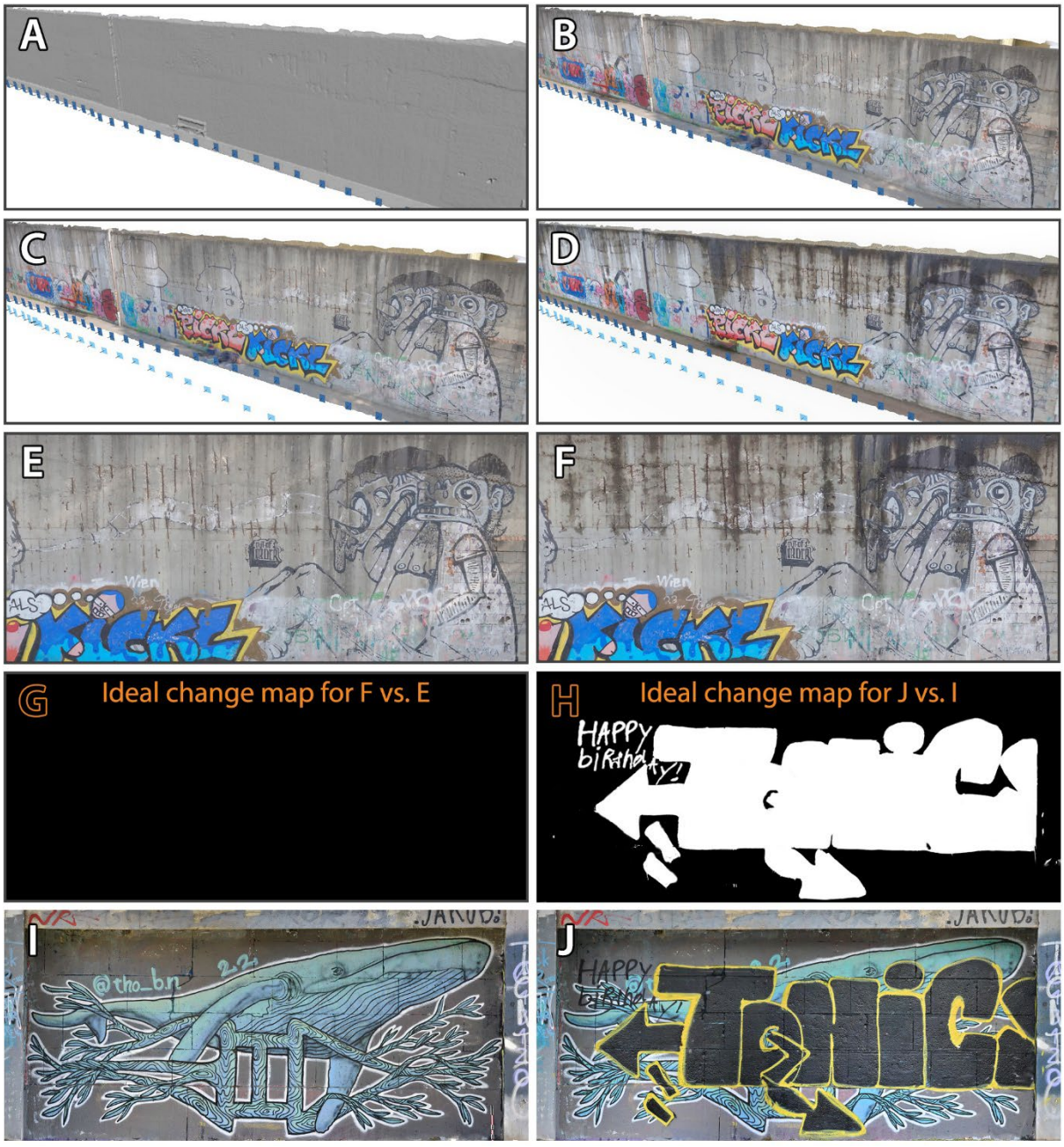


Figure 12 – The sequence of insets A to D explain how two photo events could result in two pixel-perfect aligned textures (E and F), from which one could extract a change map. In this case, the change map (G) should be blank because all changes that occurred are unrelated to the graffiti. This is not the case for the scene changes between insets J and I. Here, inset H depicts the ideal change map. Both change maps were manually generated with Adobe Photoshop 2022.

At that stage, the mesh computed on Monday gets textured with the Wednesday photographs Figure 12D) so that two textures exist, partly displayed in Figure 12E and Figure 12F. Ideally, these texture images are pixel-

perfect aligned so one can look for differences between any two pixels at any location. In its most simple way, this last step could subtract the Monday texture from the Wednesday texture to yield a so-called change map or change image. Since this change map depicts any relevant difference that occurred in the graffiti-scape between Monday and Wednesday, it is a perfect guide for the follow-up photography tour on Thursday.

The hard part of this whole workflow is, however, the change detection step. So far, none of the tested algorithms has proved capable of robustly computing change maps in a reasonable amount of time. The challenges to this problem predominantly lie in the large pixel counts of the images and the different photo renderings of an unchanged scene. Let us consider the last issue. Photographing an invariant graffiti scene once in cloudy conditions and once in harsh sunlight will result in two photos that look different. Not only might the colours look distinct, but the sunlight will generate strong shadows that are absent in the other photograph. Although a human quickly understands that the graffiti-scape itself did not change, designing an algorithm robust to these graffiti-irrelevant photo differences has proven hard. The same problem occurs after a rain shower. The ideal change map (Figure 12G) between Figure 12E and F is blank because the only scene variation between both photo events relates to rainwater running down the concrete (see Figure 12D and F). These challenges notwithstanding, INDIGO will continue to invest time in this change detection approach – mainly focusing on more uncomplicated cases like Figure 12H – because it could prove helpful for many heritage monitoring projects. To achieve substantial progress in this WP, INDIGO actively looks worldwide for students in image processing and computer vision that could write their Master's thesis on this topic (which also means that the current monitoring strategy stays in place as long as no progress is achieved in this WP).

Finally, this GoPro-based monitoring approach must deal with one more challenge: by-passers unavoidably appearing in photographs. Given that all INDIGO data become publicly available at the end of the project, it is of the utmost importance to anonymise every person or other relevant personal data (like number plates) in these photos. And again, detection robustness and speed of execution are critical. Luckily, INDIGO could already successfully test the software by Celantur. Celantur specialises in the anonymisation of still images and videos. The software blurs faces and can anonymise entire bodies, also when people are partly obscured (Figure 12A-B) or depicted as tiny figures in highly overexposed parts of the photo (see Figure 12C). In addition, Celantur's software features annotated output with confidence values and can deliver binary photo masks. These masks can be applied at any stage of INDIGO's entire image processing workflow (see the next WP), ensuring that the original photos stay unaltered.

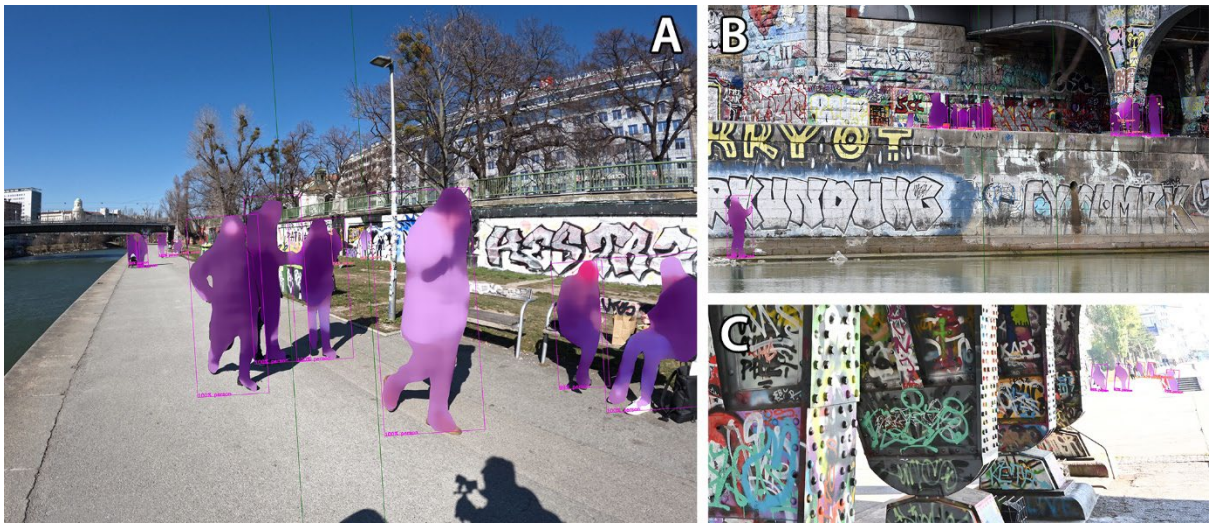


Figure 13 – The binary masks (applied in purple) generated by Celantur's anonymisation software. Entire bodies can be masked, irrespective of people's distance to the camera (close in A or very far in C). Partial occlusions (A and B), busy graffiti backgrounds (B) and overexposure (C) do not seem to impact the software's performance.

WP 12 – Image processing

This WP was only intended to start in year two, so the fact that nothing has been done is normal. Specifically, this WP will integrate and apply all the colour correction, orthorectification, segmentation and annotation tools on the photos collected during years one and two. As mentioned above, photo anonymisation will also be applied by default. Apart from finding a good integration, this package is solely implementational and does not need any research. The vast majority of human power will go to the annotation step, for which the detailed graffiti knowledge of Stefan Wogrin will be of the utmost importance.

