GSOE9820

Engineering Project Management

Robot Blacksmith Project

Project Management Plan

SUBMITTED BY:

DREAM TEAM

BY SIGNING THE BELOW DECLARATION, I AGREE WITH THE CONTRIBUTION LIST PROVIDED FOR THE PROJECT AND THAT I HAVE NOT INCLUDED ANY PLAGIARIZED CONTENT FOR MY INDIVIDUAL CONTRIBUTIONS.

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Member Contributions	•	•	•	•	•	•
Declaration	(signed)	(signed)	(signed)	(signed)	(signed)	(signed)

1 Project Charter

1.1 Project Background

The invention of the Computer Numerical Control (CNC) machine revolutionized the global manufacturing industry, allowing manufacturers to produce items with incredibly high precision without sacrificing speed and consistency. This was followed by the introduction of the additive manufacturing process, also known as 3D printing, which gave users the ability to create objects with far more complex shapes by building items layer by layer. While both methods have their inherent benefits, they both come with significant drawbacks. CNC manufacturing leaves large amounts of waste materials as material is stripped away, and objects created with additive manufacturing have known limits to their structural integrity given the resolution of the printer, as well as open-air exposure during the formation process.

Metamorphic manufacturing was designed in response to these two problems, built around the idea of reshaping raw materials rather than trimming away or compounding material. It allows for much finer grained control over the structural properties of the material, inspired by how a blacksmith can reshape metal using only heat and compressive force. It seeks to extend this even further, by using modern computational systems and artificial intelligence to create highly complex geometrical objects, all without the need to create a cast or a die for each individual object [1].

1.2 Project Objectives

The objective of the project is to build a shared MM cell at UNSW which will be used as a foundation for technological development and interdisciplinary research between universities and private institutions. The project's benefits are closely aligned to UNSW's 2025 Strategy[1]: "to improve lives globally through innovative research, transformative education, and commitment to a just society". This project exemplifies these in the following ways:

A. Academic Excellence:
    a. Deliver a facility capable of sustaining high quality research and encouraging academic excellence to contribute to the strategy involving University Research quality, sustaining UNSW within the top 50 research-intensive universities worldwide,
    b. Contribute to Educational Excellence by enabling lecturers to use it to enhance their mode of instruction,
    c. Deliver a facility that offer hands-on experience to over 500 students and researchers each year across the engineering and science disciplines,
    d. Design a facility that enables at least 5 research articles published in the Q1 journals each year and 2 co-published research with the Group of 8 or other international universities,
    e. Design a cutting-edge course on Metamorphic Manufacturing to be offered in UNSW by 2025.
B. Innovation and Engagement:
    a. Collaborate with other faculties within UNSW (School of Computer Science and Engineering) and foster research opportunities with universities from the Group of 8, as well as industry projects.
    b. Provide a new avenue for collaboration with international institutions,
    c. Develop entrepreneurship and innovation, enhancing opportunities for the start-up culture and increasing the number of startups that the UNSW Founders Program supports to 1100 by 2025,
    d. Open additional opportunities for research funding by approximately $5 million from knowledge exchange and other contract works with external organizations within five years of the project's completion (E5),
    e. Increase UNSW's brand awareness by issuing promotional material showcasing UNSW's state-of-the-art facilities, targeting future students in alignment with UNSW 2025+.

[1] 2025 Strategy Update, UNSW January 2020

f. Becoming a global leader in research on metamorphic manufacturing technology, contributing to the advancement of modern digital manufacturing.

1.3 Project Stakeholders and Benefits

1.2.1 Academic community

- Student
  - Current Students – The MM cell will be accessible for current undergraduate and postgraduate students interested in research, or for students taking the UNSW course on additive manufacturing. Their access to state-of-the-art facilities and education will serve to improve their employability and competitiveness in the rapidly evolving job market. PhD students will be able to conduct research in a highly innovative field and collaborate with researchers from other universities, improving their research output and paving the way for additional research grants and funding,
  - Alumni – Alumni will benefit from the improved reputation of UNSW, potentially leading to increased financial contributions, and access to their professional network,
  - Future – The facility can improve the quality of life of the student community by providing a venue for extracurricular activities, attracting highly motivated students.
- Academic:
  - Research – The MM cell will provide a space for collaboration and innovation, attracting researchers to deliver cutting edge research, increasing the university's overall research output,
  - Teaching – The MM cell contributes to Educational Excellence by providing a facility that allows students to develop hands-on experience with the course material (transformative education),
  - Research Companies – The facility would enable the university to attract partners from industry, providing opportunities for grants and partnerships (wider social engagement),
  - Other Universities – The facility would enhance our partnerships with other Go8 universities through collaborative research (knowledge exchange).
- UNSW Executive – The overall enhanced reputation of the university would aid in increasing revenues and securing funding for the university's various pursuits, improving the institution's financial sustainability.
- Project Sponsor (Dr. Xiaopeng Li) – As the main sponsor of this project, its completion would serve to enhance his personal reputation while providing a facility allowing him to conduct further research into his area of interest.

1.2.2 External Community

- Australian government (primarily Australian Research Council, see Communication Plan)
  - As the largest single contributor to the economy, the government may be interested in providing research grants to enhance its own capabilities,
  - The university's continued record of providing state-of-the-art facilities and education would serve to attract international students, following Australia's overall strategy for education.
- Industry partnership
  - Industrial proponents may be interested in becoming early adopters of this new, cutting-edge technique as a way of driving down costs and improving output. This could lead to research and scholarship funding, as well as partnerships with industry competitions such as the Lightweight Innovations for Tomorrow (LIFT) Manufacturing Institute.
  - The MM cell would allow for research into techniques that could help environmental sustainability by reducing material waste and energy consumption, thereby decreasing manufacturers' carbon footprint.
- Local Outreach
  - A larger university presence would benefit the local community through increased economic activity, and an improved reputation and media profile.

2 Scope Statement

This project aims to deliver a metamorphic manufacturing cell (MM cell) within the UNSW campus. This includes the renovation of a room on campus to accommodate all the necessary equipment. Given the rapidly evolving nature of the field, the cell will be designed with modularity in mind, such that components may be added, removed, or swapped out as needs arise and as paradigms change within the broader research community. Each component of the MM cell has been chosen to cover some aspect of the five fundamental elements of metamorphic manufacturing (STARC)[2].

2.1 Acceptance Criteria

The project will be considered complete once all sub-deliverables have been fulfilled. The MM cell will undergo a final test, wherein it will be required to transform a bar of titanium into a 3D shape, given through a CAD model designed by the project sponsor. The project will be considered closed once all deliverables have been turned over to the project sponsor.

2.2 Deliverables

The primary deliverable for this project will be a fully functional MM cell, equipped with the tools necessary to reshape 1-kilogram bar of titanium or low alloy steel based on a given CAD model. A sample layout is provided in Appendix F.

The MM cell can be decomposed into the following major sub-deliverables:

2.2.1 Facility Renovation

The chosen facility will be renovated to fit the electrical and safety requirements of the MM cell. The project will include the development of a layout design, and a request for proposal will be developed to solicit contractors to perform the renovation.

2.2.2 Staging Area

The staging area refers to a location separate from the rest of the MM cell in which researchers may place their material inputs prior to the manufacturing process. To ensure the researchers' safety, a plexiglass shield will be installed, and materials must be fed through a conveyor belt. Light curtains will be installed to ensure that any machinery remains off while there are people within the cell.

2.2.3 Robotic Deformation System

The robotic deformation system will consist of a robotic arm and a power hammer. The robotic arm will be used as a workpiece manipulation unit, adjusting the pose of the material over the power hammer, while the power hammer will be used to apply force to the material to deform it.

2.2.4 Induction Furnace

A furnace will be installed to apply heat to the material prior to forging. An induction furnace was chosen over other types of furnaces because of its portability and its lowered impact on the environment compared to alternatives such as gasoline or coal-powered furnaces.

2.2.5 Sensor Array

The sensor array will consist of six depth cameras, which will be used to monitor the dimensions and geometry of the material in real-time, as well as the current state of the workpiece manipulation unit and power hammer. Its data will be fed into the materials deformation simulator. In addition, the sensor array will include an infrared sensor to measure the temperature of the material.

[2] [2]

2.2.6 Central Control System

The central control system refers to the computer that will be used to process the sensor data, simulate the material, and send commands to the robotic deformation system and induction furnace. It will also have all the standard amenities available to university computers, such as intranet access.

2.2.7 Deformation Simulator

The deformation simulator will be a software application designed to model the physical properties of the material and accurately simulate its deformation given stress. An application programming interface (API) will be provided to allow other applications to feed it sensor data, manipulate its simulated actuators, and extract data for further processing.

2.2.8 Morphology Solver

This will consist of a software application which utilizes artificial intelligence to develop a sequence of actions to morph the material into a given goal state. The application will interface with the deformation simulator and robotic deformation system. Users will interact with this system by loading a predefined CAD file and specifying parameters to control the solver (e.g. maximum action sequence length).

2.2.9 Project Documentation

The project documentation will describe all the information necessary to properly operate, maintain, and extend the system's hardware or software components. It will be provided to academics and technicians at the end of the project covering all aspects of the MM cell.

2.3 Exclusions

The project deliverables are limited to the components specified above. Though the facility will provide capacity for possible extensions to the cell, the development, maintenance, and installation of such extensions are beyond the scope of this project.

During the renovation, the project team will not be responsible for the removal of any structures found during the construction of the facility that were not present in UNSW's provided blueprints.

2.4 Constraints

This project will operate under a fixed budget of $2,000,000.00, including any contingencies. Project funding will be provided by the project sponsor. All purchases related to the project must be coursed through UNSW's Strategic Procurement Team.

In addition, all processes required to produce the facility, as well as all activities performed in the operation of the facility itself, must abide by UNSW's Work Health & Safety policies.

2.5 Assumptions

This project will operate under the assumption that a room has been provided prior to the commencement of this project. The room provided is assumed to be in good condition and pre-approved to be transformed into a laboratory by NSW (SafeWorkNSW) and UNSW (OH&S Guidelines).

3 Work Breakdown Structure

Given the major project deliverables outlined in Section 2 – Scope Statement of this document, their related work packages can be decomposed further to provide a clearer representation of the work that must be completed to ensure their successful delivery (PMBOK Section 5.4)[3]. The complete work breakdown structure diagram may be found in Appendix A.

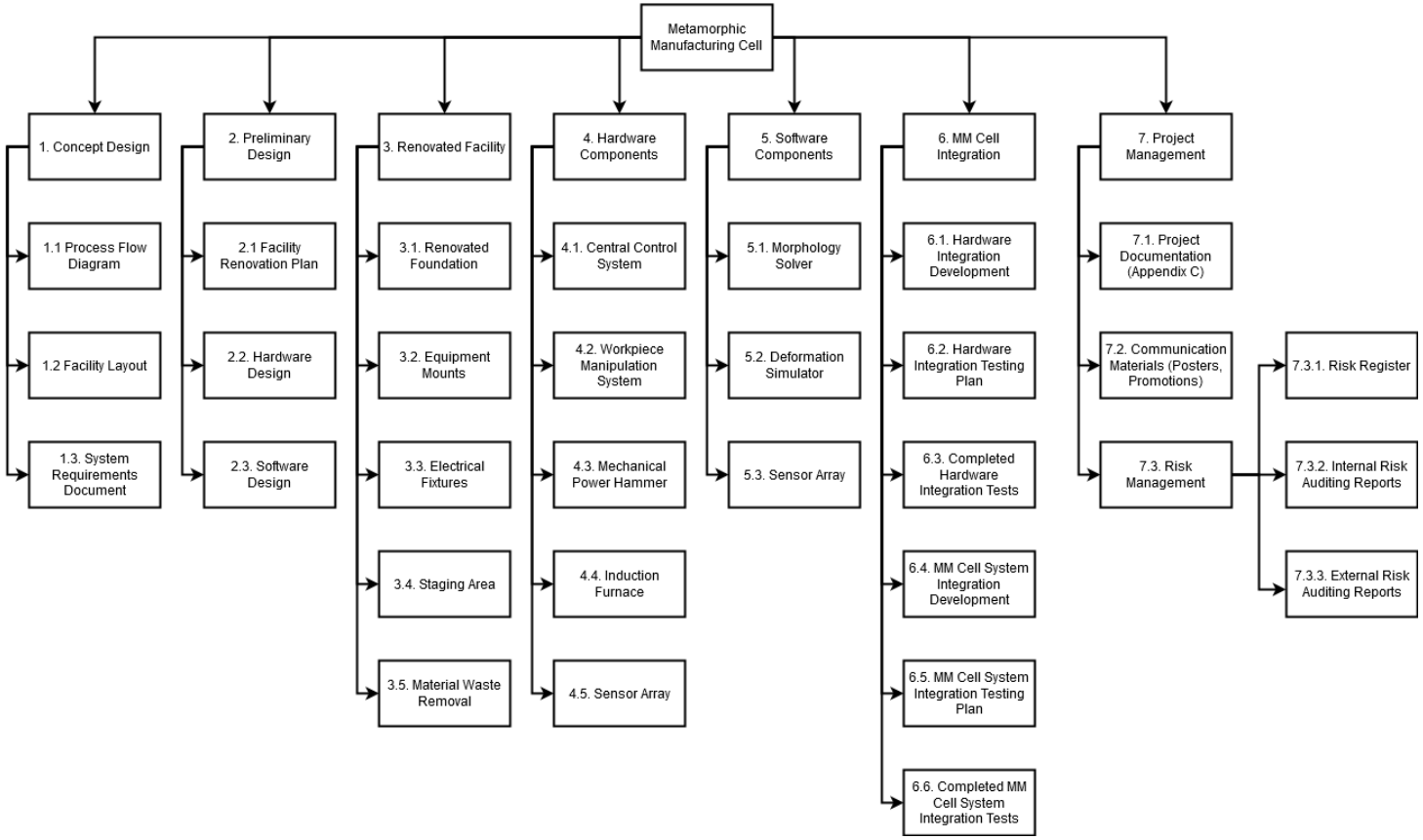

Figure 1 : Work breakdown structure

[3] [1]

4 Cost & Time Estimation

Table 1 presents a summary of the Project Cost and Duration estimates. The full breakdown for each of the work packages can be seen in Appendix H.

