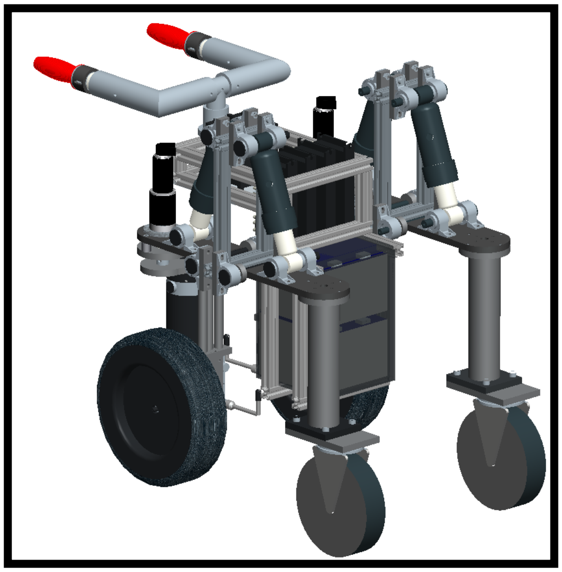
Design and Control of an Outdoor Robotic Walker

Operations Manual – April 2012

By:

John Jagusztyn, Jonathan Lenoff, Michael Bunne

Department of Mechanical Engineering



Project Sponsor

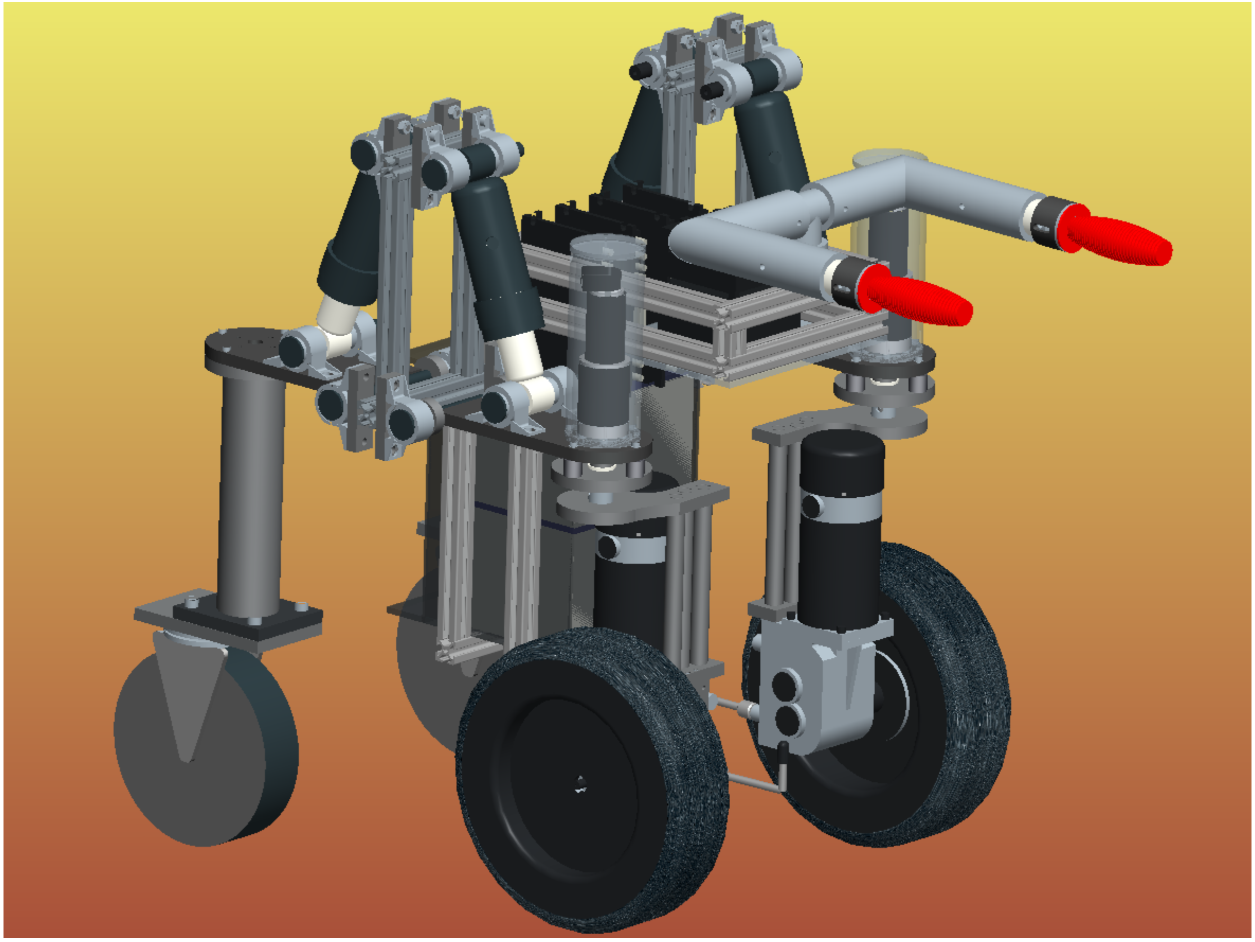
Dr. Emmanuel G. Collins, Ph.D – *Department of Mechanical Engineering*

