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Nikolai Paukkonen

TEN YEARS OF PHOTOGRAMMETRY AND LIDAR: DIGITAL 3D DOCUMENTATION IN FINNISH ARCHAEOLOGY BETWEEN 2013–2022

Abstract

The realities of archaeological fieldwork have been revolutionized by new digital documentation methods. Among these are various new ways to produce photorealistic and/or accurate 3D measurements, namely photogrammetry and laser scanning. They have become well known technologies but the actual frequency of their use in day-to-day fieldwork has not been studied before. The 'Quality instructions on archaeological fieldwork' (*Arkeologisten kenttätöiden laatuohjeet*) document, published by the Finnish Heritage Agency in 2013, states that all archaeological reports have to mention the technologies and methods used. Using a collection of some 3600 digitized reports from between 2013 and 2022 I show how widespread the use of these novel methods has actually been during the decade in Finland, and what are the implications of their use. What kind of actors are the most prevalent users? Have the methods been widely adopted, or are some more traditional methods still more popular?

Keywords: fieldwork methods, digital archaeology, LiDAR, laser scanning, photogrammetry, digital humanities, Finnish archaeology

Nikolai Paukkonen, P.O. Box 4 (Yliopistonkatu 4), 00014 University of Helsinki. nikolai.paukkonen@helsinki.fi
ORCID 0000-0002-4072-9379

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INTRODUCTION

During the 2010s 2020s, digital 3D documentation and measurement methods, especially Structure from Motion (SfM) photogrammetry and LiDAR (Light Detection and Ranging, colloquially also known as laser scanning), have become generally accepted tools in archaeological fieldwork in Finnish projects. At least that is how it might seem, when reading publications written by enthusiastic users and developers about computer applications, digital tools, and novel devices. It is significantly more difficult to reach the actual situation on the field: have LiDAR and photogrammetry actually become the mainstay of archaeological measurements, or are their users still a minority? Another question pertains to the details of their use: what equipment and software are the most popular, and why?

These questions are difficult to grasp, especially in a country where the majority of archaeological fieldwork is performed by private companies. With new innovations and expensive investments in equipment, training and software, it is reasonable to expect that many private actors do not wish to open the details of their workflows or setups. However, the final fieldwork reports are required to be submitted to the Finnish Heritage Agency (FHA) – and are required by law to be public documents – which means that they offer an opportunity to study the proliferation of new technologies and methods.

In this paper I present an overview of the development and increase of the use of SfM photogrammetry and LiDAR documentation in Finnish archaeology, with a focus on the years after 2013. This year was chosen as a starting point, since in 2013 the 'Quality instructions on archaeological fieldwork' (Arkeologisten kenttätöiden laatuohjeet) document was published (Finnish Heritage Agency 2020a). It states that all archaeological reports must mention the technologies and methods that have been used in the field work and reporting stages, therefore giving a reason to expect that this information would be available in the reports from that year onwards. The instructions have been updated a few times since 2013 – the newest version being from 2020 – but as far as I was able to find out, the need for explicating the used documentation and measuring methodology has been included since its first version. In the oldest document available through The Wayback Machine, it is stated that in the excavation report at least the following data must be included (Finnish Heritage Agency 2016: 37):

- Description of the work process
- Used methods and principles of documentation
- Used devices and software (brand, model)
- Used coordinate and vertical coordinate reference systems
- Ground control points

The instructions are not legally binding and instead work just as guiding principles. Consequently, strict adherence to these directives has not been consistently observed.

The main source material for this study is formed by data gathered from publicized fieldwork reports of archaeological actors working in Finland. Additionally, I present a summary of earlier publications and other work in Finland related to this theme. Ultimately, the result will be a realistic assessment of the level of archaeological measurement technology in Finnish fieldwork.

The fieldwork reports submitted to FHA from 2017 to 2023 were available at the FHA *Asiat* ('Documents' or 'Cases'; literally 'Things') portal (https://asiat.museovirasto.fi), whereas the earlier ones were accessed through the *Kyppi* cultural heritage service portal (https://www.kyppi.fi/palveluikkuna/). Since neither of the browser-based portals offer a possibility for mass downloading reports per annum, I used a custom web crawler script to collect the data. The analysis of these reports – which are some 3600 in total – could be partially automated, but a lot of it had to be done manually. This meant opening each report individually, skimming the contents for possible sections about methodology, and inspecting the figures and appendices for possible SfM or LiDAR generated images. However, images of point clouds, 3D meshes or other similar data without any indications of what technology had been used were not considered hits. Additionally, some individual reports were not machine-readable and had to be studied more carefully, usually by trying to find any paragraphs describing methodology and technology.

Pioneering work in photogrammetry and LiDAR use has been done in Finnish archaeology already during the 1990s, but many of these reports and papers have been published only in Finnish (or seldom in Swedish), making international comparative study difficult. Thus, this paper will also act as a way for non-Finnish speaking scholarly audience to acquire an overview of the history of archaeological 3D documentation methodology in Finland during the 21st century.

