GSOE9820

ENGINEERING PROJECT MANAGEMENT

ROBOTIC BLACKSMITH PROJECT

PROJECT MANAGEMENT PLAN

Submitted By: Group 1

Name:	Andrew Cvetko	Benjamin McCoy	Charles Ewart	Jane Chen	Jimmy Hong	Jinglin Wang	Manavh Sharma	Yunhe Hu
zID:	z3330071	z3464555	z3331148	z3212275	z5017130	z5011751	z3372680	z3351805
Contributions:	Project Charter WBS Cost Estimate Final Review	Project Charter HR Mgmt Plan Network Diagram Formatting Referencing Final Review	Project Charter Stakeholder Mgmt Plan Stakeholder register Final Review	Project Charter WBS, HR Roles & Responsibility, Cost and Time Estimates, Time Phased Budget and Project Contingency Reserve Plan	Project Charter Stakeholder Mgmt Plan Stakeholder Communications Plan Final Review	Project Charter Risk Mgmt Plan Project Schedule Final Review	Project Charter Project Scope Management Strategy Final Review	Project Charter Risk Mgmt Plan Final Review
Declaration:								

Contents

1. Project Charter

1.1. Background

Metamorphic Manufacturing (MM) is an emerging technology that extends and automates the role of a traditional "blacksmith". Metamorphic Manufacturing uses computer-controlled systems to perform controlled deformations of materials to produce components with specific material properties (The Minerals, Metals & Materials Society, 2019).

The purpose of this Project Management Plan is to outline the plan to deliver a MM Cell to UNSW, including all required products and associated deliverables as defined in Section 3.1. The high-level requirements for this project are driven by the UNSW 2025 Organisational Strategy and are presented in Table 1 (UNSW, 2020).

Table 1. Project Alignment with UNSW Strategy

UNSW Strategic Objective	High Level Project Requirement
Academic Excellence	Generate cutting-edge research
	Create new fields of research and study for students
Innovation and Engagement	Foster entrepreneurship within UNSW
	Encourage industry partners to work with UNSW
Social Impact	Reduce the cost and environmental footprint of manufacturing
	Promote collaboration among schools and universities

1.2. Project Objectives

The key objectives for this project are:

- To design and build a MM cell for research into incremental forging technology that will be used by PhD students, student project teams and commercial partners within six months of delivery of major components.
- To provide training and knowledge transfer to UNSW staff and researchers who would like to use the MM cell. This will include a training manual and supporting documentation to be issued upon completion of construction and testing, and further ongoing support for 6 months after this time.
- To verify, at a system level, the capabilities of the facility against the specified requirements within one month of project completion. Verification is to be completed in the form of acceptance tests, and carried out primarily by UNSW staff, assisted by third parties where required. All verification outputs will be held by UNSW.

1.3. Project Scope

The scope of this project includes:

- Delivery of an MM Cell to UNSW
- Training and handover to UNSW staff
- Acceptance testing of the facility against stakeholder requirements
- Provision of operational support for 6 months after facility handover.

This scope statement is detailed further in Section 3.1.

1.4. Project Benefits

Table 2. Project Benefits

Project Objective	Primary Beneficiaries	UNSW Strategy Alignment	Benefits
Construct MM Cell	UNSW students / researchers Dr Xiaopeng Li	Academic Excellence: Research Quality	- Increase number of Higher Degree Research (HDR) completions - Increase student engagement and satisfaction - New courses linked to the industry - Improved retention of researchers
Ongoing Support	UNSW Researchers	Innovation and Engagement Social Impact	- Increase the scale and number of partners engaged with UNSW - Increase the number of innovative manufacturing developments - Increase the number of research papers co-published with external partners
Verify MM Cell Capabilities	UNSW Researchers	Academic Excellence	- Staff can quickly utilize new equipment - Increase cumulative number of highly cited researchers.

1.5. Summary Budget and Schedule

The summary project schedule is shown in Table 5 and defines dates for high level milestones, as well as a period of ongoing support after the facility has been built.

1.6. Project Risks and Assumptions

Project risks are discussed in more detail in Section 3.7, the Risk Management Plan.

One of the main assumptions made in this project plan is that the required material and human resources will be readily available from the market and if any team members leave this project, their position will be quickly filled with a limited impact on the project schedule. This assumption has allowed Group 1 to develop an ambitious schedule of completing the project within 6 months. If this assumption is determined to be incorrect, there are contingencies in place (discussed in Section 3.7) to manage this, however the project duration may need to be extended.

Additional assumptions made in this plan include that the resources of the UNSW Human Resources department will be made available to Group 1 and that they will work with us for the hiring and on-boarding of team members. Additionally, Group 1 has assumed that a work space will be provided for the team of 8 in the Willis Annexe and that this workspace will include the resources need to carry out the project such as internet availability, electricity supplies and running water.

2. Management Strategy & Definition of Success

This project will be considered a success if the following measures are met:

1. Completion of Project Deliverables as stated in Section 3.1.2.
2. Total project cost not exceeding 2,000,000 AUD, as constrained by the customer requirement.

Group 1's management strategy for ensuring this success criteria is met involves:

- Initial agreement on project priorities and scope. As this is implicitly defined by the customer requirements, project cost shall be constrained to 2,000,000 AUD, project scope shall be enhanced. The detailed scope is presented in Section 3.1. The impact on project time shall be accepted, subject to stakeholder review.
- Developing cost and schedule estimates (Sections 3.3.1 & 3.3.2) based on a detailed, low-level WBS (Section 3.2). Project Management tools have been utilised to develop and maintain the project schedule in several formats (Detailed tabular breakdown - Section 5.1, Gantt - Section 3.4.1 and Network Diagram - Section 3.4.2). Project status can be easily tracked and adjustments to scope can be made through these tools.
- Performing a detailed risk assessment (Section 3.7.3) on all risks identified to date, including those based on project assumptions. A risk register (Section 3.7.4) will be maintained throughout the project to ensure all risks are tracked and controlled.
- Developing a stakeholder engagement strategy (Section 3.5) to ensure the project achieves the correct level of transparency with all parties involved and allow stakeholders to provide input to project scope.
- As the success of this project will depend heavily on project staff, a detailed Human Resource management plan (Section 3.6) has been developed to ensure there is a clear and consistent approach to staff management.

3. Project Plan

3.1. Scope Statement

The project scope statement has been iteratively developed and reviewed with input from the following items included in this report:

- Project Charter (Section 1)
- Project Risk Register (Section 3.7.4)
- Project Assumptions (Section 1.6)

As well as the requirements specification provided by the project sponsor. These requirements are reproduced without alteration in Table 3, they drive the design of the MM cell and the planning and management strategy for this project.

Table 3. Project Requirements

Technical Requirements	Project Requirements
The UNSW MM Cell: 1. Shall produce a forged part from a CAD model. 2. Shall incorporate real-time quality control and diagnostic instrumentation which enables control of the dimensions and properties of the forged part. 3. Shall have an integrated, programmable control system, which coordinates all of its functions. 4. Shall produce a range of forged components for a range of industrial applications without using a specific forging die to shape any component. 5. Should hot forge commercially available Ti alloys. 6. Should hot forge commercially available low alloy steels. 7. Should allow, after conducting further research into and updating of software in (3), that (1) and (4-7) be achieved without operator intervention.	The UNSW MM Cell Project: 1. Shall deliver the MM cell, including its design, procurement, construction, and commissioning. 2. Shall use existing infrastructure and services at UNSW (Kensington), 3. Or shall include the provision of any required new infrastructure and services. 4. Shall cost less than AUD 2,000,000 including any contingencies. 5. Should demonstrate alignment between its objectives and the UNSW 2025 Strategy

3.1.1. Project Scope Description

This project aims to deliver an MM Cell to UNSW that meets the technical requirements listed in Table 3. Compliance with technical requirements shall be demonstrated through system level acceptance testing that will be carried out as part of this project.

In addition to the delivery of physical facilities, this project shall also ensure operational knowledge is transferred to UNSW personnel. This will be done through the development of user manuals and training of UNSW staff.

Also included in project scope is the provision of a 6-month period following build completion, in which UNSW staff have access to operational support from third parties. This is included to ensure UNSW has access to sufficient resources to build their own knowledge base on the MM facilities.

3.1.2. Project Deliverables

- Functional Metamorphic Manufacturing Facilities located in UNSW that meet customer requirements as listed in Table 3.
- Training packages (documentation and manuals) for operation of facilities.
- Acceptance Test documentation demonstrating compliance of facilities with customer requirements
- Contractually guaranteed Third Party operational support for six months after operational facilities have been handed over to UNSW.

