# The Autonomously Returning Chair (The A.R.C)


Group 44 - The Chairmen

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**Narrative:**

As technology advances so do our living styles, we start to use technology to give us a sense of comfortability. Therefore, we recognize that the chair is an essential comfort in our lives, because most people are seated throughout the majority of their days, therefore, it is important to have a chair that can provide more practicality than the average chair. We found that oftentimes returning a chair back to the original position is neglected since we believe we are returning to the chair immediately or we believe it is simply unnecessary. This habit can cause the workspace or living area to be messy or even be a tripping hazard. When this problem is scaled up to a room of chairs, we can easily see that this can become a tedious task to fix the positions of every chair. With the Autonomously Returning Chair, the A.R.C., we can improve the organization of chairs within our working or living space.

**Goals & Objectives:**

We hope to create a prototype that would behave like a standard office chair while someone is seated in the product. This would allow the user to have the freedom to wheel the chair in any direction they desire and be seated comfortably while using the computer, managing paperwork, or accomplishing any other deskwork. However, the A.R.C. would also be capable of autonomously returning to a previously set position after a certain amount of time following someone getting up and leaving the chair.

**Core Features:**

The A.R.C. has several different features that are specifically created to provide convenience and cleanliness in the users workspace. The chair will be capable of supporting the user and allowing the user to freely wheel it around like a standard office chair. It will also utilize a transmitter to act as its destination point and a receiver on the chair itself will be used to find and direct the chair towards the said destination. While this feature can be used in a variety of ways, the main concept in mind was for the product to return to a desk or table under an office or workplace environment. Wheels and motors will provide mobility for this autonomous movement. The chair will utilize multiple sensors to sense obstacles in its path for obstacle avoidance as well as determine how long the seat has been left vacant. The latter is important in implementing a time delay before the chair begins returning to the set destination. Rechargeable batteries will act as the power source to prevent any charging cables from interfering in mobility during product use. Lastly, we will implement a status notification with an LED to inform the user of the chair's behavior during use. Altogether, The A.R.C. will be able to autonomously start returning to an infrared transmitter, which will be used as the starting position, thus keeping the workspace and living area free from straggling chairs.

**Product Functionality:**
A crucial aspect of the A.R.C. is the two modes it can be used in. If the user sits in the chair, user detection will occur via pressure plate, turning off the A.R.C. Once the device has been switched off, it will behave like a standard office chair, capable of supporting the weight of the user and being wheeled around on standard caster wheels.

The A.R.C. will activate once the pressure plate detects that the user has left the chair for a certain amount of time. Once the A.R.C is activated, the transmitter will send out a signal to the product's receiver, which will then trigger the electric motors to proceed towards the transmitted signal. The status of the chair is shown via LED lights being off, blinking, or on. The states of the LED correspond to the A.R.C. being off, the A.R.C. being too far away from the destination, and the A.R.C. heading towards the set destination respectively. To ensure that the destination will be reached, the A.R.C. will be equipped with object detection/ avoidance capability, via the use of sensors. This function will ensure that the A.R.C. will be able to reach 'home' no matter the mess found in its path. Finally, as mentioned, the A.R.C will come attached with its own battery power supply, making the whole device wireless.

Using a lightweight metal stool as the seating of choice, it will provide a solid frame that can structurally support the load, as well as have the space to accommodate the electronics underneath the seat. There will be two sets of four wheels that will serve two different purposes. Regular caster wheels will be active when the A.R.C. is off and someone is seated to provide the familiar weight bearing and gliding feel associated with office chairs. When the user stands up, the electronic omni-wheels will become active, meaning they will be exclusively in-contact with the floor and will change to autonomous mode.

**Standards Discussion:**
While in use by a user, our product is meant to be able to act as an office chair. As such, we must consider the standards of office chairs outlined by the United States Department of Labor's Occupational Safety and Health Administration. With the main focus being the comfort and safety of the user these standards can be separated based on the component of the chair they focus on: the base, the backrest, the seat, and the armrests.

The base of the chair is the key to stability. There should be five (or more) strong legs to provide adequate support and avoid the chair tipping over. Furthermore, the wheels should be caster wheels to allow the user easier to maneuver. The chair should have a backrest that is placed to fit the lower back and support a variety of seated postures. The seat of the chair should be at a height such that the user has feet support (contact with the ground or footrest) encouraging knee placements slightly higher than the seat of the chair. Finally the armrests must be at the correct height to allow relaxed shoulders while supporting the lower arms and the right width to allow easy access/exit from the chair while keeping the arms close to the body.