CISCOR
CENTER FOR INTELLIGENT SYSTEMS, CONTROL, AND ROBOTICS

Department of Mechanical Engineering

FAMU-FSU College of Engineering

2525 Pottsdamer St, Tallahassee, FL 32310

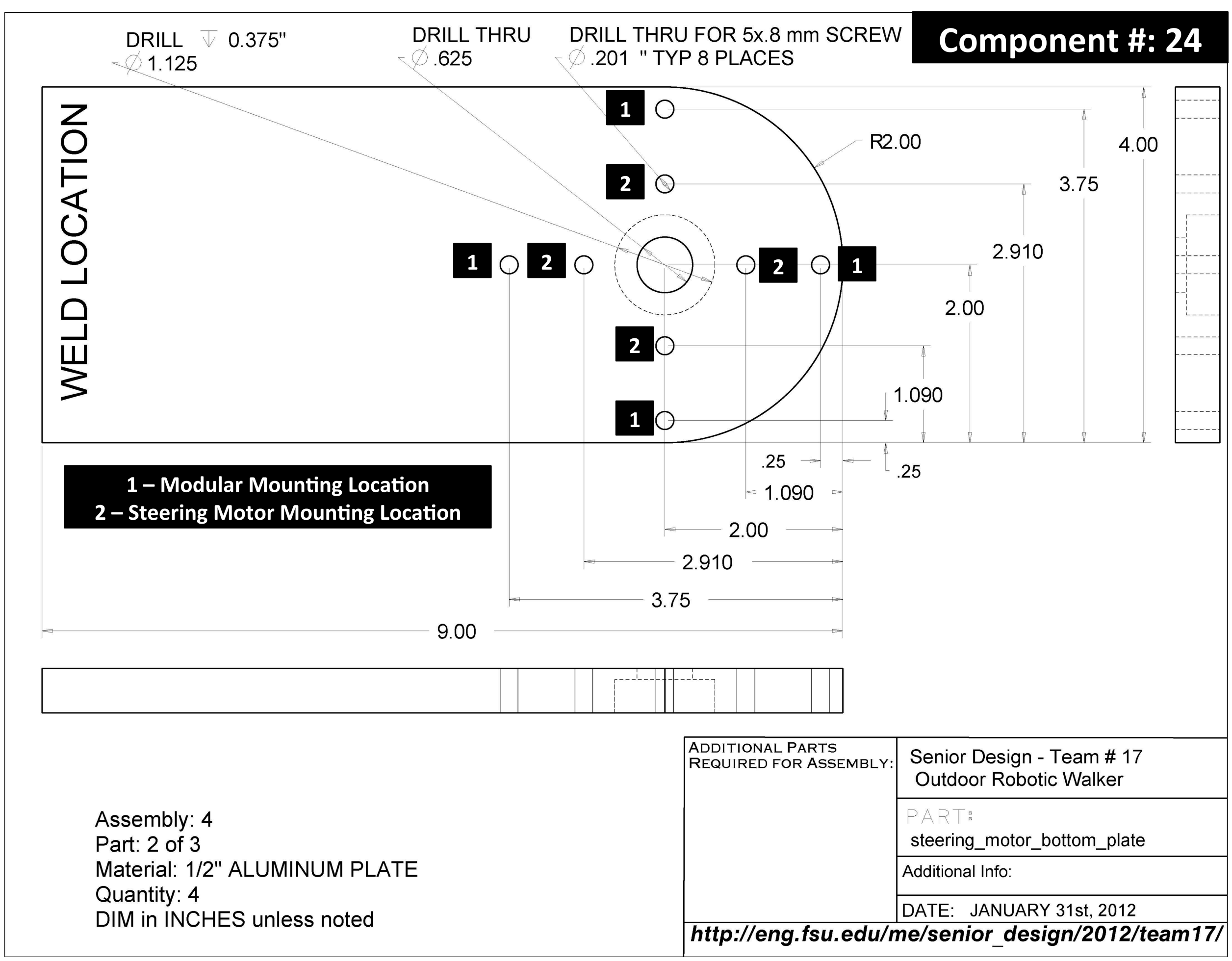


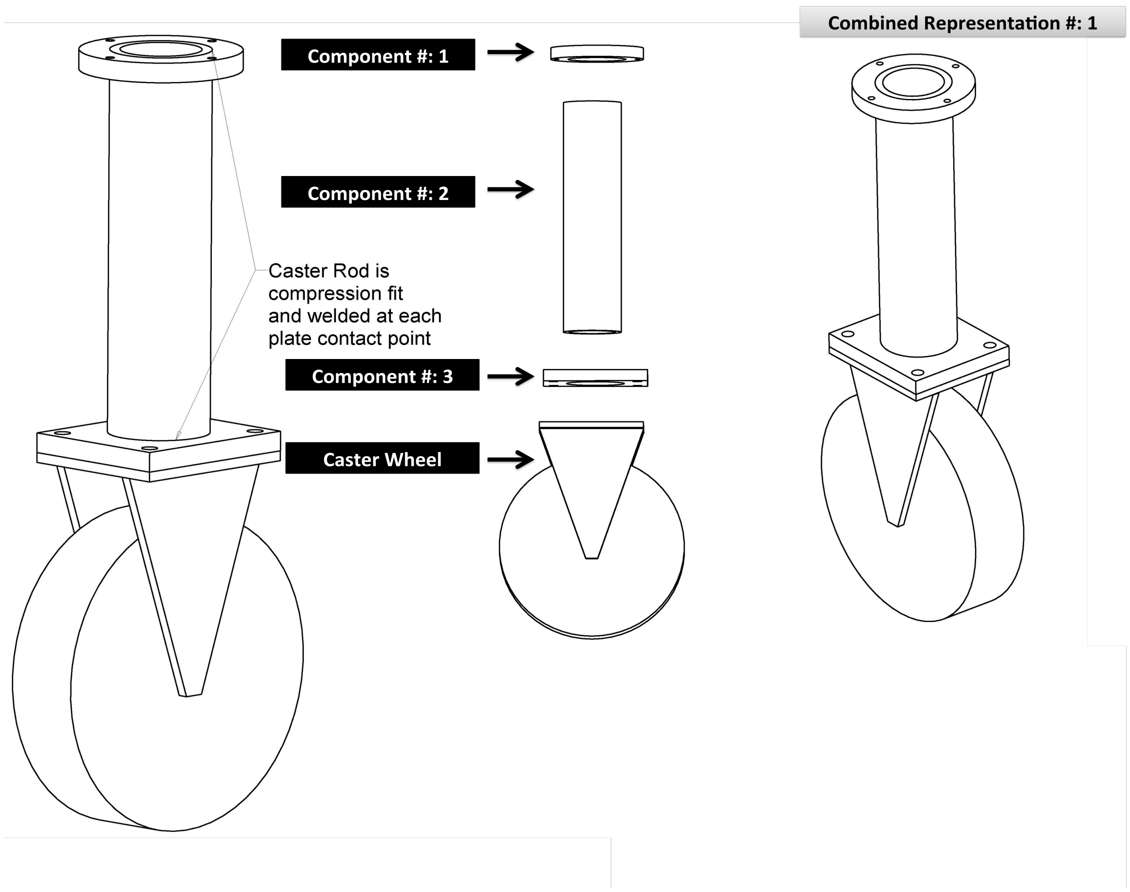
Part 1 – Basic Functionality

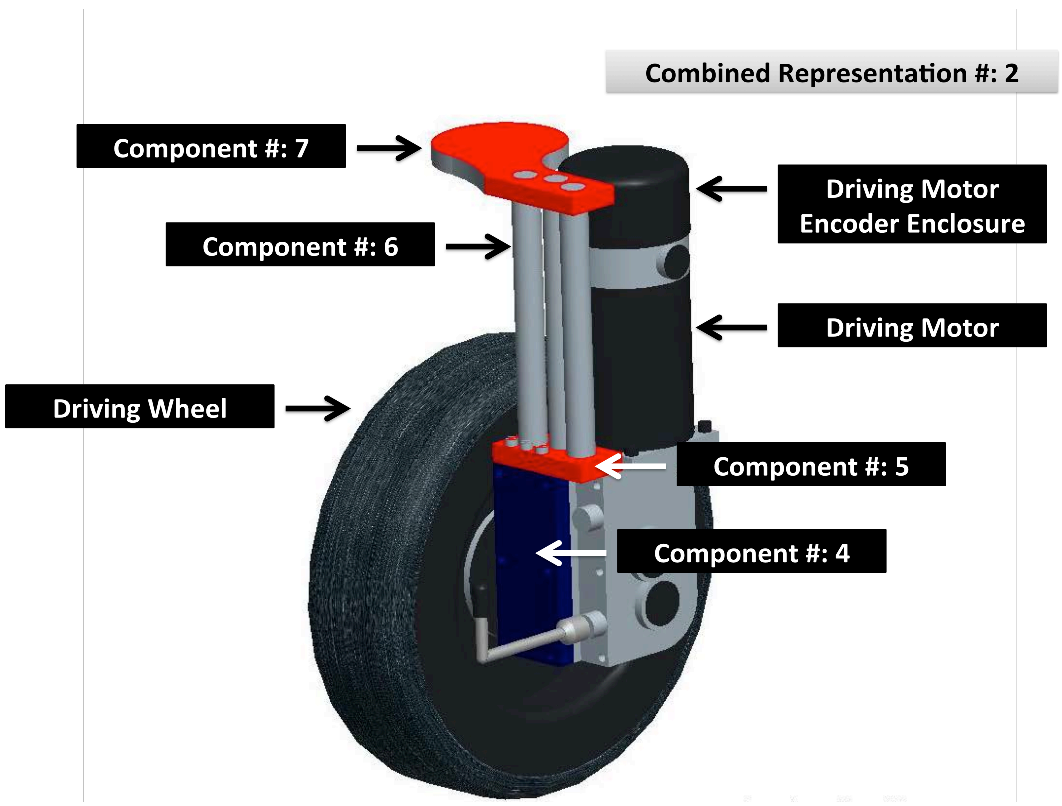
Intuitive interaction between the user and walker should be implemented to successfully operate the system. Using potentiometers to accurately determine the systems varying force input will allow the user to assume rudimentary kinematic principles to guide the walker for the purpose of intent. However, directing our walker in absolute accordance to the user's force inputs may fluctuate relating to the linear precision our 10kΩ potentiometers. With a max displacement of one inch, the inexpensive potentiometers may result a fallacious kinematic pattern of our walker evoked by the user.