WP 13 – Thesaurus

Any graffiti analysis depends on how graffiti are defined and classified. For example: some scholars and graffitists voice that legally permitted graffiti do not deserve the label 'graffiti'. Even though such terminological distinctions do not guide INDIGO's recording, the project must strive for terminological clarity to populate the database with unambiguous metadata. The creation of a graffiti thesaurus must accomplish this. Being a finite set of terms (i.e. a controlled vocabulary) with hierarchical relations, this thesaurus will make INDIGO's classification explicit and hopes to serve as a reference for the broader academic graffiti community. Since the thesaurus is considered one of the essential project deliverables, it has received substantial attention. However, its construction has proved challenging, not at least because of the difficulty related to defining graffiti itself. As a concept, graffiti is used in archaeological circles to describe ancient Roman inscriptions, but is equally well-used by sociologists and art historians to talk about colourful contemporary sprayings. Being an archaeological and heritage science project, INDIGO wants to consider all major and minor aspects of the term in its thesaurus. Based on this general definition, related concepts like street art and mark-making get defined, as are the countless graffiti subcategories.

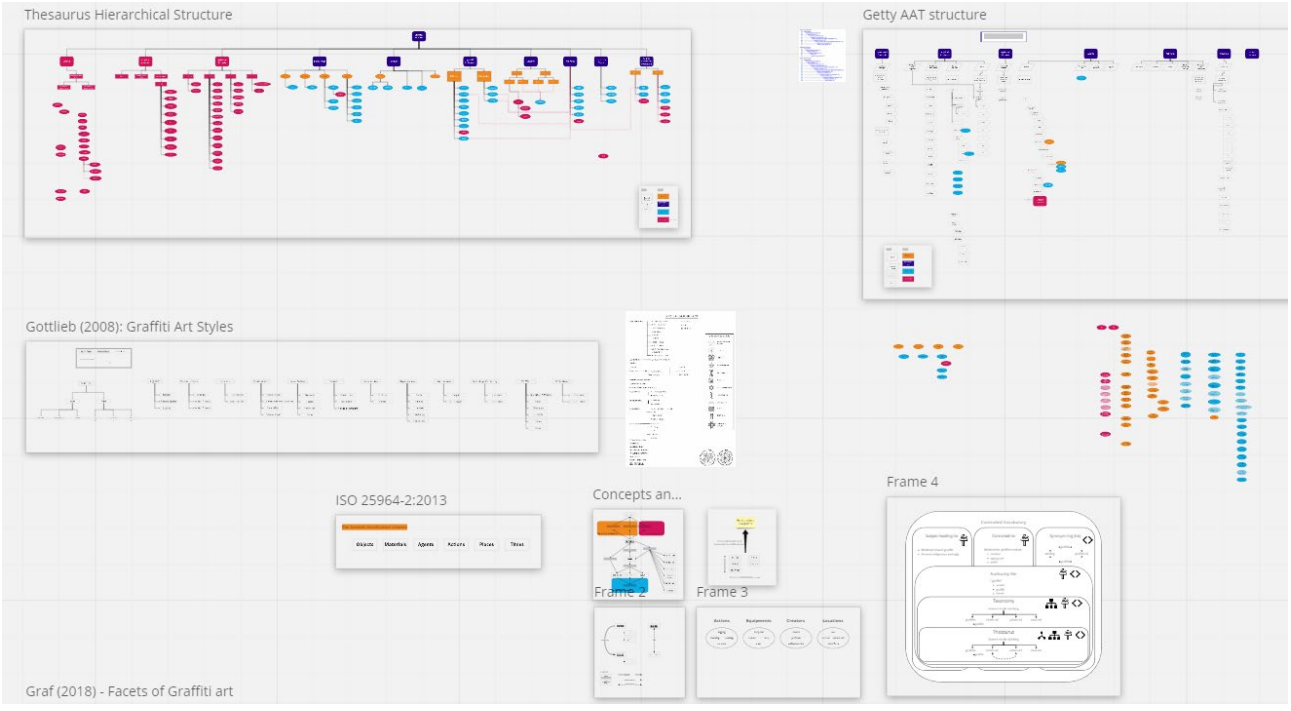


Figure 14 – Some of the different structures developed in MIRO to structure the graffiti thesaurus.

Besides some fundamental problems in defining overarching terms, it has also proven hard to find a proper way to structure all terms hierarchically. Over the past twelve months, many designs have been proposed (see Figure 14 for some examples). Discussing those designs was not always straightforward since experts on thesauri are not, per se, experts on graffiti and vice versa. To aid us in this process, INDIGO has contacted the Getty Research Institute (the author of the authoritative Getty Art and Architecture Thesaurus) and influential

scholars like Ann Graf. There is currently (i.e. September 2022) a consensus to model the entire INDIGO thesaurus structure after the AAT. How this structure can be ported to the semantic web is something INDIGO discusses with the people at the ACDH-CH (mainly Massimiliano Carloni).

A positive side effect of creating this thesaurus is that diverse sources about graffiti have been consulted, effectively leading to a continuously increasing reference database. This database – built in the open source software Zenodo – will also be made available at the end of the project and likely constitute the most extensive reference database on graffiti.

WP 14 – Spatial database

Collecting and processing data without a sound data management system is irresponsible. This WP aims to create a spatial database to manage and query all (meta)data. The need for robust database integration with the online platform (see WP 16), support for spatio-temporal queries, and adherence to the CIDOC CRM ontology standard make this task considerably challenging. At the same time, data entry should be customisable and painless. INDIGO has chosen the CIDOC CRM-based OpenAtlas database as its solution. Because INDIGO deals with spatially 3D data and many graffiti only live for a few days, two specific but profound OpenAtlas changes were needed: 1) the support for 3D geometries and 2) a temporal resolution smaller than one year. As of September 2022, these features have been (entirely or partially) implemented; the INDIGO staff also had the opportunity to play around in OpenAtlas to see how it operates. However, to start ingesting data, a few more requirements need to be fulfilled:

- Creating a first version of the thesaurus, implemented into a semantic framework and imported into OpenAtlas.
- Generating a sample data set with 3D geometries and metadata-rich images, enabling the OpenAtlas team to check the extra functionality needed to deal with them. This is only possible when it is clear how – and at what stage – various metadata will be embedded into the photos. WP 10 deals with this and should propose a solution by the end of 2022.

INDIGO's data processing complexity and WP interrelationships become apparent when observing Figure 15. For instance, the flowchart reveals how the thesaurus is essential for steps 2 (i.e., metadata annotation) and 4 (i.e., OpenAtlas data ingestion). At the same time, the specific implementation of step 2 is researched as well.

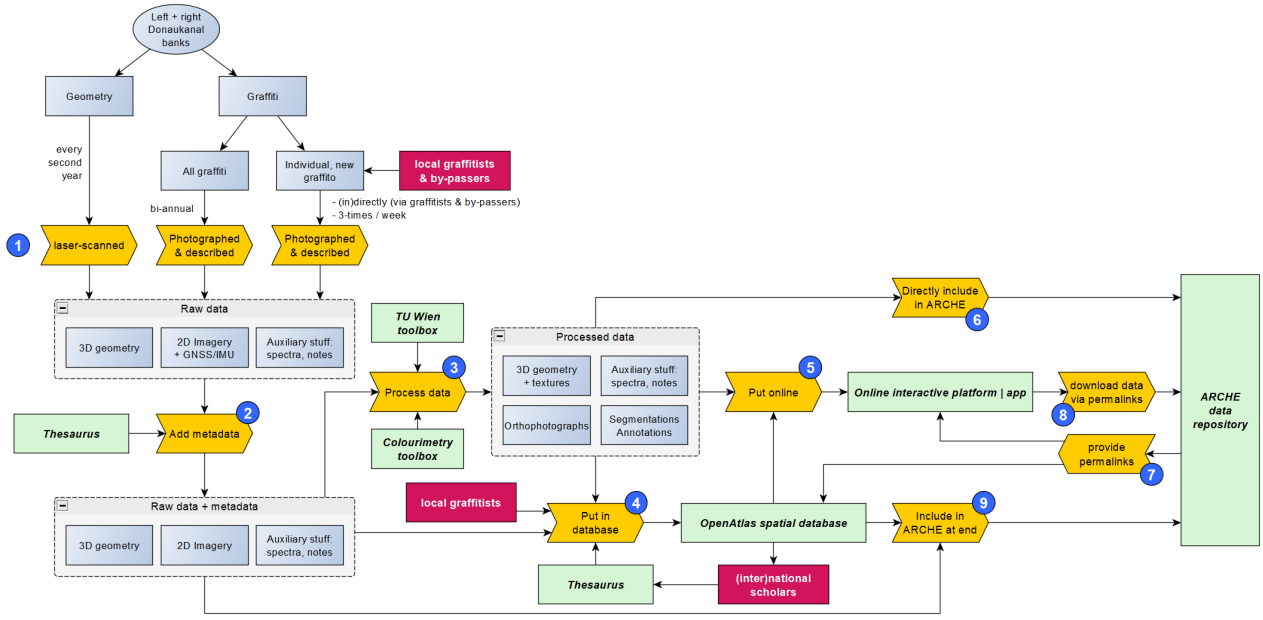


Figure 15 – INDIGO's envisioned data pipeline.

Finally, OpenAtlas might still have to add functionality to store and query temporal relationships before data ingestion can start. Spatio-temporal queries are a big deal for INDIGO, but temporality is typically given very little attention in archaeology. This also explains the lack of tools to deal with the temporal aspect of cultural heritage, despite being one of its core characteristics. Given the detailed temporal data collected in the project and knowing that spatio-temporal reasoning is the topic of Jona Schlegel's PhD, INDIGO hopes to improve upon the state-of-the-art in this aspect through the dialogue between Jona and the OpenAtlas team. Without further delays, data ingestion into OpenAtlas should start around February 2023.

WP 15 – Data ingestion

Data are not only ingested in OpenAtlas (for clarity covered mainly in the previous WP) but also in ARCHE, the certified repository of the ACDH-CH. At the ACDH-CH, discussions have taken place on how data from OpenAtlas should flow to ARCHE (to minimise manual work) or vice versa. As part of the ingestion discussion, INDIGO has also settled for an "In Copyright" statement for all its photographs (see WP 4). However, Figure 15 indicates that ARCHE ingestion only can occur after a few other WPs have yielded specific results. Data ingestion in OpenAtlas and ARCHE is expected to start at the end of January 2023, circa three months later than initially planned.