In this paper, 'photogrammetry' or '3D photogrammetry' are used to refer to the modern software-based technology that uses 2D digital photographs to generate textured mesh models or point clouds in 3D coordinate system. All kinds of LiDAR are often called 'laser scanning'. This includes aerial laser scanning (ALS) and terrestrial laser scanning (TLS), often done with tripod-mounted systems. Recently, lightweight mobile LiDAR systems have complicated the division between ALS and TLS, since similar sensors can be deployed on small drones, cars, backpacks or even mobile phones. Here 'LiDAR' is used to denote traditional TLS devices, but also other smaller laser scanning devices used in excavation context, whereas ALS is used only in the context of large-scale airplane mounted devices.

Earlier studies

Both LiDAR and photogrammetry were experimented in Finnish archaeology already in the late 1990s and early 2000s. First adopters were working in cooperation with non-archaeologist professionals, such as researchers from Helsinki University of Technology during the Finnish Jabal Hārūn project in Jordan, where rudimentary photogrammetric images were used in coordination with total station measurements in making a 3D model of the site (Frösén et al. 2001: 359–360; Koistinen 2000). However, actual day-to-day documenting of the excavation process was not made using these methods, and for accurate 3D data only total stations were relied upon (Haggrén et al. 2005: 4). Similarly, in another Finnish international project in Pompeii, photogrammetric measurements were used to support other methods to record the architectural features (e.g., Heiska 2008b).

Laser scanning had its early adopters in the 2000s as well. Due to its significant costs, the technology was not widely adopted, however. In 2007 a Callidus CPW8000 terrestrial laser scanner was tested at the medieval site of Aboa Vetus in Turku, with promising results (Uotila 2007: 15–17; Heiska 2009: 91–92). Later, a Faro Focus 3D was used in the same location (Uotila & Korhonen 2011: 12). A Mensi GS200 scanner was used in the Finnish Pompeii project for documenting the house of Marcus Lucretius (Heiska 2009: 89). Typically, these cases were isolated and did not lead to continuous workflows or habitual adoption of the method.

Generally, only some earlier work has been published as peer-reviewed articles or otherwise in relevant publications. Starting from the early adopters in the early 2000s, some single case studies from Finnish or international teams with a Finnish component have been made available (e.g., Heiska 2008b; Junnilainen et al. 2008). Single case studies have showed the possibilities of the methods (e.g., Haggrén 2007; Heiska 2008a: 41; Seitsonen & Holappa 2011; Debenjak 2015; Lehto & Uotila 2017; Seitsonen 2018), but no publication has considered how widespread the use of these methods has actually been during the years.

To my knowledge, systematic overviews and quantitative studies of documentation technologies and techniques in Finnish archaeology have not been done earlier. Usability and quality of these methods in single sites has been studied only recently as well (e.g., Paukkonen 2023; Hakonen et al. 2015). The only exception to this void is the subfield of Finnish maritime archaeology, where an overview of its history has been published including some notes on the used documentation and measurement methodologies – however, no actual statistics are included there, either (Marila & Ilves 2021).

Internationally, widespread studies attempting to extract numerical data about the prevalence of technology adoption in archaeology has been understandably difficult as well. Firstly, the field reports are typically difficult to access *en masse*, either on national or international level. Secondly, even if they are available, there is typically no sufficiently accurate metadata or standardised formats to find out the details of the technologies used for fieldwork. General discussion about the possibilities and the pros and cons of photogrammetry and laser scanning have been ubiquitous (e.g., Magnani et al. 2020; Roosevelt et al. 2015; Dallas 2015), but there is very little data about the actual spread of their usage.

A survey of peer-reviewed publications about archaeological photogrammetry was published in 2021 (Marin-Buzón et al. 2021), but scientific publications might not give a realistic picture of the realities of the majority of conducted fieldwork. An attempt to make a comparable survey of Finnish peer-reviewed articles, theses, and other scholarly works was performed using Google Scholar for the purposes of this article, but the results were inconclusive, with many years yielding no results at all. Regardless, archaeological fieldwork in Finland includes a lot of supervision work and smaller projects, for which the fieldwork report submitted to the local authorities is often the only extant document. It could be that, despite all the proof-of-concept papers and case studies, there is still room for advocacy of integrating these technologies in research and fieldwork in general (Magnani et al. 2020).

Studies examining the problems of using public Finnish archaeological databases have been published before. Roiha and Holopainen, while researching a different kind of problem, wrote about the issues related to the reusability and failure to produce the FAIR principles in the FHA Antiquities record. The record is accessible through the *Kyppi* portal, and often contains also links to the field reports (Roiha & Holopainen 2023). Beginning in 2023, the national '*Arkeologia 2.0*' project is aiming to renew the Finnish archaeological knowledge, research infrastructure and development, but its ultimate effects are still impossible to evaluate at its current planning stage (Finnish Heritage Agency 2023).