3.1.3. Acceptance Criteria

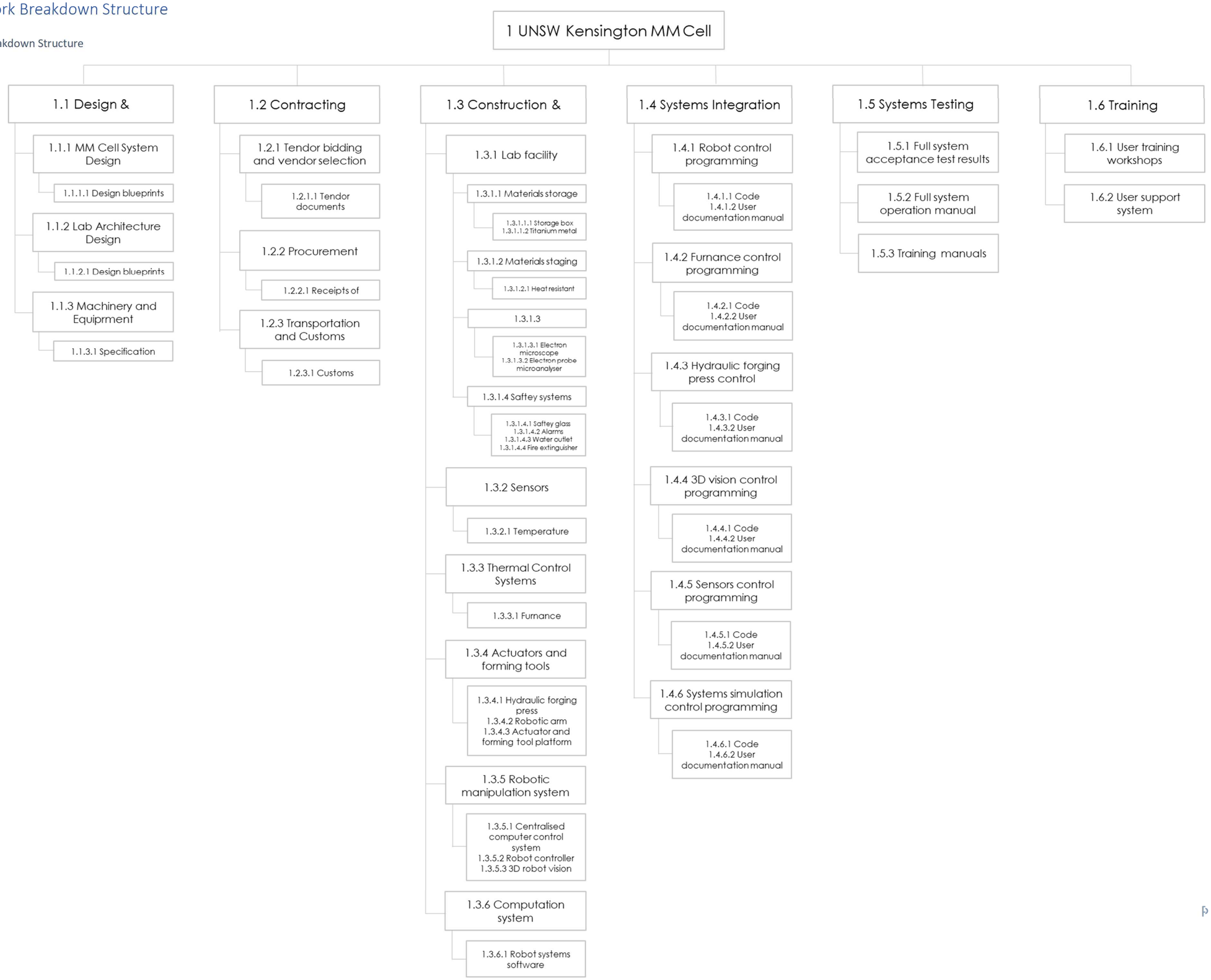
- Testing of facilities and sub-components have been completed, and testing demonstrates compliance with requirements specified in Table 3. Acceptance testing results must be signed off by a UNSW representative.
- Training material is complete and has been reviewed by UNSW representatives.
- Contracts stipulating ongoing operational support for the MM facility have been drawn up and reviewed by UNSW representatives. All support contracts have been agreed to by the necessary parties.

3.1.4. Project Exclusions

- Testing of additional capability, more than specified in the Technical Requirements (e.g. use of non-metallic materials).
- Procurement of raw material for use in facility.
- Promotion of the facility and development of promotional material.
- Development of educational material, excluding operation manuals (e.g. Material targeted to students or instructors for use in University coursework development).

3.2. Work Breakdown Structure

Figure 1. Work Breakdown Structure



3.3. Cost and Time Estimates

3.3.1. Cost Estimates and Management Strategy

The Project Manager (PM) will be responsible for managing and reporting on the project's cost throughout the duration of the project. During fortnightly steering committee meetings, the PM will meet with the project sponsor to present and review the project's cost performance for the preceding fortnight. Performance will be measured using Earned Value Management (Lock, 2013). The following four earned value metrics will be used to measure project cost performance:

- Schedule Variance
- Cost Variance
- Schedule Performance Index (SPI)
- Cost Performance Index (CPI)

A variance of +/-0.2 in the CPI is considered acceptable. The PM must report the reason for exception and provide a detailed corrective plan if the variance is greater than 0.2. The project sponsor has the authority to make changes to adjust the project scope within the budget limit.

The project budget is detailed in Table 4 (below).

Table 2. Project Budget Overview

Control Account	Control Account Name	Work Package Cost (AUD $)	Work Package Contingency Reserve (AUD $)	Cost Base Line (AUD $)	Management Reserve (AUD $)
1.0	Management Reserve				**137,600**
1.1	Design & engineering	101,000	500	101,500	
1.2	Contracting	651,400	5,500	656,900	
1.3	Construction & Installation	248,500	34,000	282,500	
1.4	Systems Integration	607,000	20,000	627,000	
1.5	Systems Testing	120,000	2,500	122,500	
1.6	Training	72,000	0	72,000	**1,862,400**
				Total Budget	**2,000,000**

3.3.2. Time Estimates and Management Strategy

The overall duration of the project is estimated at 6 months, with start and end dates of January 4, 2021 and June 30, 2021 respectively. The overall duration is based on the assumptions that the required human resources are hired before the project start date (see Section 3.6.2, Acquiring Human Resources) and the post-implementation user support duration is not included. The post-implementation user support is estimated at 6 months duration or 450 total hours, with maximum 20 supporting hours per week, whichever occurs first, after the project closure date.

A detailed view of the project schedule is presented in the project schedule Gantt Chart and Network Diagrams shown in 0 and 3.4.2 respectively.

A preliminary schedule of activities of each work package can be found in Section 5.1, Appendix – Detailed Budget and Schedule. A summary schedule is provided in Table 5 (below).

Table 3. Summary Project Schedule

Task ID	Task Name	% Complete	Duration (Days)	Start	Finish
1.1	Design & engineering	100%	15	04-Jan-21	22-Jan-21
1.2	Contracting	100%	48	25-Jan-21	31-Mar-21
1.3	Construction & Installation	100%	65	25-Jan-21	23-Apr-21
1.4	Systems Integration	100%	35	26-Apr-21	11-Jun-21
1.5	Systems Testing	100%	8	14-Jun-21	23-Jun-21
1.6.1	Training	100%	5	24-Jun-21	30-Jun-21
1.6.2	Post-implementation support	100%	132	01-Jul-21	31-Dec-21

