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| EE495/CME495 |
| EE495/CME495 Project Plan |
| Revision 2 |

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| Thomas Hu, Jordan Smith, Jason Wong  10-1-2019 |

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# Purpose

The purpose of this document is to present the project plan for the EE495/CME495 capstone project which will be taken on by group #5.

## Document Identifier

This document is identified as:

**CD2 – EE495/CME495 Project Plan**

## Applicable Documents

Applicable documents include:

**CD1 – EE495/CME495 Problem Defintion**

## Revision History

|  |  |
| --- | --- |
| **Revision** | **Changes** |
| 1 | Initial Revision |
| 2 | Edited the task numbers in Table 2‑2 – Work Breakdown Structure to be easier to read. |

# Initial Project Plan

## Discussion

The team consists of two electrical engineers and one computer engineer. Jordan’s study streams are Circuits and Power. Thomas’ streams are Digital Signal Processing (DSP) and Circuits. Jason’s streams are Digital Systems and Computer Software. Due to the focus areas of each team member, responsibilities will be split into the following roles:

**Jordan**: Hardware development (primary), controller development (secondary)

**Jason**: Software & controller development (primary), project management (secondary)

**Thomas**: Systems design (primary), project management (secondary)

## Risks to Project Performance/Schedule

A list of risks that may impact the quality of the final product or project schedule include:

* Equipment lead times - some components that will be used in the design may have long lead times because they aren’t mass-produced products.
  + This will be mitigated by ordering components immediately after a final design is chosen.
* Component reliability - there is a possibility that the components ordered will not be reliable due to being new products, or due to being specialty components which may not have been tested to the extent of a component meant for larger market.
  + This can be mitigated by ordering components from more experienced vendors in the market, as well as avoiding ordering products that were recently introduced to the market.
* Outsourcing production - Doepker Industries will be helping build parts of the rotational unit, primarily the head/tail frame. Poor communication of design may result in Doepker building parts which may not be suitable for the design that the team envisioned.
  + This will be mitigated by creating clear documentation that will communicate exactly what the team wants built by Doepker Industries, and by communicating with Doepker to prevent misunderstandings.
* Unit is operated in an unexpected environment - Doepker Industries has multiple factories where the unit will be operated. Each factory will have different operating conditions, with the most important factor to keep in mind when designing the unit being that the unit must be compatible with the electrical systems used at each factory.
  + The team will design the unit to be compatible with all of the sites that the client provides electrical specifications for.

## Deliverables

Listed below are the deliverables for this project.

* Bill of Materials (BOM)
* Schematic diagrams
* Circuit board layout
* Software (firmware)
* Factory Acceptance Test Procedures
* Factory Acceptance Test Results
* System design document
* User manual
* System Block diagram
* Final Report

## Milestones

Listed in Table 2‑1 are major project milestones and their expected completion dates:

|  |  |
| --- | --- |
| Table 2‑1 - Project Milestones | |
| **Milestone** | **Date** |
| Problem Definition/Project Plan | October 1, 2019 |
| System Requirements Specification | October 25, 2019 |
| System Design Document | December 5, 2019 |
| Begin Unit Production | December 6, 2019 |
| User Manual | December 26, 2019 |
| System Verification Plan | January 6, 2020 |
| Perform Factory Acceptance Testing | February 13, 2020 |
| Final Report | April 10, 2020 |

## Work Breakdown Structure

Attached below in Table 2‑2 is the work breakdown structure which details the team member responsible for each task in designing the system and how many hours are budgeted for each task:

