Design Criteria and Target Specifications

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Table of Contents

[1. Prioritized Design Criteria 4](#_Toc95080785)

[1.1 Functional Requirements 4](#_Toc95080786)

[1.1.1 Table 1.0: Functional Requirements 4](#_Toc95080787)

[1.2 Non-Functional Requirements 4](#_Toc95080788)

[1.2.1 Table 1.1: Non-Functional Requirements 4](#_Toc95080789)

[1.3 Constraints 6](#_Toc95080790)

[1.3.1 Table 1.2: Constraints 6](#_Toc95080791)

[2 Benchmarking 6](#_Toc95080792)

[2.1 Updated user benchmarking 6](#_Toc95080793)

[2.1.1 MicroBot 6](#_Toc95080794)

[2.1.2 Igus 6](#_Toc95080795)

[2.1.3 X-Series Robotic Arms 7](#_Toc95080796)

[2.1.4 RobotDigg 6 DOF Coffee Make Robot Arm 7](#_Toc95080797)

[2.1.5 Lynxmotion 7](#_Toc95080798)

[2.2 Technical Benchmarking 7](#_Toc95080799)

[2.2.1 7](#_Toc95080800)

[3 Target Specifications 8](#_Toc95080801)

[3.1 Table 1.3: Target Specifications 8](#_Toc95080802)

[4 Reflection 9](#_Toc95080803)

[5 Bibliography 10](#_Toc95080804)

# Prioritized Design Criteria

## Functional Requirements

### Table 1.0: Functional Requirements

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number | Need | Design Criteria | Verification Method | Relative importance(1-5, with 5 being most important) |
| 1 | Be able to hold a reasonably sized camera, pen, and nozzle. | Clarity of purpose | Test | 5 |
| 2 | The robot head (end effector) can be attached and detach. | Detachable | Test | 3 |
| 3 | Having a 3 DOF arm to enable better movement | Technical need | Test | 4 |
| 4 | Have water blasting end-effectors | Technical need | Test | 4 |
| 5 | Work automatically | Automation | Test | 4 |
| 6 | Using a vacuum and disposable container | Technical need | Test | 2 |

## Non-Functional Requirements

### Table 1.1: Non-Functional Requirements

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number | Need | Design Criteria | Verification Method | Relative importance (1-5, with 5 being most important) |
| 1 | Ability to shut off once it senses the motion of people walking around | Safety | Test | 5 |
| 2 | Ability to withstand high-pressure nozzles to water blast corrosion | Corrosion resistance | Test | 4 |
| 3 | Minor repairs and modifications every three months, and major repairs and modifications every 6 to 12 months. | Product life | Test | 2 |
| 4 | Precise in its movement | Quality | Test | 4 |
| 5 | Identify the nearby space to ensure it completes its programmed tasks. | Robot ability | Test | 3 |
| 6 | System should be built off a common language such as c++, python, GRBL, etc. | Operation code | Test | 2 |
| 7 | Can be use by people with little experience | User friendliness | Test | 3 |
| 8 | Less power consumption | Efficiency | Analysis and Test | 3 |

## Constraints

### Table 1.2: Constraints

Engineering Design: Robotic Arm Prototype – Constraints

|  |  |  |  |
| --- | --- | --- | --- |
| Constraint | Description | Rough Estimates | Verification |
| Dimensions (size) | Length, height, and width of the arm are limited to a small and compact environment (ex. Pipe configurations of ship) | Size when deployed:  <1  (approximately <10.8 ft)  Size when Collapse:  <1m x 1m x 1m  (approximately <35.3 ) | Analysis |
| Weight | Must be light weight, easy to carry around in a tight space (ex. Up and down the ladders) | <1 kg (approximately 750 g) | Analysis |
| Time | Scheduled to be completed within three months. The deadline is March 31st | March 31st  (approximately < 2 months from now) | Certain |
| Cost | Spend a budget that is less than $100 | <$100 | Estimate, check and review |

# Benchmarking

## Updated user benchmarking

### MicroBot

Compared to the Microbot, including a twisting and tilting axis within our 3 DOF abilities would enhance movement and flexibility. Ensuring stability and precision is something other robot arms look for and would be beneficial to include in ours. Easy use and being open-source increases simplicity when being used by non-technically inclined employees. Microbot has the ability to record and replay complex motion which is an ability we could include in our design. The Microbot uses Blockly, G Code, and Python in the Software, and uses C C++ and JAVA while programming API. These are useful abilities we could include in our design.

### Igus

Igus is a robotic arm meant for material handling and assembly. It can perform tasks like welding, painting, and drilling. There are 4 or 5-axis robotic arms with self-lubricating, maintenance-free plastic joints. The robotic arm has a payload up to 30N, cycle times from 6 seconds, and reach up to 790mm. This is useful to know for our project to get an idea of how much force our arm can stand and how far it could be able to reach.

### X-Series Robotic Arms

This robotic arm is rigid, lightweight, contains T-Slot Aluminum Extrusions, and has a 90-degree elbow. Its reach is 550mm, with 360-degree rotation and a total span of 1100mm. The industrial grade bearing arm has a working payload of 150g. There are 2 different mounting solutions available, wood screws, or thumb screws and pem nuts. This is beneficial information for our project because we can use the ideas of mounting solutions through using similar screws to what the ReactorX 200 Robot Arm has.