3.4. Project Schedule

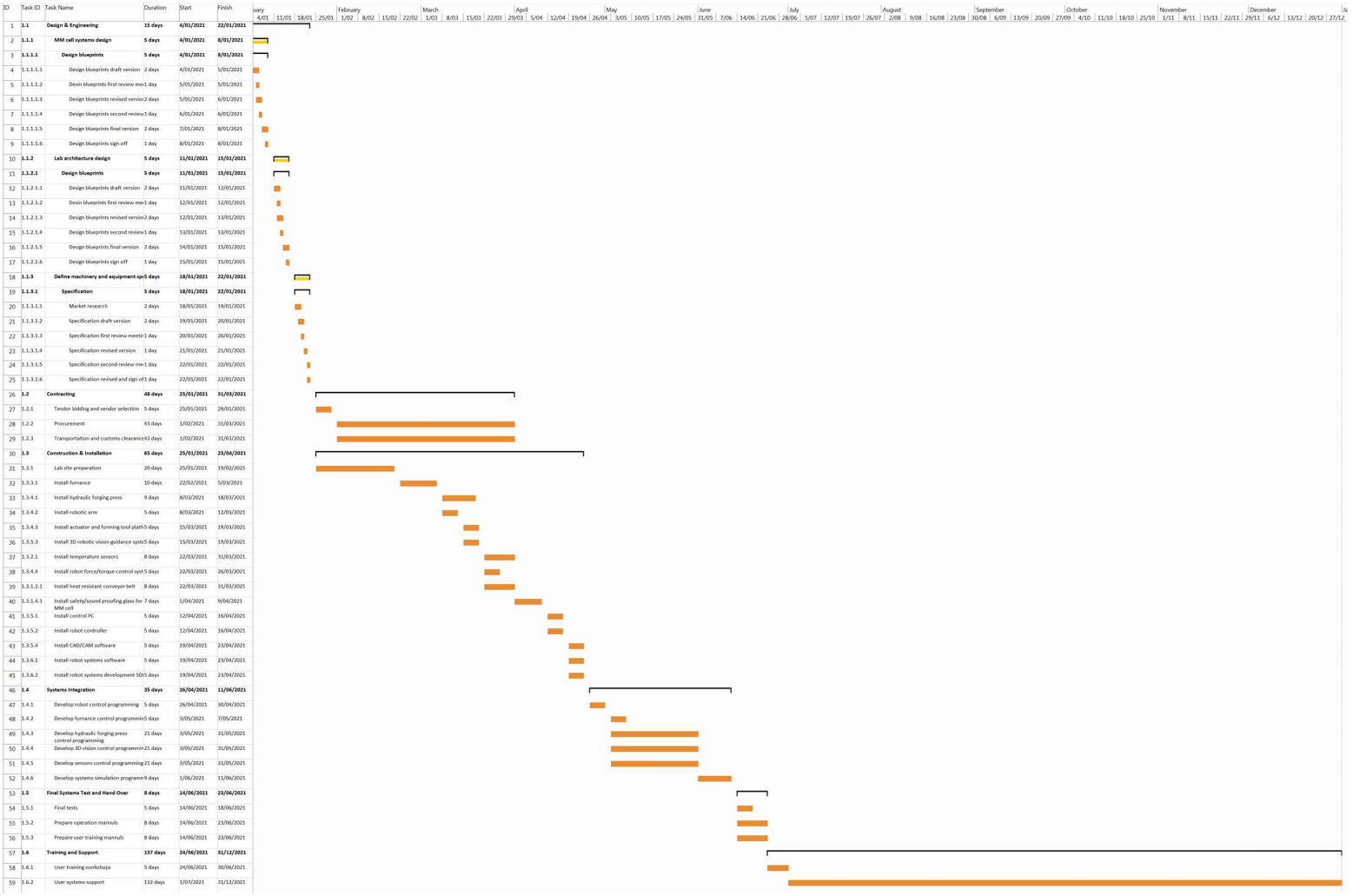
The project schedule is reproduced in the following formats:

- Gantt Chart - to show broader time scope of the project.
- Network Diagram - to show dependencies between work packages and highlight critical tasks.
- A further detailed schedule with budget allocations to individual work packages.

The former two are presented in the proceeding Sections. The latter is presented in Section 5.1, Appendix – Detailed Budget and Schedule.

