Optimal Design: Travel Computer Mount

TEAM 3:
Kelly Valentine, Blaine Ericson and Caitlin Martin
Project for NSF

Client Contact:
Brenda Stenglein
Ashford, CT
1 Optimal Design Project

1.1 Introduction

The various assistive devices on the market are making it easier for those challenged with physical disabilities to be active. Assistive communication devices such as the Dynavox Vmax allow people to express themselves, whom otherwise could not. The client has a severe case of cerebral palsy and expressed a need for a travel mount in order to have access to his Dynavox Vmax while in the car, thus enabling him to communicate away from his desk. There remains no product on the market, which would support the Dynavox in a moving vehicle. A Dynavox Vmax vehicular mount would help the client and others.

The design of the travel computer mount must accomplish several important goals in order to fulfill the requirements needed of the device. First of all, the mount must fully support the Dynavox Vmax computer. It must completely secure the computer in place during travels and therefore must withstand vibrations and large stresses in the event of an accident. Furthermore, the user must be able to remove the computer from the mount easily upon exit of the car while still being able to easily attach the computer back onto the mount when entering the car. The computer mount must be able to fit into the user’s vehicle as well as a variety of different car models to add versatility of the design. In addition, the mount must be properly positioned to the best position for the user. This includes the height of the mount and the viewing angle of the computer. Most importantly, the computer mount must be safe to both the user, the other passengers in the vehicle, and the driver.

To implement these goals, the computer mount’s physical dimensions were measured to ensure proper fit. The mount (see Figure 1) will be located on the back of the front passenger seat and will be secured from the head rest of the seat. This will not restrict the view of the road for the driver nor will it be in the way to the other passengers while it provides for the proper viewing angle for the user. The mount will use an adjustable mounting system to attach the mount to the car but still allow for the mount to be removable. This will also provide for the mount’s placement in different vehicles. The framework of the mount will be made of steel to hold the system’s shape during traveling and in the case of an accident. The two side poles of the framework will hold the Daessy bar as well as the Daessy quick release mounting plate. The mounting plate will be able to swivel about the rod to change the viewing angle of the computer. It will also provide an attachment mount for the computer to the frame of the mounting system. Since the mounting plate is made specifically for the Dynavox computer, the attachment will be firmly fit together. Each of the parts of the system will be further described in detail in the next section.

The optimal design was chosen from two other possible options. The first option (see Figure 2) consisted of a metal arm unit that would be connected to the framework under the user’s seat of the vehicle. This was decided to be an inconvenience to the user and their helper upon entering and exiting the car. The system was also very bulky and might possible be hard to remove. There is also an issue with the clamping system to the bars under the vehicle’s seat and the possibility of using the mount in another car. The fit would have to be made to the current car and may not possibly fit into another vehicle.
The second design (see Figure 3) consisted of a similar arm unit but would be attached to the user’s car safety seat (not the actual seat of the vehicle). This design was again very bulky and could possibly be an inconvenience to the other passengers in the car as it would take up the room of the middle back seat. It could also potentially be in the way of the driver’s view if moved into certain locations. The optimal design was chosen because of the removability and the compactness of the system’s design. It was also decided to be the safest for the user and the other passengers of the vehicle.

Figure 1: Optimal Design (angled side view on right, front view on left)

Figure 2: Alternative Design – Passenger Seat Attachment
1.2 Subunits

Dynavox VMax Computer

The Dynavox VMax computer provides a way to communicate for disabled people. This is the computer the mount will be made especially to fit. The user is able to work the computer with a head controlled button. There is a speaker which allows the user to comprise words, sentences, and commands and the system will output the sounds the user needs to say.
Daessy Folding Quick Release Base

The Daessy Folding Quick Release base allows for rotation, and will thus allow the user to alter the angle of the Dynavox to achieve the optimal viewing angle. The base provides for the device to be attached to a horizontal tube with six locking positions for quick adjustment of the device’s angle. There is a retractable, spring loaded pin to secure the folding quick release base at the chosen angle.