WBS Deliverables	Working days	HR Cost	Contingency Time Buffer	Contingency Budget	Material Cost	Total Cost
1. Concept Design	40	$49,046.20	-	$5,000.00	-	$54,046.20
2. Preliminary Design	55	$21,072.80	-	-	-	$21,072.80
3. Renovated Facility	103	$15,149.97	-	$2,000.00	$26,700.00	$43,849.97
4. Hardware Components						
4.1 Central Control System	20	$11,146.61	20	$12,500.00	$25,000.00	$48,646.61
4.2 Workpiece Manipulation System	80	$41,059.53	40	$96,500.00	$150,000.00	$287,559.53
4.3 Mechanical Power Hammer	80	$31,759.64	20	$61,500.00	$80,000.00	$173,259.64
4.4 Induction Furnace	80	$31,759.64	-	$27,500.00	$44,000.00	$103,259.64
4.5 Sensor Array	20	$7,311.44	20	$8,561.60	$2,500.00	$18,373.04
5. Software Components						
5.1 Morphology Solver	310	$165,725.91	20	$19,497.60	-	$185,223.51
5.2 Deformation Simulator	310	$155,977.33	20	$14,623.20	-	$170,600.53
5.3 Sensor Array	130	$58,491.50	-	$19,497.60	-	$77,989.10
6. MM Cell Integration	100	$225,674.62	-	$64,500.00	-	$290,174.62
7. Project Management	540	$77,472.73	-	-	-	$77,472.73
		$891,647.91		**$331,680.00**	**$328,200.00**	**$1,551,527.91**

WBS Level 2

WBS Level 3

Table 1 : Time and Estimate of the Project

The contingency budget provided in Table 1 covers both the HR cost and material cost (see Appendix E). The breakdown of the contingency budget is $194,930 for HR cost and $136,750 for material cost. Based on these figures and the ones from the table, the comparison of total cost between HR and Material expenses can be seen in figure below.

The total contingency budget of $331,680 represents 27.20 % of the planned cost which is very likely in complex and innovative projects.

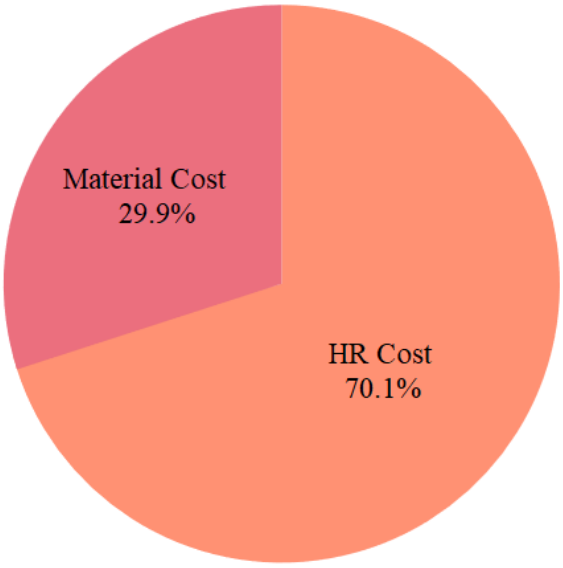

Figure 2 : Comparison between total HR Cost and Material Cost

5 Network Diagram

To describe the relationship between various work packages and examine the flow of activities, a network diagram is included in Appendix B, following the logic specified in Lock, Chapter 14[4]. The precedencies in the Diagram follow the patterns described in Work Breakdown Structure of this document. All durations are listed in working days and aligns with the estimated timeframe set in Cost and Time Estimation.

Notably, the development of the deformation simulator, and to a lesser extent the morphology solver, are critical to ensuring that the project is completed on time, i.e. they lie along the critical path described in Lock Chapter 14[5]. The length of their development also adds a significant cost burden to the completion of the project.

To address this concern, each software component is expected to be developed simultaneously, however, acceptance testing for any individual software component is contingent on the completion of any other component which is more closely integrated to the hardware of the MM cell. Given the experimental nature of the project, software teams will be expected, but not required, to use Agile development to manage the delivery of their respective sub-components.

Other risk events which may potentially affect the schedule are discussed in Appendix D, in the Risks and Opportunities Register.

6 Project Schedule

The project is expected to be finished within 540 working days. A full week is considered as 5 working days where each day represents eight (8) hours of work. The timeline showing the Key Project Milestones is presented in Figure 3, to give an overview of the Project Schedule. A detailed version that shows all work packages involved can be seen in Appendix G and Appendix I.

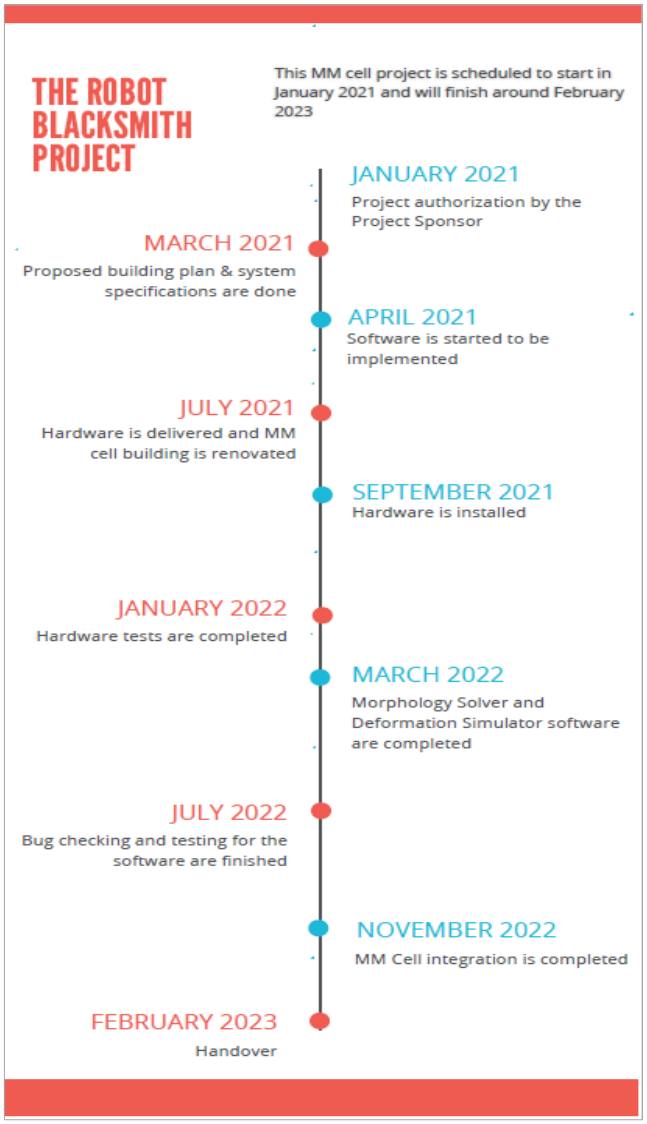

Figure 3 : Project Timeline Overview

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[5] [3]

7 Stakeholder Management and Communication Plan

7.1 Stakeholder Management Plan

7.1.1 Stakeholder Identification

Section 13.2.3.1 of PMBOK® 6th ed[6] presented a structured approach to identify, analyse, and engage stakeholders that directly or indirectly impact the direction, progress, and outcome of the project based on their needs, concerns, interests, influence, and authority. To this end, being able to recognise the right stakeholders for a particular project is critical as their involvement primarily determines the fate of the project. For the MM Cell Project, the Team used iteratively the tools and techniques specified in Section 13.1.2.1 (Expert Judgment) and 13.1.2.2 (Data Gathering) of PMBOK® 6th ed[7] to produce the list of relevant stakeholders by the end of the Planning Phase. This list, is shown in Appendix C: Table 5 and Table 6 which contain the identification information and contact details of each stakeholder, including the nature of their expected involvement in this Project whether Primary (through Project Execution) or Secondary (through the UNSW Strategy) and their current association with UNSW (Internal or External).

7.1.2 Stakeholder Analysis and Engagement

Some of the data analysis tools mentioned in Section 13.1.2.3 of PMBOK® 6th ed[8] were employed to further classify the stakeholders identified in the previous section. Each of the stakeholders was evaluated based on the level of Power (impact of stakeholder to the project) and level of Interest (impact of project to the stakeholder), in relation to the Project. The outcomes were numerically represented from 1 to 5 where 1 is the lowest rating (Very Low) and 5 is the highest rating (Very High). A detailed definition of the different ratings specific for each metric is presented in Appendix C: Table 8.

The two metrics were then considered as the decision criteria in a Decision Matrix shown in Appendix C: Table 9, to identify the stakeholders' engagement levels which were then refined and translated to the four organisational capabilities (see Appendix C: Table 10) for the efficient management of stakeholders. Through this multicriteria analysis, the Project Manager will be able to engage each stakeholder effectively during project execution and in decision making to maximise their individual contributions and meet their specific needs. The analysis and proposed engagement plan for each identified stakeholder is shown in Appendix C: Table 7.

7.1.3 Stakeholder Engagement Monitoring

One of the concepts presented in Chapter 13 of PMBOK® 6th ed[9] about developing the Stakeholder Plan is the iterative nature of the activities involved. A routine checking of the Plan is necessary to capture changes to the stakeholder information which could occur at any point in the Project lifecycle, even during the execution and control phase. Such changes could have significant implications to their project goals or contributions, and thus must be re-examined to adjust, if necessary, the management approach of the concerned stakeholders. For the MM Cell Project, the Stakeholder Management Plan will be checked regularly and updated as often as necessary to maintain the accuracy of the Stakeholder Register and Stakeholder Analysis and Engagement. Where applicable, other sections of the PMP will be revised accordingly to ensure the change is integrated across the PMP. Some of the areas that could be affected are the Stakeholders and Benefits, Communication Plan, Risks Assessment, Project Schedule and Project Cost.

The stakeholder monitoring will be scheduled fortnightly and at every milestone completion which are both in line with the frequency of Risks Audit as part of Risk Response Control. The identification of new risks that relates to stakeholders will be captured in this review process and also through the use of other tools described in Risk

[6] [1]
[7] [1]
[8] [1]
[9] [1]

Identification. Through this constant monitoring and integration, it can promptly address new risks to manage its overall impact to the Project. Similarly, the opportunities arising from the movements in stakeholder power and influence will be aptly exploited to maximise the value-adding capacity of each stakeholder. Any change to the Plan will be subject to the change management process where a change request is required.

7.2 Communication Management Plan

7.2.1 Governance

This Communication Plan is based on the principles presented in 10.1.1 Project Communications Management PMBOK® 6th ed[10] and this document will be the reference in managing and controlling all communication channels to exchange information during the project execution. Through this Plan, the Project aims to deliver, retrieve, or exchange relevant information of the appropriate quality and quantity using different media between and among relevant stakeholders in a timely manner to satisfy the goals of each stakeholder as indicated in Stakeholder Analysis and Engagement, accomplish outcomes presented in the Project WBS and ultimately deliver the Project Objectives.

To have an effective communication trail and efficient use of resources, the Project Manager will be the central point of all communications within the Project and the main conduit between the Project Team and the Organisation (UNSW Community). Additionally, the Project Manager will be accountable for the interactions with external linkages, in coordination with the relevant functional teams of the host organisation.

7.2.2 Project Documents and Communication Management

As shown in in Appendix C: Table 11, the Communication Management Overview of the Project uses some of the communication methods presented in 10.1.2.5 PMBOK® 6th ed[11] which will form part of the Project Management activities to generate the Reporting Documents for this Project (see in Appendix C: Table 12). In reference to 10.2.1.2 Project Documents and 10.2.1.3 Work Performance Reports PMBOK® 6th ed[12], the Project Documents will contain but not limited to details about the activity status, risks, concerns, challenges, and change requests which will be used to produce summary dashboards, project reports, Action Plans, promotional materials, among others.

The communication materials will be shared to all relevant stakeholders (Primary and Secondary) for the purpose of disseminating execution-related information (e.g. reporting), promoting the Project Benefits in relation to the UNSW 2025 Strategic Priorities, gauging movements in the stakeholders' level of support, interest, and influence, requesting for feedback, or inviting for collaboration and partnership. The Project Team will adapt also the 5C Rules in Written Communications and some Communication Skills mentioned in 10.1 PMBOK® 6th ed[13] as additional measure to prevent misunderstandings which could lead to undesirable project outcomes.

In the first few Project Team daily meetings facilitated by the Project Manager, there will be an allocated discussion time for each Work Package (led by a Supervisor) with the whole Team. As the Project progresses, only the highlights and critical updates will be presented. For any issues raised, the Project Manager will retain the relevant members to discuss the details of the raised issue and dismiss the others whose tasks are not related and/or impacted by the incident so they can carry on with their activities. If needed, an emergency meeting can be arranged depending on the resources required, urgency, and criticality of the issue.

7.2.3 Communication Plan Updates

The approach to re-evaluate and update the Communication Plan will be similar to what is discussed in Stakeholder Engagement Monitoring. Before any revisions to any part of Plan is made, a change request will be submitted and subject to the integrated change control process of this Project.

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[10] [1]
[11] [1]
[12] [1]
[13] [1]

8 Human Resource Plan

The Human Resource Plan was developed using Resource Management guide provided within PMBOK[14].

8.1 Identification of resources

The project will use a 6-person project management team for coordination. This was identified using the Schedule and Work Breakdown Structure (WBS). These fixed term contracts are derived using the responsibilities determined within the RACI Chart and aligned with the previously mentioned schedule and WBS. With the exception of the Professional Officer and the Process Engineer, the roles with be a fixed-term 1-year contract. The Process Engineer will have a contract for the life of the project to ensure testing stages are completed and the Professional Officer will be expected to manage the MM Cell on behalf of the school while also continuing industry engagement and undertaking new projects for the school. Further to this team, software engineers will also be hired for delivery of the software systems.

8.2 Acquiring resources

Roles and responsibilities will be provided to UNSW Human Resource who will manage the recruitment process of the project team. Construction and procurement will make use of UNSW's Tenderlink service to obtain the resources necessary for these stages. This reduces risk of workforce sourcing issues however there is room for risk of under-budgeting potential tenders. These potential extra costs were appropriately assessed and where appropriate, have a separate Contingency Budget allocated, based on their risk ratings. There is also the potential for sourcing issues of the project team so recruitment should begin by October 2020, to ensure more than ample time to mitigate this risk. A full list and more detailed discussion of HR-related risks is covered within the Risk Management Plan.

8.3 Organisational Chart

The organisational chart in Figure 4 sets out the clear hierarchy required for the project. This will minimise conflicts over authority and help ease decision making.