Research about field reports and various forms of data available in them has been studied in the Nordic countries, but not by quantifying documentation and measurement methodology. Knowledge-creating processes in archaeological field reports on a larger and more qualitative scale have been studied in Sweden, but on significantly smaller datasets (Huvila et al. 2021: 1114; cf. Huvila et al. 2022: 3–4). There are, however, some notions about tools and methods used, but with discouraging results – quite often the reports just mention 'usual documentation' having been used for the project in question (Huvila et al. 2021: 1116–1117, 1121).

In the category of knowledge and information creation studies, this research also belongs to the topic of archaeological 'paradata', data about the process of gathering archaeological knowledge. In that theoretical framework, one terminological classification for the work done in this article would be the study of KMP, 'knowledge-making paradata' (Börjesson et al. 2022: 2).

METHODS AND MATERIAL

Extraction of the data

Neither of the FHA services, Kyppi or Asiat, provide any options for mass downloading of documents; they need to be downloaded individually in PDF format. Additionally, the metadata provided is lacking, so discerning different categories of documents is challenging, as the *Asiat* portal contains also other files, such as excavation permits. With the later reports uploaded to the *Asiat* portal, some complications were caused by the fact that the reports were categorized based on the year they were added to the database, instead of the year of their submission or completion. Using two custom Python scripts the downloading from both portals could be automated, so that all the PDF files containing the keyword '*Tutkimusraportti*' (i.e., 'Research report', including both excavation and survey reports) could be extracted. In the *Asiat* portal the information regarding the search results could be found as a JSON file on the server, from which the user can get a formatted list of the document identification numbers and use them to download the actual PDF files *en masse*. For the *Kyppi* portal the HTML file had to be parsed directly to extract the links to the PDF files.

It is worth noting that in Kyppi the reports are stored under two distinct registers: *Kulttuuriympäristön tutkimusraportit* and *Arkeologiset hankkeet* (i.e., Cultural Envinronment Research Reports and Archaeological Projects). They have a significant overlap, but some reports may be visible only in one or the other. The initial query was performed on the *Kulttuuriympäristön tutkimusraportit* register, the results from which were then compared with the results from the *Arkeologiset hankkeet* register. This should ensure that the set of reports studied here is as complete as possible, but some individual documents may be missing. Additionally, a small number of reports have been use-restricted (for instance, due to some personal information contained in the files) and are not available online. These have not been included.

The downloading was performed during the weekend nights to minimize the effect on other users due to the possible strain on the servers. Regardless, all the downloaded files were manually opened and checked to ensure that they indeed were reports from actual field work projects. Field work permits and reports of analyses (such as osteological or radiocarbon dating reports) were removed from the material at this stage.

Figuring out the final coverage of this extraction process was done by comparing the results with the annual FHA financial reports, which contain some vague data regarding the number of submitted reports, often contained within the sections detailing yearly performance. The FHA does not keep accurate statistics about the number of reports themselves, and the data I was provided by email was clearly missing even hundreds of projects for some years (Pers. com. FHA archives record keeper E. Kykkänen, e-mail to the author 23 November 2023).

The numbers deduced from the financial reports vary greatly, from 200 to 344 annual reports in the years 2018–2020, whereas the number of reports from the years 2013–2017 vary between 822 to 13061. This, however, is most likely caused either by alternating ways of choosing which reports were included in the count, or the retroactive digitization of older reports (Finnish Heritage Agency 2020b: 38; 2017: 29; 2015:27). The yearly average of the reports extracted by me was 317 reports. It is not clear what reports are included in the financial data, and whether it includes reports that were processed after the year was completed. Thus, at least based on the scale of this comparison and assuming the financial data from years 2018–2020 represents the actual reports submitted during the year, it seems that the coverage of the data gathered for this research is rather good.

Processing and analysis

The reports were categorized into two groups according to their type: Group 1, contains various kinds of invasive fieldwork or other work that typically requires extensive and/or accurate documentation, such as excavations, supervisions, test trenches and architectural documentation. Group 2 contains field surveys and other surveys, which are mostly non-invasive and use only limited measurement equipment, such as GPS antennae. The focus of this study is on Group 1 due to the suitability of these methods for that kind of fieldwork. Site inspections or evaluations, which were generally not a uniform group, were left outside both Group 1 and Group 2, although some individual ones do mention using some of the methods under study here. The reports were grouped by the year during which the fieldwork was performed, which allows for year-by-year comparison. In case of multi-year projects, the last year of the project was chosen to represent the whole project.

Initially, the analysis of the reports was planned to be fully automated, but due to unpredicted variation in the quality of the reports they had to be inspected manually as well, at least on a superficial level. Many reports did not include a separate section for the methods, equipment and software used. The usage of terminology was also often inaccurate. Especially in the earlier reports the methods and technologies were not clearly named, but instead would just be presented as ‘3D-modelling’, ‘3D photographing’ or ‘scanning’. Similarly, the sporadic use of laser rangefinders or telemeters was noted during the inspection of the results of automated querying (e.g., Tiainen & Koskinen 2018: 5).

