Workflows 5

Currently, digital reconstructions are mainly a process in one single context by interdisciplinary workgroups using expert technologies. 3D reconstructions in the humanities are primarily created within long-term interdisciplinary projects. This chapter provides an overview of the team processes and workflows to create 3D reconstructions. Interdisciplinary teamwork creates specific challenges due to the different work processes of the disciplines involved—e.g., humanities, design, and computing. Since 3D reconstructions are projects, both processes and quality need to be managed. This chapter contains a set of empirically grounded recommendations for the organization and management of 3D reconstruction projects.

Guiding questions

- What are generic process models for 3D reconstruction projects?
- What are typical project settings?
- What are the recommendations for those projects?

Basic terms

- Interdisciplinarity
- Project management

As highlighted in the previous chapter, interdisciplinary collaboration is a key feature of many 3D modeling projects in the humanities; this chapter highlights some key features and strategies for cooperation.

S. Münster et al., *Handbook of Digital 3D Reconstruction of Historical Architecture*,
Synthesis Lectures on Engineers, Technology, & Society 28,
https://doi.org/10.1007/978-3-031-43363-4_5

Further reading: Research on Workflows
In contrast to philosophical approaches, little empirical research exists on practices and users of digital 3D modeling in the humanities [1]. As an example, Huvila investigated user roles and practices in archaeology [2, 3] as well as certain practices within the ARKDIS project [4]. Another empirical perspective is the research on usability and requirements for software design for humanities researchers, which were investigated within the VERA project [5, 6].

5.1 The Process of 3D Reconstruction

The process of digital 3D reconstruction encompasses the creation of a virtual modelby means of software tools, which is mostly done by specialized modelers, followed by visualization, through which the model is rendered into a presentation format. This process is usually closely accompanied by historical research through which a sound understanding of the object to be modeled is developed on the basis of sources that provide information from the past [7–9].

Further reading: The 3D Digitization Process
For 3D digitization, process, and workflow schemes [10–13] differ greatly by application scenario parameters, e.g., retrieval technology and heritage object parameters. Workflows involve two key aspects: documentation (data acquisition, e.g., of image or range data, and registration) and 3D modeling (computing into a 3D model, including point cloud generation, structuring and modeling, and texture mapping) [14, 15].

Data Acquisition

Data acquisition quality is influenced by several attributes [16, 17]:

- Resolution: size and granularity of the samples.
- Accuracy of the measure: variation from the original.
- Repeatability.
- Environmental sensitivity including robustness of the acquisition method under different climate conditions (e.g., light, wind, temperature).

Framework conditions are set by acquisition time, portability of the equipment, flexibility (e.g., to retrieve at different conditions), and price [15]. Depending on attributes, framework conditions and purpose different technologies are used for 3D data acquistion (Figs. 5.1 and 5.2).

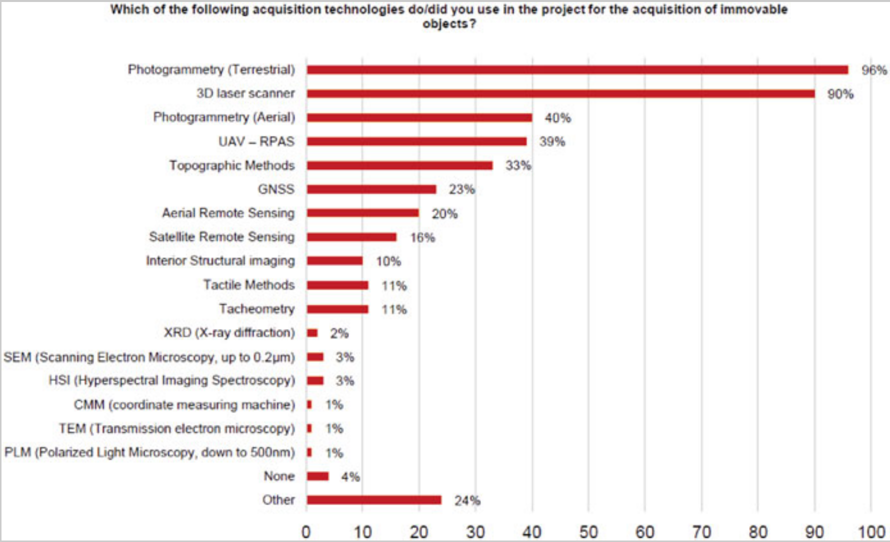


Fig. 5.1 Acquisition technologies used in projects relating to immovable objects [18, p. 30]