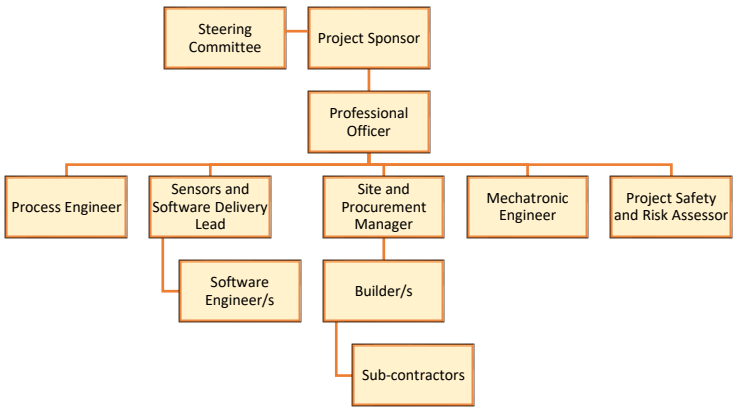

Figure 4: Organisation Chart

8.4 Roles and responsibilities

Authority for each role is detailed within the RACI Chart in Table 5.

8.4.1 Process Engineer

Position: Full-Time. **Duration:** 1.75 years. **Grade:** 5. **Salary/Rate:** A$84,967. **Responsibilities:** The successful candidate will develop, configure, and optimize the industrial processes related to the MM Cell from inception through to certification. This includes the designing, running, testing, and upgrading of any and all systems and processes. In doing

[14] [1]

this, they will need to ensure they manage cost and time constraints and provide process documentation and instructions. **Competence:** The successful candidate will have 5+ years of relevant experience including in process simulations, excellent technical skills, and knowledge of process related standards. They will have a strong familiarity with Australian and NSW Health and Safety Regulations. It is expected they are degree qualified or are suitably certified to match their experience.

8.4.2 Sensors and Software Delivery Lead

Position: Full-Time. **Duration:** 1 year. **Grade:** 7. **Salary/Rate:** A$105,650. **Responsibilities:** The successful candidate will coordinate and manage the software development process using Agile methodologies. They will also coordinate and manages the sensor development and installation process. **Competence:** The successful candidate will have excellent technical skills and proven experience managing agile software projects. They will also be familiar with hardware system design and integration with experience to match. The role will require the successful candidate to be an analytical thinker who can successfully manage a small team. To complement the Agile experience, they should have matching qualifications. As the lead, they should have 2+ years of leading similar teams and 8+ years industry experience.

8.4.3 Site and Procurement Manager

Position: Full-time. **Duration:** 1 year. **Grade:** 6. **Salary/Rate:** A$96,316. **Responsibility:** The successful candidate will ensure that construction is completed on time and within budget. To do this, they will need to oversee the direction of the project by ensuring that specifications and requirements are being met while coordinating and supervising construction workers. They will also need to assist the professional officer to negotiate contracts, secure necessary permits and leases, and devise fruitful procurement and sourcing strategies. **Competence:** The successful candidate will have 5+ years relevant experience with proven knowledge of sourcing and procurement techniques. It would be beneficial if they also had a passion and dexterity for “reading” the market. To support their experience, they will need to be talented in negotiations with an aptitude for decision-making and working with numbers. Due to the variable size of their team during the life of the project they will demonstrate strong leadership capabilities in the context of construction management.

8.4.4 Professional Officer

Position: Full-time. **Duration:** Ongoing. **Grade:** 8. **Salary/Rate:** A$118,122. **Responsibility:** The successful candidate will be performing a split role comprised of managing this project and performing wider industry engagement on behalf of the School and UNSW. They will primarily be responsible for providing expert advice to all stakeholders on the efficient use of the MM Cell while driving a culture of continuous improvement by leading the evaluation of the MM Cell infrastructure, service delivery and training. This will include providing innovative solutions to improve systems, procedures, and protocols of the MM Cell. Their secondary role will be to ensure the successful delivery of the project. In doing so, this will position them to successfully fulfil the primary role. To do this, they will need to lead project planning sessions, coordinate staff and internal resources, manage project progress and adapt work as required through use of stage gates and iterative methods. Crucially, they will need to manage and maintain relationships with all stakeholders and to successfully engage with industry by coordinating research agreements and partnerships. Upon the successful completion of the project, they will also conduct a project review and consolidate all project documentation. **Competence:** The successful candidate will hold a degree in Engineering, Physics, Electronics, Computer Control Instrumentation or similar, or an equivalent level of knowledge gained through any other combination of education, training and/or experience. They will have demonstrated experience in providing technical support and expertise in teaching laboratories, extensive experience developing, managing, and implementing Health and Safety processes and procedures in laboratories and in undertaking risk assessments. To complement this, they will have demonstrated experience with mechanical systems as well as basic mechanical and electrical workshop skills. They will also need to have a demonstrated ability to effectively supervise a small team of staff, providing leadership and direction, with a commitment to continuous improvement through long-term planning. Finally, they should have demonstrated success in managing high level technical projects and in developing online

educational resources with a demonstrated ability in the provisioning of support and advice to researchers and students on the technical aspects of laboratories.

8.4.5 Mechatronic Engineer

Position: Full-time. **Duration:** 1 year. **Grade:** 5. **Salary/Rate:** A$84,967. **Responsibility:** The successful candidate will design, develop, and enhance electro-mechanical systems and mechatronic devices by creating automated systems and the software to control them. This will require developing design documents for mechanical parts and final products as well as selecting the required tools and materials for the manufacturing process. **Competence:** The successful candidate will hold a degree in Engineering, Physics, Electronics, Computer Control Instrumentation or similar, or an equivalent level of knowledge gained through any other combination of education, training and/or experience. They should have relevant experience that demonstrates strong mathematical, analytical, and creative thinking skills. This role will require someone who has the ability to work in a team or alone with a focus on attention to detail.

8.4.6 Project Safety and Risk Assessor

Position: Full-time. **Duration**: 1 year. **Grade:** 5. **Salary/Rate:** A$84,967. **Responsibility:** The successful candidate will conduct the continuous inspection of the project site, to ensure a hazard-free environment, conduct the assessments and approvals of subcontractor safety plans and promote safe work practices on site. They will need to provide verification of tools and equipment to ensure good quality, create and enforce safety guidelines and programs, carry out drills and exercises on managing emergency situations, conduct investigations on accidents, verify that all safety reports are submitted to related government institutions and respond to workers' safety concerns. Finally, they will need to establish and maintain health and safety communication structures that are aligned to UNSW's safety policy and procedures. **Competence:** The successful candidate will have 5+ years of experience in the running of high level OH&S Management systems, demonstrated experience arranging OSHA-mandated evaluations of the site and experience and competencies in hazard Identification, and risk management. They should also be familiar with the requirements of maintaining an accredited system in line with ISO 90001 Quality and ISO 14001 Environmental Standard. Relevant accreditations will be looked upon favourably.

8.4.7 Software Engineer

Position: Full-time. **Duration**: 1 year. **Grade**: 6. **Salary/Rate**: A$96,316. **Responsibility**: The successful candidate will be required to assist with the development of the software implementation within an Agile environment. They will need to constantly enhance the system applications by developing standard operating procedures, identifying opportunities for improvement, making recommendations, and designing and implementing all recommended changes. This will require the maintenance of codebases and peer reviewing code changes while liaising with colleagues to implement technical designs and investigating and using new technologies where relevant. On conclusion, they will provide a written knowledge transfer document. **Competence:** The successful candidate will be a degree qualified software engineer or hold an equivalent level of knowledge gained through any other combination of education, training and/or experience. They should have a passion for solving problems and providing workable solutions using their knowledge of algorithms and data structures. They will have worked experience within an Agile environment using their strong analytical and reasoning skills to visualise processes and outcomes from conception to implementation. This will require a demonstrated proficiency in troubleshooting software issues and debugging a large codebase with previous experience with robotics being favourable.

8.5 Team development and Training Strategies

The team will be provided with access to UNSW's library of learning resources such as LinkedIn Learning which they can complete at their leisure. In addition, opportunities to attend conferences will also be provided. This will be arranged by the Professional Officer who will also determine conference suitability using their industry engagement knowledge.

UNSW HR have been provided with a detailed role and responsibility expectation for each role. This eliminates the need for any additional training to be undertaken to bring a team member up to speed. If further training is identified by the Professional Officer that can facilitate a better outcome, this will be conducted at the sponsors discretion using funds from the contingency budget.

8.6 RACI Chart

Deliverable	Project Manager	Process Engineer	Sensors and Software Delivery Lead	Site and Procurement Manager	Mechatronic Engineer	Project Safety and Risk Assessor	Software Engineer
Concept Design	**C**	**A**	**R**		**R**	**C**	
Preliminary Design	**C**	**A**	**R**	**I**	**R**	**C**	**I**
Hardware Components	**I**	**C**	**C**	**C**	**A**	**I**	**I**
Software Components	**I**	**C**	**A**	**C**	**C**	**I**	**R**
MM Cell Integrations	**I**	**A**				**I**	
Project Management	**A**						

Table 2: RACI Chart

Key:
R – Responsible for completing the work
A – Accountable for ensuring task completion/sign off
C – Consulted before any decisions are made
I – Informed of when an action/decision has been made

8.7 Recognition plan

The objective of this project is to deliver an innovative technological facility and as such, successful completion allows for increased notoriety of project team members through research publications. Further, this is an incredibly relevant recognition for the Professional Officer. To assist with the drafting of these publications, the following will be made available by the project sponsor:

- Upon successful completion of the project, any team member who satisfactorily completed all assigned work packages on time will receive a certificate of thanks from the UNSW Executive team at a dedicated ceremony,
- Team members who successfully complete all of their assigned tasks will have their photo taken at the ceremony for inclusion in external and internal publications,
- All publications upon the launch of the facility will reference the project team and their success.

9 Risk Management Plan

9.1 Overview

For most of the projects, having tasks which are not completed in the planned duration and budgets are almost inevitable[15]. Hence it is critical to develop a risk management plan to "identify, evaluate, respond to, monitor and report of the risks"[16]. This Risk Management Plan will follow the process recommended in the PMBOK to outline how risks will be assessed and managed for the MM cell project. This Risk Management Plan is prepared following the process of risk management planning, risk identification, risk assessment, risk response development, and risk response control. The detailed risk management approach is presented in the Appendix J.

9.2 Prioritized Risks and Response Strategies

Based on the management approach indicated in Appendix J, a risk register has been developed for this Project and presented in Appendix D of this report. In this section, the 10 Risks Events with the highest risk values are presented, including their proposed response strategies, in Table 3 which is shown in the next two pages. It is recommended that the following are to be read in conjunction with Work Breakdown Structure, Cost and Time Estimation, Project Schedule, and Time-Phased Budget.

9.3 Risk Response Control

Key risk response controls include constant monitoring, control, and improvement. New, changing, and outdated risks should be continuously recorded and reported[17]. It is hence recommended to:

i. Conduct internal risk audits every fortnight, or when proposed by project key stakeholders.
ii. Conduct external risk audits at key milestones or when steering committee believe necessary.
iii. Update Project Risks and Opportunities Register (Appendix D) accordingly.
iv. Process Project Change Order Request, if necessary, to set up corrective and preventive measures as part of the Performance Integrated Change Control process[18].

[15] [3]
[16] [4]
[17] [1]
[18] [1]

Task ID.	Risk event	Risk owner	Impact	Likelihood	Severity	Risk value	Response management strategies	Mitigation	Contingency plan
4.1.2 4.2.2 4.3.2 4.4.2	Vendor offers are higher than expected	Project team	Affects project scope	4	5	20	Mitigate	More than two cost estimating methods are used for accurate estimation and contingencies are included in the project budget	Escalate to the project sponsor and provide details of scope changes, if any are required, through change request form
4.1.4 4.2.4 4.3.4 4.4.4	Delays in procurement of robotic arms, furnace, power hammer or central control system	Project team	Project delays	3	4	12	Transfer	Add time buffers and order at an early stage Include late penalties in the supplier's contract	
4.2.6	Robot fails commissioning tests	Project team	Project delays	4	3	12	Mitigate	Time buffers are included the schedule so that additional tests can be performed to debug robot faults	Redo tests
6.6	MM cell system fails the test	Project team	Delays the project	3	4	12	Mitigate	Time buffers are included in the schedule so that additional tests can be performed to debug system faults	Redo test
1.3	System requirements documents not detailed enough	Project team	Project delays and affects project quality	2	5	10	Mitigate	Comprehensive system requirements should be drafted which will be reviewed by the expert committee	Escalate to the project sponsor and provide details of scope changes, if required, through change request form
2.1.1	Missing key specification requirements in request for proposal (RFP) for facility renovation	Project team	Affects project quality, scope, and delays project	2	5	10	Mitigate	Strong specification requirements should be drafted for the facility renovation RFP which will be reviewed by the expert committee	Escalate to the project sponsor and provide details of scope changes, if required, through change request form

Task ID.	Risk event	Risk owner	Impact	Likelihood	Severity	Risk value	Response management strategies	Mitigation	Contingency plan
2.1.2	Bid documents received does not meet the requirements of the renovation project in terms of cost or specification	Project team and sponsor	Affects project quality, scope, and delays project	2	5	10	Active acceptance		Review renovation RFP and work on contract terms with the short-listed tenderers
3.1	Facility renovation is more complex than expected requiring additional resources	Project team	Affects project quality and delays project	2	5	10	Transfer	Contractor should be allowed to do a comprehensive site assessment before their bid submission and include that contractor shall bear the cost of any additional materials or equipment required to complete the renovation in the contract	
3.5	Unforeseen material waste clean-up cost	Project team	Affects project scope and budget	3	3	9	Transfer	Include the clean-up cost as part of contractor's bid submission	
5.1.3 5.2.3 5.3.4	Critical bugs and system errors are found during the implementation of morphology solver, deformation simulation and sensor array	Project team	Delays the project	2	4	8	Mitigate	Time buffers are included, and a thorough software test plan is drafted which will be reviewed by the expert committee	Work around the critical bugs and system errors and keep project sponsor updated. Change project end date, if necessary, through change request form

Table 3: Prioritised Risk Register (Showing top 10 risks only)

Other project risks identified together with their mitigation strategies or contingent actions are included in Appendix D.

10 Time-Phased Budget

The allowed project budget (Planned Value) against the project duration is demonstrated in Figure 5, with the detailed figures demonstrated in Table 4 below. From the figure, it is shown that approximately one-fifth of the project budget will be spent in the first 1/3 of the project duration (9 month), while majority of the project planned value occurred in the 2nd tertile of the estimated project time.

Reference can be made to Work Breakdown Structure, Cost and Time Estimation and Project Schedule for more details.