3.4.1. Project Schedule Gantt Chart

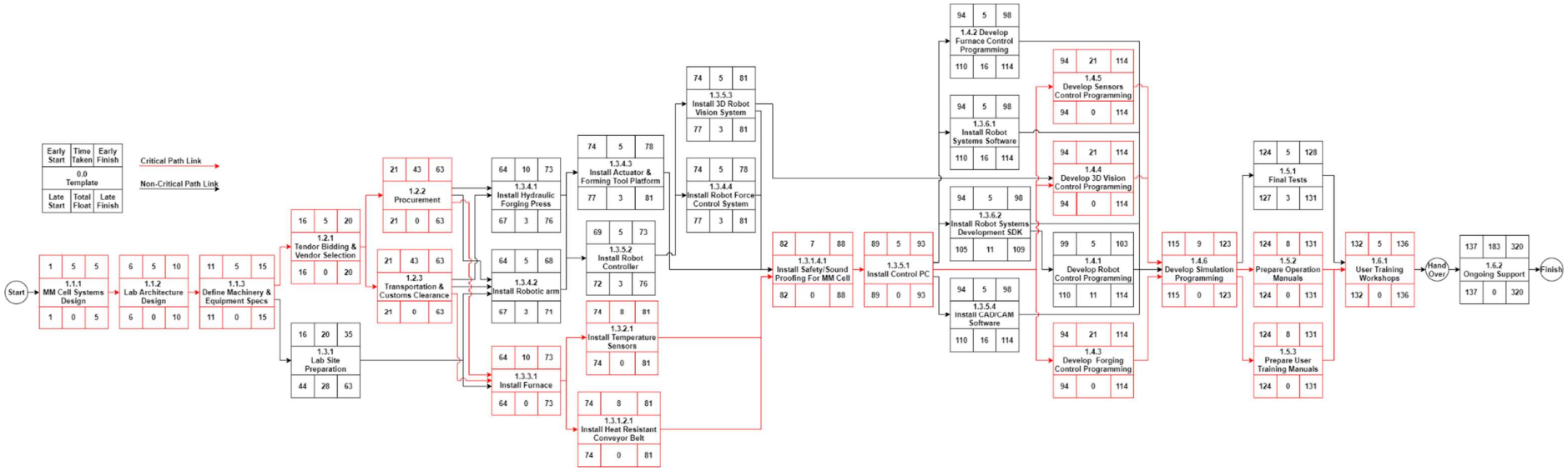
Figure 2. Project Schedule Gantt Chart



ID	Task ID	Task Name	Duration	Start	Finish
1	**1.1**	**Design & Engineering**	**15 days**	**4/01/2021**	**22/01/2021**
2	**1.1.1**	**MM cell systems design**	**5 days**	**4/01/2021**	**8/01/2021**
3	**1.1.1.1**	**Design blueprints**	**5 days**	**4/01/2021**	**8/01/2021**
4	1.1.1.1.1	Design blueprints draft version	2 days	4/01/2021	5/01/2021
5	1.1.1.1.2	Desin blueprints first review me	1 day	5/01/2021	5/01/2021
6	1.1.1.1.3	Design blueprints revised versio	2 days	5/01/2021	6/01/2021
7	1.1.1.1.4	Design blueprints second review	1 day	6/01/2021	6/01/2021
8	1.1.1.1.5	Design blueprints final version	2 days	7/01/2021	8/01/2021
9	1.1.1.1.6	Design blueprints sign off	1 day	8/01/2021	8/01/2021
10	**1.1.2**	**Lab architecture design**	**5 days**	**11/01/2021**	**15/01/2021**
11	**1.1.2.1**	**Design blueprints**	**5 days**	**11/01/2021**	**15/01/2021**
12	1.1.2.1.1	Design blueprints draft version	2 days	11/01/2021	12/01/2021
13	1.1.2.1.2	Desin blueprints first review me	1 day	12/01/2021	12/01/2021
14	1.1.2.1.3	Design blueprints revised versio	2 days	12/01/2021	13/01/2021
15	1.1.2.1.4	Design blueprints second review	1 day	13/01/2021	13/01/2021
16	1.1.2.1.5	Design blueprints final version	2 days	14/01/2021	15/01/2021
17	1.1.2.1.6	Design blueprints sign off	1 day	15/01/2021	15/01/2021
18	**1.1.3**	**Define machinery and equipment sp**	**5 days**	**18/01/2021**	**22/01/2021**
19	**1.1.3.1**	**Specification**	**5 days**	**18/01/2021**	**22/01/2021**
20	1.1.3.1.1	Market research	2 days	18/01/2021	19/01/2021
21	1.1.3.1.2	Specification draft version	2 days	19/01/2021	20/01/2021
22	1.1.3.1.3	Specificaiton first review meetir	1 day	20/01/2021	20/01/2021
23	1.1.3.1.4	Specificaiton revised version	1 day	21/01/2021	21/01/2021
24	1.1.3.1.5	Specificaiton second review me	1 day	22/01/2021	22/01/2021
25	1.1.3.1.6	Specification revised and sign of	1 day	22/01/2021	22/01/2021
26	**1.2**	**Contracting**	**48 days**	**25/01/2021**	**31/03/2021**
27	1.2.1	Tendor bidding and vendor selection	5 days	25/01/2021	29/01/2021
28	1.2.2	Procurement	43 days	1/02/2021	31/03/2021
29	1.2.3	Transportation and customs clearance	43 days	1/02/2021	31/03/2021
30	**1.3**	**Construction & Installation**	**65 days**	**25/01/2021**	**23/04/2021**
31	1.3.1	Lab site preparation	20 days	25/01/2021	19/02/2021
32	1.3.3.1	Install furnance	10 days	22/02/2021	5/03/2021
33	1.3.4.1	Install hydraulic forging press	9 days	8/03/2021	18/03/2021
34	1.3.4.2	Install robotic arm	5 days	8/03/2021	12/03/2021
35	1.3.4.3	Install actuator and forming tool platf	5 days	15/03/2021	19/03/2021
36	1.3.5.3	Install 3D robotic vision guidance syste	5 days	15/03/2021	19/03/2021
37	1.3.2.1	Install temperature sensors	8 days	22/03/2021	31/03/2021
38	1.3.4.4	Install robot force/torque control syst	5 days	22/03/2021	26/03/2021
39	1.3.1.2.1	Install heat resistant conveyor belt	8 days	22/03/2021	31/03/2021
40	1.3.1.4.1	Install safety/sound proofing glass for MM cell	7 days	1/04/2021	9/04/2021
41	1.3.5.1	Install control PC	5 days	12/04/2021	16/04/2021
42	1.3.5.2	Install robot controller	5 days	12/04/2021	16/04/2021
43	1.3.5.4	Install CAD/CAM software	5 days	19/04/2021	23/04/2021
44	1.3.6.1	Install robot systems software	5 days	19/04/2021	23/04/2021
45	1.3.6.2	Install robot systems development SDI	5 days	19/04/2021	23/04/2021
46	**1.4**	**Systems Integration**	**35 days**	**26/04/2021**	**11/06/2021**
47	1.4.1	Develop robot control programming	5 days	26/04/2021	30/04/2021
48	1.4.2	Develop furnance control programmin	5 days	3/05/2021	7/05/2021
49	1.4.3	Develop hydraulic forging press control programming	21 days	3/05/2021	31/05/2021
50	1.4.4	Develop 3D vision control programmir	21 days	3/05/2021	31/05/2021
51	1.4.5	Develop sensors control programming	21 days	3/05/2021	31/05/2021
52	1.4.6	Develop systems simulation programe	9 days	1/06/2021	11/06/2021
53	**1.5**	**Final Systems Test and Hand Over**	**8 days**	**14/06/2021**	**23/06/2021**
54	1.5.1	Final tests	5 days	14/06/2021	18/06/2021
55	1.5.2	Prepare operation mannuls	8 days	14/06/2021	23/06/2021
56	1.5.3	Prepare user training mannuls	8 days	14/06/2021	23/06/2021
57	**1.6**	**Training and Support**	**137 days**	**24/06/2021**	**31/12/2021**
58	1.6.1	User training workshops	5 days	24/06/2021	30/06/2021
59	1.6.2	User systems support	132 days	1/07/2021	31/12/2021

3.4.2. Project Network Diagram

Figure 3. Project Network Diagram



3.5. Stakeholder Management and Communication Plan

The stakeholder register is summarised in Table 6 and detailed in Section 3.5.1 (McKinsey & Company, 2020).

Table 4. Stakeholder Register

Stakeholder	Category	Interest (0-3)	Influence (0-3)	Expectations	Communication Channel
Dr Xiaopeng Li	Primary	3	3	Fully functional MM cell.	Personal check-in meetings. Phone call updates for high level milestones. Weekly email summaries of progress.
Professor Chun Wang	Primary	2	1	Fully functional MM cell with a focus on not exceeding budget.	Email notifications, agenda summaries. Phone call updates for high level milestones.
UNSW researchers	Primary	1	3	Functioning MM cell as well as the required training to utilise effectively.	Obtain input early to form requirements. Keep engaged using monthly newsletters.
Contractors/Suppliers	Secondary	3	3	Clear instructions regarding standards and expectations, on-time payments.	Personal check-ins, contract negotiations. Phone calls for urgent communications.
UNSW academic staff	Secondary	2	1	No disruptions from lab construction and its ensuing usage.	Monthly email newsletters for engagement. Feedback forms.
UNSW engineering students	Secondary	1	3	No disruptions from lab construction and its ensuing usage. Information on how the technology works	Monthly email newsletters for engagement. Feedback forms.
Environmental groups	Tertiary	0	1	No violation of environmental safeguards	Monthly email newsletters.
Industry representatives and SME owners	Tertiary	1	1	Transparent information regarding technological developments coming out of the lab	Monthly email newsletters.

3.5.1. Detailed Stakeholder Management Strategy

3.5.1.1. Primary Stakeholder Engagement

Dr Xiaopeng Li - Due to his high level of both influence and interest, Group 1 will manage engagement with Dr Li closely by holding regular check-in meetings, fortnightly steering committee meetings (where performance, risk, schedule and budgeting are discussed), phone call updates for high-level milestones and weekly email summaries of progress.

Professor Chun Wang - His high level of influence means Group 1 will keep Professor Wang well informed by email notifications and agenda summaries as well as phone call updates for high level milestones.

UNSW Researchers - Researchers will have less influence than other primary stakeholders but have a high level of interest which dictates that they should be kept well informed. Additionally, Group 1 will obtain a deep level of input upfront from this stakeholder group to help form requirements. Finally, the researchers will receive monthly newsletters to keep engaged in the project.

3.5.1.2. Secondary Stakeholder Engagement

Contractors & Suppliers - Use UNSW's pre-existing channels to make contractors aware of the project so they can make bids (Tenderlink UNSW, 2020). High level of engagement via the contractors and suppliers' account managers during negotiations to ensure both parties are aware of expectations and standards. Account managers will also have continued active engagement with suppliers to ensure smooth delivery of key parts and will perform regular inspections. PM will require regular updates on progress of the work and if costs are in line with projections. Shift to a low level of engagement once their work is completed, however Group 1 will require a way to contact them if issues arise stemming from their work, or if knowledge is needed of how equipment was installed.

Academic Staff – The project administrator (see Section 3.6.1) will send monthly newsletters to engineering staff letting them know about the renovation explaining how construction may affect the space, potential noise, as well as the benefits to teaching and research. May require higher levels

of engagement once the project is finished and they are educated on lab specifics. Group 1 will also provide a feedback channel for staff through surveys and feedback forms administered by the project administrator.

3.5.1.3. Tertiary Stakeholder Engagement

Environmental Groups - These groups are important to engage early to ensure the facilities aren't going to face any opposition or stir unnecessary controversy.

Industry Representatives and SMEs - People involved in engineering at other universities will be informed via existing inter-university communication channels (UNSW Knowledge Exchange, 2020). Interested parties will learn of the lab through papers published by the university through the IEEE or other organisations involved in disseminating technical information (IEEE UNSW Student Branch, 2020).

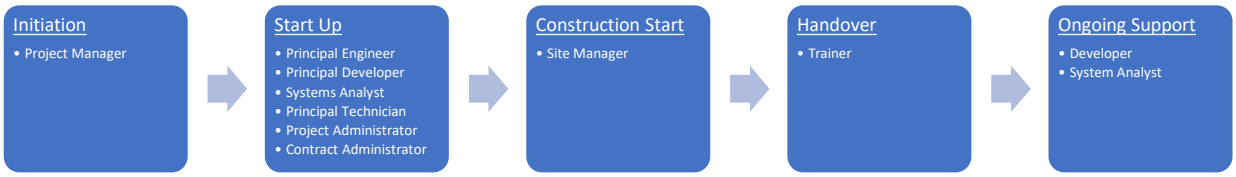
3.6. Human Resource Plan

The HR plan outlines how to estimate, acquire, manage and utilize the human resources required to carry out this project.

3.6.1. Estimating Human Resource Requirements

To estimate the human resources required for this project, the budget and WBS were used as the primary inputs alongside expert judgement from Group 1 as several group members have experience on similar projects. Using the inputs, the staff required for each stage of the project was developed using a bottom-up estimation method (Project Management Institute, 2017), and required positions are listed in figure 4 with roles and desired attributes found Section 3.6.2.2.

Figure 4. Team Members Required for each Project Stage



3.6.2. Acquiring Human Resources

3.6.2.1. Hiring Strategy

The hiring for this project will be carried out by UNSW's Human Resource department and will therefore be in alignment with UNSW's Recruitment and Selection policy and will help contribute towards the organisation's 2025 strategy (UNSW HR, 2020).