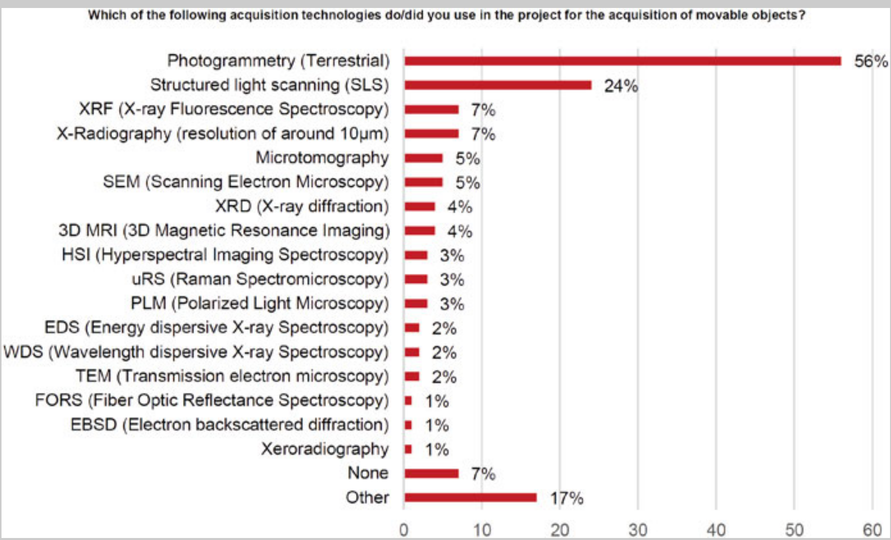


Fig. 5.2 Acquisition technologies used in projects relating to immovable objects [18 p. 31]

Data Processing

Data processing comprises a wide range of mostly algorithmic approaches to creating a 3D model out of the acquired data. The aim of related workflows is to set up a multi-stage data processing pipeline, which varies by data type, quality, expected results, and object(recent examples for museum artifacts [19], monuments [20]). Pipeline design is influenced by objectives including levels of output quality, velocity, reproducibility, flexibility, robustness, and automation [21, 22]. This contradicts with the huge variety of cultural heritage qualities [23, 24]. Recent achievements use data fusion [21] to improving model quality.

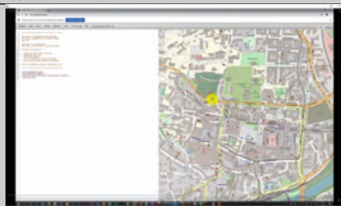
In view of the resulting division of labor, it is essential to consider cooperation, communication, and quality management. The entire working process of virtual 3D reconstruction can roughly be divided into sources, modeling, and visualization (Fig. 3.1), which may be made up of numerous steps and tasks and take on different forms (Fig. 5.3).

Further reading: 3D Reconstruction Step-By-Step Tutorial
This tutorial was recorded in 2020 as a video screencast and describes the 3D reconstruction of a historical townhouse from a cadastral plan and photography for the web. Tools and services used are the Overpass Service,[1] QGIS,[2] and Maxon Cinema 4D (Fig. 5.3).[3]

[1] https://wiki.openstreetmap.org/wiki/Overpass_API/Overpass_QL#out, accessed on 1.2.2023.
[2] https://www.qgis.org, accessed on 1.2.2023.
[3] https://www.maxon.net, accessed on 1.2.2023.

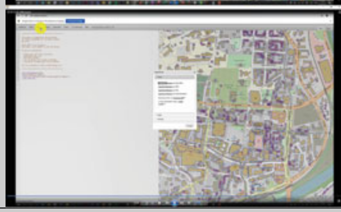
Stage 1: Export of vectorized building footprints from Open Street Map (OSM) via the Overpass Exporter

1



Export vectorized building footprints from OSM via Overpass.

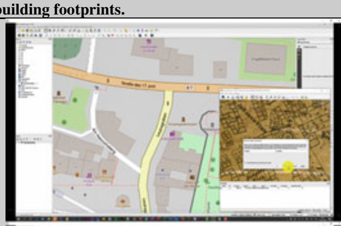
2



Mark a square on the map and the building layer from OSM selected for exporting.

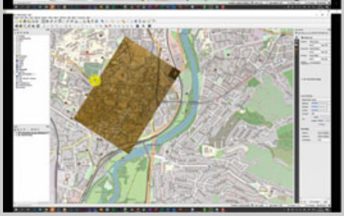
Stage 2: Georeferencing with QGIS: QGIS is an open GIS used to match the historical map and the building footprints.

3



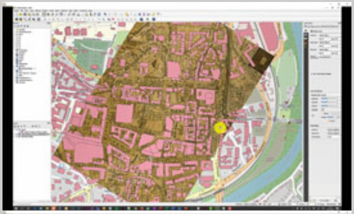
Import the OSM base layer and the historical cadastral plan as raster layers. Select corresponding points via the georeferencing tool.

4

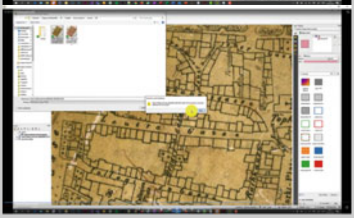


After defining corresponding 6–10 points the transformed map is projected to the OSM base layer.

Fig. 5.3 Example workflow: printout of a video tutorial for the 3D reconstruction of a historical townhouse from a cadastral plan and photography for the web [25]

5 

Import the OSM building paths as vector layer.