Additional complications were related to the nature of simple word-based querying. For instance, searching for the word ‘LiDAR’ would also show hits for reports that mention that there was no aerial LiDAR (ALS) data available for the area, or that some earlier report had used some LiDAR technology, but that it was not used in the current project, and so forth. This led to the need to also do a superficial manual investigation of the reports. A quick visual examination would show if the file contained images of point clouds, 3D-meshes or orthophotos generated by photogrammetry pipelines or LiDAR equipment. The hits given by the automated queries were always checked and investigated further, especially to find out the software and hardware that had been used. Despite the quality instructions of FHA, the actual standards for accepted excavation and survey reports are often rather ambiguous. Only some actors include systematically a ‘methods and technologies used’ section in their reports. Thus, sometimes the information regarding the technologies had to be gathered from appendices or captions. Often it was not available at all.

As a secondary processing stage, usage of total stations and ALS data were also recorded, although they were not the focus of this study. These have been included because the prevalence of these technologies has not been studied before either. They also allow for a comparison on how other relatively new technologies that require investments in hardware and material have been adopted in Finnish archaeology. As will be explained below, ALS data for the whole country has been made available free of charge by the National Land Survey of Finland, which has made its usage convenient.

Due to the limited size of the dataset – N=3652, Group 1=1279, Group 2=1430, excluding site inspections – an Excel spreadsheet was deemed sufficient for gathering the results. This spreadsheet has also been made available in an independent online repository for reviewers and other researchers.

RESULTS

The results of Group 1 are shown in Table 1. As mentioned above, Group 1 includes excavations, test trenches, supervision work and documentations. These projects have clear use cases for SfM photogrammetry, laser scanning and total stations. Conversely, survey and inspection reports (Group 2) do not include almost any mentions of the aforementioned methods, but instead do feature ALS use.

The overall results have been visualised in Figure 1. The number of ALS mentions in Group 1 reports is mostly due to the use of publicly

Table 1. Results from Group 1, containing excavations, supervisions, test trenches and documentation projects.

Year	Total	Photogrammetry	%	LiDAR	%	Total station	%	Aerial LiDAR	%
2013	131	2	1.53	4	3.05	37	28.24	8	6.11
2014	108	7	6.48	4	3.70	40	37.04	7	6.48
2015	140	10	7.14	7	5.00	36	25.71	18	12.86
2016	135	11	8.15	3	2.22	36	26.67	15	11.11
2017	112	4	3.57	2	1.79	23	20.54	13	11.61
2018	157	11	7.01	9	5.73	41	26.11	12	7.64
2019	114	12	10.53	6	5.26	34	29.82	9	7.89
2020	141	11	7.80	19	13.48	30	21.28	6	4.26
2021	153	28	18.30	19	12.42	52	33.99	5	3.27
2022	88	14	15.91	21	23.86	15	17.05	3	3.41

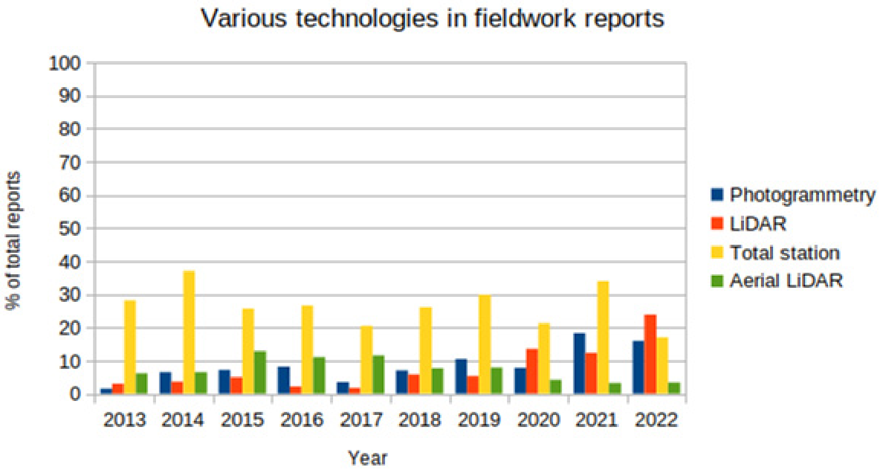

Figure 1. Different technologies used in fieldwork reports as percentage from the total.