The standards given also discuss how the armrests, seat, and backrest should all be adjustable to allow the user to find the right setting for them (an alternative would be to have the chair made specifically to the user, but, this is rare and inefficient for chairs designed to be used by a variety of people). Furthermore, these same components should be made of a soft, comfortable material and have rounded edges.

While we will keep these standards in mind, our product is meant to be a prototype so while we will aim to keep the A.R.C. safe for human use, we will not be focussing extensively on comfort in favor of providing a working prototype that addresses the cleanliness problem discussed earlier.

**Stretch Goals:**

Once the initial prototype is complete, given that we have the time and resources we would like to expand our initial prototype to operate on a larger scale, meaning, we would create them to be compatible with several different A.R.C. devices. We want to implement the A.R.C. to work in commercial spaces, such as classrooms, where they can be accessed via “Smart Technology” (apps, Ipads, tablets, etc.) to create placement designs. For example, if it is a classroom, then the janitor can simply press a button and all the chairs will exit the classroom and wait in the hallway, after he is finished cleaning, he can press a different button and the chairs will return to their last known location. Given more time and resources we would also like to add a feature for professors to use to change the location of the chairs and make set locations. In other words, they can have multiple settings for multiple lectures, such as: lecture setting; the chairs will form a “U” shape in the class. Discussion setting; the chairs will form an “O” shape in the class. And finally, a wall setting (where the chairs go against the wall) for active participation.

Having addressed the long term goals, the current specifications of the various components of our product (as well as the entire product in general) are identified and detailed in Table 1 shown below.

**Requirement Specifications:**

| Specification | Requirement | Value |
|---|---|---|
| Weight | Must be lightweight for mobility | ≤ 12 pounds |
| Weight Capacity | Must be capable of supporting a certain amount of weight | ≤ 300 pounds |
| Velocity | The motors will move with a steady velocity | 2 meters/second |
| Torque | Motors will generate a certain torque | 1.3 Newton*meters |
| System Start Time | Time transmission signal search after prompt | 1 second |
| Signal Transmission | The transmitter will transmit a signal up to a distance | ≤ 6 feet |
| Signal Detection | Will be able to detect/receive signals from the transmitter | ≤ 6 feet |
| Time to Find Signal | Time for receiver to find signal | ≤ 3 seconds |
| Obstacle Distance | Sensors will detect obstacles within a certain range | 4 inches |
| Obstacle Avoidance | Will navigate around obstacles in a timely manner | ≤ 5 seconds |
| Voltage for Control System | Amount of voltage needed to power the control system | 3.3 Volts |
| Voltage for Motor Controller | Amount of voltage needed to power the motor controller | 5 Volts |
| Voltage for Motors | Amount of voltage needed to power all motors | 12-24 Volts |
| Battery Life | Time before the A.R.C. requires charging | 12 hours |