From the beginning of the project, INDIGO's graffiti overview photographs have also been integrated into the Spraycity archive. As agreed, project INDIGO gets credited (see an example here). In this way, INDIGO also supports the local and twenty-year-old graffiti database curated by Spraycity (a vital INDIGO partner).

WP 16 – Online platform

The open access online platform is where all WPs culminate. The textured 3D views will allow visitors to look at present-day graffiti in their geographically-correct urban setting or scroll through time and visually experience the works' time-span. A section to browse through detailed graffiti orthophotographs plus functions to download and extensively query (meta)data should also be present.

Various technologies have been explored in the first project year, and the team has settled for the Cesium platform. With the fixed technological framework, the platform's wireframing phase can start in September 2022. To not end up empty-handed, INDIGO will consider that the 3D platform's integration with OpenAtlas and ARCHE could still take longer than anticipated (despite the realistic plan sketched above). That is why the platform's first version will be centred around the 2D orthophotos (generated in AUTOGRAF – see WP 9), with all necessary database querying functionality for this 2D environment. Visualising data on a map is also more manageable than creating a smooth 3D experience. However, with the input of VRVis, specific domain knowledge gets injected into INDIGO, so achieving an interactive 3D platform still looks pretty realistic from a technological point of view.

WP 17 – Symposium 1

Project INDIGO has planned two workshops (covered by this and the following WP). The first workshop was called goINDIGO 2022 and tackled all aspects concerning documenting, archiving and disseminating graffiti-scapes. Section A6 provides all relevant information on this workshop.

WP 18 – Symposium 2

The second INDIGO symposium – goINDIGO 2023 – will take place from Wednesday, the 21st of June, until Friday, the 23rd. To minimise the effort needed in organising goINDIGO 2023, most of the goINDIGO 2022 ingredients will be reused: the location, the layout for the programme and book of abstracts, and the catering. In that way, the significant efforts put into organising goINDIGO 2022 will pay off again.

WP 19 – Fundraising

This WP is realistically scheduled for the last project months. Although writing a proposal in the middle of year two is highly unlikely, the FWF has recently launched their Emerging Fields call with an end-of-January 2023 deadline. To check the appropriateness of this call to raise funds for an INDIGO prolongation, the project leader will attend an FWF webinar in October. Besides this FWF call, it is not decided yet for which call a new project proposal will be written at the end of year two.

2. Status Work Plan (according to the time line in the proposal)

The initial GANTT chart of project INDIGO is displayed below (Figure 16). Every WP is depicted and colour-coded according to the five research pillars of project INDIGO:

- Pillar A: Acquisition
- Pillar B: Processing
- Pillar C: Management
- Pillar D: Dissemination
- Pillar E: Analysis

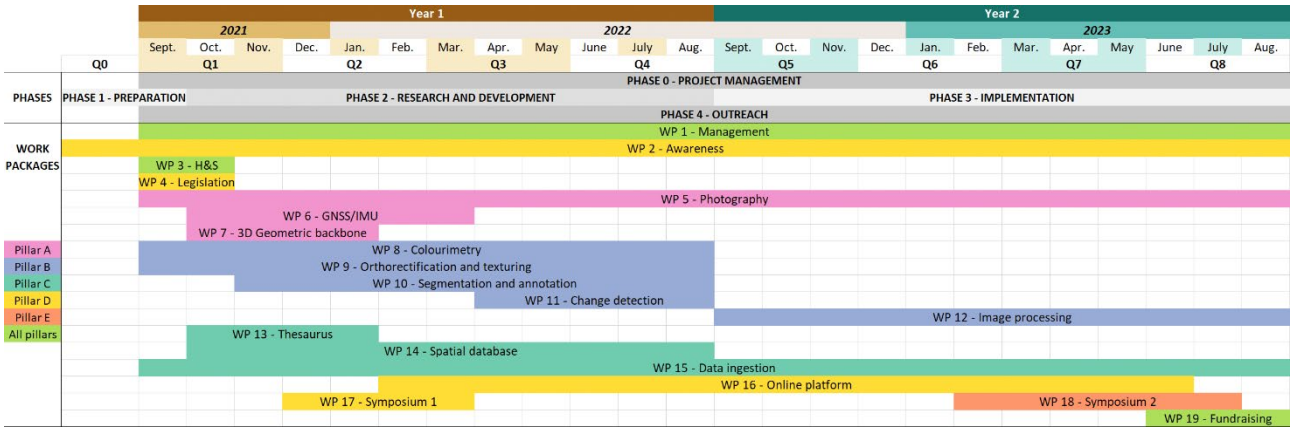


Figure 16 – Initial INDIGO GANTT chart.

Figure 17 displays INDIGO's one-year progress in GANTT form. The open indigo rectangle indicates the month in which this report was written. Every WP is greyed out according to the progress made and the time still needed to complete it. For instance: WP 1, WP 2 and WP 5 have fulfilled all the goals during the first year but continue in year 2. WP3 and WP 4 are finished. WP 6 and WP 7 have seen various amounts of progress. WP 6 needs two more months to finish it, WP 7 needs three more months before all goals are reached. The same can be said for WPs 8, 9 and 10. WP 8 needs to validate COOLPI and aims to create a graffiti colour target. WP 9 only needs some final tweaks to AUTOGRAF. WP 10 still needs to develop a final segmentation and annotation workflow. Although WPs 11 and 13 have seen considerable research, nothing is greyed out as the all foreseen time (or even more) is needed to finish them. WP 12 would, anyhow, only start in year 2. WP 14 has seen progress, but not to the extent hoped for (as detailed before). As explained above, some core topics of WP 15 are delayed by a few months due to different goal settings or setbacks of various nature. Still, INDIGO photos were ingested into the Spraycity archive throughout year one. WP 17 is finished, but September was used to finalise the proceedings (hence the one remaining yellow block). WPs 18 and 19 were from the beginning scheduled for year two.

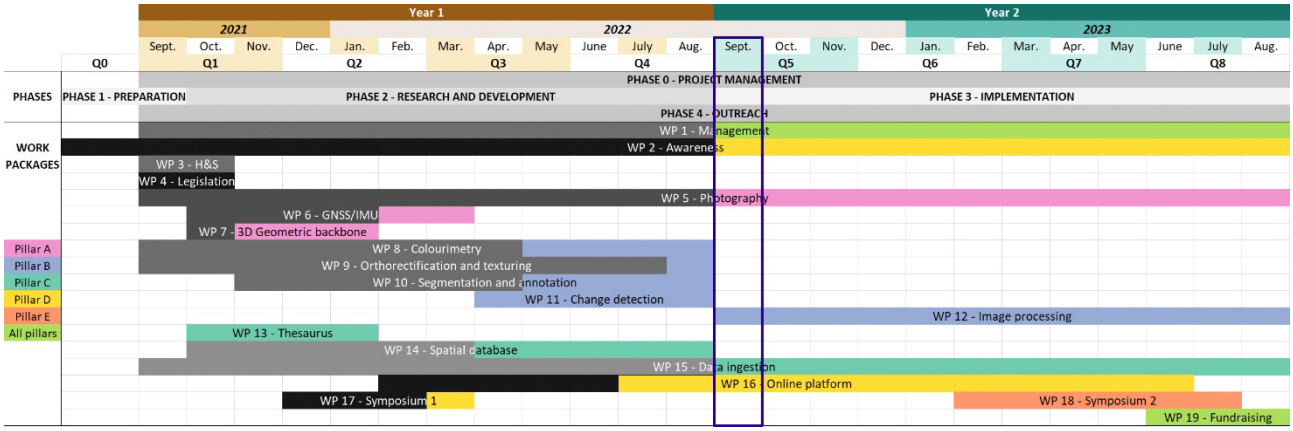
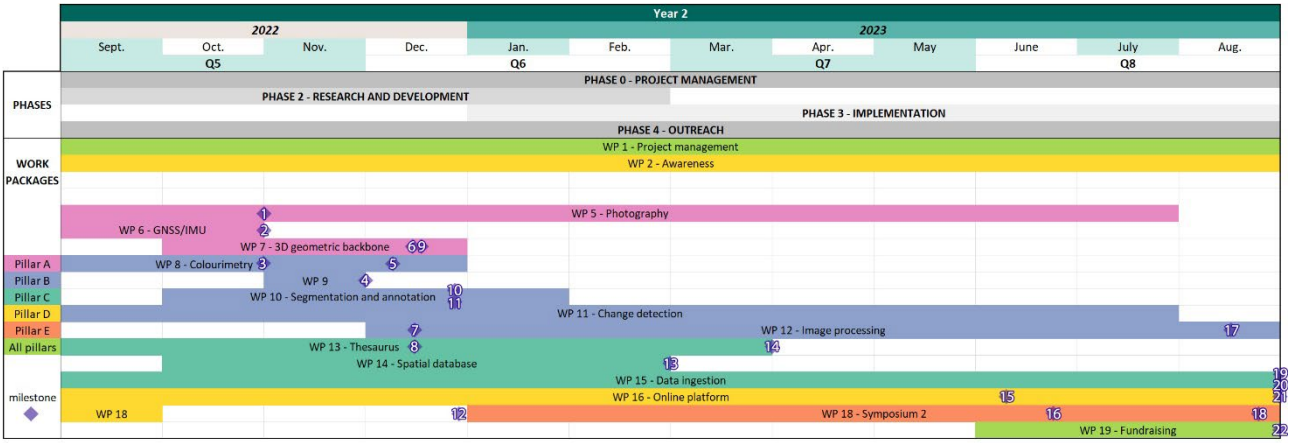


Figure 17 – The INDIGO GANTT chart after one project year.