Cylindrical Rod

The cylindrical rod passing through the Daessy base will be purchased from the Daessy company to ensure a perfect fit, and sufficient mechanical properties. The free body diagram below shows the forces acting on the cylindrical rod holding the Folding Quick Release Base and the Dynavox. The weight of the Dynavox, the quick release base and the bar are labeled Wd, Wqb, and Wbar respectively. The reaction forces at each of the supporting elbows are labeled Rex and Rey.
$W_d = 6.875\text{lbs}$

$W_{qb} = 1\text{lb}$

$\sum F_x = 0 = Re \, x - Re \, x$

$\sum F_y = 0 = 2 \, Re \, y - (W_d + W_{qb} + W_{bar})$

$Re \, y = \frac{W_d + W_{qb} + W_{bar}}{2}$

Figure 5: Cylindrical Rod with Force Equations

**Adjustable elbow joints**

These adjustable allow for the user to adjust the height of the screen, and thus accommodates for growth. The elbow joints will slide up and down the “L” bars on either side of the mount. The free body diagram below shows the stresses acting on the bars. The weight of the upper portion of the bar will be denoted as “Wubar”. The weight of the lower portion of the bar is “Wlbar”, and the reaction forces at the end of the bar proximal to the headrest are Rbz and Mrb. The height and width of the bars are denoted by hbar and wbar respectively.

$\sum Mrb = 0$

$Mrb = Wubar \left( \frac{W_{bar}}{2} \right) + Wlbar \left( \frac{hbar}{2} \right) + Re \, yh$

$\sum F_y = 0 = -(Re \, y + Wlbar + Wubar) + Rby$

$Rby = Re \, y + Wlbar + Wubar$

$Rby \leq 30\text{lbs} = 0.294N$

$\sum F_z = 0 = Rbz$

Figure 6: Forces acting on the L bars on each side of the mount.
With the calculated reaction forces at the connection between the L bars and the attachment plates, the corresponding stresses can be analyzed to ensure proper sufficient strength of materials.

**Attachment Point**

The mount will be attached to the back of the passenger’s seat headrest. This position makes the screen easily viewable to a back seat passenger, without being obtrusive to the other passengers in the car.

The mount will be secured to the metal posts connecting the headrest to the seat. The design will include two metal plates that will clamp down on the head rest post via wing nuts. The free diagram below shows the stress acting on the front plate of attachment. This stress analysis was necessary to determine the whether the spacing between the pins was small enough to ensure that the system would not fail. The diameter of the pins will be 0.25 in (0.635 cm), the width of the bar w will be 2.5 cm, and the thickness t will be 0.635 cm. The maximum calculated shearing stress in the pins was far smaller than the maximum tensile strength of stainless steel, which proves that the system would not fail. The shear force in each of the pins will be denoted as $V_{pin}$, while $F_{pin}$ will represent the compressive force of each pin.
\( \tau \text{ max stainless} = 186 MPa \)
\( t = 0.5 cm \)
\( w = 2.5 cm \)
\( R_{by} \leq 0.294 N \)
\( dpin = 0.635 cm \)
\( S \text{ min} = 11 cm \)

\[ V_{pin} \text{ max} = \frac{\pi \tau \text{ max} \ dpin}{4} \]

\[ V_{pin} \text{ max} = 5.89 kN \]

\[ V \text{ max} = 2R_{by} \]

\[ Q = \left( \frac{w}{2} - \frac{dpin}{2} \right) \left( \frac{w}{4} - \frac{dpin}{4} \right) \]

\[ I = \frac{1}{12} tw^3 \]

\[ q = \frac{VQ}{I} = \frac{2R_{by} \ t}{8} \left[ \frac{w^2 - 3wdpin + dpin^2}{tw^3} \right] \]

\[ V_{pin} = \frac{S \text{ min} \ q}{3} \]

\[ V_{pin} = \left( \frac{S \text{ min}}{3} \right) \left( \frac{2R_{by} \ t}{8} \left[ \frac{w^2 - 3wdpin + dpin^2}{tw^3} \right] \right) \]

\[ V_{pin} = \left( 0.011 m \right) \left( 0.267 N/m \right) = 0.980 N \]

\[ V_{pin} \ll V_{pin} \text{ max} \]

Figure 7: Forces and Stresses Acting on the Securing Plate.

Since the plates on either side of the headrest posts are made of the same material and undergo the same stresses as shown in the free body diagram below, the second plate will also be sufficient to hold the Dynavox securely in place.
The bolts will secure the two plates around the headrest posts by wing nuts. Each plate will have this layer of rubber lining the face touching the headrest posts. This rubber layer will maintain a firm grip on the headrest posts with a high coefficient of friction. It will also offer some shock absorption as well as protection between the metal of the headrest posts and the attachment plates. Since the attachment plates use the pressure of the two plates to clamp the unit to the headrest, the mount will be able to fit in all vehicles (providing they have a removable front passenger seat headrest). This allows the mount to still be used if the user purchases a new vehicle as well as provide the mount to be used by all people in a range of cars.

