Spartan Superway Wheelchair Restraint System

Technical Report

By
ENGR 195D

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Chapter 1: Prototype Design

Initial Design Concepts

The first design choice was a system that would use a set of arms to compress the sides of the wheelchairs. This design was inspired by Quantum, an automatic rear-facing securement station, shown in Figure 1. In this design, one arm was parallel to the floor while the other one was perpendicular to it. The parallel arm would be located close to the wall of the Spartan Superway pod and would be held a few inches above the ground. The other one would be in the inner side next to other passenger seats. Once activated the second arm would rotate and come down to the level of the parallel arm and then both would compress the sides until a certain force was reached. This design seemed like a feasible solution because it was a faster procedure compared to traditional systems and would keep the user secure throughout the whole ride. However, it failed to take into consideration that some wheelchairs do not have their wheels aligned and the arms would only be able to apply pressure to two wheels rather than all of them. This was a major problem because it could lead to wheelchair damage or cause injury to the user. Another problem with this design was that wheelchair users carry belongings with them on their sides and defeated the purpose of a user-centered design. Additionally, the Spartan Superway is estimating that each pod will be able to transport 4-6 passengers and made personal space a vital part of our design.

Figure 1: Quantum securement station

In order to solve the issues that the first designed faced, we took the design into a totally new direction. The main issues we wanted to solve included: the amount of space the design would use, ensuring that the design would work for all wheelchairs and making sure that the users items were not damaged. The main concept for the new design was the use of universal grippers that would grip to one side of the wheelchair as seen in Figure 2 below. The idea was that no matter what the wheelchair looked like, this system would work because the universal grippers would secure the wheelchair regardless of its shape. This design worked with most wheelchair designs as well with scooters which are classified as wheelchairs under the ADA. This design was also the one that used the least amount of space of any design we have come up with. Lastly, we were able to keep the entire system at a low height which would prevent the suction cups from coming into contact with the user's belongings. This design was going to use an air cylinder on each gripper arm to control the movement, but we were also going to need an air compressor to maintain a vacuum in the grippers. This became a flaw for this design because it would create cause an undesired noise. We did not continue with this design after presenting it during the EPICS design review due to the unknown knowledge of the grippers and we were advised to avoid pneumatic systems due to their complications.

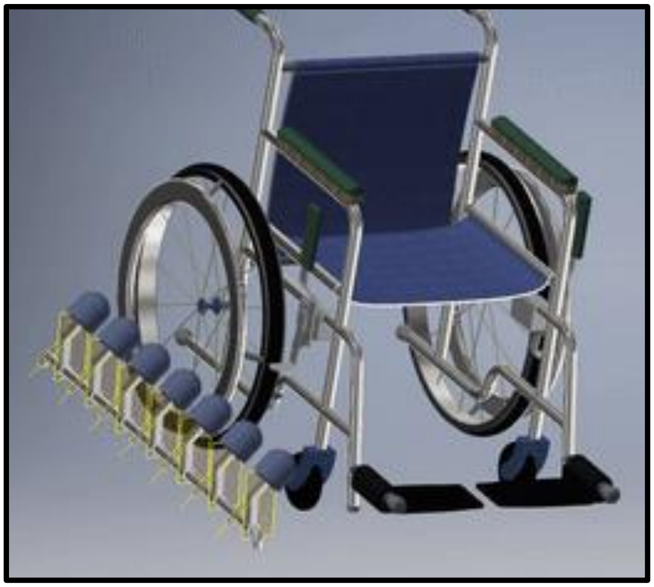

Figure 2: Gripper arm design

The third design the team developed was a set of lifting platforms that would be completely underground. The design was composed of 8 pairs of rising stoppers that would lock the wheelchair in place without invading the personal space of the surrounding passengers. In this design, a DC motor would use gears to transfer rotational motion to a stainless-steel bar which would serve as a pivot point for the lifting platforms. The design seemed feasible and able to fulfill the engineering specifications required by our community partner. This design was able to utilize space efficiently and able to secure a wider range of wheelchair designs. However, the design failed to keep all its components completely underground because one of the gears would stick out and could lead to passengers getting injured. The concept and mechanical idea of this design was kept and updated until we arrived at our final design.