The hiring process will involve the PM providing UNSW with role descriptions (see Section 3.6.2.2), followed by UNSW HR advertising for each role for a period of at least two weeks. Any finalist candidates will be interviewed by a project panel involving Group 1 representatives and the project sponsor, as is typical of the UNSW hiring procedure. After a position is filled, the onboarding and induction process will be carried out by UNSW HR.

As the project sponsor would like the project to start in the first weeks of January, the hiring process will be required to start during November to provide enough time for advertising, interviews, background checks and contingencies.

3.6.2.2. Position Descriptions

For each full-time member of the team, the following position descriptions will be sent to UNSW HR for advertisement.

Position: Full-time **Project Manager**, Level 9 Step 3, 6 months (Hired – Group 1)
Role: PM is who has experience in developing new technologies through integrating software and engineering solutions to develop the first metamorphic manufacturing cell in Australia for UNSW. This person will be required to work with the project sponsor to play the lead role in planning, executing, monitoring, controlling and handing over the project once it is completed.
Attributes: The successful applicant will have the relevant qualifications and minimum 8 years' experience in project managing similar projects. They will need the leadership skills to head a team of 8 in an agile and collaborative work environment and strong organisational, communication and issue resolution skills. They will pay excellent attention-to-detail and can effectively manage multiple streams of work and conflicting deadlines.

Position: Full-time **Principle Engineer**, Level 8 Step 5, 6 months
Role: Principal Engineer is to work on the design and architecture of the first metamorphic manufacturing cell in Australia. This position will also assist with vendor selection for any equipment and parts, supervise and manage all engineering works and be responsible for quality compliance.
Attributes: The successful applicant will have the relevant qualifications and at least 8 years' experience in electronic and mechanical engineering. They will have passion for technology and problem solving and strong teamwork and communication skills. They possess the skills to be in a leadership role with a principle technician who will report to them and be able to manage any sub-contractors that they hire to carry out required work packages.

Position: Full-time **Principal Developer**, Level 8 Step 5, 4 months
Role: Principal Developer is to design and develop all interfacing programs for the first metamorphic manufacturing cell in Australia. This role will require the integration of multiple complex systems including computer vison, robotic arms, sensors and actuators and more.
Attributes: The successful applicant will have the relevant qualifications and at least 8 years' experience in API and system integration programming to carry out the integration of multiple systems required to operate the MM cell. This team member will also have the leadership skills to manage a systems analyst who will report to them as well as any sub-contractors they hire to carry out required work packages. The successful candidate will have good problem-solving and communication skills and will enjoy working in an agile environment with a small team to develop cutting-edge technologies.

Position: Full-time **Systems Analyst**, Level 6 Step 3, 4 months
Role: Systems Analyst is to help with the development of Australia's first metamorphic manufacturing cell for UNSW. This person will be responsible for the documentation of all manual systems, system tests, systems error investigation and resolution and the transfer of knowledge after project completion.
Attributes: The successful applicant will have the relevant qualifications and at least 5 years' experience as a system analyst working in similar projects. They require strong communication and problem-solving skills and will enjoy working collaboratively in an agile and fast-paced work environment.

Position: Full-time **Principle Technician**, Level 6 Step 3, 6 months
Role: Principle Technician is to help develop Australia's first metamorphic manufacturing cell for UNSW. This position will supervise all onsite technicians' job, manage and resolve all technical issues, ensure quality and safety compliance and more.
Attributes: The successful applicant will have at least 10 years of experience as the chief technician for similar projects. They will have good attention-to-detail and documentation skills, the ability to

set up and use appropriate test equipment and have a strong emphasis on safety. They will also require the ability to work in a collaborative environment and therefore will need good communication and teamwork skills.

Position: Part-time **Project Administrator**, Level 3 Step 5, 6 months
Role: Project Administrator is to manage project communications, engage with stakeholders, oversee the schedule and budget allocations as well as manage the procurement and payments of any equipment or resources required to assemble the first metamorphic manufacturing cell in Australia for UNSW.
Attributes: The successful applicant will have at least 3 years of experience in project administration. They will require excellent written and verbal communication skills and strong attention to detail to adapt to possible changes in schedule and budget allocations. The right candidate is will have good problem-solving skills and is ready to work in a collaborative, agile and fast-paced environment.

Position: Part-time **Contract Administrator**, Level 3 Step 5, 6 months
Role: Contract Administrator is to manage all contract related matters including any bidding processes, vendor management and prepare any legal documents for the first metamorphic manufacturing cell to be built in Australia.
Attributes: The successful applicant will have at least 3 years of experience working in contract administration. They will require a strong understanding of Australian Standards and experience in procurement of equipment and resources. They will need to have strong communication and team working skills and be comfortable working in an agile, fast-paced environment.

Position: Full-time **Site Manager**, Level 6 Step 3, 6 months
Role: Site Manager is to manage the preparation of the lab for the first metamorphic manufacturing cell to be built in Australia. This person will also supervise all non-equipment related site tasks such as safety compliance and site audits.
Attributes: The successful applicant will have at least 5 years' experience as a site installation manager for similar projects. They will also need strong communication and interpersonal skills to manage all the contractors and staff on-site.

Position: Part-time **Trainer**, Level 7 Base 2, 1 month
Role: A trainer is to set up training systems and conduct user training workshops for UNSW researchers and staff looking to use the first metamorphic manufacturing cell built in Australia.
Attributes: The successful applicant will have at least 3 years of experience in the field and will have strong attention to detail and time management skills, as well as strong written and verbal communication skills.

3.6.2.3. Hiring Sub-Contractors

Throughout the project there may be work packages that require more labour or specific expertise than can be provided by the full-time staff working on the project, for example this might include installation of the lab's sound proofing and safety glass or the lab's design and preparation. For these one-off tasks, the budget includes money allocated to hire sub-contractors to help perform these tasks. The sub-contractors will be hired on a casual basis through UNSW HR (Tenderlink UNSW, 2020) and will be the responsibility of the staff member who is responsible for the work package, though any hiring must be signed off by the PM, contract administrator and UNSW HR before being approved.

3.6.2.4. Scarcity of Human Resources Strategy

If there is a scarcity of human resources in one or more positions, there are three contingency options that could be used to fill the roles, depending on which role shows scarcity. The first, is to increase the advertised salary for the role and take this money from the contingency budget. The second is to allow some junior roles to work remotely, this will expand the pool of talent to cities within Australia that have a similar time zone, however, this work arrangement likely would not work for any of the principle roles or any of the on-site roles. Lastly, additional benefits could be advertised with the role, for example the opportunity to take one rostered day off per fortnight, or flexible work hours. This issue is discussed further in the Risk Register (Section 3.7.4).

3.6.2.5. Inductions and Training

As mentioned previously, onboarding and inductions will be carried out by UNSW HR, however, there are some project specific inductions that will be required for this project. For example, this project may involve working with large equipment, hot furnaces, moving robotics and other hazards. As such, each employee will be required to attend a safety induction and training workshop carried out by the project administrator.

3.6.3. Managing Human Resources

3.6.3.1. Communication Plan and Meeting Schedule

The staff will be expected to use MS Teams as the primary tool for communication and a Teams channel will be set up by the project administrator. MS Teams was chosen as it is UNSW's preferred software of choice for managing team projects (UNSW IT, 2020).

The project team will adopt an agile work environment due to the short timescale and multi-disciplinary aspects of this project, as such the project team will meet daily for morning stand-ups to discuss work objectives for the day and collaboratively work through any issues (Project Management Institute, 2017).

3.6.3.2. Location

It is expected that the primary workspace location for this project will be in the Willis Annexe on the UNSW Kensington campus. This location will be near the MM cell lab to allow for easy access to equipment. However, if required, some project staff may be able to work remotely.

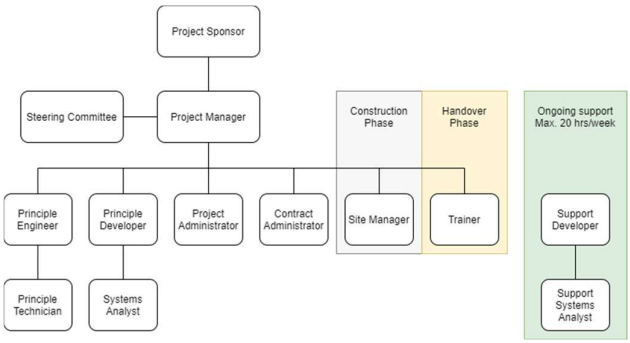
3.6.3.3. Resolving Issues

As the team will be adopting an agile work environment, any issues that occur can be raised during the daily meetings and then discussed collaboratively. Any issues that need further escalation can be brought to the steering committee during fortnightly meetings discussed in Section 3.3.1.