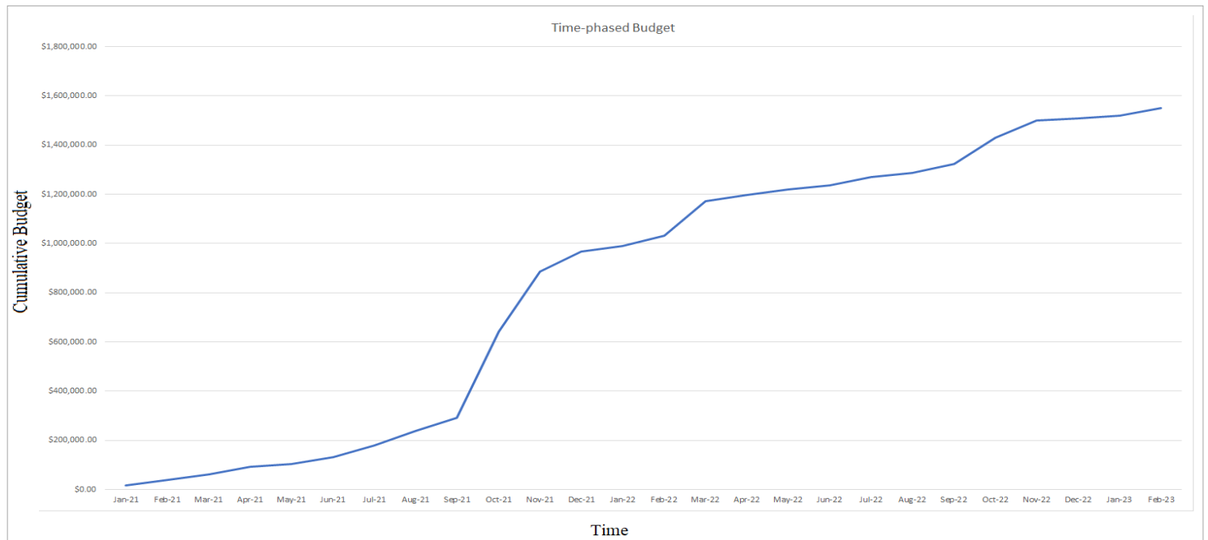

Figure 5: Planned Value of Project over Time

Table 4: Project Cost Breakdown with respect to Time

Work Packages	Cost	Jan-21	Feb-21	Mar-21	Apr-21	May-21	Jun-21	Jul-21	Aug-21	Sep-21	Oct-21	Nov-21	Dec-21	Jan-22	Feb-22	Mar-22	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Jan-23	Feb-23
1.1 - Process Flow Diagram	$5,346.66	$5,346.66																									
1.2 - Facility Layout	$10,000.00	$10,000.00																									
1.3 - System Requirements Document	$38,699.54		$19,349.77	$19,349.77																							
2.1.1 - Facility Renovation RFP	$2,149.97				$2,149.97																						
3.4.1 - Staging Area Equipment RFQ	$2,149.97				$2,149.97																						
4.1.1 - Central Control System RFQ	$2,149.97				$2,149.97																						
4.2.1 - Robotic Workpiece Manipulation System RFQ	$2,149.97				$2,149.97																						
4.3.1 - Mechanical Power Hammer RFQ	$2,149.97				$2,149.97																						
4.4.1 - Induction Furnace RFQ	$2,149.97				$2,149.97																						
2.2.1 - Sensor Array Schematic	$4,874.29				$4,874.29																						
4.5.1 - Sensor Array RFQ	$2,149.97					$2,149.97																					
2.1.2 & 3.4.2 - Facility renovation agreement & staging area document	$4,299.95						$2,149.97	$2,149.97																			
4.1.2 & 4.2.2 - Control System & Workpiece Manipulation system contract documents	$4,299.95						$2,149.97	$2,149.97																			
4.3.2 & 4.4.2 - Power Hammer & Induction forge contract documents	$4,299.95						$2,149.97	$2,149.97																			
4.5.3 - Sensor Array procurement contract	$4,299.95							$2,149.97	$2,149.97																		
5.3.1 - Sensor Array Software Design	$4,874.29					$4,874.29																					
5.3.2 & 5.3.3 - Sensor Array Software Implementation & Testing Plan	$29,245.75								$9,748.58	$9,748.58	$9,748.58																
2.3.1 - Morphology Solver Software Design	$4,874.29				$4,874.29																						
2.3.2 - Deformation Simulator Schematic	$4,874.29				$4,874.29																						
5.1.1 & 5.1.2 - Morphology Solver Software Implementation & Testing Plan	$121,857.40						$10,154.78	$10,154.78	$10,154.78	$10,154.78	$10,154.78	$10,154.78	$10,154.78	$10,154.78	$10,154.78	$10,154.78	$10,154.78	$10,154.78									
5.2.1 & 5.2.2 - Deformation Simulator Software Implementation & Testing Plan	$116,983.00						$9,748.58	$9,748.58	$9,748.58	$9,748.58	$9,748.58	$9,748.58	$9,748.58	$9,748.58	$9,748.58	$9,748.58	$9,748.58	$9,748.58									
5.2.3 - Deformation Simulator Software Simulated Testing	$29,246.07																		$14,623.04	$14,623.04							
5.1.3 - Morphology Solver Software Simulated Testing	$29,246.07																			$14,623.04	$14,623.04						
3.1 - Renovated Foundation	$28,000.00							$14,000.00	$14,000.00																		
3.3 - Electrical Fixtures Installed	$2,500.00									$2,500.00																	
3.2 - Equipment Mounts Installed & Cleaning	$1,500.00									$1,500.00																	
6.2, 4.2.5, 4.3.5, 4.4.5 - Hardware Integration, Workpiece Manipulation System, Mechanical Power Hammer, Induction Furnace Testing Plan	$20,639.76								$10,319.88	$10,319.88																	
3.4.4 - Installed Staging Area Equipment	$13,700.00									$6,850.00	$6,850.00																
4.1.4 - Installed Central Control System	$42,846.66										$42,846.66																
4.2.4 - Installed Robotic Workpiece Manipulation System	$250,799.85										$250,799.85																
4.3.4 - Installed Power Hammer	$145,799.85											$145,799.85															
4.4.4 - Installed Induction Furnace	$75,799.85											$75,799.85															
4.5.4 - Installed Sensor Array	$18,373.04										$18,373.04																
5.3.3 - Sensor Array Calibration	$4,874.29												$4,874.29														
4.2.6 - Robotic Workpiece Manipulation System Tests Completed	$17,199.90												$17,199.90														
4.3.6 - Power Hammer Tests Completed	$17,199.90												$17,199.90														
4.4.6 - Induction Furnace Tests Completed	$17,199.90												$17,199.90														
5.3.4 - Sensor Array Testing	$38,994.34														$19,497.17	$19,497.17											
6.3 - Hardware Component Tests Complete	$99,162.73															$99,162.73											
6.4 & 6.5 - MM Cell System Integration Development & Live Testing	$69,362.40																					$34,681.20	$34,681.20				
6.6 - MM Cell System Integration Testing	$133,862.40																						$66,931.20	$66,931.20			
5.1.4 - Morphology Solver Software Live Testing	$14,622.87																								$7,311.44	$7,311.44	
5.1.5 & 5.2.5 - Deformation Simulator & Morphology Solver Software Release Version	$29,245.75																										$29,245.75
Salary of Project Manager (Professional Officer)	$77,472.73	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72	$2,979.72
Total	$1,551,528.00	$18,326.38	$22,329.49	$22,329.49	$30,502.44	$10,003.99	$29,333.01	$45,482.99	$59,101.52	$53,801.55	$351,501.21	$244,482.78	$79,357.07	$22,883.09	$42,380.25	$141,542.98	$22,883.09	$22,883.09	$17,602.76	$32,225.79	$17,602.76	$37,660.92	$104,592.12	$69,910.92	$10,291.16	$10,291.16	$32,225.44
Cumulative		$18,326.38	$40,655.87	$62,985.37	$93,487.81	$103,491.80	$132,824.81	$178,307.79	$237,409.31	$291,210.86	$642,712.08	$887,194.86	$966,551.93	$989,435.02	$1,031,815.27	$1,173,358.26	$1,196,241.34	$1,219,124.43	$1,236,727.19	$1,268,952.98	$1,286,555.74	$1,324,216.66	$1,428,808.78	$1,498,719.70	$1,509,010.86	$1,519,302.01	$1,551,527.91

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[6] University of Queensland, Australia, Enterprise Risk Matrix, Brisbane, QLD: University of Queensland, 2019.

12 Appendix A Work Breakdown Structure

12.1 Design Process

Taking elements from the engineering design process, the project will undergo multiple stages of design, with each step representing increasing levels of detail. The MM cell's conceptual design will be created by the project management team and is intended to serve as a focal point for all design decisions as the project progresses and should include detailed descriptions of the specifications required for each component. The conceptual design is then passed on to specialists, sourced externally for the facility renovation, and internally for all other academically focused aspects of the project. Each specialist category is then required to produce a preliminary design describing a detailed solution according to their project component before they can proceed with any further work.

12.2 Facility Renovation

The facility renovation will be undertaken by an external contractor. The contractor will be determined through a bidding process, coursed through UNSW's Strategic Procurement Team. As part of the bidding process, contractors will be required to submit a detailed solution that aligns with the system requirements.

12.3 Hardware Procurement

The acquisition of each major hardware component is coursed through UNSW's Strategic Procurement Team. Following its procurement, each component is required to go through testing, both to ensure that the product is delivered without defects, and to measure each component's capabilities for use in the simulated environment.

It is generally assumed that all the equipment will be bought off-the-shelf, with any further modifications being conducted by researchers as extensions to the MM cell. Such extensions are not covered under the scope of this project.

All hardware components procured are expected to meet the system requirements of the project. However, detailed development and planning regarding their integration will begin only once procurement documents have been signed for all components.

12.4 Software Development

Because of the highly specialized nature of each software sub-deliverable in this project, each software component described in the Scope Statement will be developed by separate teams with experience in the fields related to their respective deliverables.

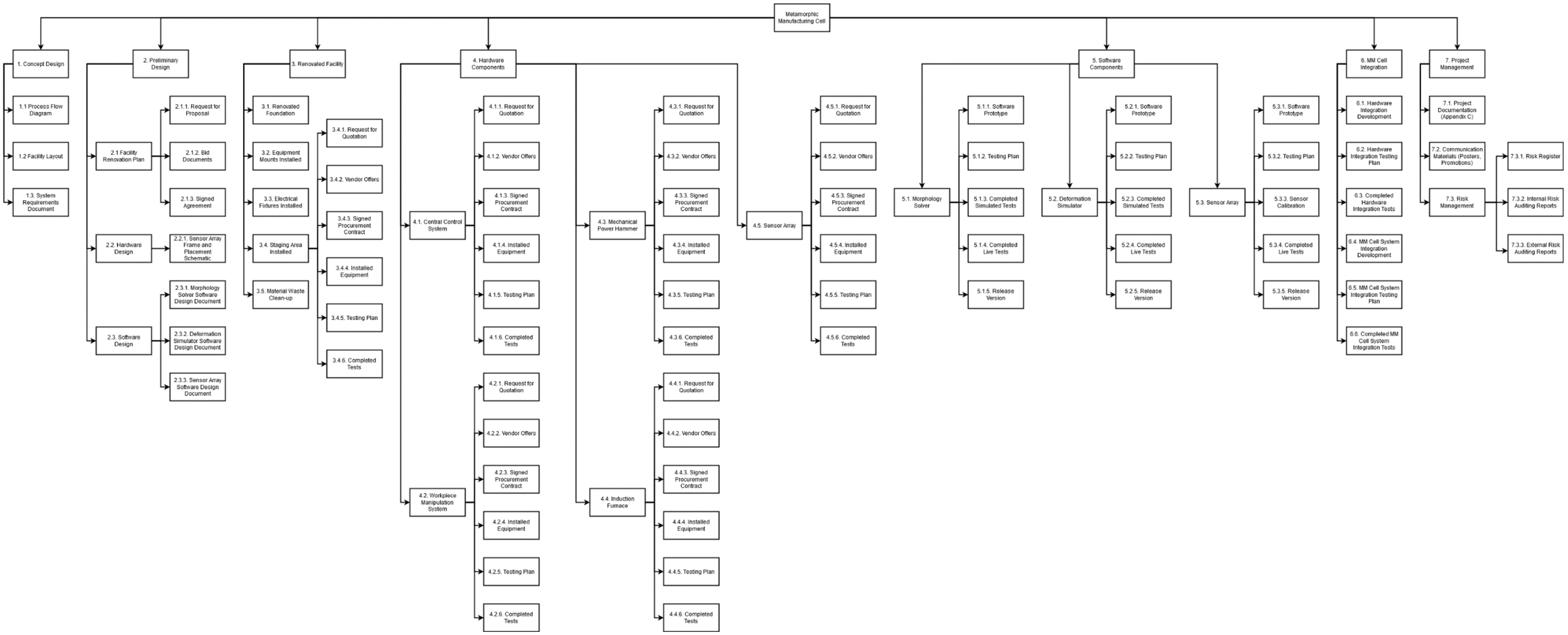

Figure 6 : Work Breakdown Structure (WBS)