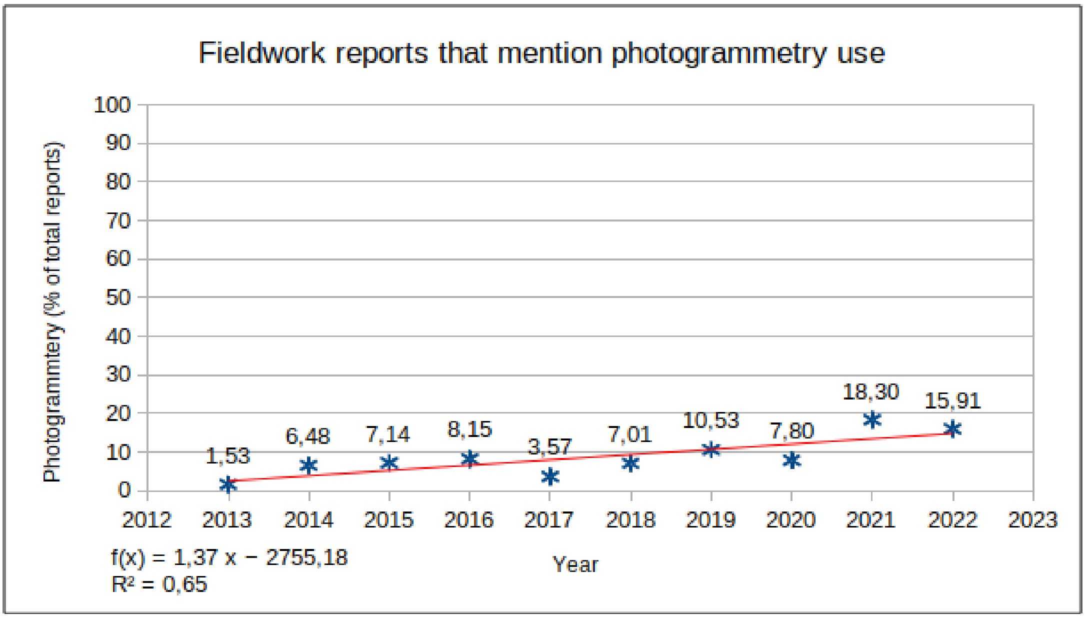

Figure 2. Yearly percentage of Group 1 reports mentioning photogrammetry use and its linear regression depicted as a red trend line.

available data as a background for plotting maps about other measurements done during the field-work – the ALS data was never generated by the projects themselves.

Photogrammetry

Many applications of photogrammetry in archaeological fieldwork had already been experimented with and published in the early 2000s, as was shown earlier. Some pioneering work had been done even earlier than that. However, photogrammetry-based methods were not in wide use in 2013, based on the published fieldwork reports. All in all, only two reports singled out any kind of photogrammetry as a documentation method during that year. This means only c. 1.50% of the total of Group 1, or c. 0.45% of the whole total in 2013.

When observing the yearly variation, there seems to be a general increase in the relative number of reporting about photogrammetry. The mean of the yearly data is 8.6% and the median 7.5%, and just by observing these results one can see that all results since 2018 have been equal or above the median. This increase seems to fit with the data gathered by Marin-Buzón from the years 2010–2019, which was based on scientific publications about photogrammetry in archaeology, where a systematic hike in prevalence is also visible (Marin-Buzón et al. 2021, Fig. 5).

After plotting the data, a trend line was calculated using linear regression (Fig. 2). It further confirms that there has been a systematic increase in the relative reported use of this technology in archaeological fieldwork projects during the period.

Regardless of the statistical analyses, an increase is visible. Since 2018, the number has been always equal to or over the median, with 2021 seeing a clear surge. Due to the nature of the reports, significant increases can be caused by single actors choosing to publish large area projects as separate reports: in 2021, Maanala Oy and Heilu Oy reported altogether 13 separate excavations in Hartola area in eastern Häme, with each report mentioning the use of photogrammetry. Similarly, in 2019 FHA Field Services reported four separate excavations in Savukoski area (in eastern Lapland), all of which report photogrammetry as a measurement method.

In addition to the equipment used to take the photographs, which was very seldom explicated, another important detail was the software used. This, however, was also not typically specified in the report. When the software was specified, Agisoft Metashape (and its earlier iteration Photoscan) was without a doubt the most common choice all the way from 2013 to 2022. Interestingly, the Russo-Ukrainian war, which begun in 2014 and then escalated in early 2022, has not seemingly had any visible effect on the use of the Russian Agisoft Metashape, which retained its dominating position through all the years. This is probably due to its easy graphical user interface and actors getting accustomed to it. No report specified the type of license used, which is not surprising, considering the generally frugal level of detail in the reports. It might also be possible that Agisoft's free 30-day trial periods have persuaded many coincidental users to give photogrammetry a try.

Other choices reported were RealityCapture and DroneDeploy, which were each used only by single actors, and both coming into use only after 2019. PhotoModeler was reported of having been used once in 2014 (Haggrén et al. 2014: 22). For some reason, possibly related to the popularity of Agisoft, no free and open-source software (FOSS) has been reported at all, even though open-source projects such as VisualSFM or Alicevision Meshroom have been easily accessible for almost a decade now and are well documented.

The photographic equipment used was only seldom described. Some reports mention the use of digital single-lens reflex (DSLR) cameras for other photography, and it can be assumed that the same tools were used for the photogrammetric documentation. Unmanned aerial vehicle (UAV) or drone-based photographs have been used only in few cases and by few actors, such as Ark-byroo Oy (e.g., Ynnilä 2019: 15), Muuritutkimus Oy (e.g., Uotila et al. 2020: 5) and the FHA Field Services (e.g., Seppä & Laulumaa 2020: 28–29).