Nr	What	Pillar	WP	End data	Deliverable type
1	Total coverage survey 2	A	5	30/10/2022	Data
2	Second GNSS/IMU device + manual	A	6	31/10/2022	Hardware + software
3	Paper COOLPI (sensors)	B	8	31/10/2022	Publication
4	Optimised version AUTOGRAF	B	9	30/11/2022	Software
5	Graffiti reference target	B	10	05/12/2022	Hardware
6	Final 3D mesh DK	A	7	16/12/2022	Data
7	Image processing pipeline	B	12	19/12/2022	Software
8	First version thesaurus	C	13	19/12/2022	Publication
9	LOOCV script and paper	A	7	20/12/2022	Software + publication
10	Segmentation tool	B	10	20/12/2022	Software
11	XMP namespace	B	10	20/12/2022	Software
12	Publication goINDIGO 2022 proceedings	D	18	27/12/2022	Publication
13	Final structure OpenAtlas	C	14	27/02/2023	Software
14	Final version thesaurus + paper	C	13	31/03/2023	Publication
15	First version online platform	D	16	09/06/2023	Software
16	Symposium 2	E	18	21/06/2023	Symposium
17	All images processed	B	12	14/08/2023	Data
18	Submit proceedings symposium 2	E	18	21/08/2023	Publication
19	All data ingested in OpenAtlas	C	15	31/08/2023	Data
20	All data ingested in ARCHE	C	15	31/08/2023	Data
21	Updated version online platform	D	16	31/08/2023	Software
22	New project proposal	A-B-C-D-E	19	31/08/2023	Funding

Nr	What	Pillar	WP	End data	Deliverable type
1	Total coverage survey 2	A	5	30/10/2022	Data
2	Second GNSS/IMU device + manual	A	6	31/10/2022	Hardware + software
6	Final 3D mesh DK	A	7	16/12/2022	Data
3	Paper COOLPI (sensors)	B	8	31/10/2022	Publication
4	Optimised version AUTOGRAF	B	9	30/11/2022	Software
5	Graffiti reference target	B	10	05/12/2022	Software
10	Segmentation tool	B	10	20/12/2022	Software
11	XMP namespace	B	10	20/12/2022	Software
17	Image processing pipeline	B	12	14/08/2023	Data
7	All images processed	B	12	19/12/2022	Software
8	First version thesaurus	C	13	19/12/2022	Publication
14	Final version thesaurus + paper	C	13	31/03/2023	Publication
13	Final structure OpenAtlas	C	14	27/02/2023	Software
19	All data ingested in OpenAtlas	C	15	31/08/2023	Data
20	All data ingested in ARCHE	C	15	31/08/2023	Data
15	First version online platform	D	16	09/06/2023	Software
21	Updated version online platform	D	16	31/08/2023	Software
12	Publication goINDIGO 2022 proceedings	D	18	27/12/2022	Publication
18	Symposium 2	E	18	21/08/2023	Publication
16	Submit proceedings symposium 2	E	18	21/06/2023	Symposium
22	New project proposal	A-B-C-D-E	19	31/08/2023	Funding

Nr	What	Pillar	WP	End data	Deliverable type
1	Total coverage survey 2	A	5	30/10/2022	Data
6	Final 3D mesh DK	A	7	16/12/2022	Data
17	All images processed	B	12	14/08/2023	Data
19	All data ingested in OpenAtlas	C	15	31/08/2023	Data
20	All data ingested in ARCHE	C	15	31/08/2023	Data
22	New project proposal	A-B-C-D-E	19	31/08/2023	Funding
5	Graffiti reference target	B	10	05/12/2022	Hardware
2	Second GNSS/IMU device + manual	A	6	31/10/2022	Hardware + software
3	Paper COOLPI (sensors)	B	8	31/10/2022	Publication
8	First version thesaurus	C	13	19/12/2022	Publication
12	Publication goINDIGO 2022 proceedings	D	18	27/12/2022	Publication
14	Final version thesaurus + paper	C	13	31/03/2023	Publication
18	Submit proceedings symposium 2	E	18	21/08/2023	Publication
4	Optimised version AUTOGRAF	B	9	30/11/2022	Software
7	Image processing pipeline	B	12	19/12/2022	Software
10	Segmentation tool	B	10	20/12/2022	Software
11	XMP namespace	B	10	20/12/2022	Software
13	Final structure OpenAtlas	C	14	27/02/2023	Software
15	First version online platform	D	16	09/06/2023	Software
21	Updated version online platform	D	16	31/08/2023	Software
9	LOOCV script and paper	A	7	20/12/2022	Software + publication
16	Symposium 2	E	18	21/06/2023	Symposium

Figure 18 – On top: the GANTT chart for project INDIGO's second year, with all milestones indicated. Below, all milestones are sorted by milestone number, WP, and deliverable type.

Figure 18 visualises the current time plan. In addition, the GANTT chart also depicts the milestones set by project INDIGO. The latter are sorted in various ways in the lower part of Figure 18.

Since current and future research has been detailed in section A1, the reader is asked to check the respective WPs for progress and plans (the GANTT chart in Figure 18 reflects all of them). Finally, it remains important to stress a few points:

- The visual computing and virtual reality experts of VRVis will join in WP 16 and provide substantial support
- Benjamin Wild can work longer on project INDIGO. He will mainly push progress in the WPs where Python programming experience is needed:
    - WP 7: writing custom scripts for handling massive data in Metashape and performing necessary statistical tests such as Leave-One-Out Cross Validation (i.e., the LOOCV script mentioned in milestone 9).
    - WP 9: finetunig AUTOGRAF and ensureing it can use COOLPI's output as input.
    - WP 10: creating a Python-based graffito segmentation tool that enables the creation of a 2D boundary polygon which AUTOGRAF can use to yield a 3D version.
- INDIGO hopes to find students to support WP 11. Several research groups have been contacted already (see Section A10), and more are to follow.
- Since the goINDIGO 2022 proceedings will be published at the end of 2022, INDIGO will use the proceedings' advertisement to announce goINDIGO 2023.
- The goINDIGO 2023 symposium is not only a critical milestone to spread awareness about the online 3D platform, but also to forge academic partnerships for the subsequent proposal writing.

3. Publications

INDIGO is an open-data and open-access project operating according to the FAIR principles. Whereas project data will become available at the project's end via the ARCHE data repository, all scientific output can be found at different locations:

- INDIGO's Zenodo community
- a dedicated ResearchGate project page
- the INDIGO project website

On all three locations – and the website of the respective publishing house – one will find the two peer-reviewed papers that INDIGO has published so far:

- Verhoeven, G.J., Wild, B., Schlegel, J., Wieser, M., Pfeifer, N., Wogrin, S., Eysn, L., Carloni, M., Koschiček-Krombholz, B., Molada-Tebar, A., Otepka-Schremmer, J., Ressl, C., Trognitz, M., Watzinger, A., 2022. *Project INDIGO – document, disseminate & analyse a graffiti-scape*. Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci. XLVI-2/W1-2022, 513–520. DOI: 10.5194/isprs-archives-XLVI-2-W1-2022-513-2022.
    - This article won the **best paper award** at the **3D-ARCH 2022 conference**. More info on this award is available here.
- Nocerino, E., Menna, F., Verhoeven, G.J., 2022. *Good vibrations? How image stabilisation influences photogrammetry*. Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci. XLVI-2/W1-2022, 395–400. DOI: 10.5194/isprs-archives-XLVI-2-W1-2022-395-2022

As of September 2022, one edited volume and six papers are submitted:

- Molada-Tebar, A., Verhoeven, G.J., 2022. *Towards colour-accurate documentation of anonymous expressions: Challenges and Solutions*, in: Document ǀ archive ǀ disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium, Vienna, Austria. 11-13 May 2022. Urban Creativity, Lisbon.
- Schlegel, J., Carloni, M., Wogrin, S., Verhoeven, G.J., 2022. *Making a mark - Towards a graffiti thesaurus*, in: Document ǀ archive ǀ disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium, Vienna, Austria. 11-13 May 2022. Urban Creativity, Lisbon.
- Verhoeven, G.J., Schlegel, J., Wild, B., Wogrin, S., Carloni, M. (Eds.), 2022. *Document ǀ archive ǀ disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium*. Urban Creativity, Lisbon. Submitted.
- Verhoeven, G.J., Carloni, M., Schlegel, J., Wild, B., Wogrin, S., 2022. *Editorial introduction – getting listeners for walls that speak*, in: Document ǀ archive ǀ disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium, Vienna, Austria. 11-13 May 2022. Urban Creativity, Lisbon. Submitted.
- Verhoeven, G.J., Wogrin, S., Schlegel, J., Wieser, M., Wild, B., 2022. *Facing a chameleon – How project INDIGO discovers and records new graffiti*, in: Document ǀ archive ǀ disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium, Vienna, Austria. 11-13 May 2022. Urban Creativity, Lisbon. Submitted.
- Wild, B., Verhoeven, G.J., Wieser, M., Ressl, C., Schlegel, J., Wogrin, S., Otepka-Schremmer, J., Pfeifer, N., 2022. *AUTOGRAF - AUTomated Orthorectification of GRAFfiti photos*. Heritage, Submitted.
- Wild, B., Verhoeven, G.J., Wogrin, S., Wieser, M., Otepka-Schremmer, J., Pfeifer, N., 2022. *Urban Creativity meets Engineering. Automated Graffiti Mapping along Vienna's Donaukanal*, in: Document ǀ archive ǀ disseminate graffiti-scapes. Proceedings of the goINDIGO2022 international graffiti symposium, Vienna, Austria. 11-13 May 2022. Urban Creativity, Lisbon.

The INDIGO team also created two software packages (COOLPI and AUTOGRAF). Their source code can be freely downloaded from the INDIGO GitHub account.

- the COlour Operations Library for Processing Images (COOLPI) is an open-source Python toolbox including procedures for the colour correction of RAW photos. The code resides here, while an extensive user manual is available at https://graffitiprojectindigo.github.io/coolpi.
- AUTOGRAF (AUTomated Orthorectification of GRAFfiti photos) is an open-source python-based Metashape add-on which enables the automated orthorectification of graffiti photos. The source code can be found here.