## Gantt Chart

A Gantt chart is attached in Appendix A to show the general timeline of the project.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Table 2‑2 – Work Breakdown Structure | | | | | | |
| Task Number | **Task Name** | **Assignee** | **Hours Budgeted** | **Task Start** | **Task Deadline** | **Predecessor** |
| 1 | **Create Problem Definition and Initial Project Plan** | Thomas | **10** | **Fri 9/20/19** | **Fri 10/1/19** |  |
| 1.1 | Create Problem Definition | Jason | 5 | Sun 9/22/19 | Wed 9/25/19 |  |
| 1.1.1 | Define Scope | Jason | 1 | Sun 9/22/19 | Tue 9/24/19 |  |
| 1.1.2 | Define Objectives/Constraints | Jason | 2 | Wed 9/25/19 | Wed 9/25/19 |  |
| 1.1.3 | Review Safety/Environmental Regulations | Jason | 2 | Tue 9/24/19 | Wed 9/25/19 |  |
| 1.2 | Create Project Plan | Thomas | 5 | Wed 9/25/19 | Fri 9/27/19 | 1.1 |
| 1.2.1 | Create Work Breakdown Structure | Thomas | 2 | Wed 9/25/19 | Fri 9/27/19 |  |
| 1.2.2 | Create Gantt Chart | Thomas | 2 | Wed 9/25/19 | Fri 9/27/19 |  |
| 1.2.3 | Perform Risk Analysis | Thomas | 1 | Wed 9/25/19 | Fri 9/27/19 |  |
| 2 | **Sign and Return Non-Disclosure Agreement to Client** | Jordan | **1** | **Fri 9/20/19** | **Wed 9/25/19** |  |
| 2.1 | Discuss Non-Disclosure Agreement with Supervisor | Jordan | 0.5 | Tue 9/24/19 | Tue 9/24/19 |  |
| 3 | **Meet with Supervisor** | Jordan | **7** | **Mon 9/23/19** | **Mon 3/23/20** |  |
| 4 | **Create Requirements Specification** | Thomas | **8** | **Fri 10/11/19** | **Fri 10/25/19** |  |
| 4.1 | Review Requirements with Client | Jordan | 2 | Thu 10/24/19 | Thu 10/24/19 |  |
| 5 | **Draft Detailed System Design Document** | Thomas | **30** | **Fri 11/1/19** | **Thu 12/5/19** | 4 |
| 5.1 | Perform System Design | Thomas | **8** | **Fri 11/1/19** | **Fri 11/15/19** |  |
| 5.1.1 | Create Block Diagram | Thomas | 2 | Mon 11/11/19 | Fri 11/15/19 |  |
| 5.2 | Perform Hardware Design | Jordan | **20** | **Fri 11/1/19** | **Fri 11/22/19** |  |
| 5.2.1 | Draft Design Schematics | Jordan | 10 | Fri 11/1/19 | Fri 11/15/19 |  |
| 5.2.2 | Spec System Components | Jordan | 10 | Fri 11/15/19 | Fri 11/22/19 |  |
| 6 | **Make/Perform Interim Project Presentation** | Jason | **20** | **Fri 11/1/19** | **Tue 11/26/19** |  |
| 6.1 | Make Interim Project Presentation | Jason | 18 | Fri 11/1/19 | Mon 11/25/19 |  |
| 6.2 | Present Interim Project Presentation | Jason | 2 | Tue 11/26/19 | Tue 11/26/19 | 6.1 |
| 7 | **Write Interim Project Report** | Thomas | **20** | **Fri 11/15/19** | **Thu 12/5/19** |  |
| 7.1 | Review Initial Project Plan | Thomas | 2 | Fri 11/15/19 | Fri 11/22/19 |  |
| 8 | **Acquire System Components** | Jordan | **6** | **Mon 11/25/19** | **Mon 11/25/19** | 5.2.2 |
| 9 | **Perform System Development** | Thomas | **60** | **Fri 12/6/19** | **Fri 1/10/20** | 5 |
| 9.1 | Develop Software | Jason | 25 | Fri 12/6/19 | Fri 12/27/19 |  |
| 9.2 | Build Hardware | Jordan | 20 | Fri 12/6/19 | Fri 12/27/19 |  |
| 9.3 | Perform System Integration | Thomas | 15 | Mon 12/30/19 | Fri 1/10/20 | 9.1, 9.2 |
| 10 | **Create System Verification Plan** | Thomas | **37.5** | **Fri 12/20/19** | **Mon 1/6/20** | 4 |
| 10.1 | Define Use Cases | Thomas | 10 | Fri 12/20/19 | Sun 12/22/19 |  |
| 10.2 | Define Test Cases | Thomas | 10 | Mon 12/23/19 | Fri 12/27/19 | 10.1 |
| 10.3 | Write Test Procedures | Thomas | **15** | **Wed 1/1/20** | **Fri 1/3/20** | 10.2 |
| 10.3.1 | Review Test Procedures with Client | Jordan | 2.5 | Wed 1/1/20 | Fri 1/3/20 |  |
| 11 | **Perform Acceptance Tests** | Thomas | **40** | **Mon 1/13/20** | **Thu 2/13/20** | 10 |
| 11.1 | Perform Integration Testing | Jason | 20 | Mon 1/13/20 | Tue 1/21/20 | 8, 9 |
| 11.2 | Review Integration Test Results with Customer | Jordan | 2.5 | Wed 1/22/20 | Wed 1/22/20 | 11.1 |
| 11.3 | Perform Factory Acceptance Tests with Client | Thomas | 7.5 | Mon 1/27/20 | Fri 1/31/20 | 11.2 |
| 11.4 | Write Factory Acceptance Report | Thomas | 10 | Mon 2/3/20 | Fri 2/7/20 | 11.3 |
| 12 | **Write User Manual** | Thomas | **30** | **Fri 12/6/19** | **Thu 12/26/19** | 5 |
| 13 | **Prepare Final Project Presentation and Demonstration** | Jason | **40** | **Mon 3/2/20** | **Fri 3/20/20** | 5, 11 |
| 13.1 | Make Final Project Presentation | Jason | 20 | Mon 3/2/20 | Tue 3/10/20 |  |
| 13.2 | Review Presentation with Client | Jordan | 1.5 | Wed 3/11/20 | Wed 3/11/20 | 13.1 |
| 13.3 | Present Final Project Presentation | Jason | 1 | Fri 3/20/20 | Fri 3/20/20 | 13.2 |
| 13.4 | Prepare Project Demonstration | Jordan | 15 | Mon 3/2/20 | Thu 3/19/20 |  |
| 13.5 | Demonstrate Project | Jordan | 2.5 | Fri 3/20/20 | Fri 3/20/20 | 13.3 |
| 14 | **Write Final Project Report** | Thomas | **60** | **Mon 3/2/20** | **Fri 4/10/20** | 11 |
| 14.1 | Review Report with Client | Jordan | 2 | Mon 3/30/20 | Tue 4/7/20 |  |