TLS and other laser scanners

The situation in 2013 was quite similar for laser scanning as it was for photogrammetry (Fig. 3). Only four instances of their use were reported, 3.05% of the total (Table 1). Three of them were by Muuritutkimus Oy and one by University of Oulu. The used scanner is specified only in one of Muuritutkimus Oy's projects, where it was Riegl VZ-1000, but it can be assumed that rest of the projects

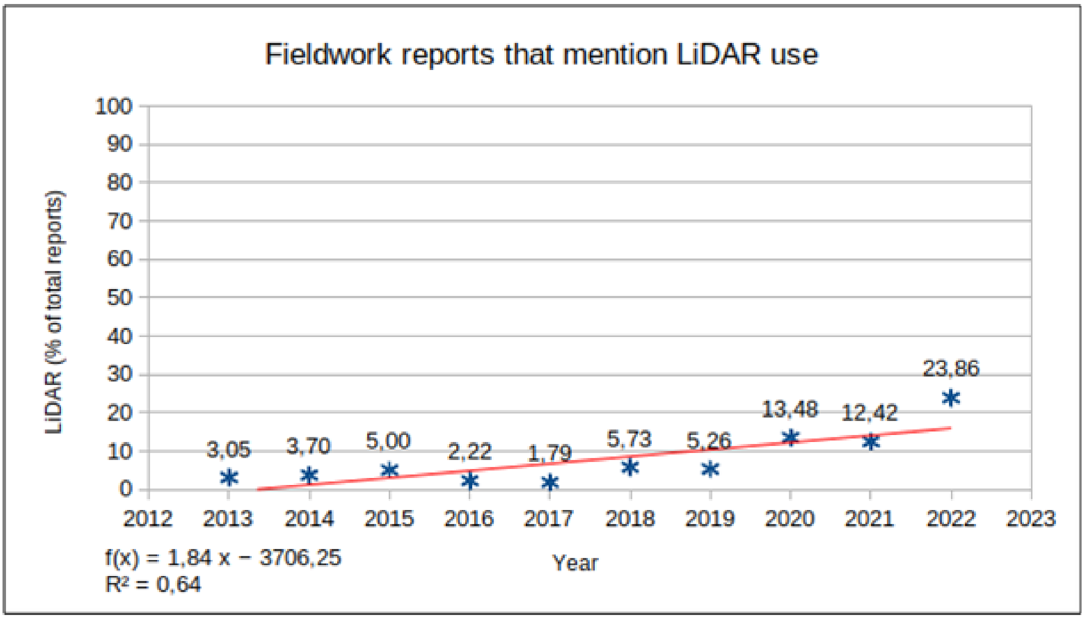

Figure 3. Yearly percentage of Group 1 reports mentioning LiDAR use (not including ALS) and its linear regression depicted with a red trend line.

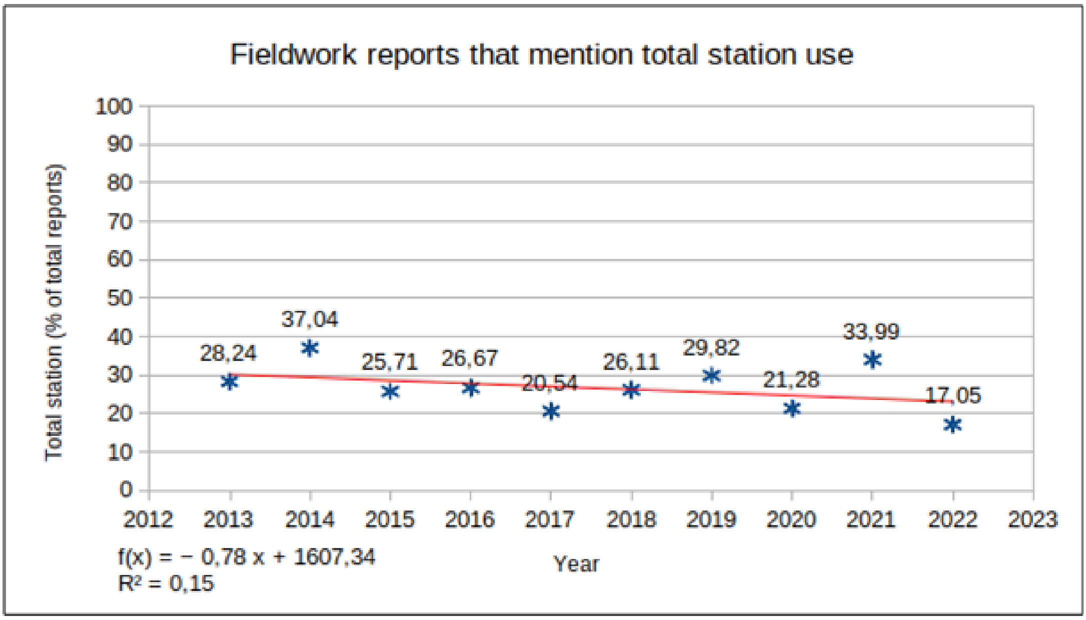

Figure 4. Yearly percentage of Group 1 reports mentioning total station use and its linear regression depicted with a red trend line.

used the same device, since it also appears in reports from later years.