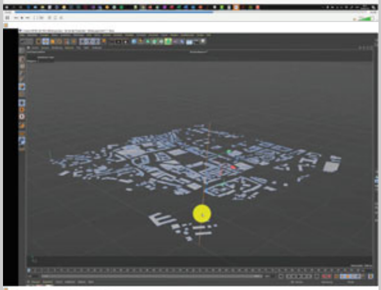
6 

Export the transformed cadaster map as png raster graphic, OSM building ground plot layer as kml markup file.

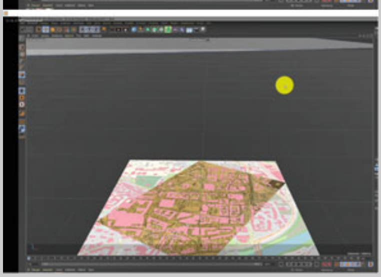
Stage 3: 3D Modelling and texturing in Maxon Cinema 4D

7 

Convert the kml layer to dxf file format via a web conversion service. Cinema 4D cannot import kml files directly.

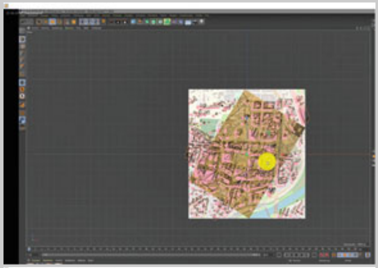
8 

Import the converted layer as dxf in Cinema4D.

9 

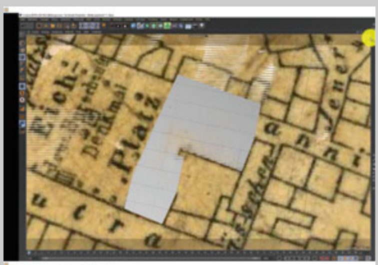
Import of raster graphics

Fig. 5.3 (continued)

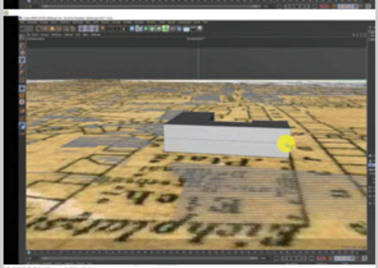
10 
Scale layers to aligning both, vectorized ground plots and the historical raster graphics.

11 

Draw outline of the building footprint as spline path by clicking outer points.

12 

Extrude object via NURBS to create a volumetric geometry.

13 
Convert object into a polygonal geometry and insert a horizontal cut.

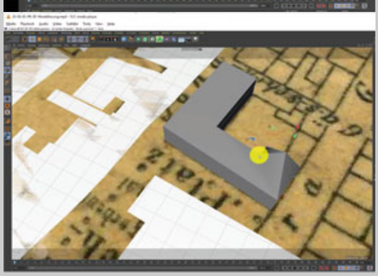
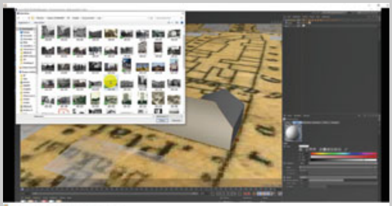
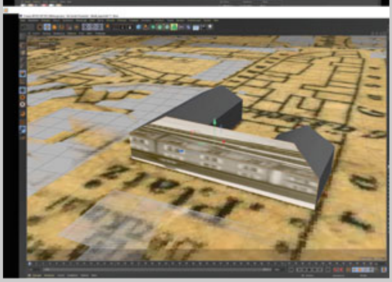
14 
Select two upper opposite points each and set distance = 0 to center.

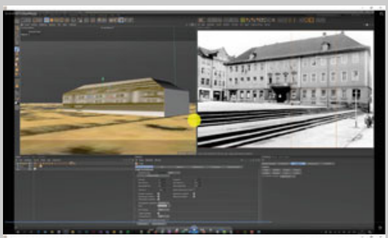
Fig. 5.3 (continued)

15 

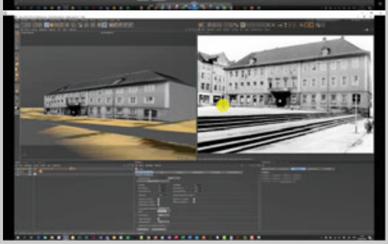
Create a new empty material definition and load image showing the front of the building.

16 

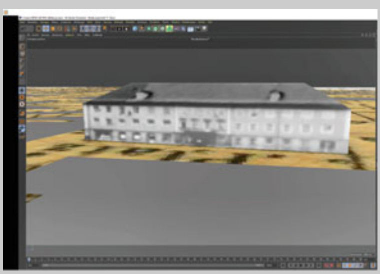
Select facade polygons and apply material to those polygons.

17 

Switch to "texturing mode" and select texture to adjust.

18 

Align outer points of the texture coordinates to the edges of the photo texture.

19 

Calculate texture as raster graphic.

Fig. 5.3 (continued)

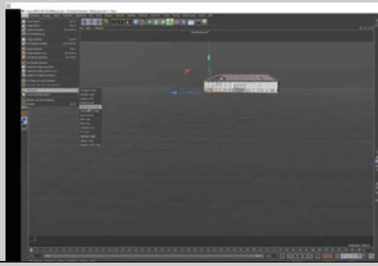
20		Export as Collada file to upload into a web viewer.