2 Realistic Constraints

The development of the car mount will be limited by many factors. Since this project is funded by the National Science Foundation Engineering Design Projects to Aid Persons with Disabilities (NSF) they will have to approve all budget appropriations. The family will be responsible for any future maintenance costs. The availability and costs of materials will affect the overall design. The metal piping in the framework will consist of stainless steel for durability and easy maintenance. There are also some parts manufactured by Deassy will be utilized. These parts include the quick release mount and two securing rods to allow the computer screen to attach to the mount.

Aside from economic constraints, other restrictions in the design of the device remain. The computer mount must fit within the back seat of the car and still allow the user and others to sit comfortably and safely. The placement of the mount on the back of the front passenger seat will provide for the optimal viewing placement for the user to see the screen. It will be located immediately across from him. The mount will also have the
option to adjust the height with the poles to change the location of the screen in preparation for future growth of the user.

The mount must also be able to hold the weight of the computer and withstand repetitive use. The materials of the framework will ensure the system’s durability. Since the computer connection pieces are being purchased from Deassy, the company will insure the durability of the product. It will also guarantee that the computer will fit the mounting parts because they were made specifically for the computer. The quality of the materials and the warrantee of the clip will increase the quality and allow for the repetitive uses during the user’s travels in the vehicle.

The mount should not be obtrusive or dangerous to Sean and the other passengers in the car. The design will also be attached to the front passenger seat headrest. The connection will be flush between the seat and the headrest and will not create any discomfort to a passenger in the front seat. The mount should be safe during operation of the vehicle as well as in the event of a car accident, and it should also be clear of any airbags in the vehicle. As a result, it was found to be best placed behind the front passenger seat. This will avoid all airbags in the current vehicle owned by the user. In the future, it would also avoid most airbags with the only possible contradiction being a side backseat airbag on the door of the car. In which case, it would still avoid impacting the mount to the computer user.

Also, the mount must be able to withstand and remain unaffected by temperature changes in the car. The metal of the mounts will not melt or contort by the temperature fluctuations in a vehicle. These temperatures not only include the changes that occur daily but also as the seasons change. It must withstand the hot temperatures of summer and the cold winter brings.

Throughout the day, the shifting sun will cause the computer screen to be viewed from different angles at different times. This brings about the need for the computer screen to be able to tilt up or down to the appropriate viewing angle. To accomplish this, a rod from Deassy will be purchased that allows the mount to rotate about the horizontal mounting pole. This will ensure the user’s proper view of the computer screen to aid in the communication taking place.

Since the assistive jumping device is being built for a disabled clientele, it is extremely important to keep safety a priority. The people designated to use the system will not be able to support or protect themselves if something were to go wrong with the system. There may also be a difficulty in communication, hence why the mount was to be built, and therefore may not be able to explain a problem with the unit. It would be extremely unethical to take advantage of this situation in any form.

In addition to these considerations, there are political issues that must be addressed. The many misconceptions about Sean’s condition cause a stereotypical view of those with cerebral palsy. Certain doctors and most of the educational system have their own ideas of Sean’s abilities and possible improvements. The school system’s concern for their own legal liabilities causes them to limit Sean’s movement while he is in their custody. There are also some doctors that agree with this limited movement strategy claiming that there is no hope for improvement in Sean’s condition. On the other hand, there are doctors that agree with the family’s beliefs in keeping Sean active to increase his independent movements.
3 Safety Issues

The basis behind mounting the computer in the car is to allow for full communication while traveling in the vehicle. The computer is essential for the user to speak to others in the car and portray his or her needs. Without the ability to communicate in the car, the user’s safety is at risk. It also is risky to the safety of the driver and other people in the car if the driver constantly needs to turn around or look in the rear view mirror in order to understand what the disabled person in the back seat is trying to say. The mount will allow the client to safely communicate with others in the car without being a distraction to others.

Safety also played a large role in the design of the computer mount. The main concern was the potential for the vehicle to be in an accident, both collisions and in the event of stopping fast. In such cases, the mount needed to be safely secured to the location point. This attachment point was decided to be the front passenger seat headrest. The car’s safety features will most likely secure the seat to the car and not allow the seat to move if the car were to stop fast.

There will also be a solid framework structure of the entire unit so the computer will not “flap” as the car moves and the screen will be at the same location at all times. Since the solid structure will not “flap” as the car travels,

The user of the mount must be able to safely get into the car. Since there is major impairments to the motor skills of the user, getting in and out of the vehicle is not a simple task and requires the help of an additional person. With the mount against the front seat, it will not be a safety hazard while getting into the vehicle. The mount will also be detachable and further ensures the mount will not be an obstacle while entering or exiting the vehicle.