However, whereas photogrammetry saw a steady rise in usage during the years studied, laser scanning increased greatly only in the last three years, beginning from 2020. With photogrammetric methods one could see that they were at least experimented with by many different actors. LiDAR use is clearly a different matter: only a few companies or other actors use them at all, and only for one of them – Muuritutkimus Oy – they are in common day-to-day use during the later years of the period studied. This is most likely caused by the price of the investment and the relative difficulty of their use: when an archaeological actor has invested in a TLS device and the relevant training of their employees, they obviously want to get a return from it. In turn, SfM photogrammetry can be experimented with inexpensively or even for free, which is probably the main cause for its relatively widespread experimental use.

The devices most often reported were Riegl VZ-400i and Riegl VZ-1000 TLS devices, operated by Muuritutkimus Oy. The only other repeatedly used TLS scanner was Leica ScanStation 2, operated by the University of Oulu. Trimble S10, a hybrid of a scanner and a total station, was used by FHA Field Services in few cases. Some mobile devices were also visible in the later reports: iPhone 12 Pro (which includes a LiDAR sensor) and a Faro Freestyle 2 handheld scanner were reported a few times, both used in fieldwork projects of Muuritutkimus Oy. Regardless, disappointingly many reports did not include information about the equipment used for scanning. Even fewer actors mentioned what software was used to further process the point cloud data.

None of the actors reported using drone-mounted LiDAR equipment during this period. Laser scanning could also be performed by renting the device elsewhere, or alternatively, by employing specialist outsider companies. This has been done a few times according to the material, but it has not been commonplace (e.g., Laulumaa 2015).

Comparable technologies

Use of total station has varied between one fifth and one third of the total (Fig. 4). No clear increase can be seen in the usage, which is understandable, considering that the technology has not had similar democratizing price and efficiency developments as photogrammetry (with powerful GPU computing becoming available for consumers) and LiDAR (with ever more affordable hardware available). Total stations have been present in Finnish archaeology at least since 1990s (e.g., Pesonen 1996) and are commonly taught in archaeology programs at universities – indeed, total station use is often considered a basic skill for a field archaeologist in Finland. The slight decrease that might be inferred from the data is possibly a result of total stations becoming, while not ubiquitous, still a commonplace technology, meaning that some report writers deem them self-evident and not requiring separate mentioning. Alternatively, the change may be due to the increased availability of GNSS-devices, which may be replacing total stations especially on smaller projects.

As mentioned earlier, querying for the keyword 'laser' gave a plenty of hits for mentions of ALS. It was widely used in various projects, especially in large scale archaeological surveys performed by companies such as Mikroliitti Oy, Keski-Pohjanmaan Arkeologiapalvelu Oy and the archaeological field service department of FHA. This does not come as a surprise, since the National Land Survey of Finland has been providing good quality point clouds of the whole country free of charge starting from 2008 (Koivisto & Laulumaa 2013: 52), which are of immense help when planning a survey.

Reported ALS usage has seen a slight increase during the years 2013–2022 (Fig. 5). Typically, they are mentioned as having been inspected in hillshade visualisation to find new archaeological sites, such as tar pits and military installations. However, as the data has become more easily accessible as various pre-processed visualisations (such as the National Land Survey of Finland MapSite online geoportal), it is very likely that ALS is used even more commonly, but it has just not been reported. Two reports included a mention of using computer vision technologies for automated site recognition, which shows a promise in the technology, but also that it is still far from being commonly adapted into Finnish archaeological fieldwork (Kuusela 2022a; 2022b; also, Anttiroiko et al. 2023).

It is worth noting, that of all the inspected reports between 2013–2022, 64.9% mention none of these technologies. For some, they have perhaps become so self-evident that they have

