

Assignment 2: HPAR7007 Archaeological Specialist Practice

INTRODUCTION

Archaeological photogrammetric recording can be visualised as four main workflow stages; planning and preparation, data capture, data processing and, lastly, presentation and archiving (Historic England, 2017, pp. 14). A project manager should seek to implement a range of approaches and measures for each of these workflow stages to ensure that a team new to the process of photogrammetry carries out the survey both correctly and safely.

The expansive application of photogrammetry within an archaeological context is vast. New technologies and methodologies are constantly developing and outpacing the rate at which standards, guidance, policies and regulations can be developed; the latest comprehensive industry guidance (Historic England, 2017) is now six years old at the time of writing. Therefore, there is an ethical responsibility for project managers to develop measures and approaches that can deliver safe and correct outputs in line with fundamental principles, such as Principles 1.5, 3 and 5.2 of the ClfA Code of Conduct (ClfA, 2014a).

This report seeks to highlight the importance of such approaches and measures when introducing photogrammetry to a new team, as well as tailoring them to each of the individual workflow stages. Its four sections start by summarising why each workflow stage is key to the success of the project before identifying the potential opportunities for unsafe or incorrect survey that could occur. The following sub-sections then detail some approaches and measures relevant to each workflow stage that could help to ensure the survey is conducted safely and accurately. The report concludes with a summary of these measures, their links to each workflow stage and why it is important they are implemented.

1. PLANNING AND PREPARATION

Planning and preparing for a photogrammetric archaeological project, paying careful attention to the generic and project-specific requirements of the different workflow stages, is fundamentally key to its success. A failure to plan effectively can lead to plenty of

opportunity for systematic errors and mistakes during data capture and processing as well as potential health and safety issues (Historic England, 2017, pp. 13). These may include but are not limited to; incorrect system configuration, errors with camera settings and sensors, lens distortion, refraction, incorrect photo alignment or control point-matching and unsafe data capture methodologies whilst working at height, depth or underwater for example.

Therefore, introducing and integrating this first planning stage of the photogrammetric workflow process to a project team is vitally important and ethically responsible, especially for a new team or newly developed technologies and methodologies. The following sub-sections detail some of the possible approaches and measures designed to achieve this outcome. They go on to demonstrate how they will assist in ensuring the final output is produced accurately and correctly whilst using a safe methodology.

1.1 Produce Project-Specific Method Statements and Plans

Method statements for photogrammetric recording surveys, such as Section 3.2 of Yeates (2020), are often short, simple and broadly applicable summary statements that allow for a degree of flexibility during survey if circumstances change unexpectedly. However, they offer little direct practical site-specific guidance to the project team and more detailed method statements could provide invaluable help during survey for a team that is relatively new to this technique. Added detail will help tailor the methodology to each project in advance and identify any unique requirements or necessary changes in approach during the planning stage, giving the new team time to learn, train and prepare.

More detailed project-specific method statements could also be articulated as a series of steps or a checklist guide to be completed by the project team before, during and after survey as a mechanism to ensure that the eventual output was produced correctly and safely in accordance with the agreed methodology. However, it is still important that broader contingency statements developed in reference to overarching industry-approved standards and guidance are maintained to allow for the flexibility to adapt during survey if needed.

A project-specific approach will likely be a necessity in many cases, especially when recording cultural heritage assets within a particularly complex environment. In the example of Pascoe *et al.* (2017), conducting an underwater photogrammetric survey of the wreck of 'Invincible,' a refined methodology was required to safely produce a high quality and usable research output. Section 4 of this Historic England research report details an extended methodology that considers issues of safe diving, survey and recording techniques whilst underwater.

1.2 Prepare for Training in Advance

Providing appropriate training in advance to a team that may be new to photogrammetry will be one of the most effective ways of planning and preparing for them to undertake the task correctly and safely. Carrying out a photogrammetric survey requires knowledge and training in certain core skills such as digital photography, camera alignment and model processing, amongst others (Historic England, 2017 pp. 1). However, it may also be the case that an upcoming project requires a specific kind of additional training identified as part of the project-specific methodology and risk assessment; such as ECITB approved training for working at height (HSE, 2014 pp. 2) or the Civil Aviation Authority (CAA) approved theory test for drone pilot registration (CAA, 2019), for example. Further training could also include knowing when, where and who to ask permissions from to fly a drone, as well as obtaining the appropriate insurance and licenses. Training on how to maintain and monitor safety equipment will also be a legal requirement (HSE, 2002 pp. 1).