Fig. 5.3 (continued)

5.2 Interdisciplinarity

Interdisciplinarity refers to a “confrontation of several disciplines with a [joint] topic or issue” [26. p. 7]. Related to this, Schelsky speaks of a “partial scientific development unit at the empirical object” [27, p. 72]. Interdisciplinary collaboration is characterized by developing a joint terminology and methodology [28, 29]. Interdisciplinary institutionalization ranges from temporary collaborations to the creation of new “hybrid” research disciplines [30, p. 16], such as the digital humanities as a combination of applied computing fostering research in humanities.

An important distinction, shown schematically in Fig. 5.4, relates to forms of disciplinary collaborations. Multidisciplinarity refers to independent research on a topic by different disciplines. Transdisciplinarity names collaborative development and research on a topic including scientific disciplines as well as other stakeholders, such as non-governmental organizations or special interest groups. This concept is mainly associated with a research on complex and highly social relevant issues such as environmental protection or societal changes [32].

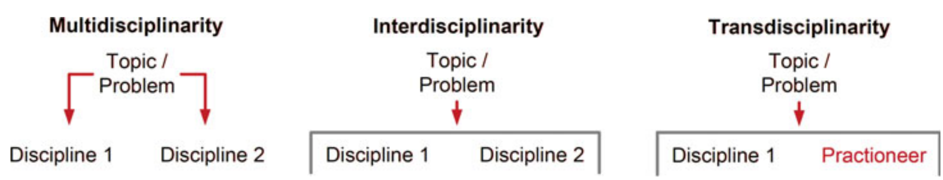


Fig. 5.4 Types of disciplinary cooperation [31, p. 7]

5.3 Modeling the Project Process

How does a 3D reconstruction project work? A general model of project processes includes the four phases of project initiation, planning, implementation, and completion [33, 34], and a parallel task of monitoring and control [35], each of which is characterized by specific objectives and characteristics (Figs. 3.4 and 5.5).

Interdisciplinary research projects do not follow a standardized project process, but each has their own rhythm [26]. Accordingly, the phases named below, and the associated work tasks do not represent a linear sequence but rather components of a process (Table 5.1).

The entire workflow is sequenced into substeps using organizational modules such as work tasks or work packages. Milestones are agreed as transition points between organizational elements, to create deadlines for work actions and to evaluate actual progress compared to planning [38].

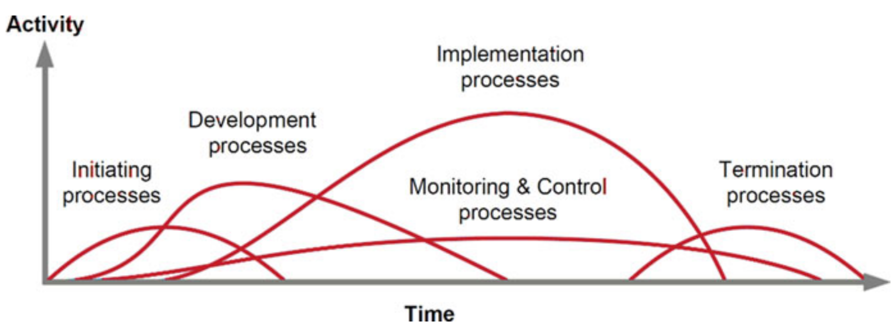


Fig. 5.5 Project life cycle [36, 310, p. 91]

Table. 5.1 Phases of interdisciplinary research [26, p. 29f., 37]

Phase	Common goals and questions
Start	Coordinating the project team (interests, positions, competencies) Operationalizing the project goals Drafting the cooperation structure Assigning roles (moderation, work packages) Developing a project plan, selecting dates for evaluation Defining quality criteria
Implementation	Elaborating intermediate and partial steps (detailed planning)
Completion	Securing results and publication Accounting for the cooperation

During intensive work phases in the run-up to "more selective events" (milestones, presentations, reports, etc.) most of the project work is done [26, p. 30]. Tasks that are not essential for achieving results, such as communication work, are neglected in these intense phases. 3D reconstruction projects are Innovative and research-intensive and are thus difficult to plan [39], so unplanned cuts—due to personnel changes or unexpected difficulties—may come to light, creating the need to adjust objectives. A particularly important aspect of academic projects is the sensible design of the overall duration of the project. Newly constituted and interdisciplinary project teams need time to build the team and set up the project [38].

5.4 3D Reconstructions as Interdisciplinary Projects

In digital reconstructions, information technologies serve to produce virtual historical models. Computer science provides the tools, while archaeology and the history of culture, art and architecture, architectural research, and museum studies provide perspectives on the content. Owing to the highly specialized nature of the tools, the model is usually not created by the persons responsible for the content, but, in interdisciplinary projects, by modelers who come from computer science, architecture, geosciences, engineering, and design. The disciplines involved in the 3D reconstruction projects have very different approaches [40]. This requires synchronization and is often the source of problems in practice.