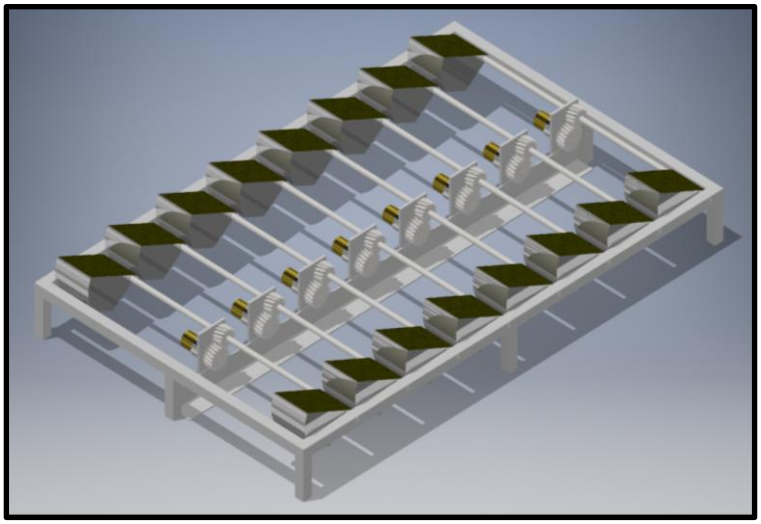

Figure 3: Third design using lifting platforms.

Final Design Concept

The final design is an updated version of the third design where the gear mechanism was changed into a push and pull concept using springs and metal strings. The hollow lifting platforms made of gauge 3 standard steel sheet metal (0.2391 in thickness) have anchor points below the surface where a spring and a set of galvanized aircraft cables manage the motion of such. The platforms have an opening at the bottom that creates a gap for the spring and cable attachments as shown in Figure 4.

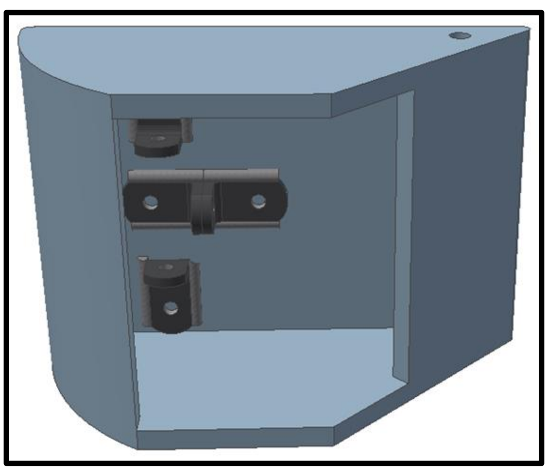

Figure 4. Lifting Platform design

The cable that is utilized in our mechanism is a 1/16-inch galvanized aircraft cable. This cable is designed to withstand a load of 96 pounds and a maximum breaking strength of 480 pounds. The structure of the cable is composed of 7 micro wires winded onto seven other wires as shown in Figure 5 below. The composition these wires form accounts for the maximum amount of force applied to the mechanism. Explicitly, two wires are used on every lifting platform to allow for the motion from the stationary position to the restraint position. In total, the amount of load that four lifting platforms can handle from the steel cables is 768 pounds.

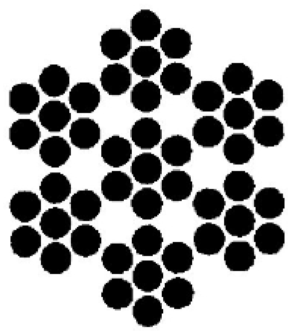

Figure 5: 7x7 Micro-cable composition

This mechanism keeps the lifting platforms completely closed when is not active. It is designed to do so by attaching the cables to a cylindrical rod which provide a downward force that keeps them in tension. At the same time, the spring provides a constant upward force leaving the platform at ground level. Each spring is attached to the frame of the mechanism and the bottom of the platforms to allow for the upward push to take place.