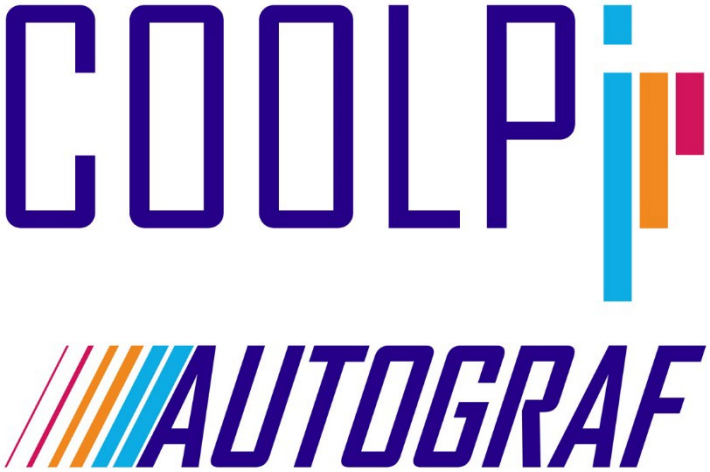


Figure 19 – The COOLPI and AUTOGRAF logos.

4. Collaborations

When considering collaborations that were not already mentioned in the project proposal, INDIGO could secure two alliances with partners from the industry:

- With EPOSA or Echtzeit Positionierung Austria, a technological leader in satellite-based positioning in Austria. EPOSA enables real-time correction of positional data from the Beidou (China), GALILEO (Europe), GLONASS (Russia) and GPS (USA) satellite constellations. Thanks to EPOSA's head of service Dipl.-Ing. Christian Klug, INDIGO can use the EPOSA correction signal freely.
- With Celantur, a Linz-based company specialising in anonymising still images and videos. The software blurs faces and can automatically anonymise entire bodies. Thanks to Alexander Petkov, CEO at Celantur, INDIGO could successfully test the software on a series of project photos. INDIGO has purchased specific hardware to run – from October onwards – the software on all project photographs by default. To that end, Celantur and INDIGO will have a mutually beneficial agreement.

On the academic side, collaborations were established with:

- Assistant Professor Ann Graf from the School of Library and Information Science at Simmons University (USA). Prof. Graf's research on organising and describing graffiti terms is especially relevant for INDIGO.
- TU Vienna's Pilot Research Ethics Committee (see WP 4 for more details).

Finally, there is essential information exchange with some key players in the photographic industry. These are not classified as industry collaborations since INDIGO does only receive advice and no products or services:

- The developers of Camera Bits and Photools. These companies build the photo management systems Photo Mechanic Plus and IMatch, respectively. Both software packages are unique as they respect almost all metadata standards and guidelines established by various organisations (like IPTC and Adobe).
- David Riecks, co-lead of the IPTC Photo Metadata Working Group.

5. Conferences and workshops attended

INDIGO staff has attended a wide variety of national and international gatherings. In the following list, internal workshops at the host and participating institutes have been omitted.

- 30/04/2021 [Online]
  - Meeting/conference: **Using Vocabularies and Linked data: #ConnectingArchaeology webinar**
  - Attendee: Geert Verhoeven
  - Before the INDIGO project start, but many INDIGO-specific questions were asked
- 17/09/2021 [Vienna, Austria]
  - Meeting/conference: **Second Heritage Science Austria Meeting**
  - Attendee: Geert Verhoeven
- 19/11/2021 [Online, Austria]
  - Meeting/conference: **Meeting Ethical commission TU Wien**
  - Attendees: Norbert Pfeifer, Geert Verhoeven, Benjamin Wild
- 17/01/2022 [Online, Austria]
  - Meeting/conference: **SynerGIS After Business Workshop, topic "SURE"**
  - Attendee: Jona Schlegel
- 02/03/2022 [Mantova, Italy]
  - Meeting/conference: **3D-ARCH'2022 - 3D Virtual Reconstruction and Visualization of Complex Architectures – 9th International Workshop**
  - Attendee: Benjamin Wild
- 31/03/2022 [Online, Australia]
  - Meeting/conference: **Pointcloud Workshop (Geospatial Research Innovation Development lab at the University of New South Wales)**
  - Attendee: Benjamin Wild
- 11/05/2022 [Vienna, Austria]
  - Meeting/conference: **goINDIGO 2022: document | archive | disseminate graffiti-scapes**
  - Attendee: entire INDIGO team
- 15/06/2022 [Online, worldwide]
  - Meeting/conference: **ARIADNEplus workshop: Semantic mapping of excavation data**
  - Attendees: Jona Schegel and Geert Verhoeven
- 20-24/06/2022 [Prato, Italy]
  - Meeting/conference: **ARIADNEplus Summer School: Mapping Existing Datasets to CIDOC CRM**
  - Attendee: Jona Schegel
- 23/09/2022 [Vienna, Austria]
  - Meeting/conference: **Third Heritage Science Austria Meeting**
  - Attendees: Geert Verhoeven and Benjamin Wild

6. Organised workshops

Because INDIGO has a technical- and more humanistic-oriented aspect, both facets were planned to be covered by two symposia. Although the COronaVIrus Disease 2019 (COVID-19) was still wreaking havoc across the world in 2022, the hope was nurtured to physically bring together specific subsections of the (scholarly) graffiti community in Vienna. The initial timing of both symposia accounted for INDIGO's project schedule, to maximise the relevancy of the discussions and insights gained (see also Figure 2).

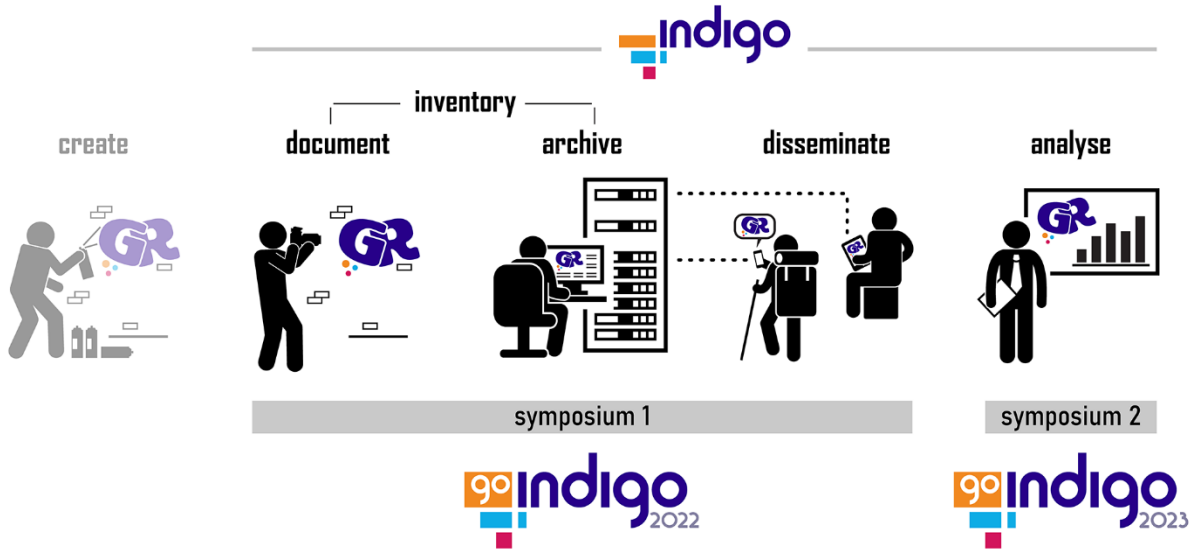


Figure 20 – The main goals of project INDIGO and how they fit within the two goINDIGO symposia.

- **goINDIGO2022** had been planned to take place six months into the project and tackle all the technical, logistic, legal, and ethical aspects of documenting, archiving, and disseminating graffiti. The idea of gathering experts and experience so early was to help avoid pitfalls on various more technical topics further down INDIGO's road.
- A second symposium – **goINDIGO 2023** – was planned for the end of the project. This gathering should focus on graffiti's socio-political and cultural impact. goINDIGO 2023 will also mark the launch of INDIGO's online platform and showcase how its stored graffiti (meta)data enables societal and cultural insights. In this way, specialists in art history, philosophy, cultural studies, law, urbanism, psychology, and communication will see the potential of this massive open-access archive, thereby ensuring this project's transdisciplinary sustainability.

Although the uncertainty created by the COVID-19 pandemic slightly delayed the goINDIGO 2022 symposium and made a hybrid event inevitable, INDIGO managed a small but successful gathering. From the 11th to the 13th of May 2022, a mixed group of sixty participants (graffiti creators, heritage professionals and graffiti academics) from twelve countries met in Vienna or online to learn from each other and build proverbial bridges. Throughout two and a half days, two keynote lectures and eighteen presentations touched upon many facets of documenting, archiving and disseminating graffiti records (see also the book of abstracts). The word cloud generated from the goINDIGO 2022 book of abstracts reflects this topical diversity (Figure 21).

Figure 21 – The word cloud extracted from the goINDIGO 2022 book of abstracts.

Still, this word cloud fails to represent the various viewpoints that speakers put forward. Such variety should always be sought after, as robust strategies for inventorying and sharing graffiti records can only be obtained when soft sciences meet hard sciences, legal experts discuss with specialists on ethics, archivists get to know web programmers and… graffitists connect with academics. INDIGO considers these *inter*- and *intra*-project collaborations an essential feature because they hold an unlimited potential to draw inspiration from peers and experts in entirely different domains. That is why the goINDIGO 2022 organising team is proud to have pulled off two highly interactive discussion sessions between those who create graffiti and those who study/archive them. Both discussion sessions were joined by six graffiti creators operating in Vienna.

Now (i.e., September 2022), the proceedings of the symposium are finalised. The book is edited by five INDIGO project members and contains five INDIGO-specific papers. Urban Creativity was chosen as the publishing house for these proceedings, not only because they are a household name in graffiti literature, but also because they enable the proceedings to be open access.