Further reading: Generic Process Models of Disciplines Involved in 3D Reconstructions

A computer science view of the visualization process

From the point of view of computer science, 3D reconstruction is a visualization project. An associated procedure ideally includes the successive steps of data input and data selection, modeling and simulation, and output (Figs. 3.5 and 5.6).

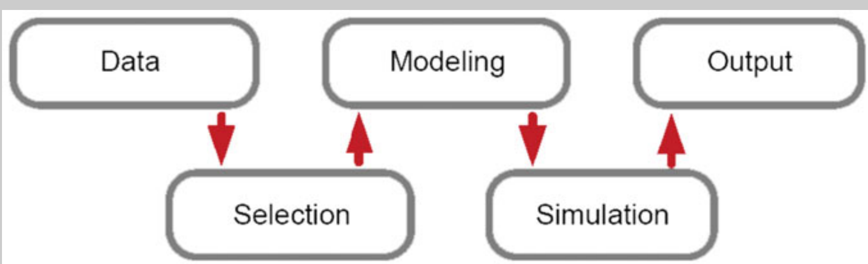


Fig. 5.6 Generic visualization process model [41]

Data: The starting point of a visualization is data. Schumann and Brodlie classify data based on their origin: as empirically measured values from a real-world or a theoretical world such as mathematics, or as designed data such as artistic representations from an artificial world, e.g. textual sources or drawn images [42, 43].

Data selection: In terms of process theory, in a historical 3D reconstruction data is selected from sources. Deduction is usually less of a problem than the extrapolation of incomplete source data. In addition to data reduction as proposed by Schumann, the following aspects of data selection arise [42]:

1. Removal of irrelevant data
2. Dataset abstraction
3. Indication of an area of interest
4. Interpolation or extrapolation of missing data
5. Compilation of the required data
6. Selection of subsets.

Modeling: A model is created using computer tools: the geometric shape is defined, virtual lighting and the material properties of the reference object simulated.

Simulation: This step comprises the creation of a geometric model, a definition of texturing, i.e., the assignment of surface color and structure or animation.

Output: The virtual 3D model is available as a digital dataset and as such is only indirectly accessible to both the editor and the viewer. To make it visible and editable, it must therefore be mapped and thus converted into static individual images or more complex mapping contexts such as animations or interactive display formats.

The design process

In the strict sense, design includes finding the form. In a 3D reconstruction, this process involves both architectural design—reconstructing a plan of the building structures [44],—and graphic design of visualizations (Fig. 5.7).

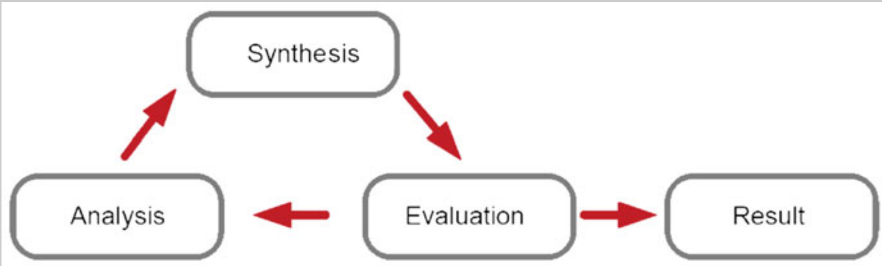


Fig. 5.7 Analysis-synthesis-evaluation model of the design

More recent design theories understand the phases of analysis and synthesis as a unit and thus explain design in terms of a complex circle (Fig. 3.6), which borrows from hermeneutics and systems theory [45]. Reference is made to the principle of "analysis through synthesis" [46, 47, p. 6]. While the ideal technical process has a clear target or termination criteria, design difficulties are generally counted among the "wicked problems" for which no clear endpoint or solutions are possible [48, 49, p. 7]. The process therefore does not end when a goal is achieved, but when the approach to the goal or external termination criteria is deemed sufficient (Fig. 5.8).