An additional safety concern of the mount was to not obstruct the driver’s view. Again, the location of the mount will not be in the way of the driver’s view. The unit will also not protrude enough from the seat to limit any view of the user in the back seat either. This is a necessity in the case of our client that the driver is able to see child in the back seat as the computer is being used and to make sure the child is safe and content in the back seat.

4 Impact on Engineering Solutions

Overall, this device may not have a profound impact on the general population. For them, average computer stands and DVD players have already been created and distributed mainstream. These mounts are designed to fit the standard computer screen or television screen. The designs are located in the front of the car for the driver to use (in the case of a police vehicle) or on the inside roof of the car for the people in the backseat to watch a movie while traveling. However, the production of this device will have a profound impact on the large group of people using the computer to communicate with others. The mount places a needed device for communication on the optimal position while traveling in a vehicle. It accommodates their needs while providing safety for the
users as well as others in the car. There will finally be a system to allow for full communication of computer users while travelling in a vehicle.

Since the mounting system is compatible with a popular brand of a communication computer, there is certainly a market for the product. This could possible be distributed on a larger scale by the company and thus creates the ability for the company to make a significant amount of money. It could be sold on the website as an accessory for the computer and be introduced to a wide range of people. There would be a large economic incentive for the company to carry this product. Each of the computers they have previously sold as well as each computer they will sell in the future will now be able to become portable during travels with an adequate mounting system to allow for proper usage.

While the number of people injured and disabled only increases daily, so does the demand for product adaption. The awareness for such products had grown, but there is still a lot more to do. There needs to be an increase in awareness to allow the disabled to participate in everyday activities taken for granted by those able to use the product. While there have been many products on the market to help the disabled in necessary tasks, most end there. There must be further research done with these products and accessories to further allow the use of these products. Not only will the adaptations promote the acceptance and normality of those disabled into the average community, but it will help make life easier to those around them. By now being able to communicate with others in a car, it can lead to a boost in self-confidence and encourage those who are disabled to strive to accomplish anything they wish.

5 Life-Long Learning

While working on the assistive jumping device, there were many new techniques and material was acquired in the process. These new concepts are one that will be remembered and utilized numerous times in the future.

Since the client has cerebral palsy, it was necessary to learn information on the condition. It came as a surprise to find out the mental capabilities of those with cerebral palsy. Many have normal brain activity and would be able to perform the schoolwork of someone the same age if it weren’t for the limited communication skills. It was also interesting to find out that only the connection between the brain and the muscles were problematic and that the muscles had the capability of normal function. It was also learned that cerebral palsy is a condition that is a result of a form of traumatic injury, usually at birth, but those affected are not born with it (i.e. it is not a genetic defect but rather a result of oxygen loss to the brain usually from the birthing process). Furthermore, there are many different types of cerebral palsy each resulting in different limitations and causing a range of severity levels of the condition.

From the start of the project and after talking with the family of the client, there has been an increased awareness of adaptations provided for the disabled. These include ones that have been created to aid those in need as well as for the neglect of those revisions neglected. While the number of these adaptive products has grown, a massive need for more still remains present. The introduction to products designed to aid the disabled to perform daily tasks has brought about a curiosity towards other designs to aid and research to help those incapable of certain tasks.
This curiosity was furthermore extended to the idea of how things work and how they are manufactured together. There has been more noticing of how everyday objects like chairs, desks, and lamps, are set up and structured. These ideas were not only related to the project at hand but also to a general knowledge of item construction. It allowed for the generation of free body diagrams on actual objects at hand, rather than from a textbook or a homework question. The concepts learned in mechanics classes as well as materials classes were able to be applied to real-life examples.

The design and creation of the assistive humping device has led to a formation of many interpersonal skills. These skills will not only aid in the project but improve the skills needed in the workplace as a future engineer. Most importantly, learning to work as a team will be a life skill used very often, especially as an engineer. Compromising to combine ideas and standing up for the ones believed to be right are essential to coming up with a final solution in any problem solving situation. It also helped learn time management and responsibility of completing the tasks assigned to oneself. Furthermore, the project taught many new techniques in technical report writing, computer aided drawings, and presentation making. In addition to the creation of the presentation, the project taught actual presenting skills when speaking to a group of people and getting clear and precise ideas across. It also allowed for the practice to persuade others to agree with the ideas at hand and to endorse those ideas with funding or support. Working on a budget and competing the task within a limited amount of time set standards consistent with those a workplace would endorse and allowed for a sample of what was to come in a career as an engineer.
References