# Appendix A – Gantt Chart

See following the following page for an image of the project’s Gantt Chart. If desired, a Microsoft Project or PDF file of the Gantt Chart can be requested from the group (email [thomas.hu@usask.ca](mailto:thomas.hu@usask.ca) to request the file).



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# Purpose

This document identifies the complete set of system requirements for the Doepker Industries Robot Rotator. It contains a matrix which identifies where the formal requirement is located, allocates each requirement to hardware or software or both, identifies one or more methods that will be used to verify each requirement, and identifies at which level of testing each requirement is verified.

As requirements are verified through analysis, inspection, demonstration or testing the documents containing the verification are identified in the matrix.

## Document Identifier

This document is identified as:

**CD3 – EE495/CME495 System Requirements Matrix**

## Applicable Documents

Applicable documents include:

**CD1 – EE495/CME495 Problem Definition**

## Revision History

|  |  |  |
| --- | --- | --- |
| **Date** | **Revision** | **Changes** |
| October 27, 2019 | 1 | Initial Revision |
| October 28, 2019 | 2 | Formatting changes, added and edited requirements. |
| November 2, 2019 | 3 | Added new requirements for the user panel after meeting with client. |
| November 14, 2019 | 4 | Modified requirements to address comments made by client. |

## Abbreviations and Acronyms

The following is a list of abbreviations and acronyms used in this document:

FAT Factory Acceptance Test

HW Hardware

SRM System Requirement Matrix

SW Software

# Requirements Matrix

The matrix in this section identifies every system requirement. Its columns are described below:

1. **Requirement ID.** A unique identifier that can be used for purposes of traceability.
2. **Source.** An unambiguous reference to the origin of the requirement.
3. **Description.** The requirement text.
4. **Allocation.** The system object or objects to which the requirement is allocated.
5. **Verification Method.** This column indicates how the requirement will be verified:

* **Analysis.** Requirements are verified by applying indirect methods such as mathematical analysis, modeling, simulation, similarity assessments, review of design, and validation of records.
* **Inspection.** Requirements are verified by direct visual observation of passive characteristics, without the use of specialized equipment or services.
* **Test.** Requirements are verified by measurement of quantitative characteristics during or after the controlled application of stimuli under appropriately controlled conditions, or by direct visual observation of active qualitative characteristics.
* **Noted.** Noted, but no verification required, such as for an information only requirement containing a "will" statement.

1. **Test Level.** The level of testing at which the requirement will be verified. The column is subdivided into the three levels of testing at which the verification of the requirement will be shown.

* **Sub.** At the subsystem test level. Subsystem tests are generally performed to verify functionality on a unit level before the unit is integrated into the system. The tests are not witnessed by Doepker Industries, but the results of the test are available for review upon request.
* **FAT.** At the Factory Acceptance Test level. The factory acceptance is performed at Doepker Industries according to test procedures. The test procedures are submitted to Doepker Industries for approval before the start of testing. Doepker Industries is requested to witness FAT.