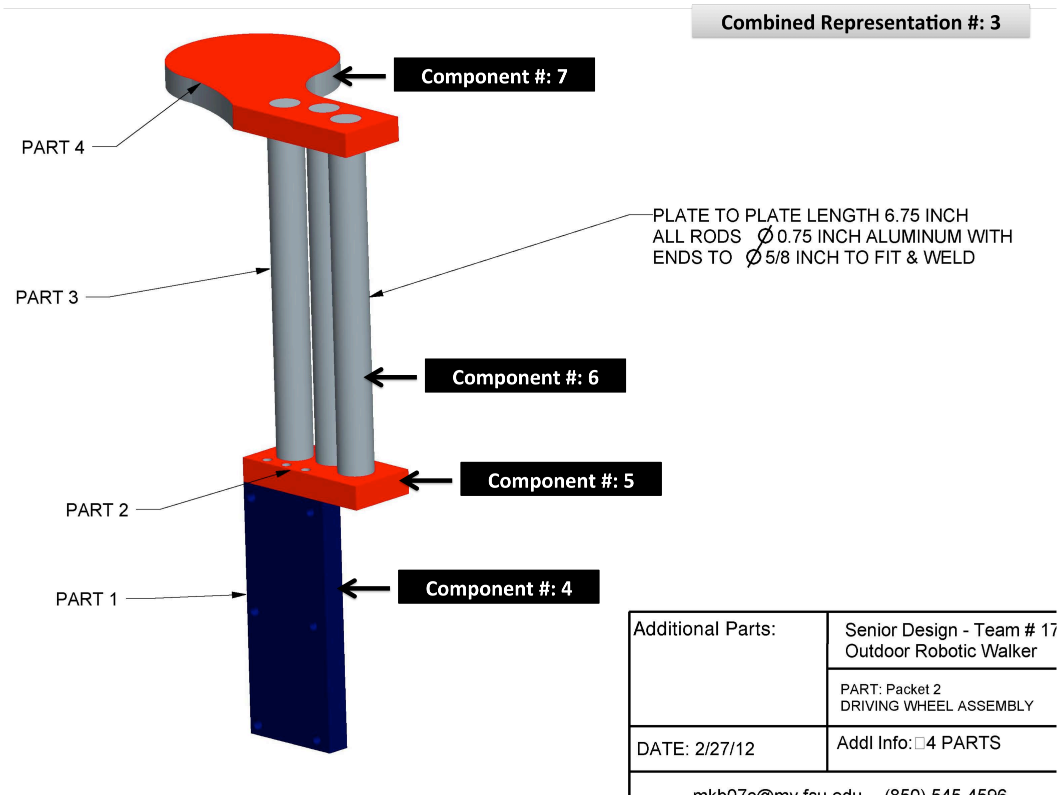
With this conditional consideration in mind, the user will interact with walker through the implementation of our spring driven handles. Composed of durable aluminum, our handles bridge the gap between human interaction and proportional mechanical response. As seen in our Functional Diagram, a PC104 Computer will interpret a potentiometer displacement within the handle and convert it to a digital electric signal. Steering and driving motor controllers will then receive that signal and output a proportional mechanical equivalent force incident on our component motors. Sufficient power will then be supplied to the driving wheels through the use of two 4600 RPM, 2.5 Amax Maxon Driving Motors, while steering the walker will be facilitated through the ample power supply of our two 3600 RPM steering Motors. Our initial goal of having our walker be semi-omni-directional was accomplished. With two passive front caster wheels and two rear driving/steering wheels, the walker allows complete maneuverability.