On the 25th of June 2023, Geert (and likely Adolfo) will give a **workshop on the colourimetric processing of digital photos**. This workshop takes place at the start of the CIPA heritage Documentation conference in Florence, Italy. The workshop will rely on the COOLPI software package developed within the INDIGO project (see WP 8).

7. Scientific Presentations

Below, all eleven scientific talks and two posters on INDIGO-specific topics are listed. If the presentation is available online, it got a DOI number over Zenodo. As with the publications, all presentations are available on the Zenodo community webpage, the project website and ResearchGate. INDIGO choose to put specific presentations not online (and give them a DOI over Zenodo), as the slides of those presentations are (almost) identical to those of previous talks.

- 17/09/2021 [Vienna, Austria]
  - Meeting/conference: **Second Heritage Science Austria Meeting**
  - Title: *INDIGO: INventory and DIsseminate Graffiti along the dOnaukanal*
  - Presenter: Geert Verhoeven
  - Invited: Yes
  - DOI: 10.5281/zenodo.6338834
- 19/11/2021 [Online, Austria]
  - Meeting/conference: **Meeting Ethical commission TU Wien**
  - Title: *INDIGO: INventory and DIsseminate Graffiti along the dOnaukanal*
  - Presenter: Geert Verhoeven
  - Invited: No
- 25/11/2021 [Vienna, Austria]
  - Meeting/conference: **Internal meeting at the PhotoCircle research group (Geodesy Department TU Wien, Austria)**
  - Title: *Photogrammetry in context of the graffiti-research project INDIGO*
  - Presenter: Benjamin Wild
  - Invited: No
- 02/03/2022 [Mantova, Italy]
  - Meeting/conference: **3D-ARCH'2022 - 3D Virtual Reconstruction and Visualization of Complex Architectures – 9th International Workshop**
  - Title: *Project INDIGO – document, disseminate & analyse a graffiti-scape*
  - Presenter: Benjamin Wild
  - Invited: No
  - DOI: 10.5281/zenodo.6339489
- 03/03/2022 [Mantova, Italy]
  - Meeting/conference: **3D-ARCH'2022 - 3D Virtual Reconstruction and Visualization of Complex Architectures – 9th International Workshop**
  - Title: *Good vibrations? How image stabilisation influences photogrammetry*
  - Presenter: Fabio Menna
  - Invited: No
  - DOI: 10.5281/zenodo.6382756
- 31/03/2022 [Online, Australia]
  - Meeting/conference: **Pointcloud Workshop (Geospatial Research Innovation Development lab at the University of New South Wales)**
  - Title: *Project INDIGO - document, disseminate & analyse a graffiti-scape*
  - Presenter: Benjamin Wild
  - Invited: Yes

- 11/05/2022 [Vienna, Austria]
    - Meeting/conference: **goINDIGO 2022: document | archive | disseminate graffiti-scapes**
    - Title: *Discovering & recording new graffiti within project INDIGO*
    - Presenter: Geert Verhoeven
    - Invited: No
    - DOI: 10.5281/zenodo.6574796
- 11/05/2022 [Vienna, Austria]
    - Meeting/conference: **goINDIGO 2022: document | archive | disseminate graffiti-scapes**
    - Title: *Achieving colour-accurate data from images: challenges and solutions*
    - Presenter: Adolfo-Molada Tebar
    - Invited: No
    - DOI: 10.5281/zenodo.6579429
- 12/05/2022 [Vienna, Austria]
    - Meeting/conference: **goINDIGO 2022: document | archive | disseminate graffiti-scapes**
    - Title: *Towards a graffiti thesaurus in SKOS*
    - Presenter: Jona Schlegel & Massimiliano Carloni
    - Invited: No
    - DOI: 10.5281/zenodo.6578470
- 12/05/2022 [Vienna, Austria]
    - Meeting/conference: **goINDIGO 2022: document | archive | disseminate graffiti-scapes**
    - Title: *Towards the automatic production of graffiti orthophotos*
    - Presenter: Benjamin Wild
    - Invited: No
    - DOI: 10.5281/zenodo.6574990
- 07/07/2022 [Wrocław, Poland]
    - Meeting/conference: **Guest lecture**
    - Title: *INDIGO - document, disseminate & analyse a graffiti-scape*
    - Presenter: Norbert Pfeifer
    - Invited: Yes
- 23/09/2022 [Vienna, Austria] - poster
    - Meeting/conference: **Third Heritage Science Austria Meeting**
    - Title: *Acquiring centimetre-accurate camera coordinates in project INDIGO*
    - Presenter: Geert Verhoeven
    - Invited: No
    - DOI: 10.5281/zenodo.7109573
- 23/09/2022 [Vienna, Austria] - poster
    - Meeting/conference: **Third Heritage Science Austria Meeting**
    - Title: *How project INDIGO automatically turns graffiti photos into orthophotomaps*
    - Presenter: Benjamin Wild
    - Invited: No
    - DOI: 10.5281/zenodo.7109431

8. Visitors

None.

9. Public dissemination

- From the start of the project, INDIGO had a project website online: https://projectindigo.eu. This website contains all relevant project info (which gets regularly updated and expanded) and features a blog section.
- Every two weeks, INDIGO publishes a **newsletter**. These newsletters – which can all be found here – always feature the same three hyperlinked sections:
    - A short mention of all upcoming meetings.
    - A photograph of a graffito recently created along the Donaukanal. Clicking on this image brings up a map with its location.
    - A short description and link to the protocol of past meetings. In that way, the INDIGO meeting protocols are freely accessible to anybody.
- Project INDIGO has an active **Instagram** account, because it is one of the main platforms where the necessary engagement with graffiti creators occurs. In one year, almost 400 people active in the graffiti scene started to follow INDIGO's Instagram. After trying out different strategies, INDIGO has now settled for four types of contributions:
    - Every second Monday, the **Newsletter** is posted.
    - Each Wednesday is **Gallery Wednesday**; new graffiti creations from the Donaukanal are shared.
    - Every second Friday is **Flashback Friday**: either relevant historical facts on graffiti are shared or a photo composition that compares a 2002-2005 versus a 2022 photo from the Donaukanal.
    - Every Sunday is **Literature Sunday** in which literature on graffiti (usually a book) is shortly described.
- The **Twitter** account of project INDIGO is less active, which explains why there are only 85 followers as of September 2022. Twitter was mainly used for advertising all the talks of the goINDIGO 2022 symposium.
- On Saturday, the 16th of July 2022, the Austrian newspaper **Die Presse** devoted an article to project INDIGO. The entire article can be found here: https://projectindigo.eu/diepresse
- Jona Schlegel and Benjamin Wild presented project INDIGO at the ***Lange Nacht der Forschung*** (Eng. Long Night of Science) [20/05/2022, Vienna, Austria]). More info and photos of the event are available here.
- Benjamin wild will present project INDIGO at the **European Researchers' Night** [30/09/2022, Vienna, Austria].
- On www.theworldinpointclouds.com, INDIGO is featured in a blog post on point cloud generation.
- Project INDIGO has been mentioned on two podcasts:
    - 31/05/2022: **ILOVEGRAFFITI.DE Podcast 69** featured *Stefan Wogrin* (https://www.youtube.com/watch?v=wf-L2Ysuqn0) talking about INDIGO (40:15 to 46:43).
    - 09/05/2022: graffiti creator *Deadbeat Hero* mentions right at the beginning of his **Artcade podcast S08 E01** (https://artcadepodcast.podbean.com/e/s08-e01-ndzw) his partaking in the goINDIGO symposium.
- The Levin Statzer Foundation started to organise boat tours in September and October 2022 along the graffiti-scape of the Donaukanal. During these tours, project INDIGO and its goals are mentioned.
- All scientific output (papers (2), software (2) and most presentations (7)) can be freely accessed via INDIGO's Zenodo community or the dedicated ResearchGate project page.

10. Group Members (Personnel Recruiting)

During the first year, there have been two replacements. Although these people were not recruited per se, they constitute a change in INDIGO staff.:

- MSc Ana-Maria Loghin (°1989) was initially planned to take care of the photogrammetric work but had found another job before INDIGO started. Her spot was filled by MSc Benjamin Wild (°1996);
- MS Martin Trognitz (°1986) went on maternity leave in February 2022. Instead, Dr. Massimiliano Carloni (°1990) took over her place within INDIGO.

Two people also joined INDIGO on the ACDH-CH side. Both help with specific aspects of the OpenAtlas software:

- MSc Bernhard Koschicek-Krombholz (°1987) is on the INDIGO payroll and responsible for the API of OpenAtlas.
- Bsc Nina Richards (°1983) is not on the INDIGO payroll. Still, she joins the team meetings for her knowledge on the CRM ontology, which partly forms the basis for OpenAtlas. Because INDIGO wants to expand the CRM ontology within OpenAtlas, Nina's input is important.

INDIGO also hopes that a few Bachelor's and Master's students join the project the following year. So far, only one Bachelor's student at the TUWien is working on an INDIGO topic: semi-automated segmentation of graffiti from photographs. His thesis is expected by the end of 2022. Good contacts also exist with professor **Hiep Luong** (professor at the Image Processing and Interpretation research group, Ghent University, Belgium) and **Sebastian Zambanini** (senior lecturer at the TU Vienna Computer Vision Lab) to actively look for Master's students. INDIGO's enormous and varied collection of photos is ideal for developing computer vision approaches, enabling students from various disciplines to push the boundaries in automated graffiti reading and change detection.

11. Organisational work

INDIGO's teamwork is founded on four management pillars:

- Day-to-day communication does not run over email but takes place on the Mattermost platform. Mattermost is an online, open-source chat service with file sharing and search options. The service is hosted at the ACDH-CH and can be accessed via a browser or dedicated app on the phone or computer. INDIGO's Mattermost server enables all staff members to communicate quickly on all relevant topics. Each WP has gotten its Mattermost channel (see Figure 22), and only appropriate project members have access to these channels. In addition, there is a "General" channel for messages that concern everybody, a "Graffiti Fun" channel for fun facts, and a "Mum, look what I have done channel" (see Figure 22). The idea of the latter channel is to post small snippets of progress (a new illustration that was made, code that was debugged, a paper that was submitted). By continuously sharing small pieces of progress, the whole team stays motivated. Finally, Mattermost also allows sending direct messages to one or more people. In that way, it removes most overhead of an email-based approach, increases project transparency and ensures that everybody stays up to date on all relevant things, big and small.