### RobotDigg 6 DOF Coffee Make Robot Arm

The coffee making robot arm has 6 DOF and a 24V DC power supply. The payload is 1 kg, max load is 2 kg, and arm length of 650 mm. One thing this robot arm specifies that could help that we haven’t seen yet is the max moving speeds. These speeds are 160 degrees/s for the JS(Rotary), 130 degrees/s for the JL(Upper Arm), and for the lower arm, arm rotary, JB(Arm Swing), and the JT(Arm Swing)’s is 200, 300, 400, and 500, respectively. The material used is aluminum which could be a great option for out design.

### Lynxmotion

This robotic arm has 4 DOF and a payload of 100g. The power supplies would be beneficial to know when completing our target specifications due to it having a lower degree of freedom than most robotic arms which usually have 6. The power supply in is 110V to 240V.

## Technical Benchmarking

### 

Companies such as MicroBot, Universal UR3, and BCN3D follow very similar technical requirements as our naval robotic arm. These requirements consist of the arms being in a small form factor and can help out with numerous small tasks that directly meet our practical needs. BCN3D is very similar to our robotic arm as they also 3D-print their robotic arms which we can use as a benchmark to know what materials we could use to build the prototype to meet our safety and creativity needs. Both the MicroRobot and BCN3D use open-source code which should be very useful in our case because it can help our practical and efficiency needs as anyone can improve our code and functionality of the robotic arm. The Universal UR3 robotic arm is a good reference to how it meets our safety needs. As stated, “The UR-3 can operate directly alongside workers without the need for any barriers due to its enhanced safety features''(Robots Done Right,2022). Our robotic arm being on a ship must be safe to be around crew members so using the Universal UR3 as a technical benchmark should be beneficial to our design and safety needs. Looking at a robotic arm called Meca500, it is claimed that it is the most precise robotic arm on the market with a repeatability of 0.005 mm. This is achievable due to its 6-axis movement (DOF). Trying to implement 6 DOF should be pondered about while creating our prototype as it can easily meet our requirement for essential accuracy for our technical needs.

# Target Specifications

## Table 1.3: Target Specifications

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Relation | Value | Units | Verification Method |
| End Effector Mass | < | 750 | g | Analysis, final test |
| End Effector Communications Protocol | = | Choice of Serial (UART) for more complex tools or PWM for simpler tools. | N/A | Test |
| Possible types of end effectors (non exhaustive) | = | Grippers, cameras, and pens. | N/A | Test |
| Microcontroller | = | Arduino Uno (ATmega328P) | N/A | Test |
| Arm Degrees of Freedom | = | X-axis translation | N/A | Test |
|  | = | Y-axis translation | N/A | Test |
|  | = | X-axis rotation | N/A | Test |
| Arm Range of Motion | > | 30 | cm | Test |
|  | > | 30 | cm | Test |
|  | = | 180 | degrees | Test |
| User interface | = | Programmable from computer using USB connection. | N/A | Test |
| Cost | < | 100 | $ | Certain |
| Operating temperature | between | -20 and 50 | °C | Test |
| Waterproofing | = | Water resistant, do not submerge. | N/A | Test |
| End Effector Mass | < | 750 | g | Analysis, final test |
| End Effector Communications Protocol | = | Choice of Serial (UART) for more complex tools or PWM for simpler tools. | N/A | Test |
| Possible types of end effectors (non exhaustive) | = | Grippers, cameras, and pens. | N/A | Test |
| Microcontroller | = | Arduino Uno (ATmega328P) | N/A | Test |
| Arm Degrees of Freedom | = | X-axis translation | N/A | Test |
|  | = | Y-axis translation | N/A | Test |
|  | = | X-axis rotation | N/A | Test |
| Arm Range of Motion | > | 30 | cm | Test |
|  | > | 30 | cm | Test |
|  | = | 180 | degrees | Test |
| User interface | = | Programmable from computer using USB connection. | N/A | Test |
| Cost | < | 100 | $ |  |
| Operating temperature | between | -20 and 50 | °C | Test |
| Waterproofing | = | Water resistant, do not submerge. | N/A | Test |

# Reflection

The client meeting impacts the development of our design criteria and specifications because we will get to understand their ideas of what is most and least important in the design. For example, ensuring the robotic arm is functional and durable was something our group expected to be very important, but the client ended up being ok with there being errors and a need for maintenance every few months, specifically every 6-12 months. We were able to gather information on what measurements and specifications were needed. This included the end-effector mass, cost, operating temperature, and more. These values are essential when making a robotic arm as we must know our limits and expectations. When updating our needs, we tended to make critical functional requirements and safety factors a 5(meaning most important) due to ethical reasons and the fact the robotic arm must work. Needs like working automatically and identifying the nearby space to ensure it completes its programmed tasks were needs we added since Deliverable B that helped us to form our final design criteria. Overall, the client meeting was beneficial but having more specific numbers and preparation for what needs they would like to specify would have made the needs more detailed and targeted to what they would actually like. This is why benchmarking is so important because it’ll allow us to get the target-specifications we need to design the robotic arm to fit their constraints and functional/non-functional requirements.

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