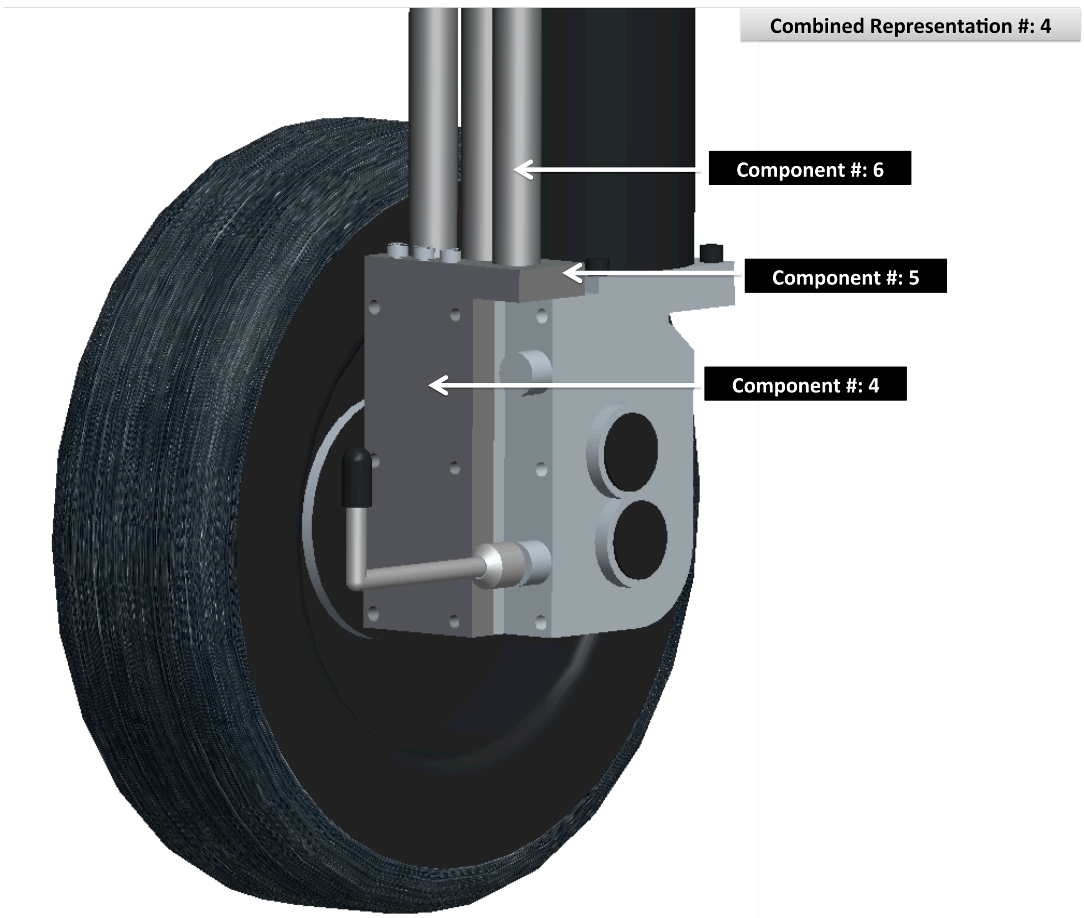
Part 2 – Exploded and Assembled Views

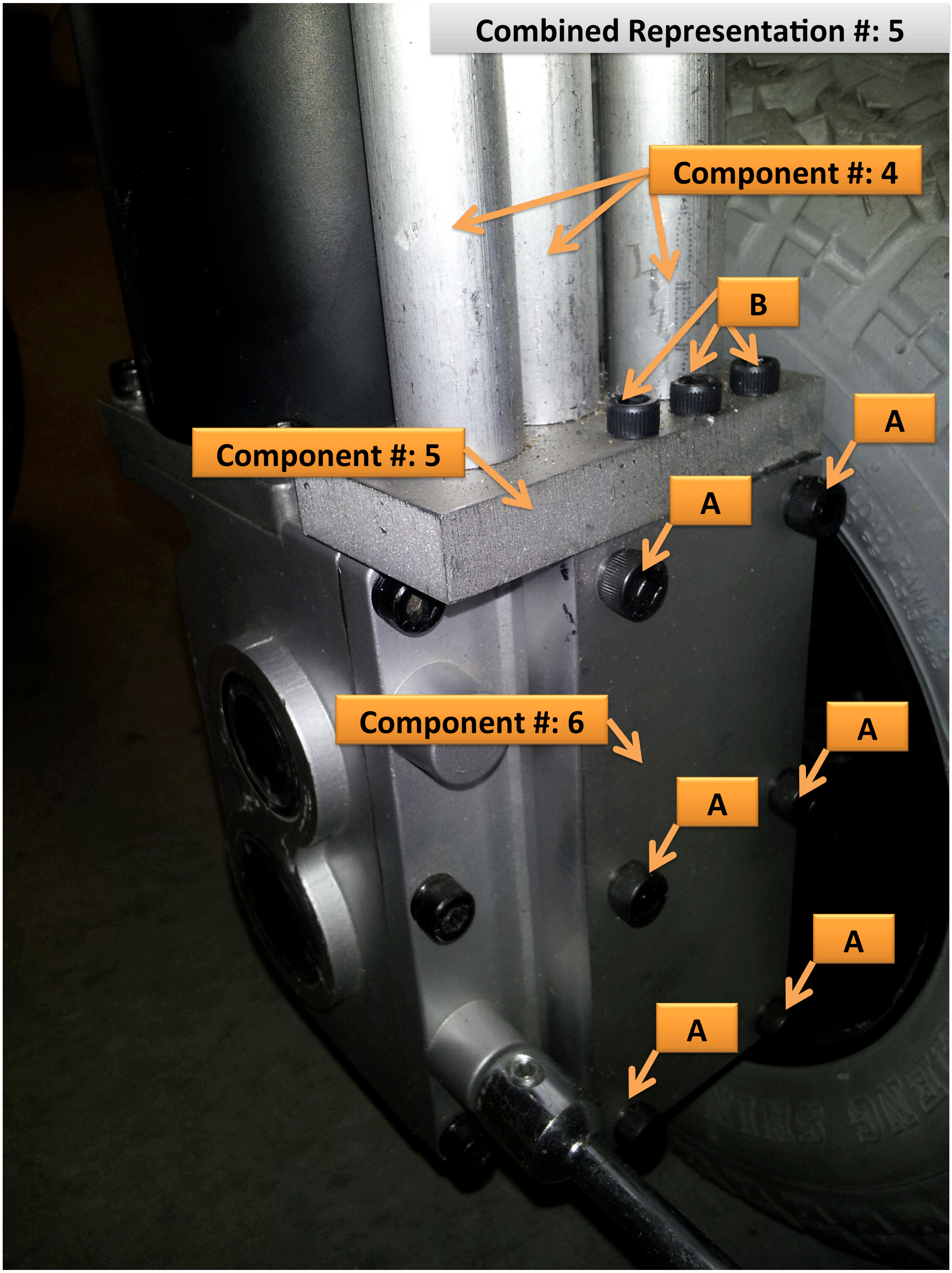


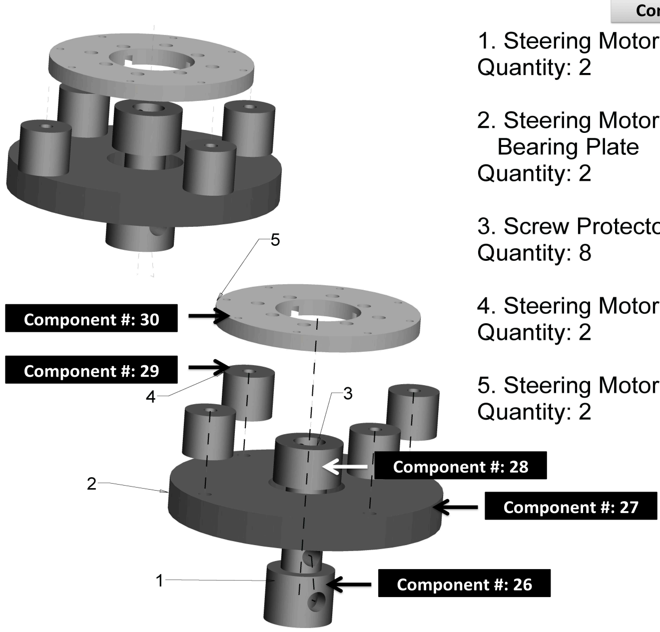

Combined Representation #: 1
Component #: 1
Component #: 2
Caster Rod is
compression fit
and welded at each
plate contact point
Component #: 3
Caster Wheel


Combined Representation #: 2
Component #: 7
Component #: 6
Driving Motor
Encoder Enclosure
Driving Motor
Driving Wheel
Component #: 5
Component #: 4


Combined Representation #: 3
Component #: 7
PART 4
PLATE TO PLATE LENGTH 6.75 INCH