3.6.4. HR Roles and Responsibilities

3.6.4.1. Organisational Structure and Hierarchical Chart

Figure 5. Organisational Structure and Hierarchical Chart



3.6.4.2. RACI Matrix

The RACI matrix outlines which team members are responsible (R), accountable (A), consulted (C) and informed (I) for each work package.

Figure 6. RACI Matrix

				Project Team						
1	UNSW Kensington MM Cell Project			Project Manager	Principle Engineer	Principal Developer	Project Administrator	Contract administrator	Site Manager	Trainer
	1.1	Design & Engineering								
		1.1.1	MM Cell System Design	A	R	I	I		I	
		1.1.2	Lab Architecture Design	A	R	I	I		I	
		1.1.3	Machinery and Equipment Specifications	A	R				I	
	1.2	Contracting								
		1.2.1	Tendor bidding and vendor selection	A	C		R	C		
		1.2.2	Procurement	A			R	C		
		1.2.3	Transportation and Customs Clearance	A			R	C		
	1.3	Construction & Installation								
		1.3.1	Lab preparation	A	C				R	
		1.3.2	Sensors	A	R	C			I	
		1.3.3	Thermal Control Systems	A	R	C			I	
		1.3.4	Actuators and forming tools	A	R	C			I	
		1.3.5	Robotic manipulation system	A	C	R			I	
		1.3.6	Computation system	A	C	R			I	
	1.4	Systems Integration								
		1.4.1	Robot control programming	A	I	R				
		1.4.2	Furnance control programming	A	I	R				
		1.4.3	Hydraulic forging press control programming	A	I	R				
		1.4.4	3D vision control programming	A	I	R				
		1.4.5	Sensors control programming	A	I	R				
		1.4.6	Systems simulation control programming	A	I	R				
	1.5	Systems Testing								
		1.5.1	Full system acceptance test results	A	C	R				
		1.5.2	Full system operation manual	A	C	R				
		1.5.3	Training manuals	A	C	R				
	1.6	Training								
		1.6.1	User training workshops	A						R
		1.6.2	User support system	A						R

3.7. Risk Management Plan

This section defines how risk will be managed by the PM who will use the risk register to store individual project risks including their category, likelihood, potential impact, mitigation and contingency plan.

3.7.1. Risk Management Approach

The PM scored and ranked all identified risks. Some of the most likely and highest impact risks have been included in the project schedule to make sure the mitigation response will be implemented at the appropriate time. Once the project has reached completion, the PM will analyse each risk and

the risk management process. According to these analyses, improvements that can be made to the risk management process for future projects will be recognised. These improvements will form part of the lessons learned knowledge base.

3.7.2. Risk Identification

The PM used Failure Mode and Effect Analysis (FMEA) (Lock, 2013) as the first step to identify the risks associated with the project.

Table 7. Failure Mode and Effect Analysis

	Item	Failure Mode	Cause of Failure	Effect	Remedy: Recommended action
1	Specification Documentation	Delay in documentation	Failure in program monitoring	Equipment delivery delay	Effective control
2	Tendor Documents	Appeal from bidding participants	Failure in program monitoring	Equipment delivery delay	Effective control
3	Equipment&Machines	Increase in time of equipment operation	Insufficient researchers	Project delivery delay	Effective control in labour budgeting
4		Increase in time of equipment operation	Insufficient equipments	Project delivery delay	Effective control in documentation
5		Not working as intended	Inaccurate estimation during design	Project delivery delay	Effective control in design
6		Not working as intended	Purchase the wrong type/model	Project delivery delay	Effective control in documentation
7		Wear and tear	Poor maintenance	Project delivery delay	Ensure good equipment&machines maintance and have back-up machines
8		Broke	Delivery failure	Project delivery delay	Purchase shipping insurance
9		Broke	Inappropriate handling	Project delivery delay	have back-up machines
10		Delay in delivery	Supplier failure	Project delivery delay	Encounter delay in schedule
11	Building	Building collapses during installation of heavey machinery	Errors in floor loading calculations	Personal injuries/Project delivery delay/Loss of reputation	Triple check key structural calculations
12		Building collapses during installation of heavy machinery	Floor slabs incorrectly poured	Personal injuries/Project delivery delay/Loss of reputation	Ensure operatives get good training and instruction. Employ competent site engineering manager
13	Laboratory	Renovation failure	Unprofessional construction company	Lab delivery delay	Effective control in tendering
14		Laboratory on fire or exploded	Inappropriate equipment operations	Personal injuries/Project delivery delay/Loss of reputation	Effective laboratory safety control i.e. fire alarm system/Onsite training before project starts
15		Environmental issues	Inappropriate waster control	Loss of reputation	Contract qualified waster disposal company
16	Centralised computer control system	Shutdown	Loss of electrical power	Project delivery delay	Power backup plan
17		Software failure	Hire inexperienced/unqualified software engineer	Project delivery delay	Hire procedure control
18		Freeze	Hacked by hacker	Project delivery delay	Cyber security control

3.7.3. Risk Assessment

Once risks are identified, they are evaluated on a four-dimensional matrix using a quantitative rating of the impact on project performance. The impacts include the scope of the project, the quality of the project, the defined project schedule and the monetary cost. This type of evaluation will provide a better numerical representation of the consequence of a risk item. The likelihood of a risk item should also be considered on top of the risk consequence level. With a pre-defined project risk tolerance level, the PM can determine which risk item needs to be treated and which risk item is acceptable. Risks are quantitatively assessed based on their consequence and likelihood.

Risks are then categorised as Low, Moderate or High depending on their Likelihood and Consequence scores as shown in Table 8.

Table 8. Risk Assessment Matrix

	1	2	3	4	5
A	Moderate	Moderate	High	High	High
B	Moderate	Moderate	Moderate	High	High
C	Low	Moderate	Moderate	High	High
D	Low	Low	Moderate	Moderate	High
E	Low	Low	Low	Moderate	Moderate