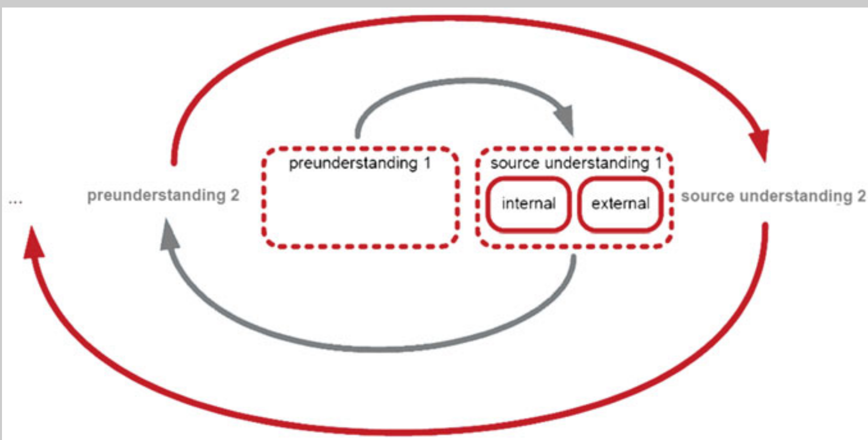


Fig. 5.8 Hermeneutic model of historical science

The historical processes

Similarly, to design processes, the historical research process has a cyclical structure (Fig. 3.7). Since the mid-1950s historical research has become primarily problem-focused [50]. This research paradigm is strongly linked to the emergence of constructivist explanatory models, based on interpreting historical facts and reassessing historical sources. In a constructivist view, each "action […] is preceded by intentions" [51, 52], whereby a source as a residue or tradition represents the intention of its historical creator. In their entirety, historical sources provide an incomplete and often contradictory picture of the past and thus an incomplete database for a 3D reconstruction. This insoluble dilemma ultimately led to the view that historical science is a limited construction [50], and as such cannot provide a reliable, holistic picture of the past. Hermeneutics represents the classic and most widespread investigation paradigm of historical sciences [53], where this qualitative method is understood as a cyclical interplay between the researcher's prior understanding and understanding of the sources. In terms of process, the latter is based on the former and, by examining sources using the methodical steps of formal "external" and content-related "internal" source criticism, the researcher expands their (pre-)understanding.

Since all three modes of work are combined in a 3D reconstruction project this can cause conflicts. A central mark of visualization processes is their decreasing flexibility over a time—with high costs in case of applying unplanned fundamental changes at late stage. Vice versa, hermeneutic processes are generating fundamental insights often late in a research process. Consequently, 3D modelling require balancing between these different work modes and mitigation e.g. by defining parameters which are most likely to become subject of change at later stages.

5.5 3D Reconstruction Project Management

5.5.1 Definition of Project Work

3D reconstruction projects are a form of temporary work organization characterized by systems of rules for coordinating the achievement of goals based on the division of labor [38]. Projects according to DIN 69,901 represent tasks which are "essentially characterized by the uniqueness of the conditions in their entirety" [54]. Central features of this form of work are task orientation, teamwork, a time limit, and transition [38, 55, 56]. All aspects of controlling projects are conceptually covered by project management. While the project as a phenomenon is at least as old as modernity, the term project management only dates back to the 1970s [57]. In general, project management offers a number of comprehensive classification schemes and standards [35]. Economics, in particular, provides an almost unmanageable multitude of recommendations and "success factors" for project management [39] as well as countless descriptions of inhibiting factors/ Kerzner defines nine possible reasons for project failure [57]: (1) poor morale, (2) poor motivation, (3) poor human relations, (4) poor productivity, (5) no employee commitment, (6) no functional commitment, (7) delays in problem solving, (8) too many unresolved policy issues, and (9) conflicting priorities between executives, line managers, and project managers.

Aspects of project management essential for theoretical consideration here include organization, goals, planning, quality, and quality management, which are discussed in the following sections.

5.5.2 Project Organization

From an economic perspective, digital 3D reconstruction projects are innovative because they are knowledge- and research-intensive, mostly prototypical, and produce new results and processes [39]. Historical 3D reconstruction projects are often cooperations between academic institutions that are largely independent of one another. Accordingly, such projects are usually organized as a "matrix" [39, 58]. A general feature of a matrix is that employees involved in the project report to several superiors, both in the sending organizational unit and the project coordinator. Such an organizational form has a high success rate and generally high efficiency compared to other organizational models [39], but requires a high level of coordination effort: the project manager's great influence over the superior of the sending institution is beneficial for project processing, though disciplinary powers, responsibility for task delegation, and control should be assigned to the project manager.

Academic projects are a particular form of matrix organization, since disciplinary powers, at least in the academic field, usually lie exclusively with the sending institution. Projects may fail due to the high risk of competing priorities being set by managers of the project and independent institutions involved [57]. According to Hausschild and Salomo [39], another key factor in the success of innovation projects is the physical proximity of participants. Hoegl and Proserpio [59] show that physical proximity not only increases community building and the frequency and variety of information transfer between project members, but also promotes their self-directed coordination; remarkably, spatial proximity does not lead to an improvement in transactional knowledge.

5.5.3 Goals

As innovation projects, 3D reconstruction projects are often a "process in which it is often not at all clear which goal is to be achieved" [38, p. 18]. Such a lack of clarity of purpose results from the high complexity of the task and the associated lack of clarity about the problem structure and unpredictability of problem components [39]. Characteristics of a lack of clear goal include "constant trying, approaching, very often connected with repetition steps" until a result "is selected as useful" [38, p. 18]. From a conflict theory perspective, lacking a clear objective potentially leads to conflicts with regard to the interpretation of a work procedure [39]. In most cases, projects do not pursue a single goal, but a whole series of goals. Such goals can not only have different qualities and priorities, but sometimes also compete [39]—for 3D reconstructions e.g. academic quality vs. completeness vs. impressing results. Finally, different objectives or priorities are often linked to individual or collective perspectives of the persons and institutions involved [39].

5.5.4 Planning and Control

An overarching and general model shows that project planning includes a trade-off between the influencing variables of time, budget, and goals (Fig. 3.8). Limited resources mean that "the 'ideal' solution cannot always be sought for scientific projects" [26, p. 33]. A major problem in the advance planning of innovation processes such as 3D reconstruction projects is the lack of knowledge about the quality of the achievable goal and the path leading there. Information and knowledge deficits require an approximate approach, which is based on a suitable sequencing and prioritization of work tasks.

