Dual Purpose Wheelchair-Platform Swing

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ABSTRACT/BACKGROUND

Individuals faced with intellectual and/or developmental disabilities require specialized services to help reach their full potential in the community. Many of them benefit greatly from mental stimulation, as it contributes to maintaining a better overall quality of life.

Certain activities, such as swinging, achieve mental stimulation by targeting the vestibular system. The vestibular system includes the parts of the inner ear and brain responsible for detecting movements and gravitational pull. Inside the brain, neurological connections process and integrate sensory information associated with controlling balance and eye movements.

This process, known as sensory integration, contributes to emotional regulation, learning, behavior, and enhanced participation in daily life. The goal of the system is to assist occupational or physical therapists in providing controlled vestibular input, which is recommended for individuals with sensory processing disabilities.

PROBLEM STATEMENT

Organizations that specialize in the care of those with intellectual and developmental disabilities must acquire separate mechanisms in order to provide swinging therapy to a variety of participants. Wheelchair swings allow individuals in wheelchairs to swing without exiting their standard or powered wheelchairs. Additionally, platform swings allow individuals who do not use a wheelchair and require more intense stimulation to swing freely in a 360° footprint.
This project focuses on the development and implementation of a dual platform-wheelchair swing, accommodating both the needs of individuals who require wheelchairs and the needs of those who do not. The main features that distinguish the apparatus from today’s product market are its indoor/outdoor capabilities and its dual purpose; the wheelchair swing subsystem can be removed from the frame and a platform swing can be installed.

**DESIGN & DEVELOPMENT**

The created project plan details how goals or objectives were met through a hierarchical breakdown of all required tasks and deliverables completed (i.e., what must be accomplished, by when, and at what cost).

Unique team roles were established. Each member understood the importance of their role and its contribution to the overall success of the project. This allowed for an increase in efficiency and consequently, the ability to complete the project in the time span allotted.

A risk chart helped identify and analyze failure modes and effects. All identified risks were prioritized and delegated among the team to ensure that they would have appropriate support throughout the project. The risk chart helped the project remain on schedule through problem avoidance and predetermined back-up plans.

Together, the team benchmarked products on the market that shared similarities with their customer’s requirements. The attractive features of existing products were identified in hopes of transferring them to the ultimate design.

Next, a functional decomposition tree of the system was created in order to define the functional need for specific concepts, such as securing the wheelchair or stopping movement.

The morphological table was then produced, facilitated organized brainstorming. The goal was to produce seven possible ways to accomplish each function identified in the
functional decomposition. Five system concepts for the apparatus were generated by selecting one of the seven options for each function and combining them.

Finally, a concept screening matrix was created. The purpose of the concept screening matrix was to directly compare the five system concepts by selecting one concept as a baseline datum. Each concept's function option scored a (+) or (-) rating in comparison to the baseline function option. The end result was all five system concepts ranked from most effective and competitive to least. The team was able to confirm results by rotating the baseline datum to a different concept and determining if the ratings remained the same.

The team chose the concept candidate that was the most effective and competitive to present to the customer for approval.

**SYSTEM**

![Figure 1: Wheelchair Swing Model](image-url)
The Dual Purpose Wheelchair-Platform Swing is comprised of six subsystems: frame, footers, platform swing, wheelchair swing, swing-to-frame, and propulsion. It is important to note that the project budget cap was $2,500.00, which impacted both design and material selections.

Frame

The size of the apparatus was determined by the space required for a grown man to use a platform swing. The frame includes knees that decrease the total system footprint. A platform swing may be further defined as a platform suspended by connections at its four corners, that can swing in a 360° footprint. The platform swing can be adjusted to a
height at which the participant's feet no longer make contact with the floor when in a sitting position. The platform is designed to reach max angle of 40° from the vertical.

Figure 3: Platform Swing Model
The frame can be separated into four major groups: Beams 1 & 2, Beams 5-8, Beams 9-12, and Beams 13 & 14.

![Diagram of frame with beam assignments]

**Figure 4: Beam to Frame Assignments**

During wheelchair swing usage, Beams 1 & 2 are each subject to a load of 404.65 lbs, the largest load on any beam in the system, excluding the propulsion shaft. These beams were made of steel square tubing to increase strength, compared to round tubing, when subjected to bending, tension, and compression forces.

To reduce the system footprint, Beams 5-7, which connect the system to the floor, have both angled and vertical components, connected by a simple weld. It was critical to address fabrication and assembly issues; steel elements do not flex easily to accommodate production variances. Triangular shaped steel gussets give the simple weld
added support and facilitate welding at the required angles. The resulting system footprint is approximately 12' x 12'.

There are five custom weldments in the frame, which allow for manageable disassembly and transport. Beams may be slid into their corresponding weldment to form a snug fit. There is a stainless steel ball lock pin connection at every weldment-to-beam connection point. A pinned connection transfers horizontal and vertical shear force; the pins prevent translational movement of the received beam inside the weldment. Pins are not intended to resist functional loads, but to ensure the assembly integration during vibrational loads.

**Footer**

Four footers connect Beams 5-8 to the floor. The purpose of this subsystem is to ensure that the system remains balanced and stable on slightly uneven surfaces.

The 12" x 12" footer plates were created from 1/4" thick steel plate. A 1" diameter hole at the innermost corner of each footer plate may receive a bolt or stake in order to keep Beams 5-8 secure. The underside of the footer plate is coated in adhesive and lined with rubber to protect flooring and further help prevent the system from walking during use.