It is recommended that training be continually monitored and under regular review in line with new requirements identified during each project's specific methodology created as part of the planning phase. Training reviews, plans and logs can be kept for each team member to ensure that staff skills are up to date with the latest legal requirements as well as identifying where upskilling may be needed to produce correct survey results. The project manager, or an identified team member, should have the specific responsibility of overseeing this training review process so it is held accountable and not forgotten. These documents should link back to the project-specific methodological and safety requirements of any given survey. This focus on the specific project's requirements will identify if training is necessary, feasible and cost-

effective within the timescale or if qualified external contractors (for example, archaeological surveyors) would be a better option.

Formal training will likely be necessary for any legal health and safety requirements, such as First Aid trained staff. An external archaeological specialist could also be commissioned to provide formalised training sessions regarding methodologies and best practice to produce high quality research outputs. However, Tucci *et al.* (2018) finds that whilst formal and e-learning style photogrammetry training sessions in a cultural heritage context are valuable, informal training consisting of learning by practice is even more effective in this setting. This could take the form of learning on-the-job with a more experienced colleague and learning via trial and error; a very useful and important teaching mechanism in many situations. However, distinction between when and where this may or may not be appropriate should be made as part of the training planning process.

1.3 Communicating Health and Safety Policies, Risk Assessments and Monitoring Documents

The most important legal and ethical consideration when introducing any team to a new process, piece of equipment or workflow should be health and safety. Whilst the basic principle of photogrammetry presents minimal health and safety implications, the environment within which it is performed could present very real risks. Project managers should follow the institution's health and safety policies and create project risk assessments as a matter of course in accordance with the legal requirements of the Health and Safety at Work Act (1974). However, extra steps can be taken during project planning to ensure the benefit of these documents is maximised, they are used as intended and interlink with each other as well as the project-specific method statements.

A clear, methodical approach to effective communication is key when mitigating health and safety risks (HSE, 2023). This starts at the planning stage by setting aside staff time and resources to identify and communicate the relevant risks and mitigations well in advance, ensuring everyone has the chance to be prepared and aware of their responsibilities. This approach also allows method statements and risk assessments to inform each other so they

are not mutually exclusive. It creates time and resources for the acquisition of any necessary health and safety equipment, set-up and training for staff and allows procedures and logs to be created that control and document the safe use of equipment and the safe methodologies to be used on site.

2. DATA CAPTURE

Cost of time and resources is often highest during the data capture stage of the photogrammetric workflow because of the expense associated with specialist survey and safety equipment, personnel, and mobilisation costs. This can result in pressures upon time and resources that provide more opportunities for safety risks and errors during data capture. Implementing approaches and measures to identify and rectify these at an early stage is a responsible way of delivering quality and accuracy in the project's final product.

The following sub-sections detail some of the recommended approaches and measures designed to minimise both health and safety risks to the team and inaccuracies in the data capture process.

2.1 Documentation during Survey

One of the most effective ways of ensuring that the data capture process was carried out correctly, whilst also informing future stages of the photogrammetry workflow, is through recording and documentation during survey. Keeping and evaluating records of camera and dGPS settings and calibration data from survey, for example, can help keep equipment up to date and functional whilst also identifying possible sources of error or changes to methodology that may have an impact further along the photogrammetry workflow. This will allow the team to adapt to these as soon as possible so they do not become a problem or cause inaccuracies in the end product. Without such documentation, there is a serious risk of a sub-standard or incorrect output that fails to meet the requirements of the project's brief, resulting in further fieldwork that will cost more in the long-run. Therefore, it is important that money, time and resources to carry out essential equipment maintenance,

documentation and recording during the data capture phase are built into the project budget and methodology in advance.

The approach taken in Part 2 and Appendix 3 of Sou (2016) is an excellent example of why it is important to document changes to the final methodology used and proves the importance of recording the exact methods employed on the day of survey when, in this case, excessive sunlight was particularly bad. Changes to the methodology used on the day of survey are recorded, including to aperture, lens and focal settings, ambient and artificial light points, balance, colour calibration, photographic alignment, angle and overlap as well as artificial shade. These adjustments all affect the end product of the survey and must be taken into account during later stages in the photogrammetry workflow, such as during data processing. As a result of documenting and recording the methodology used on the day of survey, the data processing settings, available in Appendix 3 of Sou (2016), for the 3D modelling software package Agisoft Photoscan could be adapted to the conditions recorded during data capture to ensure the end product was still an accurate output.