*Table 1: List of Specifications, Requirements, and their Values*

**House of Quality:**

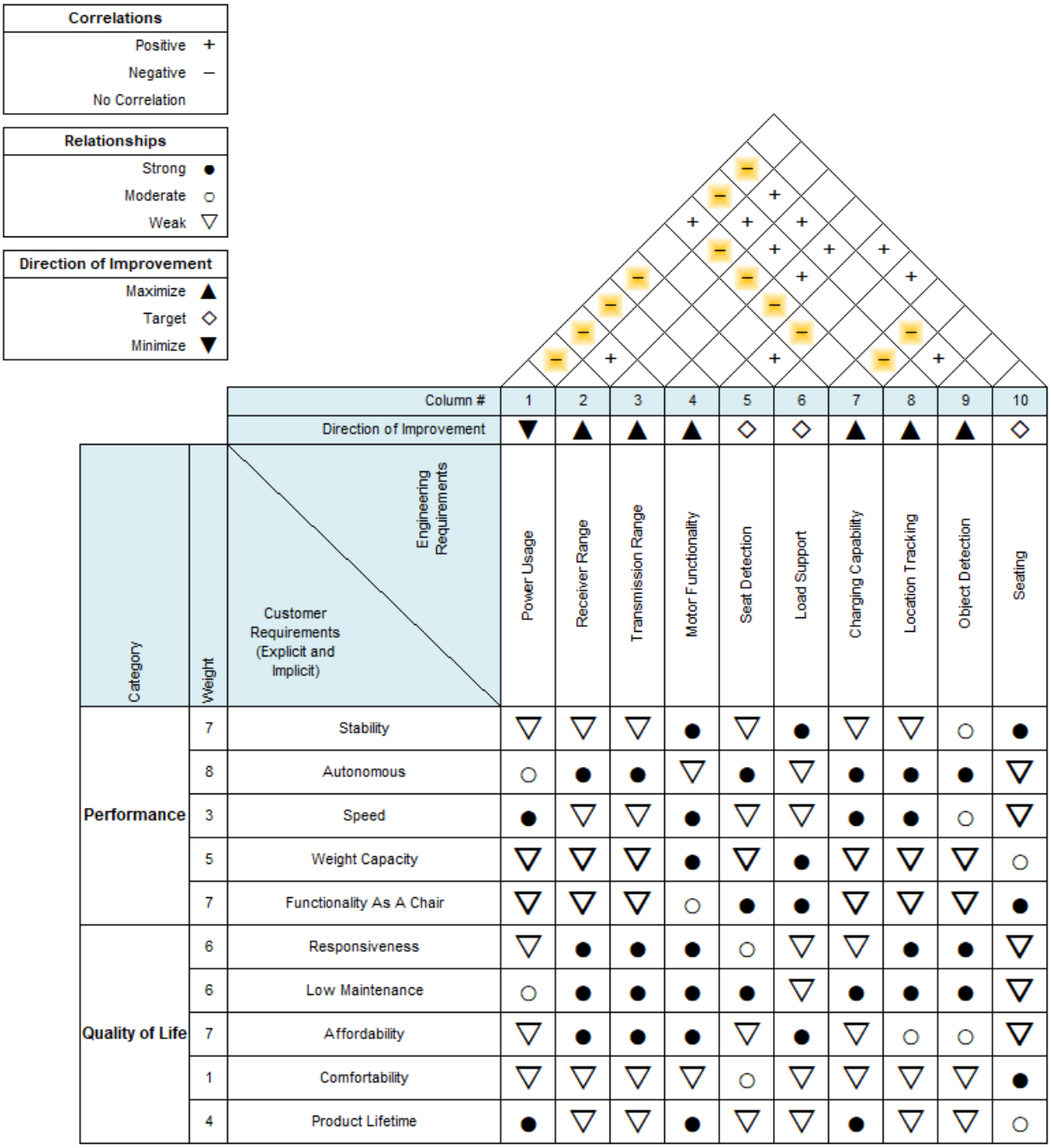


*Figure 1: House of Quality*

Figure 1, seen above, is a graphic illustrating how well our product meets client expectations. As shown, our product does well to meet the client requirements in regards to performance and quality of life. While not every engineering feature we have addresses each customer requirement, we ensured that multiple engineering features of our product address each requirement presented to us.