The mounting selected for the attachment of the cables and the compression spring under the lifting platform is a L bracket with a size 9 fitting. The criteria used to determine the best object was based on: sizing, endurance and corrosion. To ensure that enough space was left to incorporate the winding rod, compression spring and bottom mounting, a maximum of one inch was used for upper mounts. A built-in ease was also a factor in determining the mounting design. We wanted to make sure that the mount would be easy to incorporate to the lifting platform since the internal space was very limited. Lastly, our mounting must be durable and resistant as its main function is to maintain the lifting platform at the desired position. Other factors taken into account for the selection of our internal components was pre- manufactured parts, cost effective for use, and accessibility to our team. Steel wires and a compression spring were selected to position the lifting platforms because it is the most efficient manner to control using simply DC motors. When the system is in operation, the 12V DC motor rotates the gear located in the middle of the frame unwinding the strings and allowing the spring to push the lifting platforms until the desired height is reached.

User Commands and Operation:

The Wheelchair Restraint System will be pre-integrated into the floor of the Spartan Superway pods using the space under adjustable chairs. In this manner, others can use the pod for transportation when the restraint system is not in use. The system can only be accessed by requesting a pod with disability accommodation. The adjustable seat will need to be lifted in order to accommodate for the wheelchair. Once the seat is lifted, the user will need to position the wheelchair in place and then press on a “Access” button for the system to activate. Once the button is pushed, the lifting platform will rise as shown in Figure 6. Once lifted, the wheelchair will be secured and locked in place preventing the wheelchair from moving forward or backward. To disengage from the system, the user will need to simply press the button again lowering the platforms and allowing the user to safely leave the pod.