13 Appendix B Project Network Diagram

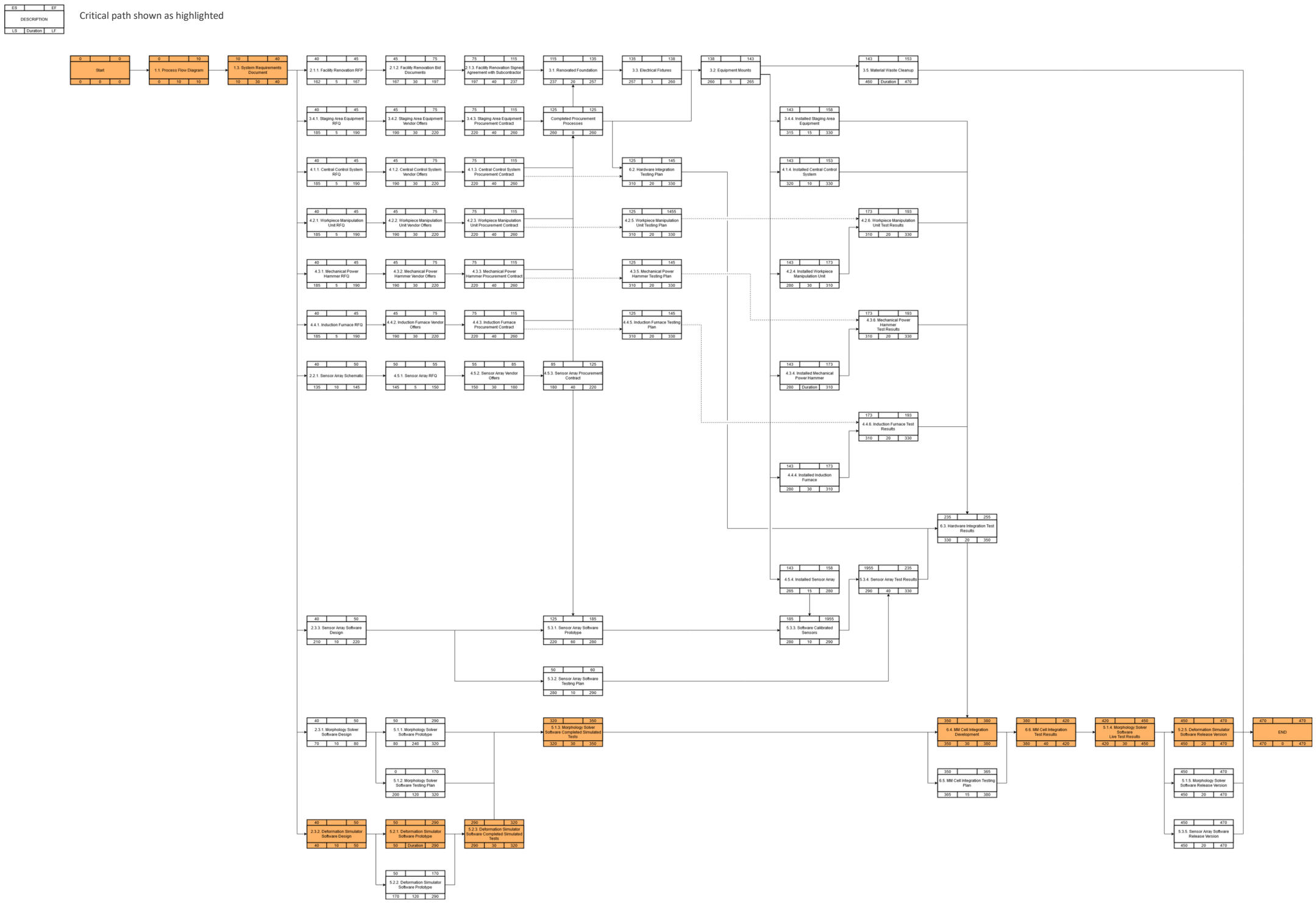

Figure 7: Network Diagram Schedule

14 Appendix C Stakeholder and Communication Management

STAKEHOLDER REGISTER

Stakeholder Name	Current Role	Project Role	Project Involvemer	UNSW Associatio	Organisation	Contact Details			Additional Notes	Latest Comms	Next Comms
						Email	Phone	Preferred Metho			
Dr. Xiaopeng Li	School of MME Senior Lecturer	Project Sponsor and Head of Steering Committee	Primary	Internal	UNSW	xiaopeng.li@unsw.edu.au	+61 2 9385 6784	Email	By appointment through email	*(enter date)*	*(enter date)*
Professor Chun Hui Wang	Head of School of MME	Member of the Steering Committee (Consultant)	Primary	Internal	UNSW	chun.h.wang@unsw.edu.au	+61 2 93853232	Email	when needed, by appointment through email	*(enter date)*	*(enter date)*
Dr. Tamsin Peters	MME Laboratory Manager	Member of the Steering Committee (Consultant)	Primary	Internal	UNSW	tamsin.peters@unsw.edu.au	+61 413 565 722	Email	when needed, contact during work hours only	*(enter date)*	*(enter date)*
Greg Kaplan	Facilities Management Director	Member of the Steering Committee (Consultant)	Primary	Internal	UNSW	greg.kaplan@unsw.edu.au	+61 2 9385 5111	Email	when needed, provide at least a day notice	*(enter date)*	*(enter date)*
Tim Neems	Finance Business Partner	Member of the Steering Committee (Consultant)	Primary	Internal	UNSW	tim.neems@unsw.edu.au	+61 435 200 335	Mobile and Email	when needed, provide at least a day notice	*(enter date)*	*(enter date)*
Jessica Leau	Professional Officer	Project Manager and PM Team Lead	Primary	Internal	UNSW	jessica.leau@unsw.edu.au	+61 xxx xxx xxx	Mobile and Email	Contact mobile no. for urgent matters	*(enter date)*	*(enter date)*
Project Management Team	See Table 6	See Table 6	Primary	Internal	UNSW	See Project Management Team	See Table 6	Mobile and Email	Contact mobile no. for urgent matters	*(enter date)*	*(enter date)*
Suppliers	N/A	Contractual (Equipment and Materials)	Primary	External	Private Companies	Contact details to be updated after Award of Business (Tender Process)				*(enter date)*	*(enter date)*
Builders/ Construction Workers	N/A	Contractual	Primary	External	Private Companies	Contact details to be updated after Award of Business (Tender Process)				*(enter date)*	*(enter date)*
Software Engineers and Designers	N/A	Contractual - To be Tendered	Primary	External	Private Companies	Contact details to be updated after Award of Business (Tender Process)				*(enter date)*	*(enter date)*
2025 UNSW Strategic Piorities Program Office		Promotes Project in line with UNSW Strategy	Secondary	Internal	UNSW	Contact through unsw2025@unsw.edu.au or call +61 2 9385 1000				*(enter date)*	*(enter date)*
Current UNSW Students (Undergraduate and Postgraduate)		Project Supporter/Collaborator (UNSW Strategy)	Secondary	Internal	UNSW	Contact directly via email or through the relevant School, Department, or Faculty				*(enter date)*	*(enter date)*
Future UNSW Students		Project Supporter/Collaborator (UNSW Strategy)	Secondary	Internal	UNSW	Contact through UNSW Global				*(enter date)*	*(enter date)*
UNSW Research Staff		Project Supporter/Collaborator (UNSW Strategy)	Secondary	Internal	UNSW	Contact directly via email or through the relevant School, Department, or Faculty				*(enter date)*	*(enter date)*
UNSW Teaching Staff		Project Supporter/Collaborator (UNSW Strategy)	Secondary	Internal	UNSW	Contact directly via email or through the relevant School, Department, or Faculty				*(enter date)*	*(enter date)*
UNSW Alumni		Project Supporter/Collaborator (UNSW Strategy)	Secondary	External	UNSW (Affiliated)	Contact through UNSW Alumni and Engagement (Jane Miller - jane.miller@unsw.edu.au)				*(enter date)*	*(enter date)*
Manufacturing Industry		Project Supporter/Collaborator (UNSW Strategy)	Secondary	External	Private Companies	Contact through UNSW Media & Content (Monica Melki - m.melki@unsw.edu.au) or directly through their websites				*(enter date)*	*(enter date)*
Partner Universities		Project Supporter/Collaborator (UNSW Strategy)	Secondary	External	Academe	Contact through UNSW Media & Content (Monica Melki - m.melki@unsw.edu.au) or directly through their websites				*(enter date)*	*(enter date)*
Government Agencies and non-Government Organisations		Project Supporter/Collaborator (UNSW Strategy)	Secondary	External	AU Government	Contact through UNSW Media & Content (Monica Melki - m.melki@unsw.edu.au) or directly through their websites				*(enter date)*	*(enter date)*
Local Community		Project Promoter/Collaborator (UNSW Strategy)	Secondary	External	Public Sector	Contact through UNSW Media & Content (Monica Melki - m.melki@unsw.edu.au) or directly through their websites				*(enter date)*	*(enter date)*
Members of the Press/Media		Project Promoter/Supporter (UNSW Strategy)	Secondary	External	Media Companies	Contact through UNSW Media & Content (Monica Melki - m.melki@unsw.edu.au) or directly through their websites				*(enter date)*	*(enter date)*
*The names, roles, affiliations and contact information that appear in this table are used for academic purposes only and not to be contacted for this Project.											

Table 5: Stakeholder Register

PROJECT MANAGEMENT TEAM

Team Members	Project Role	Organisation / Affiliation	Contact Details		
			Email	Phone	Preferred Method
*Jessica Leau	Project Manager / PM Lead	University of New South Wales (UNSW)	jessica.leau@unsw.edu.au	+61 xxx xxx xxx	Mobile for urgent matters
*Mark Saturnino	Process Engineer	University of New South Wales (UNSW)	mark.saturnino@unsw.edu.au	+61 xxx xxx xxx	Mobile for urgent matters
*Rafael Formoso	Sensors and Software Delivery Lead	University of New South Wales (UNSW)	rafael.Formoso@unsw.edu.au	+61 xxx xxx xxx	Mobile for urgent matters
*Joel Lawrence	Site and Procurement Manager	University of New South Wales (UNSW)	joel.Lawrence@unsw.edu.au	+61 xxx xxx xxx	Mobile for urgent matters
*Ramon	Mechatronic Engineer	University of New South Wales (UNSW)	ramon@unsw.edu.au	+61 xxx xxx xxx	Mobile for urgent matters
*Ningye Zhang	Project Safety and Risk Assessor	University of New South Wales (UNSW)	ningye.Zhang@unsw.edu.au	+61 xxx xxx xxx	Mobile for urgent matters
*The Project Management Team Members went through the standard UNSW Recruitment Process and were selected after careful and objective evaluation of their qualifications against the Competencies for each role. The details of the Competencies is covered in Section 8.4 of the Human Resource Plan.					

Table 6: Members of the Project Management Team

STAKEHOLDER ANALYSIS and MANAGEMENT OVERVIEW

Identified Stakeholder	Power	Interest	Project Goals	Stakeholder Contribution	Engagement Level	Organisational Capabilities	Action Plan
Project Sponsor	5	4	Steer the Scope and provide Resources	Authorise changes to scope	Empower	Maintain Engagement	Progress reports and daily project health status
Head of MME School	3	5	Objectives are satisfied	Assist the PM in decision-making	Collaborate	Maintain Engagement	Always keep in the loop and engage for solutions
MME Laboratory Manager	2	3	Meet UNSW Laboratory Standards	Work with the Project Team for the Standards	Consult	Meet their Needs	Get in-depth input up front and check from time to time
Facilities Management Director	2	3	Meet UNSW Facilities Development Guideline	Work with the Project Team for the Guidelines	Consult	Meet their Needs	Get in-depth input up front and check from time to time
Finance Business Partner	3	2	Ensures procurement process is done on time and within budget	Assist in Procurement Process with the UNSW Purchasing Team	Consult	Meet Their Needs	Get in-depth input up front and check from time to time
Project Manager (Professional Officer)	4	5	Project in control - Budget, Schedule, Deliverables	Lead Project Team and liaise with other Stakeholders	Empower	Maintain Engagement	First Point of Contact for all Project-related concerns
Project Management Team	3	5	Complete Milestones and ensure PM is always satisfied	Remove barriers, escalate concerns, reporting duties	Collaborate	Maintain Engagement	Provide resources, check dynamics, and track project status regularly
2025 UNSW Strategic Piorities Program Office	1	4	Project Outcomes to promote UNSW 2025 Strategic Priorities	Strategy Driver and Project Awareness Enabler	Inform	Manage Expectations	Keep informed, ask suggestions, and engage in opportunities for Project promotions
Partner Suppliers	2	3	Tender to meet the required specification, duration, budget	Support sponsor in decision-making	Consult	Meet Their Needs	Get in-depth input up front and check from time to time
Contracted Builders	2	2	Complete the Work Packages as specified	Provide progress, escalate concerns and required resources	Inform	Manage Expectations	Align goals and manage understanding up front and track WP status regularly
Contracted Software Engineers and Designers	2	2	Complete the Work Packages as specified	Provide progress, escalate concerns and required resources	Inform	Manage Expectations	Align goals and manage understanding up front and track WP status regularly
Current UNSW Students	1	2	no direct goal associated with this stakeholder	Potential Project Supporter/Collaborator	Monitor	Monitor Perception	Inform via general communications and monitor general perception of Project
Future UNSW Students	1	2	no direct goal associated with this stakeholder	Potential Project Supporter/Collaborator	Monitor	Monitor Perception	Inform via general communications and monitor general perception of Project
UNSW Research Staff	2	3	Express Interest or Concerns and plan for future projects	Involvement in some low risk areas	Consult	Meet Their Needs	Consult on key interest areas and project expectations relating to future plans
UNSW Teaching Staff	1	2	no direct goal associated with this stakeholder	Potential Project Supporter/Collaborator	Monitor	Monitor Perception	Inform via general communications and monitor general perception of Project
UNSW Alumni	1	1	no direct goal associated with this stakeholder	Potential Project Supporter/Collaborator	Monitor	Monitor Perception	Inform via general communications and monitor general perception of Project
Manufacturing Industry	1	1	no direct goal associated with this stakeholder	Potential Project Supporter/Collaborator	Monitor	Monitor Perception	Inform via general communications and monitor general perception of Project
Partner Universities (Local and International)	1	2	no direct goal associated with this stakeholder	Potential Project Supporter/Collaborator	Monitor	Monitor Perception	Inform via general communications and monitor general perception of Project
Government Agencies and non-Government Organisations	2	2	Interested in the Project Outcomes for potential future projects	Involvement in some low- risk areas	Inform	Manage Expectations	Keep informed and engage on their interest areas to be a Project supporter
Local Community	1	1	no direct goal associated with this stakeholder	Potential Project Promoter/Collaborator	Monitor	Monitor Perception	Inform via general communications and monitor general perception of Project
Members of the Press/Media	1	1	no direct goal associated with this stakeholder	Potential Project Promoter/Collaborator	Monitor	Monitor Perception	Inform via general communications and monitor general perception of Project

Table 7: Members of the Project Management Team

Table 8: Definition of the Different Power and Interest Ratings

RATING	POWER	DEFINITION
5	Very High	This stakeholder can direct (or have a massive impact on) the course of the project
4	High	This stakeholder can have a major impact on the project's schedule and/or budget, and/or a minor impact on the project's scope
3	Moderate	This stakeholder can have a minor impact on the project's schedule and/or budget
2	Low	This stakeholder cannot impact the project, but may know (or have access to) someone who can
1	Very Low	This stakeholder cannot directly impact the project

RATING	INTEREST	DEFINITION
5	Very High	This stakeholder is passionately advocating for the project and its outcomes, and will be devastated if the project fails.
4	High	This stakeholder is highly supportive and its benefits and will be angry if the project fails
3	Moderate	This stakeholder sees benefit to themself and/or to others in the project and will be annoyed if the project fails.
2	Low	This stakeholder sees benefit to others in the project and prefer the project to succeed, but does not feel strongly either way.
1	Very Low	This stakeholder either have no interest at all or some reservations about the project and would push for reconsideration or project termination.

