Graduation Plan

Master of Science Architecture, Urbanism & Building Sciences

Graduation Plan: All tracks

The graduation plan consists of at least the following data/segments:

Personal information	
Name	Ali Sarmad Khan
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Studio	
Name / Theme	Sustainable Design Graduation Studio (BT)
Teachers / tutors	Frank Schnater (1st) and Marcel Bilow (2nd)
Argumentation of choice of the studio	It is the only studio inside the Building Technology Track.

Graduation project	
Title of the graduation project	Feasibility of the Restoration of Built Heritage via Additive Manufacturing
Goal	
Location:	TU Delft, Preferably BKCity
The posed problem,	With the increasing prevalence of technology comes a higher standard of living which consequently increases the cost of human labor. It is a fact that skilled craftsmen are rare in the 21st Century, especially specialists in the materials and techniques that might be required for the restoration of built heritage. An advantage that technology can also provide however is that the need for skilled craftsmen, essential for certain kinds of conservation efforts, can be negated, bringing down costs. Secondly, conservation efforts are very time intensive, with the ongoing restoration of the Parthenon currently in its 40th year with an estimated end date of 2020. During these efforts the monuments are usually covered with scaffolding or kept out of the public domain, disconnecting the population with their history. With technology, the time spent on site can be reduced, since 3D Scanning is less time intensive than traditional surveying techniques and additive manufacturing machines can work day and night without a break. 3D scanning is currently being extensively used in the field of

	art, notably the digitization of Matisse sculptures in 2002-2007 for virtual comparison, something that would have taken many tools, calipers and surveyors before the advent of 3D scanning technology. With the use of additive manufacturing technology, it can also be possible to create hollow or optimized objects, something that is not possible by traditional carving techniques, making the objects lighter while retaining most of their strength.
research questions and	'What is the most efficient way to restore instances of built heritage using additive manufacturing techniques for different materials and morphologies?' RBHAM: Restoration of Built Heritage via Additive Manufacturing **Sub-questions.** The main research question gives rise to certain related sub-questions, such as: i. Is RBHAM more economical than traditional techniques? ii. Which kind of materials and morphology could benefit the most from RBHAM? iii. Is it possible to make RBHAM reversible? iv. Is it possible to use RBHAM for structural repair? v. What are the criteria for the selection of printing materials that complement the existing materials of the selected built heritage? vi. What is the role of the craftsman in digital manipulation and additive manufacturing techniques?
design assignment in which these result.	**Summary:** Collection of Literature, On-Site Experiments, Creation of a Manual **Elaboration:** The paper aims to give insight into the relevance of the project with respect to architectural conservation, to give a general

	understanding of 3D scanning and scanners, additive manufacturing techniques and 3D printers as well as the software tools required to 'interpolate' the geometry to be printed. In this context, interpolation refers to the prediction of missing geometry using existing evidence, either documented or via evidence on site (if the damaged elements are part of a series of repeating elements). Ideally, conjecture would be avoided and the interpolation would be kept as accurate as possible. Informed by the literature review, a streamlined workflow will be created, that consists of the identification of suitable candidates for the process, the scanning of the existing geometry, the validation of the digital data, the printing of the geometry and eventually, the on-site restoration process. This workflow will be tested with the help of on-site experiments (a damaged structure will be scanned and repaired) and the conclusion of the experiments will be added to the existing literature, eventually leading to a manual for conservationists. For the purposes of this report, this workflow will be referred to as RBHAM (Restoration of Built Heritage via Additive Manufacturing).

Process

Method description

Literature Review: 3D Scanning Techniques, 3D Printing Techniques, Architectural Conservation Techniques

Qualitative: 1. Interviews with conservationists. 2. Determination of candidates for intervention

Quantitative: 1. Determination of optimum scanning and printing parameters 2. Finding best reversible binding materials 3. Recording of issues and challenges 4. Compilation of manual 5. Review of manual

The literature will be compiled into a manual, and the manual will be informed by on-site experiments. A selected damaged structure (possibly a replica for research if one cannot be found) will be scanned via the use of professional 3D scanners, the damaged pieces will be analyzed, and possible insertions be interpolated. The result will then be 3d-printed using appropriate technology

and materials. The entire process will be documented and performed with varying parameters, the optimal parameters (Speed vs. Quality) will be determined, marked and included in the manual.

Literature and general practical preference

The research conducted will delve into three separate fields of expertise, 3D scanning techniques, additive manufacturing techniques and architectural conservation practices. The final result will be achieved with an amalgamation of the aforementioned fields. The research refers to three primary sources for each of these topics followed by numerous secondary sources. The three primary sources are Additive Manufacturing Technologies by Ian Gibson, David Rosen and Brent Stucker, '3D Laser Scanning for Heritage' by English Heritage and Conservation of Historic Buildings by Bernard Feilden.