**Hardware Block Diagrams:**

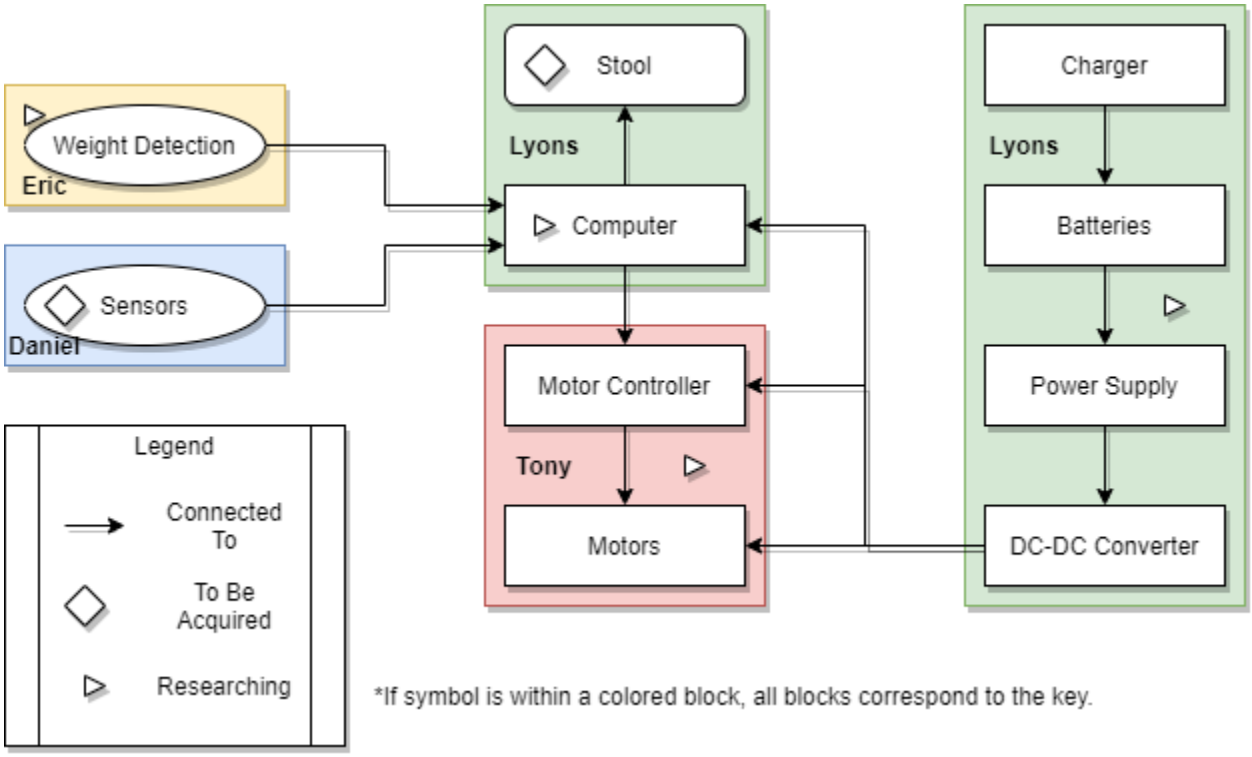


*Figure 2: Hardware Block Diagram with assigned tasks*

The block diagram shown above in Figure 2 is the general flowchart of requirements to construct the final product of an automatically returning stool. Each component relies on its corresponding connection and ultimately connects to what will become the stool. Highlighted in yellow blocks contain names to those responsible to each portion of the flowchart. Note, that all blocks will involve all team members' contributions, each enclosed name are simply those that are leading the construction of each component.