INTEREST \ POWER	1	2	3	4	5
5	Consult	Involve	Collaborate	Empower	Empower
4	Inform	Consult	Involve	Collaborate	Empower
3	Inform	Consult	Consult	Involve	Collaborate
2	Monitor	Inform	Consult	Consult	Involve
1	Monitor	Monitor	Inform	Inform	Consult

Table 9: Stakeholder Engagement Decision Matrix

STRATEGY	CLASSIFICATION	DEFINITIONS
Empower	Maintain	Authorise this stakeholder to make specific decisions about the project. Maintain engagement with the appropriate level of involvement.
Collaborate		Partner with this stakeholder to develop the solutions and action plans during Project Execution. Keep the involvement active on relevant areas.
Involve	Meet	Rely on this stakeholder's expert advice when making decisions about the project. Either retain or aim to upgrade to Maintain Classification.
Consult		Obtain this stakeholder's feedback on key project decisions that are relevent to them. Either retain or aim to upgrade to Maintain Classification.
Inform	Manage	Provide with relevant, high-level information about the project at regular intervals / milestones. Either retain or aim to upgrade to Meet Classification.
Monitor	Monitor	Track stakeholders' perception and monitor movements in Power or Interest level. Aim to upgrade this group to at least Desired Classification.

Table 10: Four Organisation Capabilities and their Definitions

COMMUNICATION MANAGEMENT OVERVIEW

Communication Level	Method or Artifacts	Activity Objective	Medium	Frequency	Target Audience	Owner	Deliverable (Project Documents)	Documentation
COMMS AREA Execution, Monitoring and Control of Project Work **STAKEHOLDERS** PRIMARY Internal and External	Kick off Meeting	Introduction of Project and its Management to key stakeholders	• Email Agenda and Minutes • Face to Face Meeting	• Once	• Sponsor • PM Team • Primary Stakeholders	Project Manager	• Agenda and Minutes • Action Items List	COMMS document saved in Project Folder
	Sponsor Meeting (Steering Committee)	Highlight previous and upcoming week activities to assess project performance and integrate any learning in future activities.	• Email Agenda and Minutes • Face to Face Meeting	• Weekly	• Sponsor and if required, other members of Steering Committee	Project Manager	• Agenda and Minutes • Action Items List	COMMS document saved in Project Folder
	PM Team Briefings	Review project progress to identify risks, opportunities, additional resources, learnings	• Email Agenda and Minutes • Face to Face / Dial-in Meeting	• Daily Stand-up (Agile/Sprint) • Weekly (In-depth Review)	• PM Team Members	Project Manager	• Agenda and Minutes • Learnings and Opportunities • Risk Register Update • Action Items List	COMMS document saved in Project Folder
	Design Team Meetings	Review design team progress to understand and escalate design and integration risks/opportunities, additional resources or support, learnings	• Email Agenda and Minutes • Face to Face / Dial-in Meeting	• At least 2x per week (Designing Period) • As needed thereafter	• Relevant PM Team member/s • Design Team	Project Manager	• Agenda and Minutes • Learnings and Opportunities • Risk Register Update • Action Items List	COMMS document saved in Project Folder
	Supplier Meetings	Review supplier offer, discuss resolutions, make clarifications and among other things relating to this particular supplier of machine/equipment/materials.	• Email Agenda and Minutes • Face to Face / Dial-in Meeting	• At least 1x per week (Procurement Period) • As needed thereafter	• Procurement Team • Relevant PM Team member/s • Design Team Lead • Construction Team Lead	Project Manager	• Agenda and Minutes • Learnings and Opportunities • Risk Register Update • Action Items List	COMMS document saved in Project Folder
	Construction Team Meetings	Review construction team progress to identify and escalate risks/opportunities, additional resources or support, learnings	• Email Agenda and Minutes • Face to Face / Dial-in Meeting	• At least 2x per week (Renovation Period) • As needed thereafter	• Relevant PM Team member/s • Construction Team	Project Manager	• Agenda and Minutes • Learnings and Opportunities • Risk Register Update • Action Items List	COMMS document saved in Project Folder
	Emergency Meetings	Immediate escalation and/or discussion of a certain critical aspect of the Project	• Phone Call • Face to Face • Email	• As needed	• Relevant Stakeholder/s	Project Manager	• Agenda and Minutes • Learnings and Opportunities • Risk Register Update • Action Items List	COMMS document saved in Project Folder
	Trainings and Support Meetings	discussion of training/support needed and its conduct to enable the workforce complete project tasks and see to its completion.	• Email Agenda and Minutes • Face to Face / Dial-in Meeting	• Once a Month • As needed	• Relevant Stakeholder/s	Project Manager	• Agenda and Minutes • Learnings and Opportunities • Risk Register Update • Action Items List	COMMS document saved in Project Folder
	Reporting Documents	Documents that contains a summary or synthesis of project details obtained from the interactions of PM with different stakeholders in meetings, phone calls, or email exchanges, organised for documentation, reporting, escalation and/or information dissemination to relevant audience.	• Email	See Table 12 Project Documents	See Table 12 Project Documents	Project Manager	See Table 12 Project Documents	COMMS document saved in Project Folder
	Notice Boards	UNSW Campus Notice Boards to promote the Project, inform its status (completed, on-going, next stage) and advertise its benefits and significance in relation to the UNSW 2025 Strategy	• Print Media	• Before or at Go Live • Every Gate Outcome • Major Events (e.g. Forums)	• UNSW Community	Project Manager	Posters and Flyers Audience Feedback	Printed Copy posted and Digital Copy saved in Project Folder
COMMS AREA Promotion, Consultation, and Collaboration **STAKEHOLDERS** SECONDARY Internal	Reports for 2025 Strategic Priorities Program Office	Provide a Progress Report including previous challenges and how they were addressed to demonstrate Team capabilities. Relate every update to any relevant themes in the UNSW 2025 Strategic Priorities to reinforce the relevance of the Project.	• Face to Face • Email	• Before or at Go Live • Every Gate Outcome • Major Events (e.g. Forums) • As needed	• UNSW 2025 Strategic Priorities Program Office (potentially the members of UNSW Leadership Team)	Sponsor or delegated to Project Manager	Audience Feedback Action Items List Opportunities	Digital Copies saved in Project Folder
	Presentations and Forums	Entice the academic community of the Project and use it to inspire and draw active participation and contribution by being supporters of this Project and become the advocates of the UNSW 2025 Strategic Priorities	• Face to Face • Videoconferencing	• Before or at Go Live • As needed	• UNSW Community	Project Manager	Audience Feedback Learnings and Opportunities Action Items List	Digital Copies saved in Project Folder
	Consultations	Group consultations to monitor perceptions and set expectations of the use and purpose of the Laboratory.	• Face to Face • Videoconferencing	• Before or at Go Live • As needed	• UNSW Community	Project Manager	Audience Feedback Learnings and Opportunities Action Items List	Digital Copies saved in Project Folder
	Emails and Intranet	Informing the Public and other Secondary Stakeholders about the Project and its potentials in the academe and industry. Promote UNSW Strategic Priorities by highlighting the contributions of this project in relation to this.	• Email • Digital Media	• Before or at Go Live • Every Gate Outcome • Major Events (e.g. Forums)	• UNSW Community	Project Manager	Audience Feedback Opportunities Action Items List	Digital Copies saved in Project Folder

COMMUNICATION MANAGEMENT OVERVIEW (continuation)								
COMMS AREA Promotion and Invitation for Partnerships and Grants **STAKEHOLDERS** SECONDARY External	Grants Applications	Expression of Interest or Application for Grants.	• Email	• near Project Completion	• ARC • Other Grants Programs	Sponsor	Application Letters and Responses	Digital Copies saved in Project Folder
	Press Releases	Advertise UNSW and its Strategic Goals through promoting the Project in public media platforms. It aims to attract attention and to reach out for any interests, particularly for collaborative research work with academic partners and funding from government and industrial sector.	• Print and Digital Media (TV Programs, Australian Manufacturing News)	• Before or at Go Live • Project Completion	• Academic and Industry Partners • Open to Public	Sponsor	Promotional Video Clip Infographics or Poster Audience Feedback	Digital Copies saved in Project Folder
	Bulletin Boards	Informing the Academic Community particularly the UNSW affiliations of the benefits of the facility in terms of research opportunities and invite for collaborative research work.	• Print and Digital Media	• Before or at Go Live • Project Completion	• G8, U21, APRU, Plus Allegiance • Academic Community	Sponsor	Promotional Video Clip Infographics or Poster Audience Feedback	Digital Copies saved in Project Folder
	Emails and Websites	Informing the Public Sector particularly the Trade Industry of the benefits of the research facility and invite expressions of interests and partnerships.	• Digital Media	• Before or at Go Live • Every Gate Outcome • Major Events (e.g. Presentations)	• Industry Partners • Open to Public	Sponsor	Invitation Letters and Responses Audience Feedback/Opportunities	Digital Copies saved in Project Folder

Table 11: Overview of the Project Communication Plan

PROJECT DOCUMENTS for PROGRESS REPORTING and PROJECT PROMOTION						
Document Type	Document Description	Document Type	When	How	From	To
Agenda Meeting Minutes	Use Agenda and Meeting Template with a control number format Meeting-XX DD-MM entry #. Template includes action items, WP affected, by who, completed and update provided by when, any support required). Meeting-PM - Project Team Meeting Minutes Meeting-SU - Supplier Meeting Minutes Meeting-SP - Sponsor (Steering Committee) Meeting Minutes Meeting-ST - Internal and External Stakeholders Meeting Minutes Meeting-EX - External Stakeholder Meeting Minutes Meeting-PR - Procurement Team Meeting Minutes	Semi-Live Document (allowed to add missed item or making corrections to the details)	Agenda: At least 1 day before the Meeting Minutes: No later than 1 day after the meeting	Email	Project Manager	Relevant Teams
Assumption Log Issue Log Change Log	Separate Documents to register assumptions and constraints, issues and resolutions, and scope change requests that arise during project execution. Each log entry is linked to relevant stakeholder/s. Linked to Action Items List	Live Documents. Update Log history.	Immediate submission of Request and its Approval, Rejection, or Modification	Email	Project Manager (support from relevant Teams)	Sponsor Relevant Teams
Action Items List	Summary Log of all Action Items throughout the Duration of the Project with reference to the Meeting Minutes control number.	Live Document. New versions for every update and log update history.	Daily	Email	Project Manager	Relevant Teams
Progress Report (includes Milestones Checklist)	Project Progress Status in terms of Budget Spending and Schedule Tracking. Any corrective or mitigate plan is added as comment for the relevant milestone.	Live Document. New versions for every update and log update history.	Beginning and End of a Milestone (0%, 100%) or different frequency depending on measurable criteria.	Email	Project Manager	Sponsor Members of Steering Committee (e.g. 2025 Strategy Program Office) Relevant Teams
Sponsor Dashboard (Executive Summary)	Sponsor Dashboard that includes summary of progress status (milestone checklist, cost and time variance analysis) and any project detail to highlight, including completed, on-going, and next milestones to deliver.	Live Document. New versions for every update and log update history.	Daily	Email	Project Manager	Sponsor
Trainings and Support Plan	Training Plan of the Team Member needing Support for Performance Development and/or necessary to accomplish a Work Package.	Permanent Documents and Materials	To be arranged internally	Email	Project Manager	Relevant Team members
Promotional Materials	Materials both in print and digital formats that are generated as part of the Project Communication Strategy involving all identified Primary and Secondary Stakeholders to inform about the Project, promote its Benefits (2025 UNSW Strategic Priorities), engage collaboration, and identify potential Grants and source of Funding.	Permanent Documents and Materials	Per stated Frequency in Communications Management Overview	Per stated Method in Communications Management Overview	Project Manager (support from relevant Teams)	UNSW Community Academic Community Manufacturing Industries Private Research Companies Grants Programs (Gov. & non-Gov.) General Public
All Project Documents will be stored and managed in the cloud using OneDrive for Business platform provided by UNSW. The integrity of the Project Data is secured through encryption.						

Table 12: Project Documents for Reporting and Strategy-related Communications

15 Appendix D Risks and Opportunities Register

Task ID.	Risk event	Risk owner	Impact	Likelihood	Severity	Risk value	Response management strategies	Mitigation	
5.1.4 5.2.4 5.3.4	Morphology solver, sensor array and deformation simulator fail the test	Project team	Delays the project	2	4	8	Mitigate	Time buffers are included in the schedule so that additional tests can be performed to debug system errors	Redo test
4.2.6 4.3.6 4.4.6	Robot, furnace, and power hammer breakdown during equipment testing stage	Project team	Adds to project cost and delivery of new equipment may delay the project	1	5	5	Transfer	Ensure equipment is under warranty and buy guarantee extensions if necessary	PM contacts the supplier for the replacement or repairment of the equipment under warranty. Inform the project sponsor and request change project end date, if required, through change request form
1.2	Architecture drawing (fit-out plan) does not meet UNSW facility requirements	Project team	Project delays	1	5	5	Mitigate	Provide design team with UNSW construction checklist. The final drawing is reviewed and approved by UNSW	
3.2 3.3 3.4.4	Poor installation of equipment mounts, electrical fixtures, and staging area by contractors during facility renovation	Project team	Project delays	1	4	4	Transfer	Strong contractor selection process based on previous project completion track record Inspection after installation to be carried out by an independent contractor	
1.2	Proposed laboratory room for MM cell not available	Project team	Project delays	1	3	3	Active acceptance	Review other possible laboratory locations as back-up	Room relocation and inform project sponsor
4.1.4 4.2.4 4.3.4 4.4.4	Central control system, robotic arms, induction furnace or power hammer are damaged during installation process	Project team	Project delays	1	3	3	Transfer	Safely store the equipment in a secure storage area Include in the contract that the contractor is liable for any damage to the equipment during the installation process Taking out construction insurance	Escalate to the project sponsor with estimated delay in project delivery and put in place a new purchase order

Opportunity ID.	Opportunity event	Opportunity owner	Impact	Likelihood	Severity	Opportunity value	Response management strategies	Additional Notes
3.1	Renovation work is easier than predicted	Project team	Reduced project duration	2	3	6	Enhance	Allows more time and resources in planning stage; encourage frequent communications
3.2	The equipment may not require any additional mounts for the robotic arms, hammer, furnace operation of MM cell	Project team	Reduced cost and duration	1	4	4	Accept	Unlikely to occur but will accept if it does occur
4.1.2 4.2.2 4.3.2 4.4.2	Vendor offers are lower than expected for project equipment and parts	Project sponsor	Reduced project cost	1	3	3	Accept	Unlikely for new technologies but can accept if does occur

Table 13: Risks and Opportunities Register

16 Appendix E Contingency Budget

Contingency reserves are the budget allocated for identified risks which are accepted. Very often, they are viewed as the part of the budget which is intended to address the know-unknowns that can affect a project. They are part of the cost baseline and the funding requirements of the project[19].

