Harness Actuating Lift System (HALS)

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Overview

The Harness Actuating Lift System is a low-manufacturing solution to the customers needs. Excluding the main frame, HALS is created using almost entirely off the shelf parts and fasteners, which greatly reduces manufacturing cost. The frame itself is a unique fin like design made of sheet metal that provides an open structure to the interior of the system. The frame can be easily manufactured and takes up little room in the overall design.

Functionality

The Harness Actuating Lift System operates in two major modes: lifting and actuating. The user is first strapped into the harness while still in their wheelchair. The user is then lifted via the winches. The entire HALS then rolls forward. The user is lower down to the elliptical. When the user begins to operate the elliptical a LabVIEW program reads data from a position sensor and adjusts the speed and direction of the winch accordingly. When the user is finished working out, they simply lift again and reverse the direction of the lower motors. They are then put lowered back into their wheelchair.

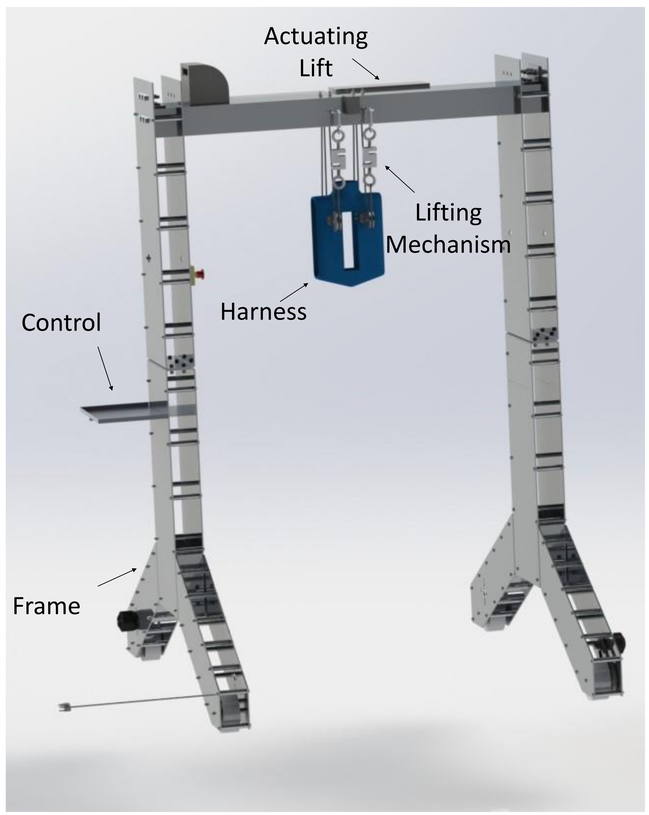

Figure 1. High-quality rendering of the HALS design.

Actuating System

- Winches that interact with the lifting mechanism and control system to move the user with the motion of the elliptical.
- These Winches were chosen due to their incredible lifting power and their high speed.

Figure 2. Off the shelf winch that will be used for the actuating system. The current chord will be attached to the pulleys and the force sensors.

Harness

- Off the shelf 3-point harness that has been modified to be a 4-point harness
- Adjustable to fit both men and women

Figure 3. Off the shelf harness that would be modified. Four pulleys would be attached to central locations to distribute the loads.

Costs

- Manufacturing ang MFG labor: $400/unit
- Assembly labor: $300/unit
- Energy costs: $0.03/unit
- Raw materials - $818.88
- OTS - $2,977.91

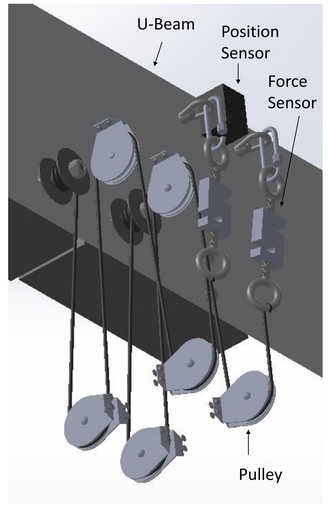

Figure 4. The pulley assembly and sensors making up the lifting mechanism. The force and position sensors communicate with the control system, and the pulley's will be connected to the harness.

Lifting Mechanism

- Two systems of three pulleys.
- Each system is attached to a winch and to points on the harness.
- This is to distribute the lifting force from the winch evenly across the user.

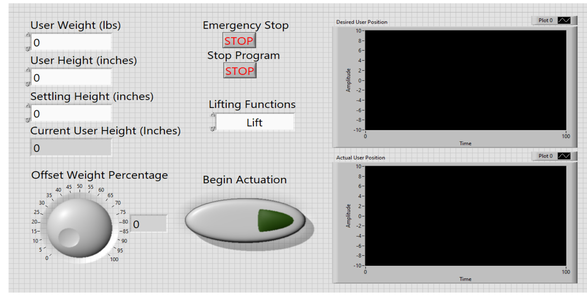

Figure 5. Example trainer view for LabVIEW program. Left side represents user info, middle area represents inputs for control, and right side represents user's actuating height

Control System

- Uses preset inputs about the user to actuate the harness to correlate to the motion of using the elliptical
- A vertical position sensor and force sensors are used in conjunction with PID control and a LabVIEW program to maintain this movement.