2.2 Support during Survey

For a team that is relatively new to the photogrammetric recording process, it will likely be particularly useful for them to have a communication and support system in place where they can easily raise any issues or concerns and get help quickly, as well as feedback more generally what is working well and what could be improved. This will be especially important during the data capture stage where there may be limited time or resources available to gather the necessary data correctly on site. Having the ability to get in contact quickly and easily with the project manager, other experienced colleagues or external professionals that can advise on the best course of action if an issue develops will be a very useful support mechanism. If feasible, it may even be sensible to arrange for the project manager, an experienced colleague or external specialist to plan visits to site during the team's first few surveys to make intentional room for discussion about what is working well, what could be improved as well as offering advice regarding any specific issues or concerns.

2.3 Safety Procedures during Survey

Whilst all team members have a duty of care for the health and safety of themselves and each other on site, having a designated team member who is responsible for ensuring all the relevant health and safety procedures are followed and documentation is completed will increase the chances of a safer survey. Their responsibilities on site may include; ensuring everyone has read and signed the risk assessment, understands the health and safety policy, method statements and mitigation strategies. They should also ensure the accident and near miss reporting books are filled in whenever necessary. This individual would not necessarily be expected to understand the detailed role-specific health and safety requirements of every specialist team member and piece of equipment on site, but rather simply to be a monitor that is responsible for implementing the overarching general health and safety requirements on site whilst also reminding and highlighting to those in more specialist roles that they are required to fulfil their own health and safety obligations.

3. DATA PROCESSING

Whilst 3D photogrammetric processing of the data captured during survey has minimal safety implications, there are plenty of opportunities for incorrect final outputs to be produced during data processing. These can be caused by error introduced either before or after processing begins as well as and misunderstandings regarding the final output required by the project.

The following sub-sections detail some of the recommended approaches and measures for a team new to photogrammetry that are designed to minimise errors in the dataset input for processing and to ensure the final processed outputs correctly match the requirements for the project's end products.

3.1 Introducing Data Hygiene

For any team, especially one that is new to the photogrammetric recording process, there will always be a chance that errors during data capture will have been made no matter how much

pre-planning was done in advance. Historic England (2017, pp. 13) suggests that the most common errors encountered during the data processing stage are caused by mistakes during photo alignment or when measuring control points, both of which can be rectified or at least improved upon before processing is completed. Other mistakes may include images of poor quality, incorrect file names, model numbers or associating photos with the wrong model. Therefore, a pre-processing data hygiene stage is an important step towards removing as much error as possible before the processing stage begins, producing the most accurate final output.

Many of these issues can be easily rectified, such as through simply identifying and inputting the correct control points. Others may be a little more labour intensive, such as manually orientating images to improve their alignment. However, perhaps the most important consideration during the data hygiene process is good communication; making changes only in consultation with members of the data capture team, alongside reference to their documentation and records maintained on site as part of measure 2.1 above. This will be especially important for an inexperienced team new to this process to ensure adjustments are not made that could result in further errors, making the final output even less accurate. Documenting and recording any adjustments made during the data hygiene stage will be an important mechanism to ensure the eventual output is correct. Such adjustments could then be reviewed, if necessary, by different team members or individuals with more experience as a form of monitoring and quality assurance of an accurate and correct final output.

3.2 Understanding the End Product

Having ensured the input data is clean and accurate, team members involved with processing the data through photogrammetric software will need to have a good understanding of the output requirements for the project's final products. Without this knowledge, the data processing stage could lead to outputs that are not correctly in line with the expectations of the project. For example, using the data captured during an aerial drone survey to produce a Digital Surface Model (DSM), when the project's output requirement was a Digital Terrain Model (DTM), will result in an incorrect final product being issued. The knock-on effect of

small errors in larger projects with multiple outputs and key workflow dependencies could result in significant delays and inaccuracies.

Continued reference by the project team to documentation such as written schemes of investigation, project designs and briefs throughout the processing stage will be key in ensuring the correct final outputs are produced. However, as an added precaution to prevent scenarios such as the above, building in stages of review during processing where the outputs being produced are checked regularly for their compliance with the final project output could be invaluable, especially for larger projects and those with a new or inexperienced team.

This review-stage would represent a responsible form of monitoring and a quality assurance mechanism, either implemented by appointed members of the team or perhaps a dedicated quality assurance officer in a MoRPHE-style project (Historic England, 2015). Such an approach could be useful for a team new to photogrammetric recording, who may benefit initially from more regular review whilst they build up experience.