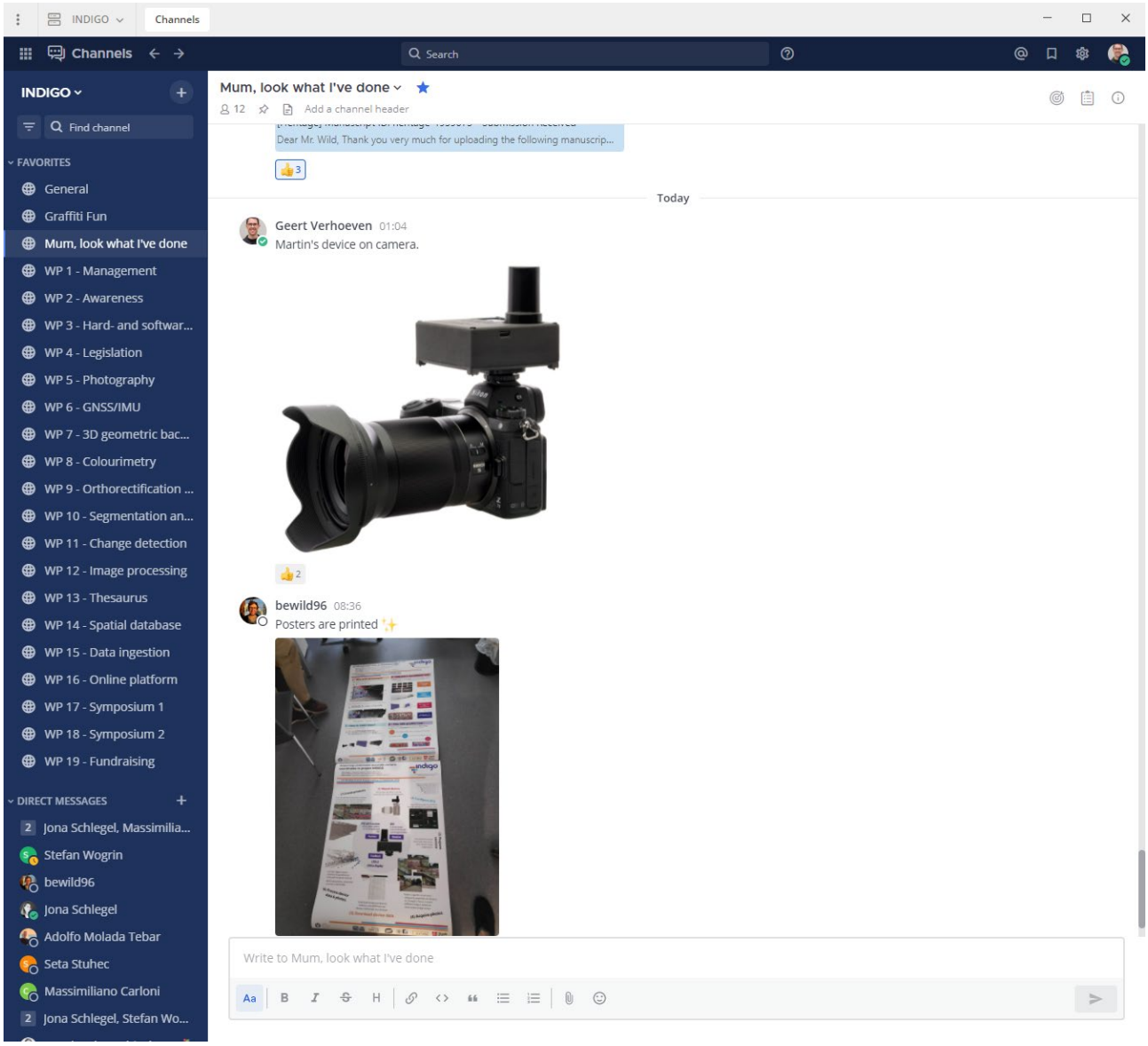


Figure 22 – INDIGO's Mattermost server interface, showing the WP-based organisation on the left, above the direct messages. The screenshot shows some examples of little progress that are shared in the "Mum, look what I've done "channel.

- Once per month (usually scheduled on that month's last Friday), there is the general INDIGO team meeting. During a team meeting, all running and upcoming research matters are discussed, as well as finances and logistics. Every team meeting also comes with a detailed agenda. Like every INDIGO meeting, a written protocol follows within a few hours (to maximally a couple of days) after the meeting. Care is taken to keep the entire meeting within one hour. All meeting protocols are freely accessible and get distributed to every interested party via INDIGO's newsletter.
- Project INDIGO has a Google account, from which mostly the Calendar and Drive functions are used. All INDIGO-relevant appointments and deadlines are stored in the Google calendar to which all team members have access. The same goes for all relevant supplementary INDIGO data (like spreadsheet, scientific papers, flowcharts, meeting protocols). Using Gdrive technology, everybody has 24/7 access to all these files from wherever they are working. INDIGO's GDrive also features a private section for documents that should only be shared by a few (such as the accounting spreadsheets). Finally, collaboration on scientific articles runs over Google Docs and Sheets.
- The fourth pillar of the management system is Teamwork, a dedicated project management software in which the project leader keeps track of the entire research programme and all deliverables.

Besides these four pillars, INDIGO also relies on many smaller collaborative tools. One of them is MIRO, a whiteboard platform used for the thesaurus. Another tool that plays an essential role in project INDIGO is sync.com. Sync.com ensures that all relevant primary data get safely and quickly stored on INDIGO's central workstation (see Figure 23). INDIGO is a "big data" project. One of the three dedicated photographers collects at least once per week >100 GB of photographs. This photographer is often Stefan Wogrin from SprayCity, who does not share an office with the other two photographers. Via a two-user account with unlimited storage, data collected by Stefan are uploaded from his home computer to Sync.com's cloud service and automatically synchronised with INDIGO's central workstation. As such, a weekly physical transfer of a hard drive is avoided, thus saving precious time. Moreover, Sync.com also stores a copy of all primary and supplementary INDIGO data in the cloud. Because the service provides end-to-end zero-knowledge encryption, not even the people at Sync.com can open INDIGO data without passing a two-level verification. That is why the service was independently reviewed as the most secure Cloud Storage solution to date. Finally, the project leader's PC also stores a copy of all data.

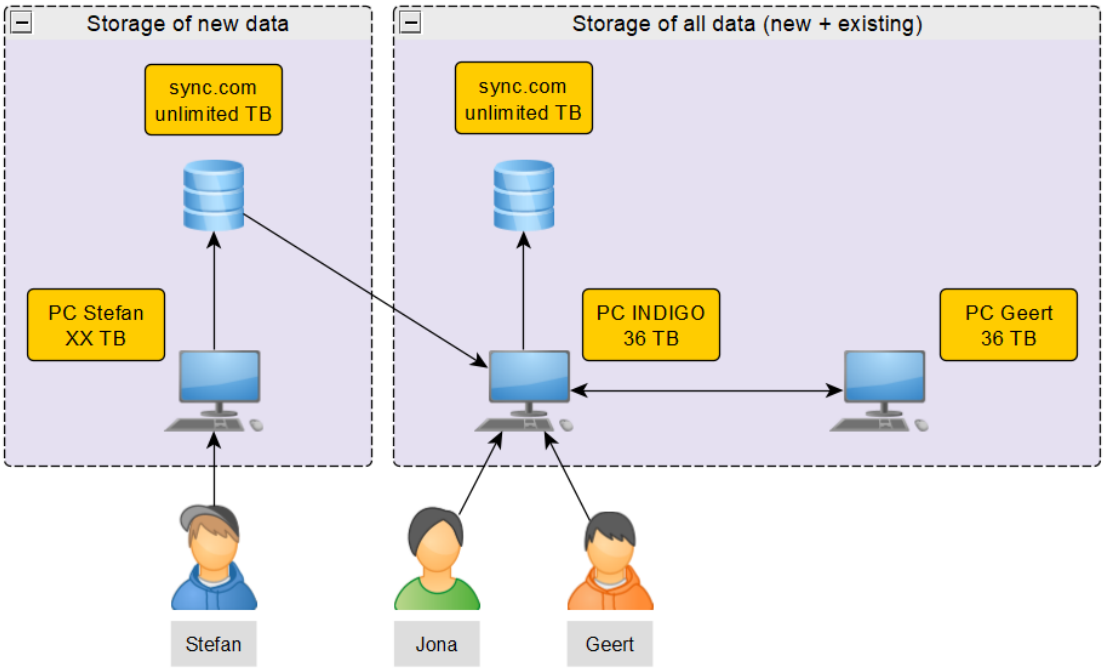


Figure 23 – Management of INDIGO's primary research data (i.e., photographs and spectrometer files).

B. Finances

1. Description of staff and other costs

The attached Excel spreadsheet **Heritage_2020-014_INDIGO_Accounting.xlsx** contains five different sheets:

- Sheet 1: the initial budget plan
- Sheet 2: the initial budget plan taking the € 20k funding reduction into account
- Sheet 3: the expenses of the LBG (host 1), using sheet 2 as a basis
- Sheet 4: the expenses of the TU Wien (host 2), using sheet 2 as a basis
- Sheet 5: all expenses of both host institutes, effectively combining sheets 3 and 4.