The question of organizational structures and tools for controlling results, which is closely related to quality management, is closely linked to planning work steps. Delegation and monitoring of tasks and staff is part of vertical organization [60]. Closely related to this is what Kräkel calls the "dilemma of organizational theory" [60, p. 116]: delegation of decision-making authority enables efficient problem solving but requires comprehensive control and coordination to achieve a common overall goal (Fig. 5.9).

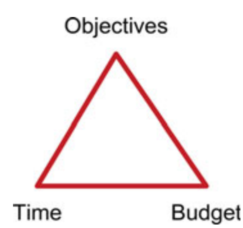


Fig. 5.9 Planning parameters of project management [38, p. 116]

There is a broad consensus that, the project manager is of outstanding importance to the success of any project. Other factors are budgets that can be managed flexibly; intensive, informal, and formalized communication; suitable sequencing and monitoring of progress [39]. Hauschildt and Salomo propose a three-step procedure for monitoring project processes [39, p. 505]:

- Ongoing determination of deviations
- Review to determine the cause
- Evaluation of deviations and, if necessary, corrections.

Who does this monitoring, and at what stages, is discussed next in a theoretical consideration of quality management. Another issue is how the people involved in such work are organized. In 3D reconstruction, this includes the organizational structures and forms of cooperation relevant to both the project and the scientific institution or community.

5.5.5 Quality

Quality is the “degree to which a set of inherent characteristics fulfill requirements” [35, p. 180]. Such requirements include, both the outcomes, i.e., **result quality** and compliance with framework conditions on the way to achieving a goal, i.e., **process quality**. Another important distinction is between **quality**, which refers to errors and inconsistencies, and **grade**, which indicates the scope or quality level of a result. Theoretical concepts of quality are presented here with two aims: to consider quality in the work process, one needs to consider approaches to quality management.

Further reading: Recommendations for interdisciplinary 3D reconstruction projects [61]

Workflow

1. run pre-projects to test cooperation, approaches, and support competence development
2. align the project early on with budgets and requirements of funding providers
3. consider the time needed for interpretation and corrections
4. set deadlines promote efficient work
5. make deadlines binding and include incentives or sanctions

Sources

6. finalize collection and analysis of sources best as possible before starting reconstruction

7. if source findings are unclear, make a first draft model to support decision-making
8. decide iteratively in case of unclear findings
9. set editorial deadlines for the inclusion of further sources

Modeling

10. consider easy editing of the model
11. develop, document, and adhere to the model system and structure
12. structure the model based on spatial, temporal, functional, and model organizational aspects (→3D Modeling)
13. sort and locate existing source information in space and time, e.g., in plans

Quality management

14. synchronize the quality expectations of all stakeholders at an early stage and recheck frequently
15. in case of multiple sources, define a primary modeling source
16. present omissions or several alternative hypotheses in the model if the findings are unclear
17. develop quality standards, e.g. on detailing, early and maintain them as far as possible
18. develop a strategy for the frequency and timing of corrections
19. make visual comparisons, e.g., of model views and sources
20. to support a visual assessment

Project management

21. subordinate management and coordination tasks in terms of time and personnel
22. allocate tasks and fill positions depending on needed and existing competencies
23. promote intrinsic motivation through "healthy" competition, public perception, and group motivation

Technology

24. allow individual software decisions in case of prior knowledge
25. use widely established exchange formats that are accessible to all stakeholders

Learning

26. in interdisciplinary projects, only teach competencies relevant to the cooperation, i.e., interface knowledge

Sustainability

27. involve participants in opening project processes
28. assign minute takers and create minutes of meetings

Communication

29. communicate too much rather than too little

30. actively communicate and broadly base decisions
31. keep stakeholders regularly informed
32. describe complex problems in several ways when communicating at a distance
33. draw up structured problem lists and communicate them in advance of a meeting
34. use simple language and intuitive formats such as pictures
35. ensure understanding e.g., by asking/repeating
36. use pictures and language as a combined medium of communication
37. use sketches and drawings as aids
38. draw or write comments directly in model visualizations

Presentation of Results

39. present sources and procedures appropriately in the presentation medium
40. carry out usability testing to determine the suitability for the target group

5.5.6 Quality Management

Quality management within a project includes all activities so that a project satisfies the requirements [35]. This includes the aspects of quality planning, its practical application and control. Quality management is thus closely linked to project planning and management. Schmidt identifies comparisons with other projects, points in a project, normative standards and quality models as essential procedures or "reference models" of quality management specifically in academic contexts [62, p. 11ff.]. Especially regarding reference models, it is essential to make the individual quality ideas of all relevant stakeholders transparent and to develop a common idea in this regard [35]. Likewise, quality management includes establishing tools for quality control, which can be done internally or externally and periodically or continuously. One merit of **continuous internal quality assurance** is that project teams have a high degree of social control. A monitoring group integrated into the project structure but outside the actual project work, or filling the role of a quality officer [35], whose tasks include checking compliance with goals or identifying defaults. Alternatively, **external quality control** can be done by people who are completely outside the project structure, such as supervisors from the institutions involved [39]. In contrast, **quality audits** are instruments of **periodic** quality control [62]. In these cases, objectives are used to monitor the status of the work and identify the need for action. Such audits as work meetings or group reviews, can be carried out both internally and by external expert commissions [35, 39]. While primarily aimed at quality assurance in the specific work context, **quality circles** [58] aim to sensitize employees and thus create a generic awareness of quality.