A steel leveling foot is welded to the center of each footer plate. The leveling foot can accommodate 15° of misalignment from the vertical. Steel threaded plugs inside Beams 5-8 receive the threaded tops of the leveling feet.
Platform Swing

The platform swing is suspended from a drilled and plugged through hole in the center tube of the top weldment. The top portion of the steel plug must counter the force of the entire platform swing subsystem. The bottom of the plug receives the threaded connection point of a universal joint allowing for rotary motion in a 360° footprint.

A 1/4" diameter galvanized steel wire rope, with a carabiner hook at one end, connects the universal joint to the joined rope connection of the platform swing.

Wheelchair Swing Platform

The wheelchair swing platform is built from 1/8" thick steel diamond plate welded to a 1.25" steel square tubing frame.
Additionally, there are four trapezoid-shaped plates of solid steel welded in the corners of the steel square tubing frame. Holes drilled in these plates serve as the connection point to the swing-to-frame subsystem.

Two female slots were cut into the steel diamond plate to receive male inserts extending from a ramp. A ramp was required to facilitate loading a wheelchair onto the platform. The ramp was also fabricated from 1/8" thick steel diamond plate welded to a 1.25" steel square tubing frame. This connection ensures that the ramp and platform remain together as they are loaded with a wheelchair participant.

Four holes were drilled into the corners of the platform diamond plate to secure Q'Straints®. Q'Straints® are devices used to anchor both standard and powered wheelchairs, commonly during vehicle transportation.

To ensure participant safety, a backstop made of steel diamond plate was welded to the front end of the platform. Slots cut into the backstop shed weight and act as handles to lift the platform into position. The slots are wrapped with handlebar tape for ergonomic purposes.

Figure 6: Platform Swing and Ramp Assembly
Swing-to-Frame

The swing-to-frame subsystem connects the wheelchair platform to the propulsion shaft.

The most significant components of the swing-to-frame subsystem are four swing-to-frame beams, created from vertical and angled components of 1'' SCH 40 steel pipe, connected by a minor weld.

![Swing-to-Frame Beams Connection to Wheelchair Platform](image)

**Figure 7: Swing-to-Frame Beams Connection to Wheelchair Platform**

The vertical component at the bottom of the swing-to-frame beam facilitates a horizontal connection between the beam and the wheelchair platform subsystem. Four holes in the wheelchair platform receive threaded rods, which are plugged and welded to extend from the vertical components of the swing-to-frame beams. A nut is threaded on from the underside of the wheelchair swing platform to secure the connection. When the wheelchair platform is suspended in the air, this connection creates perfectly vertical tension forces, distributed evenly on each nut.
A triangular-shaped plate of 1/8" steel is welded to cover the connection point of the two angled portions of the swing-to-frame beam for additional support and aesthetics.

A small cut of 1" OD 3/16" wall thickness tube extends vertically upwards from the mated swing-to-frame beams. Each vertical extension is received by a small cut of 1" SCH 80 pipe hanging down from the propulsion shaft. The connections are secured by stainless steel pins.

Figure 8: Swing-to-Frame Connection to Propulsion Shaft

Propulsion

Analysis was performed in order to determine a 110" long shaft with minimal deflection, weight, and outer diameter, while remaining within budget. It was critical to select a shaft with a smaller outer diameter, because the shaft is housed by two bearings. Bearings are more expensive and less common as the inside diameter increases.
A 1 1/4" diameter, ground, polished stainless steel shaft was selected. A ground stainless steel beam is more concentric than cold rolled, with the tighter tolerance of +/- 0.001", essential for the shaft to fit inside the bearing on either side.

The two 1 1/4" inner diameter pillow block bearings allow for simple assembly because their location can be fixed. Two mounting plates made of 1/4" steel, match the dimensions of the pillow block bearing footprint and align the bearings on a perfectly level horizontal plane.

Most notably, the steel wire rope of the platform swing subsystem is utilized in the propulsion subsystem to support the 110" long shaft at its center point. Shaft support in this location decreased the required diameter of the shaft, in turn, reducing total system weight and cost. A 316 stainless steel turnbuckle connected to the bottom end of the steep wire rope allows for adjustment in tension and length. The rope is connected to the shaft in the form of a rod end bearing.

![Propulsion System](image)

**Figure 9: Propulsion System**

**EVALUATION & CONCLUSION**

The design and development process resulted in a dual purpose system that not only meets customer requirements but far exceeds the capabilities of many current products on the market.

The wheelchair swing platform has less than 1/4" of deflection, when loaded with four grown men. All beams in the system have less than anticipated deflection when subject to loads exceeding the max load for this project. There is no visible wear on any of the
custom weldments. While the leveling footers used in the footer assembly assist in providing stability for the system on different ground types (grass, concrete, tile, etc.), they all visually unsettling deflections in the threaded connectors to Beams 5-7. To accommodate this, a tripod system is in the process of being designed; it entails a clamp around each footer with three steel members welded from a shaft collar to the footer.

Future developments intend to address assembly and disassembly ease and speed. The delivery of the system will come equip with detailed paper and video instructions. Each beam will be marked to ensure that it fits appropriately into its receiving weldment. Every decision has been made and will continue to be made with user safety as the top priority.

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