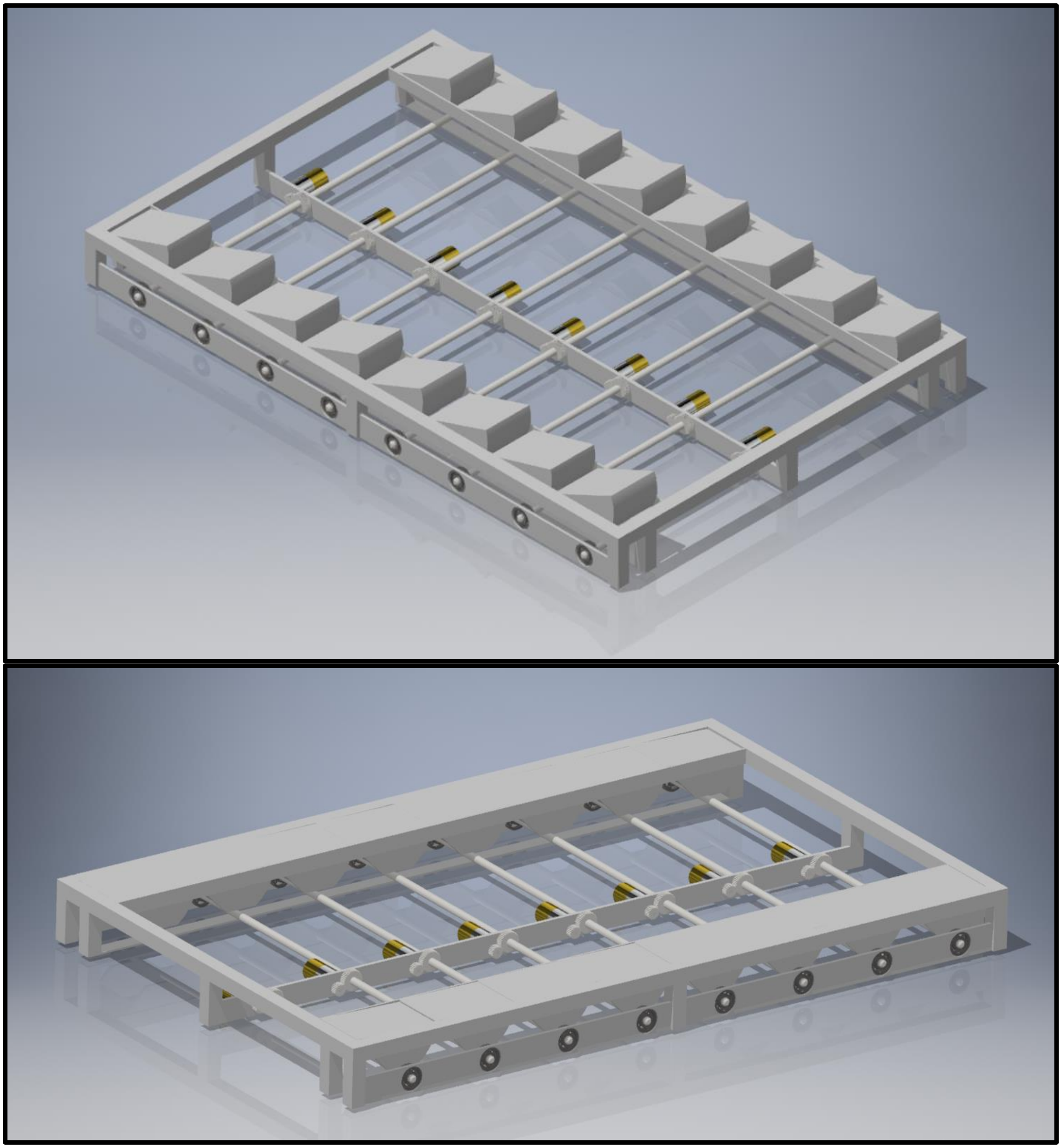

Figure 6: Full assembly of design

Chapter 2: Microcontrollers and Electronic System Interface

Since the project has taken multiple design turns, there has not been any significant development on the electrical system. As the mechanical system design finalizes, the electrical system and code for the control are now being developed. The project will use an Arduino Mega (Figure 7) to control the eight 12V DC motors in the system. The motors will be connected to four L298N motor drivers which will each be connected as seen in Figure 8. Figure 8 does not show the exact schematic because the software used to make the schematic did not have an Arduino Mega. The team is also considering using Bluetooth modules in order to help with the wiring, but might not happen in order to reduce the cost. The system also does not currently have a place to mount on the Arduino and the motor drivers, but its location will be determined once the system is finalized.