5.6 Phenomena and Strategies for Cooperation

Further reading: Example strategies

- **Competence development through preliminary projects:** The most important characteristics for adequate planning, adjustment, and control are the expertise and experience of the project planner [39]. While only rarely discussed in the literature in this context, it is essential for a subsequent empirical consideration to reduce the complexity of a problem, acquire skills, and test organizational structures through prototypical pilot projects.
- **Project sequencing:** Irrespective of any previous experience, a project plan is usually broken down into organizational units such as work packages and subtasks that are limited in terms of time and resource availability. Ideally, these are provided with a defined target level and endpoint, or milestone, enabling deviations from planning to be determined comparatively quickly and the project schedule to be adjusted [38, 39]. 3D reconstruction projects also involve a large number of previously unplanned incisions and changes [61], due to their innovative character and unpredictability, but also to organizational changes such as personnel reshuffles, which creates the need for permanent project control and the adjustment of plans in relation to these changes.
- **Priority lists:** Because innovation and research projects do not usually have a foreseeable target, an order of priorities essential instrument for planning. An important element here is weighing up decision alternatives, to identify and define the most important subgoals that need to be prioritized [39].

As proven empirically [63], many challenges for 3D reconstruction projects are connected to a lack of interdisciplinary understanding. Due to the high complexity and team-based workflows, aspects, and usage practices for communication, cooperation, and quality management are highly relevant within 3D reconstruction projects. Intensive support by images during a reconstruction process could foster interdisciplinary communication, and could be used as “creoles” [64] to exchange and share mental models. For that, it is necessary to synchronize terminologies or to employ common grounds like symbols, colors, or tags [7]. Especially if people with different disciplinary backgrounds are involved, visual media fosters communication and quality negotiations, e.g., by comparing source images and renderings of the created virtual reconstruction. Furthermore, several projects successfully adopted highly standardized conventions from architectural drawings for interdisciplinary exchange. Such decisions and tasks should be started at an early project stage and should be controlled and adapted throughout the entire process. Ideally, such visual coding schemes would be a mental model shared by all members of the project team and would be documented and based on either extant coding schemes, e.g., from engineering, or would use **natural coding** like physical analogies or concrete depictions [65] to make these issues recognizable and even accessible later. In all cases, images would only support communication and, especially for complex tasks and interdisciplinary exchange, personal contact would be more useful than communicating information over long distances. Resulting challenges include access to and evaluation of models and images to make authorship transparent, as well as references between reconstruction and (explainable) fundamental knowledge such as sources. A specific challenge is the division of the labor that is usually involved in the project. It is evident from published project reports that interpretative 3D reconstruction projects are almost always interdisciplinary in nature, with the teams mostly only coming together temporarily, unlike the situation in companies or institutions [38]. The tasks are usually divided between historical research and creation of the model. Consequently, aspects such as the organization of work, the distribution of tasks, cooperation, and communication, are important [61].

Summary

3D reconstructions are carried out within interdisciplinary innovation projects, which comprise challenges such as open-ended workflows and the need to synchronize different terminology and work processes. With regards to the latter, a big challenge is raised by the different stepping in humanities, computing, and design. Since humanities research refines with the analysis and contextualization of further sources, the technical view of 3D reconstruction seeks a clear problem definition, where fundamental changes at a late stage—common in humanities—cause a huge workload for changing a 3D model.

Concepts

- **Interdisciplinarity:** 3D reconstructions in the humanities are primarily created within long-term interdisciplinary projects. Intensive support by images during a reconstruction process could foster interdisciplinary communication, and could be used as "creoles" [64] to exchange and share mental models. To do this, it is necessary to synchronize terminologies or to employ common grounds like symbols, colors, or tags [7].
- **Project management:** In academic interdisciplinary cooperation, efficient strategies and routines of self-organization often fail to develop. Differing interests and quality expectations as well as weak incentives to finish projects efficiently often cause severe and long-lasting friction, delays, budget overruns, and conflicts between stakeholders. Moreover, team members are mostly matrix organized—in both teams and institutional structures—and multiple tasks are assigned. Even if leaders of academic projects widely influence the setting of general objectives, they have few instruments to motivate or penalize employees and to assign

individual time capacities. As a paradoxon, academic projects are often infinite, where missed deadlines and exceeded budgets are often compensated by other resources and which prioritize "perfect" quality above fit to resources.

Key literature

- Project Management Institute. A Guide to the Project Management Body of Knowledge. PMBOK Guide; PMI: Newtown Square, 2004 [35].
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