4. PRESENTATION AND ARCHIVING

Presenting and archiving the outputs from an archaeological photogrammetric survey will require careful pre-planning, specialist contributions, training and advice to ensure the correct and industry approved approach is taken by a team carrying out these tasks, especially one new to the process. Understanding the specialist requirements of data presentation and the latest standards and guidance for the compilation of photogrammetric project archives are necessary and ethically responsible measures in a rapidly advancing field of research.

The following sub-sections detail some of the recommended approaches and measures for a team new to photogrammetry that are designed to minimise potential errors or inadequacies in the final presentation and archiving of the project's end products.

4.1 Understanding Specialist Requirements

Having produced a 3D photogrammetric model and its associated outputs in the data processing stage, they may require further processing in preparation for final presentation and publication of the data. This could involve utilising GIS software or complex technical computer aided design and visual graphic design packages to develop the raw output into a final high-quality presentable and publishable piece of research. In order to achieve this correctly, it will be important for the project manager to ensure their team has access to these specialist skillsets. Understanding the strengths and limitations of a team's skillset is an important role for a project manager, especially when considering a team new to the photogrammetric recording process.

More complex digital illustration may require the skills and experience of a specialist archaeological illustrator. Therefore, if required, the project manager should engage such a specialist at the planning stage to ensure the correct final product is produced in line with the project brief. During all stages of the workflow, the project manager will need to ensure that the team work closely together with the specialist to ensure the correct data is being captured in the correct way for the purposes of the final presentable product. Some of the mechanisms and measures in section 3.2 above will be useful in achieving this, as will defined roles, responsibilities, task timeframes, scope, the methods and regularity of communication.

4.2 Creating Metadata for Archiving

Throughout the entire photogrammetry workflow process, metadata recording is key (Historic England, 2017, pp. 14). The process of creating a photogrammetric output is likely to go through many different adjustments and iterations before it is finalised, highlighting the importance of documentation, recording and, consequently, metadata to describe these changes throughout the workflow. The Archaeology Data Service has produced guides on archiving photogrammetric datasets and metadata that should be considered key documents for a project team looking to produce an accurate, usable and interoperable project archive (ADS, 2023a, 2023b).

For the archiving process to be conducted correctly by the project team, it must be a key consideration during project planning and should form part of the team's roles and responsibilities before, during and after survey. As a mechanism to ensure this occurs, the project manager may need to organise metadata and digital archiving training and acquire advice for the team in advance if necessary. Continuing to consult the relevant ADS and other industry standards and guidance documents for digital archiving, such as ClfA (2014b, 2019), throughout the different workflow stages will also be of invaluable help to the team.

CONCLUSION

Photogrammetry as an archaeological recording technique is a multi-staged process with an associated workflow, each essential to the overall success of the project. Therefore, the process of effectively introducing this method of research to a new team so that it is carried out safely and correctly must be tailored to the requirements of each workflow stage. With the rapidly increasing rate of technological and methodological developments in this field, it is part of the project manager's role and ethical responsibility to implement approaches and measures that ensure a team new to this process works together, combining their individual skillsets from each stage to safely and correctly produce an accurate final output.

Approaches and measures for safe and correct survey were identified for each of the four main workflow stages. The first planning and preparation stage is arguably one of the most important and gives the team opportunities in advance to prepare for safe and correct survey. A project manager can work with the team to construct project-specific method statements, plans, undertake training and produce relevant health and safety policies or documentation. The second data capture stage is often where the highest risk of incorrect or unsafe survey can occur and so a project manager can implement a system of on-site recording, documentation, defined safety roles and support measures for the team during survey to mitigate these risks. The data processing stage may have minimal health and safety implications, but can result in inaccurate outputs without steps such as initial data hygiene and an accurate understanding of the required final product before processing begins. Finally, understanding necessary specialist input and requirements for final product presentation and

maintaining relevant metadata throughout the survey for archiving purposes will be necessary to ensure the final output is presented and archived correctly.

Within the scope of this report, the approaches and measures a project manager can take to ensure a photogrammetric survey is carried out safely and correctly are by no means exhaustive. However, it is ethically responsible that such measures are implemented; especially for a new and inexperienced team tackling the vast and expansive applications of photogrammetry along with rapid development of new technologies and methodologies. This report has also highlighted the importance of focusing upon each workflow stage of the photogrammetric process, implementing tailored approaches and measures that will ultimately contribute towards the entire project being completed both safely and correctly.

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