Task ID	Work Packages	Work (Person-days)	Duration (Hours)	Hourly pay	Number of works	Salary Cost	Material Cost	Total Budget Reserve	Comments
4.2.4	Installed Robotic Workpiece manipulation system	30	240	53.75	1	12,900.00	75,000.00	87,900.00	Equipment prices may vary from the estimated cost as MM is a new technology The project might be delayed as the equipment will needed to be repaired or new equipment will need to be shipped and installed
4.3.4	Installed power hammer	30	240	53.75	1	12,900.00	40,000.00	52,900.00	Equipment prices may vary from the estimated cost as MM is a new technology The project might be delayed as the equipment will need to be repaired or new equipment will need to be shipped and installed
4.4.4	Installed induction furnace	30	240	53.75	1	12,900.00	6,000.00	18,900.00	Equipment prices may vary from the estimated cost as MM is a new technology The project might be delayed as the equipment will need to be repaired or new equipment will need to be shipped and installed
4.5.4	Installed Sensor Array	15	120	60.93	1	7,311.60	1,250.00	8,561.60	Equipment prices may vary from the estimated cost as MM is a new technology The project might be delayed as the equipment will need to be repaired or new equipment will need to be shipped and installed
4.2.6	Robotic Workpiece Manipulation System Tests	20	160	53.75	1	8,600.00		8,600.00	The project might be delayed if robotic arm fails its tests and tests will need to be performed again after debugging the robotic manipulation system
6.6	MM Cell System Integration Testing	30	240	53.75	5	64,500.00		64,500.00	The project might be delayed if MM cell fails its tests and tests will need to be performed again after debugging the MM cell integration system
4.3.6	Power Hammer Tests	20	160	53.75	1	8,600.00		8,600.00	The project might be delayed if MM cell fails its tests and tests will need to be performed again after debugging the MM cell integration system
4.4.6	Induction Furnace Tests	20	160	53.75	1	8,600.00		8,600.00	The project might be delayed if MM cell fails its tests and tests will need to be performed again after debugging the system faults in the furnace
5.3.4	Sensor Array Testing	40	320	60.93	1	19,497.60		19,497.60	The project might be delayed if MM cell fails its tests and tests will need to be performed again after debugging the sensor array
5.2.4	Deformation Simulator Software Simulated Testing	30	240	60.93	1	14,623.20		14,623.20	Since MM cell is a new innovative project, it is highly probable that bugs and errors will be found in the system development process which will need to be resolved
5.1.1	Morphology Solver Software Simulated Testing	30	240	60.93	1	14,623.20		14,623.20	Since MM cell is a new innovative project, it is highly probable that bugs and errors will be found in the system development process which will need to be resolved
3.1	Renovated Foundation					-	2,000.00	2,000.00	Material cost may vary from the estimated cost as MM is a new technology
5.1.1	Morphology Solver Software Design	10	80	60.93	1	4,874.40		4,874.40	The software design is highly experimental and design requirements might change over time which will require additional modifications
4.1.4	Installed Central Control System					-	12,500.00	12,500.00	Equipment prices may vary from the estimated cost as MM is a new technology
1.2	Facility Layout					5,000.00		5,000.00	Facility layout might need to be drawn again in case the laboratory room layout does not meet UNSW requirements
					TOTAL	**$194,930.00**	**136,750.00**	**$331,680.00**	

Table 14: Contingency Reserve Budget

[19] PMI Inc, A Guide to the PMBOK, p202, 6th edition, Pennsylvania 2017

17 Appendix F MM Cell Sample Layout

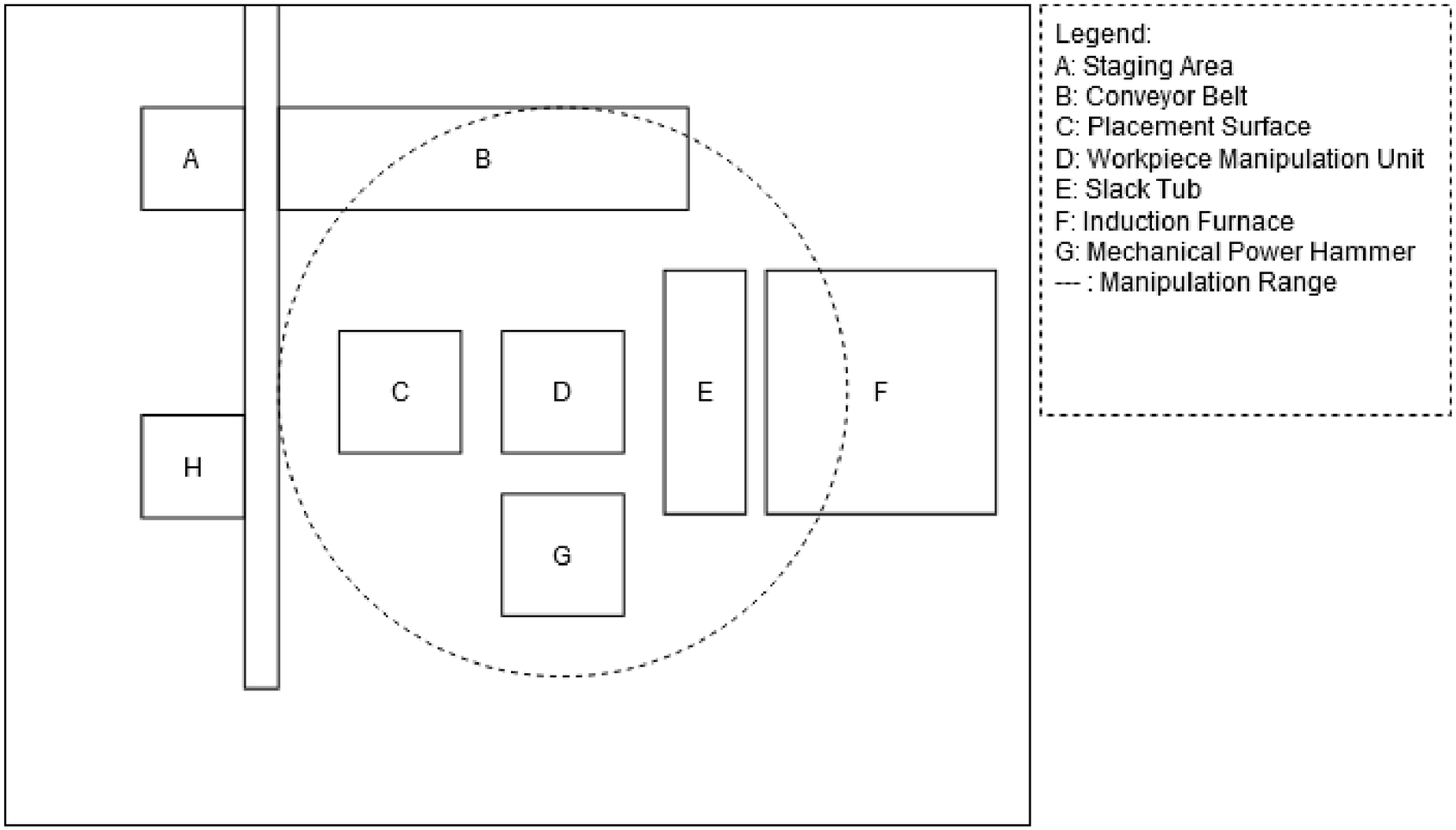

Figure 8: MM Cell Facility Floor Lay-out

18 Appendix G Schedule Table

Tasks	Done by	Working days duration	Start Date	End Date	Duration in days
Process Flow Diagram	Lead engineer	0 - 10	11/1/2021	24/1/2021	13
Facility Layout	Architect / Interior designer	10 - 20	25/1/2021	7/2/2021	13
System Requirements & Specifications Document	PM Team member 1, 2 & 3	20 - 50	8/2/2021	21/3/2021	41
Facility Renovation RFP	PM Team 1	50 - 55	22/3/2021	28/3/2021	6
Central Control System RFQ	PM Team 2	50 - 55	22/3/2021	28/3/2021	6
Mechanical Power Hammer RFQ	PM Team 3	50 - 55	22/3/2021	28/3/2021	6
Sensor Array Schematic	Sensor & software engineer	50 - 60	22/3/2021	4/4/2021	13
Morphology Solver Software Design	Software engineer 1	50 -60	22/3/2021	4/4/2021	13
Deformation Simulator Schematic	Software engineer 2	50-60	22/3/2021	4/4/2021	13
Staging Area Equipment RFQ	PM Team 1	55 - 60	29/3/2021	4/4/2021	6
Robotic Workpiece Manipulation System RFQ	PM Team 2	55 - 60	29/3/2021	4/4/2021	6
Induction Furnace RFQ	PM Team 3	55 - 60	29/3/2021	4/4/2021	6
Sensor Array RFQ	PM Team 2	60 - 65	5/4/2021	11/4/2021	6
Sensor Array Software Design	Sensor & software engineer	60 - 70	5/4/2021	18/4/2021	13
Morphology Solver Software Implementation & Testing Plan	Software engineer 1	60 - 300	5/4/2021	6/3/2022	335
Deformation Simulator Software Implementation & Testing Plan	Software engineer 2	60 - 300	5/4/2021	6/3/2022	335
Facility renovation agreement & staging area document	PM Team 1	65 - 105	12/4/2021	6/6/2021	55
Control System & Workpiece Manipulation system contract documents	PM Team 2	65 - 105	12/4/2021	6/6/2021	55
Power Hammer & Induction forge contract documents	PM Team 3	65 - 105	12/4/2021	6/6/2021	55
Sensor Array procurement contract	PM Team 2	75 - 115	26/4/2021	20/6/2021	55
Time buffer for delay in procurements (note)		105 -125	7/6/2021	4/7/2021	27
Renovated Foundation	Subcontractor	105 - 125	7/6/2021	4/7/2021	27
Sensor Array Software Implementation & Testing Plan	Sensor & software engineer	115 - 175	21/6/2021	12/9/2021	83
Electrical Fixtures Installed	Subcontractor	125 - 128	5/7/2021	8/7/2021	3
Hardware Integration, Workpiece Manipulation System, Mechanical Power Hammer, Induction Furnace Testing Plan	PM Team 1, 2, & 3	125 - 155	5/7/2021	15/8/2021	41
Equipment Mounts Installed & Cleaning	Subcontractor	128 - 143	8/7/2021	28/7/2021	20
Installed Staging Area Equipment	Subcontractor	133 - 148	15/7/2021	4/8/2021	20
Installed Central Control System	Lead engineer	133 - 143	15/7/2021	28/7/2021	13
Installed Robotic Workpiece Manipulation System	PM Team 1	133 - 163	15/7/2021	7/9/2021	54
Installed Power Hammer	PM Team 2	133 - 163	15/7/2021	7/9/2021	54
Installed Induction Furnace	PM Team 3	133 -163	15/7/2021	7/9/2021	54
Installed Sensor Array	Sensor & software engineer	133 - 148	15/7/2021	4/8/2021	20
Robotic Workpiece Manipulation System Tests Completed	PM Team 1	163 - 183	8/9/2021	5/10/2021	27
Power Hammer Tests Completed	PM Team 2	163 - 183	8/9/2021	5/10/2021	27
Induction Furnace Tests Completed	PM Team 3	163 - 183	8/9/2021	5/10/2021	27
Time buffer for sensor array implementation		175-185	13/9/2021	26/9/2021	13
Sensor Array Calibration	Sensor & software engineer	185 - 195	27/9/2021	10/10/2021	13
Time buffer for additional testing to detect faults from robotic manipulation system		183 - 203	6/10/2021	2/11/2021	27
Sensor Array Testing	Sensor & software engineer	195 - 235	11/10/2021	5/12/2021	55
Hardware Component Tests Complete	PM Team 1,2,3 & sensor engine	235 - 255	6/12/2021	2/1/2022	27
Time buffers for Morphology Solver and Deformation Simulator Implementation (bugs fixing)		300 -320	7/3/2022	3/4/2022	27
Deformation Simulator Software Simulated Testing	Software engineer 2	320 - 350	4/4/2022	15/5/2022	41
Morphology Solver Software Simulated Testing	Software engineer 1	350 -380	16/5/2022	26/6/2022	41
Time buffer for extended testing (Morphology Solver and Deformation Simulator)		380 - 400	27/6/2022	24/7/2022	27
MM Cell System Integration Development & Live Testing	PM Team 1,2,3 & sensor engineer + lead engineer	400 - 430	25/7/2022	4/9/2022	41
MM Cell System Integration Testing	PM Team 1,2,3 & sensor engineer + lead engineer	430 - 460	5/9/2022	16/10/2022	41
Time buffer for further MM cell system testing		460 - 480	17/10/2022	13/11/2022	27
Morphology Solver Software Live Testing	Software engineer 1	480 - 510	14/11/2022	25/12/2022	41
Deformation Simulator & Morphology Solver Software Release Version	Software engineer 1 & 2	510-540	26/12/2022	5/2/2023	41