**Software Block Diagram:**

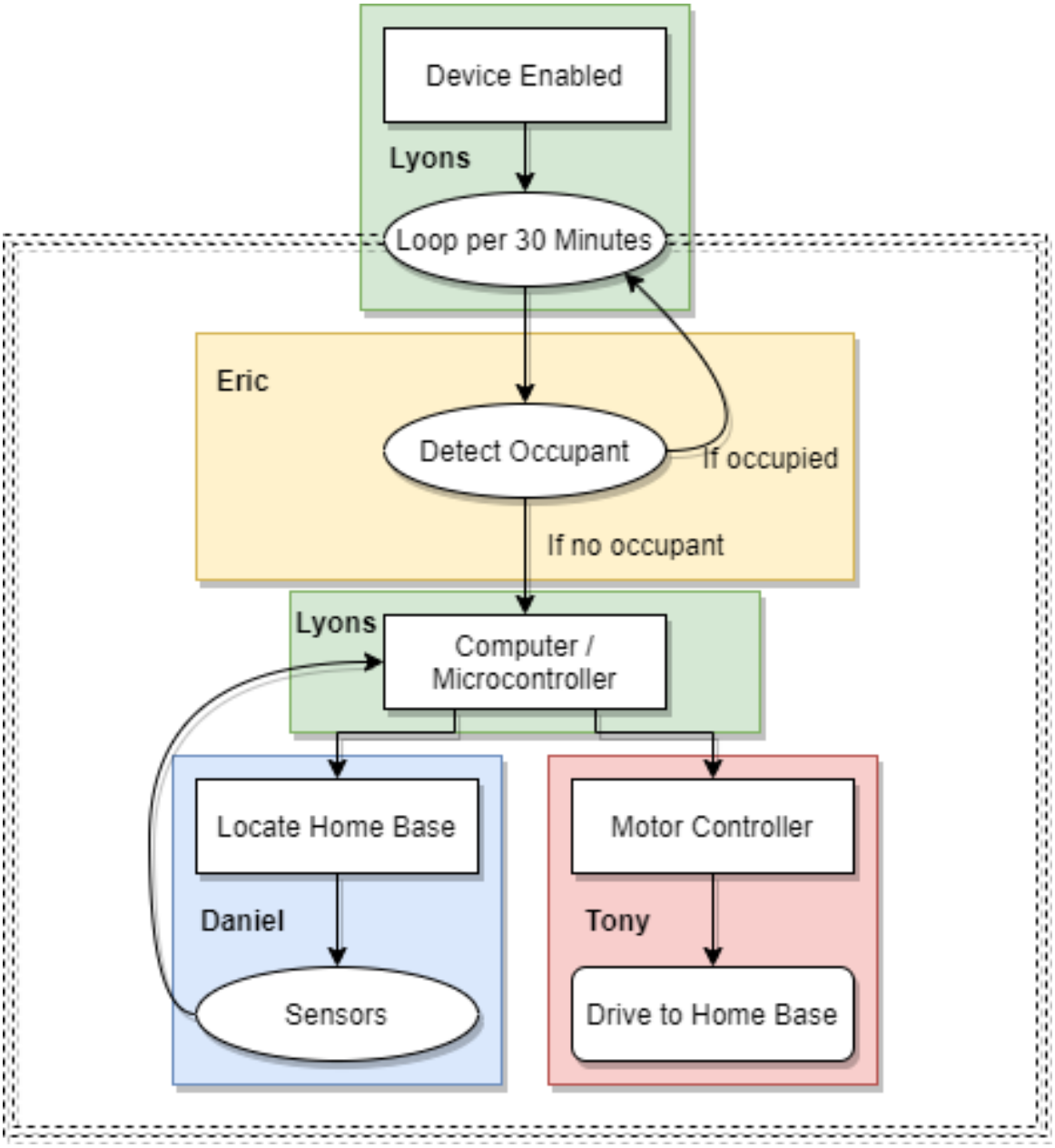


*Figure 3: Software Block Diagram with assigned tasks*

The software block diagram as represented in Figure 3 is the basic flow of the automated chair from its off to on stage. During the on stage, the system remains in a loop consistently detecting whether an individual is occupying the chair. From there, should there be no individual occupying the unit, the computer enables sensor detection to locate its home base and communicate instructions into the motor controller.

**Estimated Budget:**

| Description | Cost per Unit | Quantity | Estimated Total | Source |
|---|---|---|---|---|
| Chair | $55 | 1 | $55 | Amazon |
| Wires | $0.15 | 100 | $15.00 | Amazon |
| Microcontroller | $20 | 1 | $20 | Amazon |
| PCB | $100 | 1 | $100 | JLPCB |
| Motor Controller | $20 | 1 | $20 | Amazon |
| Omni Wheel Kit | $100 | 1 | $100 | Amazon |
| Caster Wheels | $50 | 1 | $50 | Amazon |
| Plastic Box (Home/transmitter housing) | $10 | 1 | $10 | Walmart |
| LED | $1.50 | 2 | $3 | Amazon |
| Infrared Sensors | $2.80 | 5 | $14 | Amazon |
| Pressure Plate | $10.75 | 1 | $10.75 | Amazon |
| Batteries | $20 | 4 | $80 | Amazon |
| **Total** | | | **$477.75** | |

*Table 2: Estimate of Project budget (BOM)*

**Financing:**.

In Table 2, shown above, we display our current estimation of our project's Bill of Materials (BOM). We will continue to update this table with specific details about the components we desire as we continue forward in our design process. The A.R.C. will be sponsored by the group itself, splitting the total cost as evenly as possible among all group members. If more costs arise, the group is financially prepared to cover any additional miscellaneous costs.

**Project Milestone:**
Below, in Table 3, we set the milestones we hope to achieve over the course of this project. We will use this to ensure we stay on track and ahead of our deadlines.

| **Date** | **Milestone** |
|---|---|
| 09/24 | Start Identifying Items to Test |
| 10/29 | Finish 60 page draft |
| 11/12 | Finish 100 pg draft |
| 11/26 | Create Initial (Complete) BoM |
| 12/03 | Finish Final Draft |
| 01/14 | Prototype Movement System |
| 01/15 | Prototype Sensor System |
| 02/11 | Prototype Sensors & Movement Together |
| 02/25 | Prototype Entire Product |
| 03/18 | Finished, Working Product |
| 04/27 | Presentation/Demo |

*Table 3: List of Project Milestones*