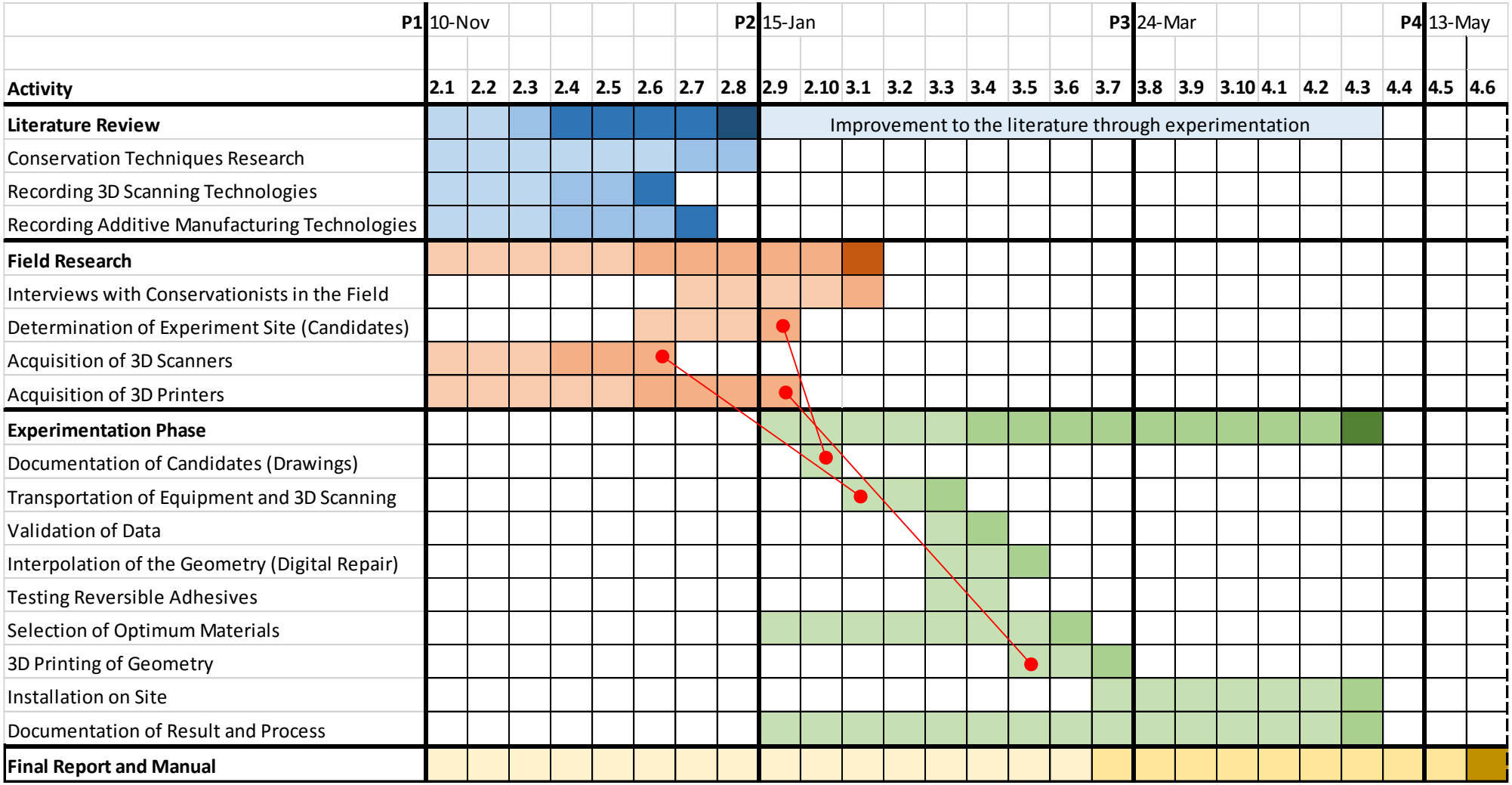
Reflection

Relevance

The goal of this project is to improve upon the toolsets available to conservationists by making use of the latest technology, thereby combining the old with the new. There is ample research in the fields of 3D scanning and 3D printing, as well as the application of the combination these technologies in the regeneration of art and even bionics. This project can provide insight into how technology can be introduced into the field of architectural conservation which has traditionally been resistant to new technology. It will also give insight into the role of the craftsman and the relevance of craftsmanship in the digital world. The resulting manual can help any architects who are looking towards technology to aid their conservation efforts get a head start and learn from the experiments performed so that any common mistakes can be avoided.

Time planning

See next page.


P1
10-Nov
P2
15-Jan
P3
24-Mar
P4
13-May
Activity
2.1
2.2
2.3
2.4
2.5
2.6
2.7
2.8
2.9
2.10
3.1
3.2
3.3
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3.5
3.6
3.7
3.8
3.9
3.10
4.1
4.2
4.3
4.4
4.5
4.6
Literature Review
Improvement to the literature through experimentation
Conservation Techniques Research
Recording 3D Scanning Technologies
Recording Additive Manufacturing Technologies
Field Research
Interviews with Conservationists in the Field
Determination of Experiment Site (Candidates)
Acquisition of 3D Scanners
Acquisition of 3D Printers
Experimentation Phase
Documentation of Candidates (Drawings)
Transportation of Equipment and 3D Scanning
Validation of Data
Interpolation of the Geometry (Digital Repair)
Testing Reversible Adhesives
Selection of Optimum Materials
3D Printing of Geometry
Installation on Site
Documentation of Result and Process
Final Report and Manual