3.7.4. Risk Register

Table 9. Project Risk Register

Risk Category	Risk ID	Risk Statement	**Impact				*Likelihood (Before)	***Overall Score (Before)	Risk	Mitigation	*Likelihood (After)	***Overall Score (After)	Risk	Contingency	Action by:
			Scope	Quality	Schedule	Cost									
Technical Risks	1	Project purpose and need is not well-defined.	3	3	1	1	C	3	Moderate	Complete a business case if not already provided and ensure purpose is well defined on Project Charter.	D	2	Low	Communicate with Project Sponsor to redesign the project purpose	Project Sponsor
	2	Project design and deliverable definition is incomplete.	3	3	1	1	C	3	Moderate	Define the scope in detail via design workshops with input from subject matter experts.	D	2	Low	Document assumptions made and associated risks. Request high risk items that are ill-defined are removed from scope.	Project Sponsor
	3	Technology-related challenges including: 1. Lack of models for evolutionary shape estimation for material classes 2. Lack of accurate predictive models of material behavior during MM process would require additional time spent in fine tuning sensors 3. Processing structure property performance relationship for MM materials are limited 4. Sensors have insufficient in-situ process monitoring and feedback control capabilities 5. Robotic integration to adjust thermal deformation, rotation, controlled cooling/heating proves difficult 6. Current technology and equipment suites not optimized for MM capabilities 7. Shortage of skilled users with expertise in using technology	2	3	3	3	C	4	High	Backup/Alternatives, Testing and modeling: Assessing whether technical uncertainties can be resolved through the use of: 1. CAD systems 2. Build models/prototypes 3. Experiments	D	3	Moderate	Initiate new academic research to address the possible causes.	Project Sponsor
Schedule Risks	4	Project schedule is too tight to meet the project deadline	3	1	3	3	A	4	High	Hold scheduling workshops with the project team so they understand the plan and likelihood of missed tasks is reduced. Share the schedule and go through upcoming tasks at each weekly project progress meeting.	C	3	Moderate	Revisit the schedule with the project team. 'Relaunch' the project schedule.	Project Sponsor
	5	Equipment & machines failure due to not working as intended, wear and tear, broken and increase in time of equipment operation.	1	1	3	2	B	3	Moderate	Effective control in design, documentation and maintenance. Have back-up machines in place. Machines should be univsrsally adatopable and not too specific so easy to find replacement. Time Buffers/Project Slack or Compression/Crashing of project schedules by running activities in parallel or changing relationships	D	3	Moderate	Contact supplier for spare parts. Contact contractor for emegency on-site repair.	Project Manager
Funding Risks	6	The project sponsors leaves	3	3	3	3	E	5	Moderate	Ensure a broad communication plan for the project spans all the critical leaders to bring as many of them as possible into a position of strong support from an organizational perspective.	E	4	Moderate	Find a new project sposor as soon as possible	Project Manager
Commercial Risks	7	Laboratory renovation failure due to Contractor delays	1	1	2	2	B	3	Moderate	Include late penalties in contracts. Build in and protect lead time in the schedule. Communicate schedule early.	D	3	Moderate	Implement late clauses.	Project Manager
	8	Supplier failure: i.e. supplier shut down, delays, physical damage of products, natural calamities, and shortage of raw materials	1	1	3	3	B	5	High	Conduct thorough research of the supplier to understand the possible supplier chain risks. Complete tendor process to chosse the most reliable supplier and have back-up supplier on record. Establish continuous monitoring processes and performance metrics to ensure that supply chain risks are identified and mitigated in a timely manner.	C	3	Moderate	Discuss with back-up supplier as soon as possible.	Project Manager
Management Risks	9	Project Managers/Researchers got new offer and quit	1	1	1	1	C	1	Low	Ensure Non-Disclosure Agreements are in place. Offer competitive benefit packages to retain talents.	C	1	Low	Hire new project managers/researchers. Detailed handover procedure in place.	Project Manager
	10	Theft of Intellectual Property, materials and equipment	1	1	3	3	B	3	Moderate	Follow security procedures, ensure Non-Disclosure Agreements and compliance certificates are in place. Verify all physical security measures in place. Secure insurance.	C	3	Moderate	Notify appropriate authorities e.g. police, faculty head and initiate internal investigations.	Project Manager
External Risks	11	Skills shortage risks in the Labour Market/Scarity of Human Resources	2	3	3	3	A	4	High	Target talent management for EL and SES employees and identifying the current strength of the leadership cadre to establish a baseline. Improve recruitment and retention strategies. Integrate workforce planning into business planning	C	3	Moderate	Increase the advertised salary for the role and take this money from the contingency budget. Allow some junior roles to work remotely. Hire internationally.	Project Manager
	12	COVID-19 results in lab shutdown	1	1	3	3	B	3	Moderate	Ensure insurance in place. Familiarise project team with emergency procedures add put back up systems in place.	B	3	Moderate	Notify appropriate authorities, including project sponsors, the faculty head of Engineering. Follow health and safety procedures.	Project Manager
Safety Risks	13	Fire and explosion	1	1	3	3	A	3	High	Ensure insurance in place. Effective laboratory safety control i.e. fire alarm system and Onsite training before project starts. Data back up plan in place.	D	2	Low	Use contingency budget to renovate laboratory and purchase damaged equipments.	Project Manager
	14	Project delayed due to key personnel got injured	1	1	3	3	D	3	Moderate	Have key personnel A and key personnel B in place. Ensure insurance in place.	E	2	Low	Use contingency budget to hire replacement personnel.	Project Manager

Likelihood: A - almost certain; B - Likely; C - Moderate; D - Unlikely; E- Rare

**** Impact: 1 - Insiginifance; 2 - Moderate; 3 - Catastrophic**

*****Overall score: 1 - Insiginifance(Impact score adds up <=1); 2 - Minor >1 and <=3); 3 - Moderate(>3 and <=9); 4 - Major(>9 and <=27); 5 - Catastrophic(>27)**

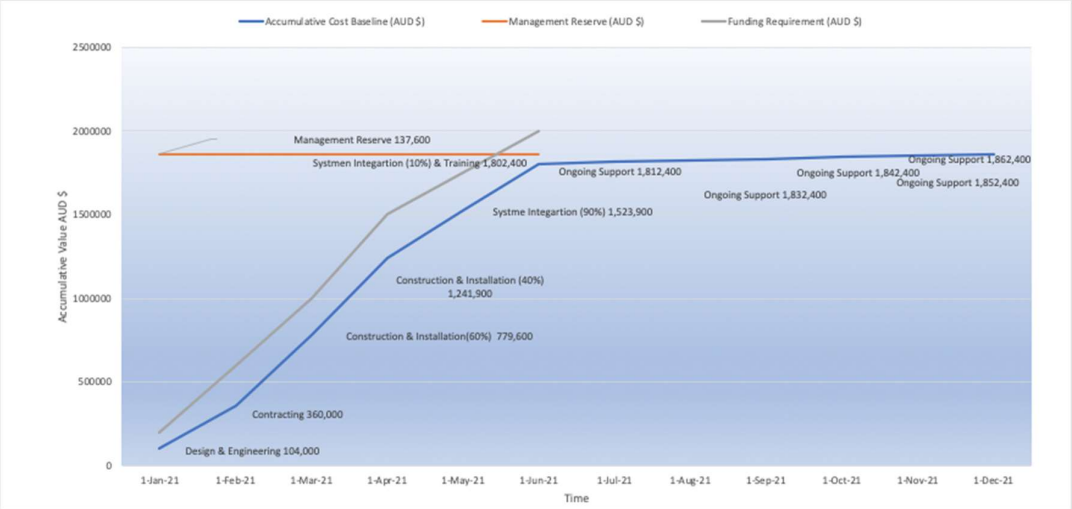
3.7.5. Monitoring and Controlling Risks

Risks will be monitored by PM and reviewed fortnightly at the steering committee meetings with project sponsors. Once the project has completed, risks will be analysed and included in lessons learned as appropriate.

During the fortnightly project team meeting the PM will discuss the status of risks that fall in the current time period. It is an on-going process to monitor these risks throughout the life of this project. As risks approach on the project schedule the PM will assure that the fundamental status updates including the risk status, recognition of trigger conditions, and the documentation of the results of the risk response will be provided by appropriate team members.

3.8. Time Phased Budget and Project Contingency Reserve Plan

Figure 7. Time Phased Budget



The grey line (fig. 7) represents the accumulated funding requirements. The total AUD $2,000,000 fund will be provided by the project sponsor as per the funding schedule shown in Table 10.

Table 10. Per Month Funding Requirements

Funding Due Date	Funding Requirement (AUD $)	Accumulative Funding Requirement (AUD $)
1-Jan-21	200,000	200,000
1-Feb-21	400,000	600,000
1-Mar-21	400,000	1,000,000
1-Apr-21	500,000	1,500,000
1-May-21	250,000	1,750,000
1-Jun-21	250,000	2,000,000

The blue line represents the accumulated cost baseline. The total accumulated cost baseline is AUD $1,862,400. It comprises of AUD $1,799,000 work package activities budget and AUD $62,500 work package contingency reserve.

The cost baseline is the summation of the approved budgets for the work package schedule activities and a fixed cost of AUD $60,000 for the ongoing support after the project is closed. It is used as a basis to calculate below two earned value metrics when the project status is 'Active':

- Cost Variance
- Cost Performance Index (CPI)

It can be changed through formal change control procedures.

The summary schedule of the cost baseline is shown in Table 11.

Table 11. Summary Cost Baseline Schedule

Time	Accumulative Cost Baseline (AUD $)	Work Packages	Project Status
31-Jan-21	104,000	Design & engineering	Active
28-Feb-21	360,000	Contracting	Active
31-Mar-21	779,600	Construction & Installation (60%)	Active
30-Apr-21	1,241,900	Construction & Installation (40%)	Active
31-May-21	1,523,900	System Integration (90%)	Active
30-Jun-21	1,802,400	10% System Integration &Documentation & Training	Active
31-Jul-21	1,812,400	Ongoing Support	Closed
31-Aug-21	1,822,400	Ongoing Support	Closed
30-Sep-21	1,832,400	Ongoing Support	Closed
31-Oct-21	1,842,400	Ongoing Support	Closed
30-Nov-21	1,852,400	Ongoing Support	Closed
31-Dec-21	1,862,400	Ongoing Support	Closed

The orange line (fig 7.) represents the Management Reserve of AUD $137,600. It is part of the project budget withheld for unforeseen work that has a high risk of impacting project scope. It is not included in the cost baseline but is a part of the funding requirements. When the unforeseen work is identified, the PM will submit a cost baseline change request to the project sponsor. The project sponsor will review and approve the change request. Once the request is approved, the required management reserve fund will be added to the cost baseline.

The Management Reserve for unforeseen work associated with work package activities is shown in Table 12.