1. **Comments.** Used to clarify the group’s interpretation of a requirement, supplement any columnar information or to denote those rows in the table that are “Title Only”.
2. **Where Verified.** Identifies one or more documents that verify the requirement. Reference to a test procedure means the completed test procedure. This column is filled in before FAT.

| Table 2‑1 System Requirements Matrix |
| --- |

| **Requirement ID** | **Source** | **Description** | **Allocation** | | **Verification Method** | **Test Level** | | **Comments** | **Where Verified** |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **SW** | **HW** | **Sub** | **FAT** |
| **RD: Rotator Design Requirements** | | | | | | | | | |
| RD-1 | Client | The system shall continuously rotate a load 360° around the horizontal axis. |  | X | Test |  | X |  |  |
| RD-2 | Client | The system shall be able to recall and rotate to a preset angular position. | X | X | Test |  | X | The position that the system can recall/rotate to will be parallel to the ground, facing upwards (0 degrees). |  |
| RD-3 | Derived | The system shall support at minimum 1177 newton-meter (N m) of dynamic torque. |  | X | Test |  | X |  |  |
| RD-4 | Derived | The system shall support at minimum 941 N m of static torque. |  | X | Test |  | X |  |  |
| RD-5 | Derived | The system shall support a load of maximum 500 kilograms (kg) weight. |  | X | Test |  | X |  |  |
| RD-6 | Derived | The system shall support a load offset of maximum 0.15 meters. |  | X | Test |  | X | The offset distance is calculated from the center of the rotator to the center of gravity of the load. |  |
| RD-7 | Derived | The system shall rotate at a minimum speed of 1.0 rotations-per-minute (rpm). | X | X | Test |  | X |  |  |
| RD-8 | Derived | The system shall rotate at a maximum speed of 5.0 rpm. | X | X | Test |  | X |  |  |
| RD-9 | Derived | The load shall remain fixed along the rotational axis when the system is not rotating. |  | X | Test |  | X |  |  |
| RD-10 | Derived | The system shall rotate to angle positions with a resolution of maximum 1°. | X | X | Test |  | X |  |  |
| RD-11 | Client | The system shall be rotated using electrically powered means. |  | X | Analysis |  |  |  |  |
| **HD: Hardware Design Requirements** | | | | | | | | | |
| HD-1 | Derived | The system shall be built using two “A” frame supports provided by the client. |  | X | Inspection | X |  | Exact size of the supports is yet to be determined. |  |
| HD-2 | Derived | The system shall remain stationary during operation. |  | X | Test |  | X |  |  |
| HD-3 | Client | The total cost of system components shall not exceed $10,000 Canadian Dollars. |  | X | Analysis |  |  |  |  |
| **ED: Electrical Design Requirements** | | | | | | | | | |
| ED-1 | Derived | The system shall operate on the following electrical power voltages:   * 120 volts (V), single-phase * 575 V, three-phase |  | X | Analysis |  |  |  |  |
| ED-2 | Derived | The system shall be operated between 0°C to 35°C. |  | X | Analysis |  |  |  |  |
| **SRR: Standards and Regulations Requirements** | | | | | | | | | |
| SRR-1 | Derived | The system shall use only RoHS compliant components. |  | X | Analysis |  |  |  |  |
| SRR-2 | Derived | The system shall audibly alert the operator when rotating. | X | X | Test |  | X |  |  |
| **SR: Safety Requirements** | | | | | | | | | |
| SR-1 | Client | The system shall have an easy-to-access emergency stop button, which stops all system operations when pressed. | X | X | Test |  | X | The emergency stop button will stop power from going to the rotator but will keep the control panel powered to protect the microcontroller. |  |
| SR-2 | Derived | The system shall have a switch to disable/enable rotation operations. | X | X | Test |  | X |  |  |
| **UIR: User Interface Requirements** | | | | | | | | | |
| UIR-1 | Client | System operation shall only be performed using physical buttons. | X | X | Test | X |  |  |  |
| UIR-2 | Client | The system shall have a control panel with buttons to rotate the system in angular steps in the clockwise and counterclockwise direction. | X | X | Inspection |  | X | RD-10 specifies the amount by which the system shall rotate per step. |  |
| UIR-3 | Client | The system’s control panel shall be able to be moved up to 10 feet away from the rotating portion of the system. |  | X | Inspection |  | X |  |  |
| UIR-4 | Derived | The system’s control panel shall indicate if the system is rotation locked. | X | X | Test |  | X |  |  |
| UIR-5 | Derived | The system shall have an on/off button and indicator. | X | X | Test |  | X |  |  |
| UIR-6 | Client | The control panel shall have buttons to rotate 45˚ clockwise and counterclockwise from the current position. | X | X | Test |  | X |  |  |