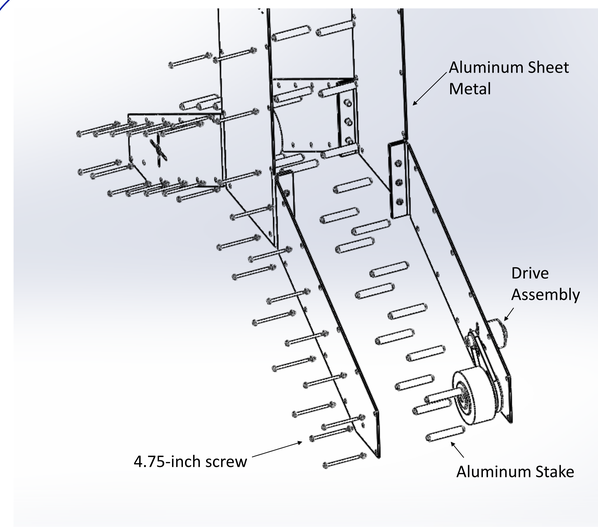

Figure 6. Upright assembly that makes up the frame subsystem. Uses stakes and bolts to hold the aluminum Sheetmetal together

Frame

- Utilizes an open structure that allows for wiring and other electrical components to be safely stored.
- Aluminum sheet metal walls to provide strength and rigidity to the system while still being relatively cheap.

	Customer need	Quantitative Metric	Design Feature	Subsystem
1)	Must fit inside a medical or rehabilitation facility	• Volumetric footprint	Able to be disassembled	Frame
2)	Runs from 120 VAC electricity from an outlet with a 15-amp breaker	• Max amps required for operation	Compatible motors	
3)	Can be used without interfering with the elliptical machine's operation	• Inside width footprint	Spacious user exercise area	
4)	Supports the full weight of the user	• Max weight supported	Rock climbing nylon cables	
5)	All design margins have an acceptable factor of safety	• Yield strength	High fatigue yield strength materials	
6)	Includes a fail-safe system to catch the user	• Response speed of failsafe mechanism	LabView control program	Lifting Structure
7)	The user is lifted and lowered at safe and comfortable speeds	• Slowest speed user can be lifted	Low speed winch motors	
8)	The system will prevent the suspended user from swinging	• Length of connection/# of connection points	Four harness attachment points	
9)	Allows the user to translate unencumbered in the vertical direction	• Smallest inside area of design	Open frame design	
10)	Prevents the user from losing balance in a sagittal fall	• Range of sagittal motion	Position sensors	
11)	Prevents the user from losing balance in a transverse fall	• Range of transverse motion	Position sensors	
12)	Lifts the user from a seated position to fully suspended	• Vertical lifting range	Tall design to accommodate all users	
13)	Moves the suspended user over the elliptical trainer	• Range of user motion	Motorized wheels	Harness
14)	Holds the user while they are being strapped in	• User Attachment points	Secure rock-climbing harness	
15)	Accommodates body sizes ranging from a 5% female to a 95% male	• Difference between min and max diameters allowed	Interchangeable harness/adjustable straps	
16)	Slowly transitions to preset offset weight	• Slowest speed actuating system can achieve	LabView program/low speed winch motors	Actuating System
17)	Offset weight anywhere from 0% to 100% of body weight	• Step size supported	User input control panel	
18)	Can be mounted on walls or ceilings or can sit on the floor.	• # of mounting/standing points	Retractable wheel allow frame to rest on ground	
19)	Provides continuous offset weight during exercise	• Minimum acceleration value	High-torque winch motors	
20)	Offset weight feels continuous despite periodic motion	• Response time of system	Responsive LabView program	
21)	Weight offset provided over the full range of the user's motion	• Volume of space in which weight offset can be supplied	Position based program working with sensors	
22)	Is programmable	• # of adjustable parameters	Customizable offset weight and emergency shutoff	Controller
23)	Has an intuitive user interface	• User survey	Simple remote control for user accessibility	
24)	Prototype cost for materials cannot exceed $4,000	• Cost	Prototype cost of $3,796.79	
25)	Emergency shut-off accessible to the user or a trainer	• Time to press shutoff button	Remote control and laptop shutoff options	
26)	Includes an automatic force-based safety limit shutoff	• Response time of emergency shutoff	Programmable control system	
27)	Visual indicator of whether system is on can be easily seen	• Area of indicator/distance from user	Laptop and frame indicate to user and trainer	
28)	Operational lifetime exceeds three times that of elliptical	• Material degradation time	Expected operational lifetime of 30+ years	
29)	FES stimulation pad electrical connections must be accessible	• Surface area of legs covered	Accessible leg area with Rock climbing harness	
30)	Overall footprint cannot exceed 2.43 m X 3.05 m (8' X 10')	• Overall footprint	Overall footprint of 1.72 x 2.51 meters	