In sheet 5, one can see that the staff costs of the LBG (Jona Schlegel and Geert Verhoeven) are as budgeted. There is only a minor deficit for Adolfo Molada Tebar. This deficit resulted from the fact that the Polytechnic University of Valencia could not participate in the INDIGO consortium (despite the signed letter of intent). After trying to find a solution for many months, the only remaining option was to pay Adolfo as a freelance researcher. In his contract, Adolfo would be compensated according to his finished deliverables. Since the last outstanding deliverable – an article on his research – was only achieved in the second half of September 2022, the small remaining sum will be paid out at the end of September 2022. After that, his contract is finished, whereas those of Jona Schlegel and Geert Verhoeven continue for one more year.
At the TU Wien host, staff costs deviate more from the initial budget plan. The scientific project support of Prof. Norbert Pfeifer – contrary to what was initially thought – was more extensive and vital for INDIGO. Johannes Otepka-Schremmer's project allocation has been reduced to compensate for this. This is also justifiable, as Johannes is a point cloud processing expert whose contribution was tied to the laser scans INDIGO would obtain from the City of Vienna. Because these scans have not been delivered so far, Johannes' contribution was relatively small.
Furthermore, costs of € [redacted] were calculated for Ana-Maria Loghin. As communicated to ÖAW, she was replaced by Benjamin Wild before the project started. At the time of the calculation, Ana-Maria was already classified in a higher staff category than Benjamin, so the personnel costs for Benjamin are inherently lower. In addition, Benjamin did not finish his Master's degree until the end of 2021, which is why full employment was only possible after December 2021. However, the budget for Ana-Maria was only calculated for the first year. As a positive effect, INDIGO can now use the surplus budget to enable Benjamin to work on the project for longer. Furthermore, fewer funds were used for travel, publications and meetings. These expenses will be incurred in various forms in the second project year.

The total cost for consumables is less than budgeted, but this is mainly due to consumables 3 and 8. Consumable 3 equals the dedicated hardware developed to obtain accurate camera coordinates and angular rotations. Martin Wieser, an unaffiliated INDIGO researcher who designs and builds these devices, had to wait several months to acquire the necessary electronic components due to supply chain issues caused by the war in Ukraine. Only at the start of September 2022 could the first copy of the GNSS-IMU device be entirely assembled. Payment will occur when the second copy is finished (expected in the first week of October 2022). The colour management kit X-Rite i1Publish Pro 3 + (consumable 8) has not been purchased, as its price rose by 50 % since the budget was made. Because prices are not expected to be lowered anytime soon, this purchase will be omitted.

The combination of consumables 1 and 2 (and to a lesser extent 5) is also a few € 1000 less than budgeted. INDIGO has intentionally not yet spent the entire budget for cameras, lenses and tablets. It became apparent in the first project months that INDIGO's photo acquisition would function with just two tablets and camera-

lens sets. Jona Schlegel and Geert Verhoeven occupy the same office and can thus efficiently share this equipment. The second camera-lens-tablet package is for Stefan Wogrin. In addition, putting this money aside has an additional benefit: it can counter possible hardware failures or damage. Due to the intensity of INDIGO's photographic activities, these are not unlikely to happen. So if INDIGO needs to buy a new lens or camera to continue operations, this is possible. As the current gear was state-of-the-art when purchased, the same hardware will still be purchasable in the following year; a new purchase will thus not influence the general photography workflow.
Overall, slightly less money was spent on PCs and monitors and more on hard drives, balancing each other out. The Adobe Creative Cloud subscription was not bought (the project leader used his private license), explaining the € 1000 difference in consumables 6. As described above in WP 3, a more accurate Konica Minolta CM-26d was purchased instead of two portable X-Rite Ci60 spectrophotometers. The total cost of both solutions is virtually identical, however. Finally, the measurement tapes (consumables 12) have not been bought because INDIGO is digitally documenting every new graffito, with measurements extracted from the 3D models rather than *in situ*.

In the second project year, hard-and software purchases will drastically drop. Apart from a few hard drives and a license for Cesium, no significant expense is foreseen (besides a potential camera replacement or additional lens).

Travel expenses are as budgeted, but costs for open access papers are so far zero. This has two reasons: first, the conference registration included the cost of the open-access paper published in the ISPRS Archives. Second, the article processing charges for the follow-up paper submitted to the journal Heritage were zero, a nice side-effect of winning the best-paper award with the initial article. However, INDIGO will spend € 2500 at the beginning of October to finance the first stage of the goINDIGO 2022 symposium proceedings. The entire proceedings will be indexed and open access, for which a € 5000 cost was agreed on with the UrbanCreativity publishing house. The second half of this sum will be transferred when the entire publication process is finished. Finally, all costs for contracts and services were paid as budgeted.

With the reduction of funding taken into account, there is thus a € 36.9k surplus after project year one. INDIGO will spend the surplus related to consumables and open-access publications in October and December. The TU Wien staff-related surplus will be used to employ Benjamin Wild longer (see above). Finally, the VRVis subcontract will likely be lowered by € 5k to ensure project INDIGO stays within the allocated funding.

2. Accounting record

See the separate Excel file called **Heritage_2020-014_INDIGO_Accounting.xlsx**. As mentioned above, this spreadsheet contains five different sheets:

- Sheet 1: the initial budget plan
- Sheet 2: the initial budget plan taking the € 20k funding reduction into account
- Sheet 3: the expenses of the LBG (host 1), using sheet 2 as a basis
- Sheet 4: the expenses of the TU Wien (host 2), using sheet 2 as a basis
- Sheet 5: all expenses of both host institutes, effectively combining sheets 3 and 4.

C. Summary/Zusammenfassung (für öffentlichkeitsrelevante Zwecke)

English

Graffiti are studied by archaeologists, sociologists, (art) historians, linguists, ethnographers, architects, anthropologists, librarian scientists, geographers, criminologists, conservators, lawyers and architects (amongst many others). Although most of these professions rely on a digital representation of graffiti at a particular stage of their research, there has been strikingly little attention to how graffiti can effectively be monitored and digitally documented. And this is precisely one of the gaps that the heritage science project INDIGO is trying to fill. Through collaboration between geomatics, data management and graffiti specialists, INDIGO aims to develop technical and logistical solutions that facilitate the systematic documentation, monitoring, and analysis of extensive graffiti-scapes.

INDIGO's first project year was primarily devoted to research and development, enabling the creation of various products that could benefit the broader heritage documentation field. From a small device that acquires centimetre-accurate camera coordinates for every photo, to COOLPI and AUTOGRAF, freely available software packages that respectively automate the colourimetric and geometric processing of thousands of photographs. Besides the advancements in database design, legislative frameworks, thesaurus development and photography workflows, INDIGO managed the organisation of an international graffiti symposium. Being the first of two planned expert gatherings, the goINDIGO 2022 symposium functioned as a communication platform for similarly-minded scholars. Simultaneously, it established a bridge between academics and the typically closed community of graffiti creators. Finally, coverage by the press, mentions in various podcasts and blog posts, as well as the publication of several scientific papers – among one award-winning – ensured the project's (inter)national visibility.

Deutsch

Graffiti werden von ArchäologInnen, SoziologInnen, (Kunst-)HistorikerInnen, LinguistInnen, EthnographInnen, ArchitektInnen, AnthropologInnen, BibliothekswissenschaftlerInnen, GeographInnen, KriminologInnen, RestauratorInnen, Juristinnen und ArchitektInnen (neben vielen anderen) untersucht. Obwohl die meisten dieser Berufsgruppen in einem bestimmten Stadium ihrer Forschung auf eine digitale Darstellung von Graffiti angewiesen sind, wurde bisher auffallend wenig darauf geachtet, wie Graffiti effektiv nachverfolgt und digital dokumentiert werden können. Und genau diese Lücke versucht das kulturwissenschaftliche Projekt INDIGO zu schließen. Durch die Zusammenarbeit von Geomatik-, Datenmanagement- und Graffiti-SpezialistInnen will INDIGO technische und logistische Lösungen entwickeln, die die systematische Dokumentation, Nachverfolgung und Analyse von umfangreichen Graffiti-Landschaften erleichtern. Das erste Projektjahr von INDIGO war in erster Linie der Forschung und Entwicklung gewidmet und ermöglichte die Schaffung verschiedener Produkte, die für die Dokumentation des kulturellen Erbes im weiteren Sinne von Nutzen sein könnten. Von einem kleinen Gerät das zentimetergenaue Kamerakoordinaten für jedes Foto erfasst, bis hin zu COOLPI und AUTOGRAF, zwei frei verfügbaren Softwarepaketen, die die kolorimetrische bzw. geometrische Verarbeitung tausender Fotos automatisieren. Neben Fortschritten in den Bereichen Datenbankdesign, Rechtsrahmen, Thesaurusentwicklung und Fotografie-Workflows organisierte INDIGO auch ein internationales Graffiti-Symposium. Als erstes von zwei geplanten Expertentreffen diente das goINDIGO-Symposium 2022 als Kommunikationsplattform für gleichgesinnte WissenschaftlerInnen. Gleichzeitig schlug es eine Brücke zwischen WissenschaftlerInnen und der typischerweise geschlossenen Gemeinschaft der Graffiti-MacherInnen. Schließlich sorgten die Berichterstattung in der Presse, die Erwähnung in verschiedenen Podcasts und Blogbeiträgen sowie die Veröffentlichung mehrerer wissenschaftlicher Arbeiten - darunter eine preisgekrönte - für die (inter)nationale Sichtbarkeit des Projekts.

D. Signatures

Principal investigator (Coordinator):

(date

Geert J. Verhoeven

(name)

(signature)

Geert Verhoeven

Digitally signed by Geert Verhoeven
Date: 2022.09.29 10:47:13 +02'00'

For the host institution:

30. September 2022 | 13:35 MESZ

(date)

Marisa Radatz
Anneliese Inreiter-Weiss

(name)

DocuSigned by:
Marisa Radatz
06DEE5CDA834428...

(signature)

DocuSigned by:
ppa Inreiter-Weiss
01AB8ABBE8B14FF...

Principal Investigator:

(date)

Norbert Pfeifer

(name)

(signature)

For the host institution:

(date)

Johannes Böhm

(name)

(signature)

Signiert von: Norbert Pfeifer
Datum: 29.09.2022 11:18:57

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Signiert von: Johannes Böhm
Datum: 29.09.2022 14:52:58

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