ALL RODS Ø0.75 INCH ALUMINUM WITH
ENDS TO Ø5/8 INCH TO FIT & WELD
PART 3
Component #: 6
Component #: 5
PART 2
PART 1
Component #: 4
Additional Parts:
Senior Design - Team # 17
Outdoor Robotic Walker
PART: Packet 2
DRIVING WHEEL ASSEMBLY
DATE: 2/27/12
Addl Info: 4 PARTS


Combined Representation #: 4
Component #: 6
Component #: 5
Component #: 4


Combined Representation #: 5
Component #: 4
B
A
Component #: 5
A
Component #: 6
A
A
A
A



Combined Representation #: 6

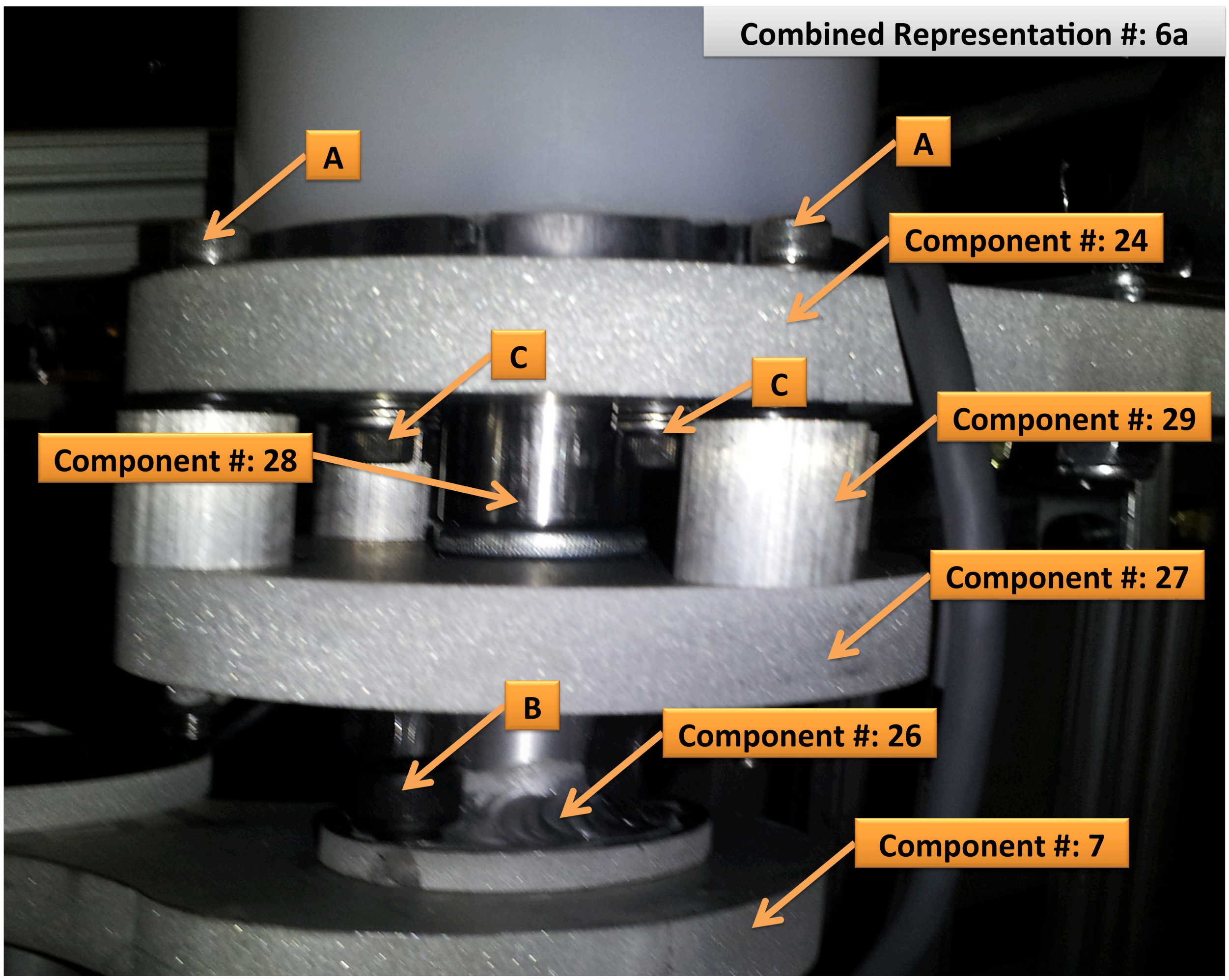
1. Steering Motor Transfer Cup
Quantity: 2