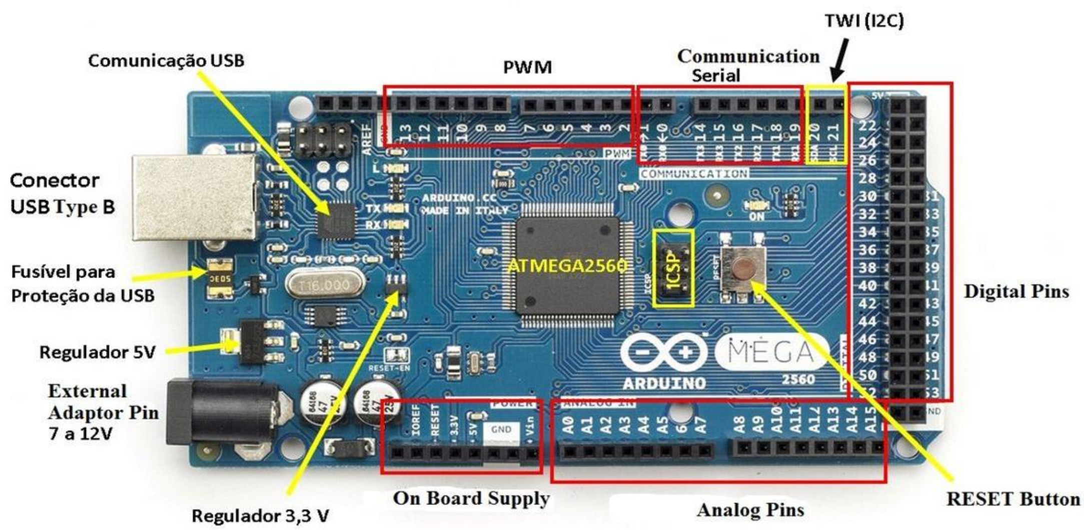

Figure 7: Arduino Mega

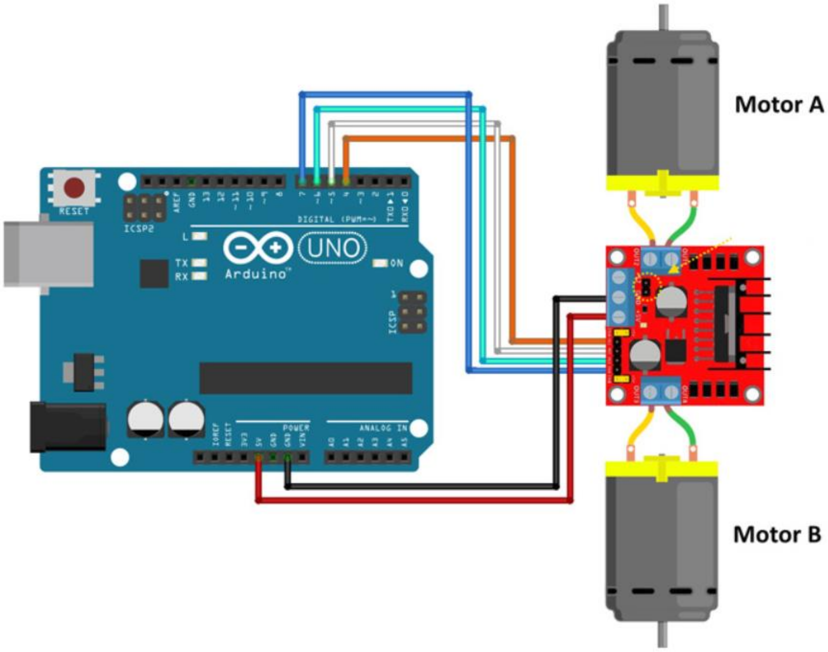

Figure 8: Electrical System Schematic

Like the electrical circuit, the code for the project has not yet been developed. Now that the team understands how the mechanical system works, the code can now be developed. Figure 9 below demonstrates the basic logic of the code and will serve as a template. For the code, the project takes the assumption that the Arduino Mega will receive a signal once the wheelchair has entered the pod and the space is cleared to raise the platforms.

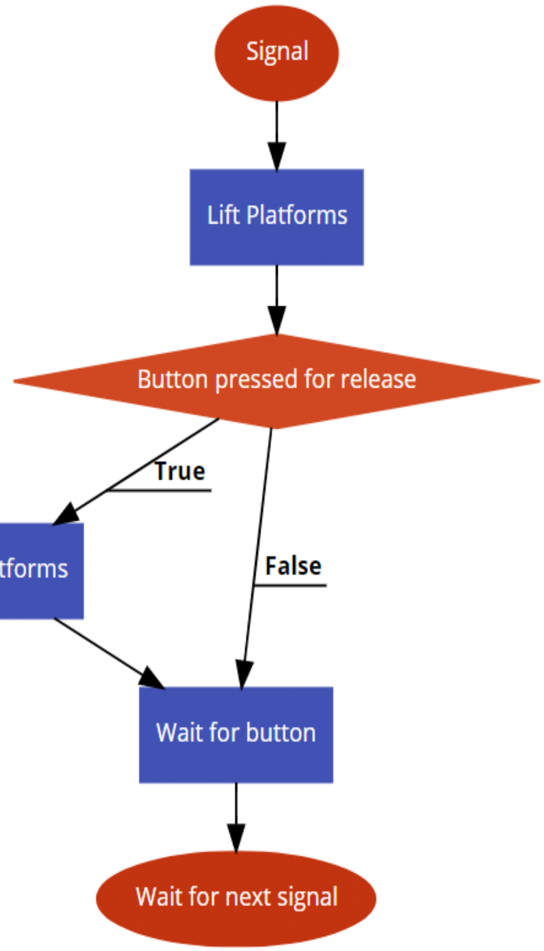

Figure 9: Code Flow Chart