19 Appendix H Detailed Cost and Time Estimation Table

Work Packages	Done by	Working days	Hourly rate	Salary cost	Contingency Time Buffer (days)	Contingency Budget (Additional Cost)	Material cost	Total Cost
Process Flow Diagram	Lead engineer	10	66.83	$5,346.66				$5,346.66
Facility Layout	Architect / Interior designer			$5,000.00		$5,000.00		$10,000.00
System Requirements Document	PM Team member 1, 2 & 3	30	53.75	$38,699.54				$38,699.54
Facility Renovation RFP	PM Team 1	5	53.75	$2,149.97				$2,149.97
Staging Area Equipment RFQ	PM Team 1	5	53.75	$2,149.97				$2,149.97
Central Control System RFQ	PM Team 2	5	53.75	$2,149.97				$2,149.97
Robotic Workpiece Manipulation System RFQ	PM Team 2	5	53.75	$2,149.97				$2,149.97
Mechanical Power Hammer RFQ	PM Team 3	5	53.75	$2,149.97				$2,149.97
Induction Furnace RFQ	PM Team 3	5	53.75	$2,149.97				$2,149.97
Sensor Array Schematic	Sensor & software engineer	10	60.93	$4,874.29				$4,874.29
Sensor Array RFQ	PM Team 2	5	53.75	$2,149.97				$2,149.97
Facility renovation agreement & staging area document	PM Team 1	10	53.75	$4,299.95				$4,299.95
Control System & Workpiece Manipulation system contract documents [1]	PM Team 2	10	53.75	$4,299.95	20			$4,299.95
Power Hammer & Induction forge contract documents [1]	PM Team 3	10	53.75	$4,299.95	20			$4,299.95
Sensor Array procurement contract [1]	PM Team 2	10	53.75	$4,299.95	20			$4,299.95
Sensor Array Software Design	Sensor & software engineer	10	60.93	$4,874.29				$4,874.29
Sensor Array Software Implementation & Testing Plan [2]	Sensor & software engineer	60	60.93	$29,245.75	10			$29,245.75
Morphology Solver Software Design	Software engineer 1	10	60.93	$4,874.29				$4,874.29
Deformation Simulator Schematic	Software engineer 2	10	60.93	$4,874.29				$4,874.29
Morphology Solver Software Implementation & Testing Plan [2]	Software engineer 1	240	60.93	$116,983.00	10	$4,874.40		$121,857.40
Deformation Simulator Software Implementation & Testing Plan [2]	Software engineer 2	240	60.93	$116,983.00	10			$116,983.00
Deformation Simulator Software Simulated Testing [3]	Software engineer 2	30	60.93	$14,622.87	10	$14,623.20		$29,246.07
Morphology Solver Software Simulated Testing [3]	Software engineer 1	30	60.93	$14,622.87	10	$14,623.20		$29,246.07
Renovated Foundation [4]	Subcontractor			$10,000.00		$2,000.00	$16,000.00	$28,000.00
Electrical Fixtures Installed	Subcontractor			$2,500.00				$2,500.00
Equipment Mounts Installed & Cleaning	Subcontractor			$1,500.00				$1,500.00
Hardware Integration, Workpiece Manipulation System, Mechanical Power Hammer, Induction Furnace Testing Plan	PM Team 1, 2, & 3	20	43.00	$20,639.76				$20,639.76
Installed Staging Area Equipment [5]	Subcontractor			$3,000.00			$10,700.00	$13,700.00
Installed Central Control System [6]	Lead engineer	10	66.83	$5,346.66		$12,500.00	$25,000.00	$42,846.66
Installed Robotic Workpiece Manipulation System [7]	PM Team 1	30	53.75	$12,899.85		$87,900.00	$150,000.00	$250,799.85
Installed Power Hammer [8]	PM Team 2	30	53.75	$12,899.85		$52,900.00	$80,000.00	$145,799.85
Installed Induction Furnace [9]	PM Team 3	30	53.75	$12,899.85		$18,900.00	$44,000.00	$75,799.85
Installed Sensor Array	Sensor & software engineer	15	60.93	$7,311.44		$8,561.60	$2,500.00	$18,373.04
Sensor Array Calibration	Sensor & software engineer	10	60.93	$4,874.29				$4,874.29
Robotic Workpiece Manipulation System Tests Completed [10]	PM Team 1	20	53.75	$8,599.90	20	$8,600.00		$17,199.90
Power Hammer Tests Completed	PM Team 2	20	53.75	$8,599.90		$8,600.00		$17,199.90
Induction Furnace Tests Completed	PM Team 3	20	53.75	$8,599.90		$8,600.00		$17,199.90
Sensor Array Testing	Sensor & software engineer	40	60.93	$19,497.17		$19,497.17		$38,994.34
Hardware Component Tests Complete	PM Team 1,2,3 & sensor er	20		$99,162.73				$99,162.73
MM Cell System Integration Development & Live Testing	PM Team 1,2,3 & sensor er	30		$69,362.40				$69,362.40
MM Cell System Integration Testing [11]	PM Team 1,2,3 & sensor er	30		$69,362.40	20	$64,500.00		$133,862.40
Morphology Solver Software Live Testing	Software engineer 1	30	60.93	$14,622.87				$14,622.87
Deformation Simulator & Morphology Solver Software Release Version	Software engineer 1 & 2	30	60.93	$29,245.75				$29,245.75
Salary of Project Manager	PM	540	59.78	$77,472.73				$77,472.73
				$891,647.91		$331,680.00	$328,200.00	$1,551,527.91
Contingency Budget included								

Table 15: Cost and Time Estimates

Note: Hourly rates are obtained using annual full-time salary of each position (see HR Plan), converted into hourly rate and additional 25% for casual loading, 1 working day is equal to 8 hours of work.
Acting as a PM for this MM cell project is a Professional Officer, it is assumed that 30% of work time of the PO is spend on managing this project.
[1] Risk register no. 2 - Delays in procurement of robotic arms, furnace, power hammer or sensors, additional cost are obtained from the warranty (2% of equipment cost) that covers shipping cost & repairment cost
[2] Risk register no. 11 - Critical bugs and system errors are found during the implementation of morphology solver, deformation simulation and sensor array, additional cost from time buffer
[3] Risk register no. 3 – Robotic manipulation system fails commissioning tests, additional cost from time buffer of testing
[4] Foundation cost covers source: https://designplusdrafting.com.au/architects-sydney-blog/
[5] Staging area cost include: Plexiglass, curtain, conveyor belt, steel frame.
[6] High performance computer with large amount of storage, processing power and high reliability.
[7] 3 UR-10 Robotic Arms source: https://cobots.se/produkt/ur10-robot/
[8] Power hammer assembled in robotic arms
[9] Induction furnace + ventilation (Centrifugal fan, duct, hood canopy, air cleaner)
[10] Risk register no. 12 - Morphology solver, sensor array and deformation simulator fail the test, additional time for testing
[11] Risk register no. 4 - MM cell system fails the test, additional time for testing

20 Appendix I Schedule in Gantt Chart

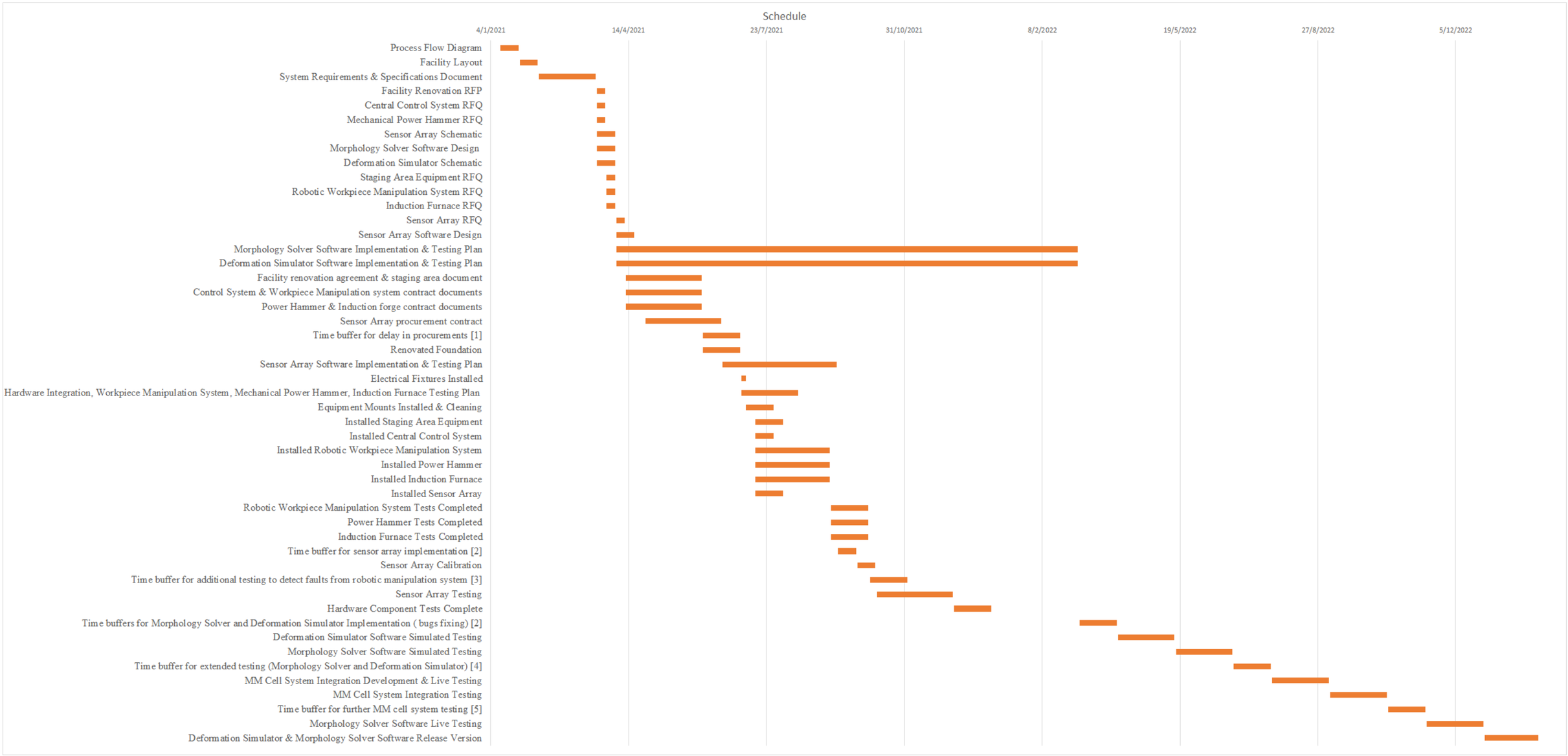

Figure 9: Project Gantt Chart

References

[1] Risk register no. 2 - Delays in procurement of robotic arms, furnace, power hammer or sensors
[2] Risk register no. 11 - Critical bugs and system errors are found during the implementation of morphology solver, deformation simulation and sensor array
[3] Risk register no. 3 – Robotic manipulation system fails commissioning tests
[4] Risk register no. 12 - Morphology solver, sensor array and deformation simulator fail the test
[5] Risk register no. 4 - MM cell system fails the test

Note: Schedule table can be seen on Appendix G

21 Appendix J – Risk Management Approach

21.1 Risk Management Planning

21.1.1 Existing Document Review

As recommended by Lock[20] in Section 7 – Risk of the *Project Management*, existing checklists and history of similar projects will be able to assist in highlighting potential problems. The following information available to the team were considered during the development of this risk management plan:

i. Interview with the project sponsor Dr. Xiaoping Li on his previous experience in developing the world first Addictive Manufacturing (AM) cell & the UNSW AM cell.
ii. Interview with external expert Stephen Kuhle (MME Senior Technical Officer) on his experience on procuring, installing, commissioning, and running robots.
iii. Approved project Charter from UNSW project steering committee as included in Section 1 of this report.

21.1.2 Internal and External Context

The internal context analysis revealed that the team conducting the projects is newly formed. However, all team members have demonstrated existing project management knowledge and experiences. The project team were also equipped with multi-disciplinary academic backgrounds and are all willing to contribute into the final project delivery.

The project is determined as the world first MM cell for research purpose and for potential future commercializing. It is considered as one of the key projects in line with the UNSW 2025 organizational strategy. Detailed project objectives and work scopes are included in the approved Project Charter in Section 1.

21.2 Risk Identification

PMBOK[21] recommended to use expert judgment, data gathering and analysis, interpersonal and team skills, prompt lists and meetings for the risk identification. In addition, brainstorming was also highly accredited by Lock in the section “identifying the possible risks"[22]. The identified risks presented in Appendix D (Risk Register) are the results of existing information review, research, interview with internal and external experts, and group brainstorming.

21.3 Risk Assessment

Risk analysis are carried out to quantify and qualify:

i. the likelihood of occurrence of each individual risk;
ii. the possible impact on the overall project outcome should they occurred; and
iii. potential measurements on risk responses.

[20] [3]
[21] [1]
[22] [3]

Reference was made to the University of Queensland[23] Enterprise Risk Matrix in performing the risk qualitative analysis.

21.3.1 Risk Likelihood

The risk probability levels in terms of likelihood applied to the risk assessment is provided in as below:

i. Very low probability (<=0.1%*): highly unlikely to occur except under minor conditions.
ii. Low probability (>0.1%-1%*): not expected, but inadequate precautionary measurements could lead to a slight chance of occurring.
iii. Medium probability (>1%-10%*): May occur and have occurred in the known history of similar projects.
iv. High probability (>10%-50%*): most likely to happen and have frequently happened in similar project history record.
v. Almost Certain (>50%*): the risk is expected to occur in most of the circumstances.

* Indicate the chance of occurring per number of similar activities performed. E.g. Based on the known record, two faulty items were revealed for the past 100 similar items delivered by a supplier. The risk is considered low with 2% chance occurring.

21.3.2 Risk Severity

The risk severity levels applied to the risk assessment is provided in as below:

vi. Trivial: no or minor impact to the final project outcome
vii. Minor: slight effort is required for managing risks to minimize impact to project outcome
viii. Moderate: the risk, if not addressed, will lead to a moderate consequence
ix. Major: Impact to project is considered significant
x. Critical: A severe consequence will happen

21.3.3 Risk Assessment Rating

The severity and likelihood of each risk are assigned with a number from 1 to 5 to represent its level of concerns. 1 represents “concern not warranted”, where 5 indicates alarming concerns. Risk rating (1 to 25) was then determined as the product of multiplying the Likelihood rating (1 to 5) and the Severity rating (1 to 5).

21.3.4 Risk Evaluation

A matrix was hence developed from the above-mentioned categories and is demonstrated in Figure 10, with risks being classified into four levels as shown in the risk matrix developed by University of Queensland[24], taking consideration to the project specifications.

[23] [6]
[24] [6]

Risk Evaluation Matrix		Severity				
		Critical (5)	Major (4)	Moderate (3)	Minor (2)	Insignificant (1)
Likelihood	Very High (5)	E (25)	E (20)	E (15)	H (10)	M (5)
	High (4)	E (20)	E (16)	H (12)	M (8)	L (4)
	Medium (3)	E (15)	H (12)	H (9)	M (6)	L (3)
	Low (2)	H (10)	M (8)	M (6)	L (4)	L (2)
	Very Low (1)	M (5)	M (4)	L (3)	L (2)	L (1)

Figure 10: Risk Evaluation Matrix

Notes:
E (15-25): Extreme, immediate action is required
H (9-14): High, additional research and measurements required as soon as possible
M (5-8): Medium, review and mitigation required
L (<5): Low risk, minor control and monitoring required

21.4 Risk Response Development

Based on the "Risk Management Strategies" developed from Section 11.5.2 of PMBOK [25] and recommended by Dr Edward Obbard[26], responses to risks identified include:

i. **Avoid** the risk by changing the plan and abandon the possible causes.
ii. **Mitigate** the risk by reducing likelihood or impact level.
iii. **Accept** some of the risks with low risk rating.
iv. **Transfer** the risk to insurance.

In addition, following strategies are proposed in developing responses to potential opportunities[27]:

i. **Exploit** the opportunity to ensure its occurrence.
ii. **Share** the opportunity to another party who can create the most benefits to the project from this opportunity.
iii. **Enhance** by increasing the probability or the impact of an opportunity.
iv. **Accept** the advantage from an opportunity**.**

The designed risks and opportunities responses to the project are included in the Project Risks and Opportunities Register in Appendix D and are also demonstrated in the Project WBS in Section 4, Project Schedule in Section 6, Stakeholder and Communication Management Plan in Section 7 and Project Time-Phased Budget in Section 10.

[25] [1]
[26] [5]
[27] [5]