2. Steering Motor Secondary Bearing Plate
Quantity: 2

3. Screw Protector
Quantity: 8

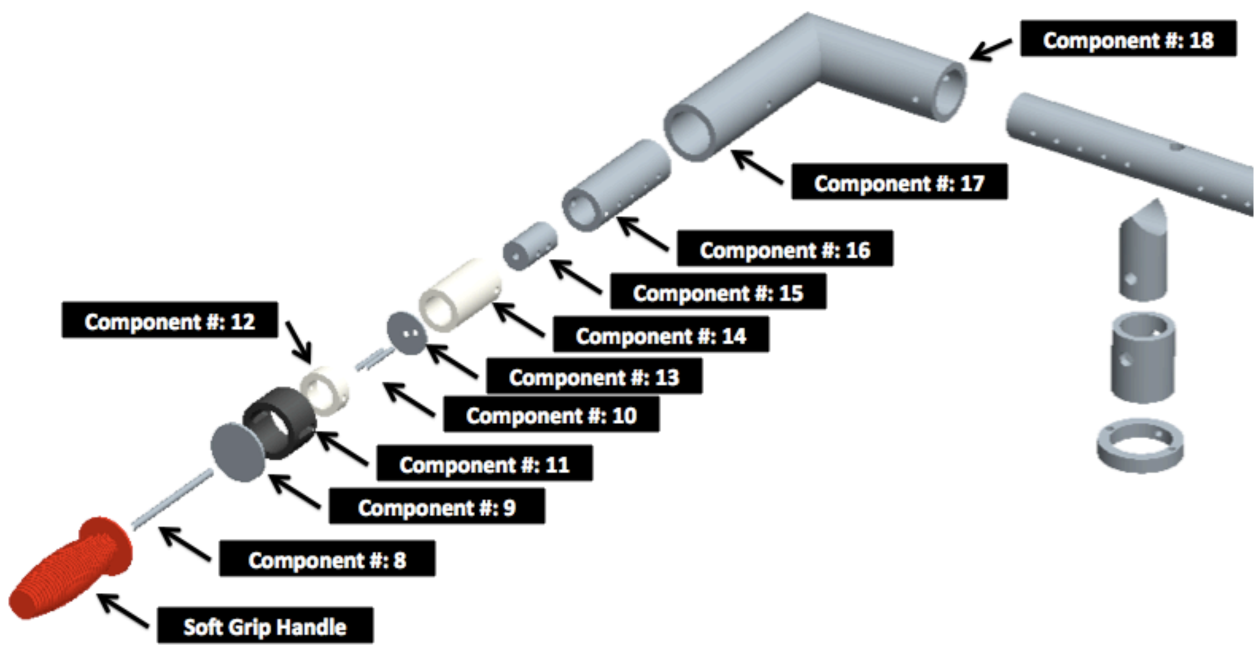
4. Steering Motor Rotation Connect
Quantity: 2