Table 12. Management Reserve

Management Reserve

Task ID	Task Name	Start Date	End Date	Duration (Days)	Unforeseen Work	Management Reserve Budget ($)	Task ID	Task Name	Start Date	End Date	Duration (Days)	Unforeseen Work	Management Reserve Budget ($)
1.2.2	Procurement	01-Feb-21	31-Mar-21	43	Additonal management cost to source alternative parts	10000	1.4.3	Develop hydraulic forging press control programming	03-May-21	31-May-21	16	Additional program management cost	10,000
1.2.3	Transportation and Customs Clearance	01-Feb-21	31-Mar-21	43	Additional warehouse management cost	50000	1.4.4	Develop 3D vision control programming	03-May-21	31-May-21	16	Additional program management cost	10,000
1.3.4.3	Install actuator and forming tool platform	15-Mar-21	19-Mar-21	5	Additional safety compliance cost	2000	1.4.5	Develop sensors control programming	03-May-21	31-May-21	16	Additional program management cost	10,000
1.3.6.1	Install robot systems software	19-Apr-21	23-Apr-21	5	Additional licence cost	9,000	1.4.6	Develop systems simulation programming	01-Jun-21	11-Jun-21	9	Additional program management cost	10,000
1.3.6.2	Install robot systems development SDK	19-Apr-21	23-Apr-21	5	Additional systems update cost	3,000	1.5.1	Final Tests	14-Jun-21	18-Jun-21	5	Additional compliance cost	600
1.4.1	Develop robot control programming	26-Apr-21	30-Apr-21	5	Additional program management cost	10,000	1.5.2	Prepare Operation Manuals	14-Jun-21	23-Jun-21	8	Additional resource	1,000
1.4.2	Develop furnace control programming	03-May-21	07-May-21	5	Additional program management cost	10,000	1.5.3	Prepare User Training Manuals	14-Jun-21	23-Jun-21	8	Additional resource	2,000
												Total	**137,600**

The PM can adjust the allocated management reserve for each activity without changing the total amount of management reserve. The PM will provide an updated management reserve to project sponsor to review before the fortnightly project steering committee meeting.

4. References

IEEE UNSW Student Branch. (2020, 07 01). *IEEE*. Retrieved from https://edu.ieee.org/au-unsw/about-us/

Lock, D. (2013). *Project Management.* Farnham: Gower Publishing Limited.

McKinsey & Company. (2020, 07 03). *The Pivitol Factors for Effective External Engagement*. Retrieved from Strategy & Cororate FInance: https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/the-pivotal-factors-for-effective-external-engagement#

Project Management Institute. (2017). *PMBOK.* Newtown Square: Project Management Institute.

Tenderlink UNSW. (2020, 07 04). *Tenders, Quotes & EOI*. Retrieved from The UNSW Difference: https://www.tenderlink.com/unsw/

The Minerals, Metals & Materials Society. (2019). *Metamorphic Manufacturing Shaping the Future of On-Demand Components.* Pittsburgh: The Minerals, Metals & Materials Society.

UNSW. (2020). *2025 Strategy Update.* Sydney: UNSW Sydney.

UNSW HR. (2020, 07 06). *Recruitment Procedure*. Retrieved from HR UNSW: https://www.hr.unsw.edu.au/services/recruitment/recruitmentprocedure.html

UNSW IT. (2020, 07 06). *Getting ready to work remotely*. Retrieved from UNSW IT: https://www.myit.unsw.edu.au/services/staff/getting-ready-work-remotely

UNSW Knowledge Exchange. (2020, 07 01). *UNSW Knowledge Exchange*. Retrieved from https://www.knowledgeexchange.unsw.edu.au/

5. Appendix

5.1 Detailed Budget and Schedule

Detailed Budget and Schedule

Task ID	Task Name	Start Date	End Date	Duration (Days)	Task Budget ($)	Payroll Month	HR Budget ($)	Work Package Contingency Reserve ($)	Work Package Contingence Event	Cost Base Line ($)	Task ID	Task Name	Start Date	End Date	Duration (Days)	Task Budget ($)	Payroll Month	HR Budget ($)	Work Package Contingency Reserve ($)	Work Package Contingence Event	Cost Base Line ($)
1.1	**Design & engineering**										1.3.5.1	Install control pc	12-Apr-21	16-Apr-21	5	500					500
1.1.1	MM Cell Systems Design	04-Jan-21	08-Jan-21	5	10,000					10,000	1.3.5.2	Install robot controller	12-Apr-21	16-Apr-21	5	10000					10000
1.1.2	Lab Architecture Design	11-Jan-21	15-Jan-21	5	8,000	15-Jan-21	81,000	500	Correct design errors	89,500	1.3.5.4	Install CAD/CAM software	19-Apr-21	23-Apr-21	5	500			1000	Rework for incorrect installation	1500
1.1.3	Define Machinery and Equipment specifications	18-Jan-21	22-Jan-21	5	2,000					2,000	1.3.6.1	Install robot systems software	19-Apr-21	23-Apr-21	5	1000			500	Rework malfunction and fix bugs	1500
1.2	**Contracting**										1.3.6.2	Install robot systems development SDK	19-Apr-21	23-Apr-21	5	500			500	Rework malfunction and fix bugs	1000
1.2.1	Tendor bidding and vendor selection	25-Jan-21	29-Jan-21	5	2,000			4,500	price variance	6,500	**1.4**	**Systems Integration**									
1.2.2	Procurement	01-Feb-21	31-Mar-21	43	568,400	15-Feb-21	81,000			649,400	1.4.1	Develop robot control programming	26-Apr-21	30-Apr-21	5	100000	44301	81000	10000	Rework malfunction and fix bugs	191000
1.2.3	Transportation and Customs Clearance	01-Feb-21	31-Mar-21	43				1,000	Price variance	1,000	1.4.2	Develop furnace control programming	03-May-21	07-May-21	5	50000					50000
1.3	**Construction & Installation**										1.4.3	Develop hydraulic forging press control programming	03-May-21	31-May-21	16	100000					100000
1.3.1	Lab site preparation	25-Jan-21	19-Feb-21	20	25,000					25,000	1.4.4	Develop 3D vision control programming	03-May-21	31-May-21	16	25000	44331	81000			106000
1.3.3.1	Install furnace	22-Feb-21	05-Mar-21	10	5,000			5,000	Rework for incorrect installation	10,000	1.4.5	Develop sensors control programming	03-May-21	31-May-21	16	20000					20000
1.3.4.1	Install hydraulic forging press	08-Mar-21	18-Mar-21	10	50,000			5,000	Rework for incorrect installation	55,000	1.4.6	Develop systems simulation programming	01-Jun-21	11-Jun-21	9	150000			10000	Rework malfunction and fix bugs	160000
1.3.4.2	Install robostic arm	08-Mar-21	12-Mar-21	5	12,500					12,500	**1.5**	**Final Systems Test and Hand over**									
1.3.4.3	Install actuator and forming tool platform	15-Mar-21	19-Mar-21	5	5,000			10,000	Rework for incorrect installation	15,000	1.5.1	Final Tests	14-Jun-21	18-Jun-21	5	10000	44362	80000	500	Additional Test	90500
1.3.5.3	Install 3D robit vision guidance system	22-Mar-21	31-Mar-21	8	25,000			5,000	Rework for incorrect installation	30,000	1.5.2	Prepare Operation Manuals	14-Jun-21	23-Jun-21	8	10000			1000	Rework for incorrect procedures	11000
1.3.2.1	Install temperature sensors	22-Mar-21	26-Mar-21	5	500					500	1.5.3	Prepare User Training Manuals	14-Jun-21	23-Jun-21	8	20000			1000	Rework for incorrect procedures	21000
1.3.4.4	Install robot force/torque control system	22-Mar-21	26-Mar-21	5	500	15-Mar-21	81,000	2,000	Rework for incorrect installation	83,500	**1.6**	**Training and Support**									
1.3.1.2.1	Install heat resistant conveyor belt	22-Mar-21	31-Mar-21	8	1,500			2,000	Rework for incorrect installation	3,500	1.6.1	User training workshops	24-Jun-21	30-Jun-21	5	5000		7000			12000
1.3.1.4.1	Install safety/sound proofing glass for MM cell	01-Apr-21	09-Apr-21	7	30,000			3,000	Rework for incorrect installation	33,000	1.6.2	User systems support	01-Jul-21	30-Jun-22	183			60000			60000
															Total	**1,247,900**		**552,000**	**62,500**		**1,862,400**