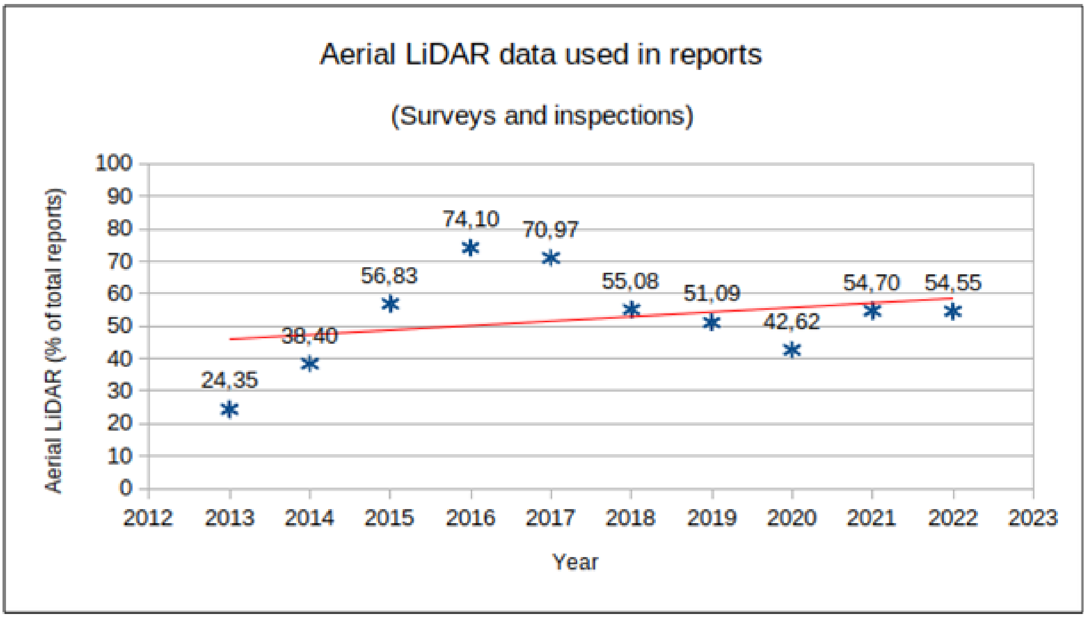

Figure 5. ALS data used in survey and inspection reports and its linear regression depicted as a red trend line.

not been mentioned in concise and quick projects (as per Huvila et al. 2021: 1113; Collis 2013). Others use GNSS RTK antennae or similar devices, especially in supervision projects or quick test trenches. Still, a significant number of projects rely on optical levels or drawing by hand with tape measures or folding rulers. Certainly, they can be accurate and quick enough for some projects, such as supervisions with sparse or no finds. The subjective reasons for depending in older technologies are beyond the scope of this study, but it is likely that the costs of investing into new equipment and training, in addition to accessibility and habit, are decisive motivations.

DISCUSSION AND CONCLUSIONS

The results of querying the fieldwork reports between 2013 and 2022 seem to indicate clearly that SfM photogrammetry and LiDAR scanning have not been widely adopted in Finnish archaeology. Pioneering work with both methods have been done already in the late 90s, but their widespread use is still in a progressing stage. The use of both methods has seen a steady increase, but often it is only due to few actors doing fieldwork. This is especially true when concerning LiDAR use in the field.

The lack of FOSS product use – especially in SfM photogrammetry and point cloud processing – is a surprising observation. One might surmise that archaeological fieldwork actors would be welcoming for software that is free of charge, modifiable and fully open about what actually happens in its processing stages. However, commercial actors might be sceptical about possible risks and liabilities, but the most important reason for this avoidance is probably the unwillingness to spend time tinkering with tools that ‘come without a warrant’. FOSS is often seen as difficult and inaccessible, which is sometimes true, but decreasingly so. Some action advocating general FOSS use in Finnish archaeology might be in place.

It is still unclear what kind of changes the national '*Arkeologia 2.0*' project will bring. The project was launched during the 2023 and is still in its early stages during the writing of this article. Apparently, the aim is to overhaul the databases and the data infrastructure related to Finnish archaeology, with some intention to also include spatial data and perhaps even point clouds and other resulting datasets from photogrammetry and LiDAR (Finnish Heritage Agency 2023).

In the context of FHA and regulations pertaining Finnish archaeology it is also worth pointing out that according to this study, the ‘Quality instructions on archaeological field work’ have not been adhered to very strictly. This may be due to the document’s unclear status – are they just instructions, or should they be seen as regulatory? Regardless, this should be considered when planning further research based on excavation reports. Even though the instructions state that some information should always be included, it may not be there in most of the reports.

The questions asked by Heli Lehto and Kari Uotila in their paper in 2017 are relevant: should archaeological fieldwork aim to surpass the minimum set by the FHA Quality instructions, why use 3D documentation methods when 2D raster maps are sufficient for reporting, and who, ultimately, should oversee developing new fieldwork methods and standards (Lehto & Uotila 2017: 9). The current FHA Quality instructions do not encourage innovation and experimentation with new fieldwork methodologies, yet many actors have begun implementing these measurement tools in recent years. The motivations behind this trend are beyond the scope of this article; however, it is worth considering some of the associated problems. If FHA does not actively support the adoption of these new methods or provide platforms for storing new types of data, the archaeological community may miss out on innovative methodologies and workflows. In particular, private actors may be reluctant to share their research and methods publicly, perceiving them as competitive advantages.

Photogrammetry and LiDAR are not silver bullets that could solve all problems regarding archaeological documentation and measurements. Moreover, they are not suitable for all kinds of sites and projects. They do, however, speed up some processes of excavation tremendously, while also giving accurate and reliable data, at least when performed properly. They show potential for financial savings, while also opening new kinds of research possibilities that could not have been done with more traditional documentation methods. However, the possibility of savings and other economic effects are difficult to assess and require further study.

One aspect that was not examined here was the subjective experiences of the different relevant actors. A well-prepared questionnaire or a set of interviews with relevant personnel, such as active field archaeologists and researchers, could provide deeper insights into the causal background of the prevailing status, i.e., the 'why-questions' telling the reasons behind some software or hardware being chosen over others (similar kind of interviews have been done by e.g., Huvila 2014). Other interesting area of study could be the situation in the Finnish archaeological education: what technologies are being taught to new students and with what equipment and software?

Regardless, the results given in this article form a steady and quantified basis for future discussion about development and adoption of field documentation methods, both in Finland and internationally.

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