5. Steering Motor Bottom Cap
Quantity: 2

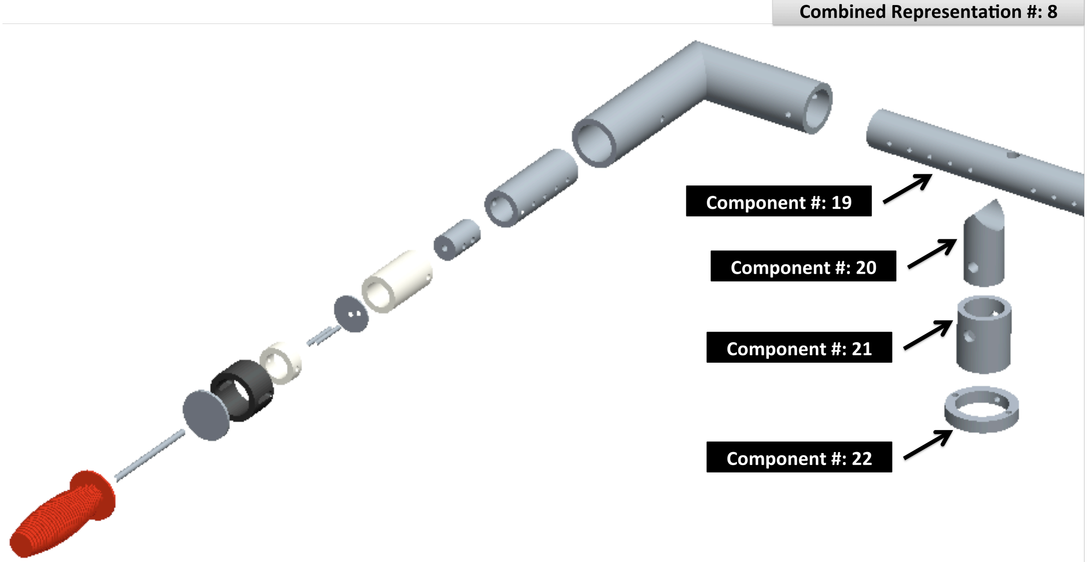


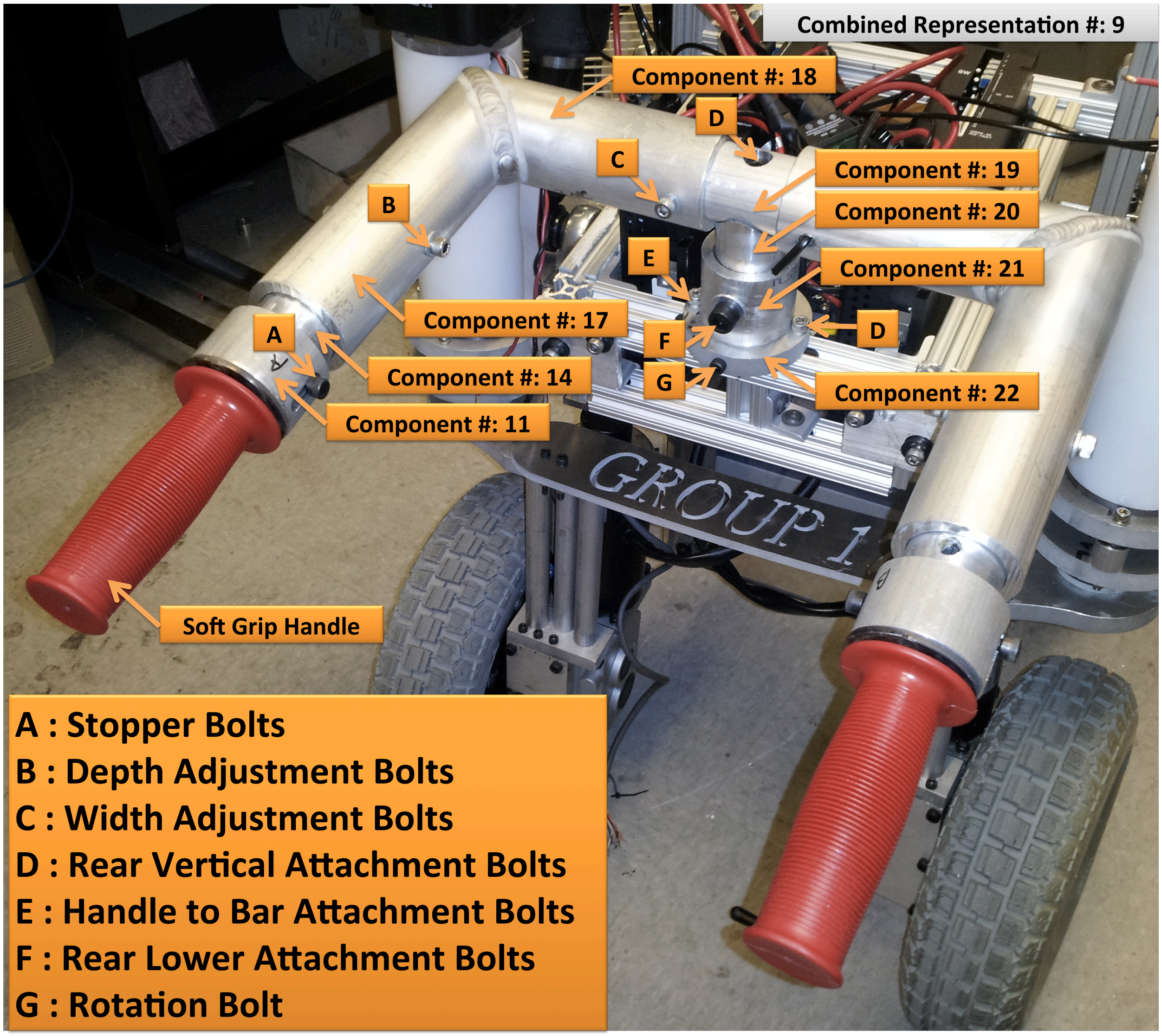
Combined Representation #: 6a

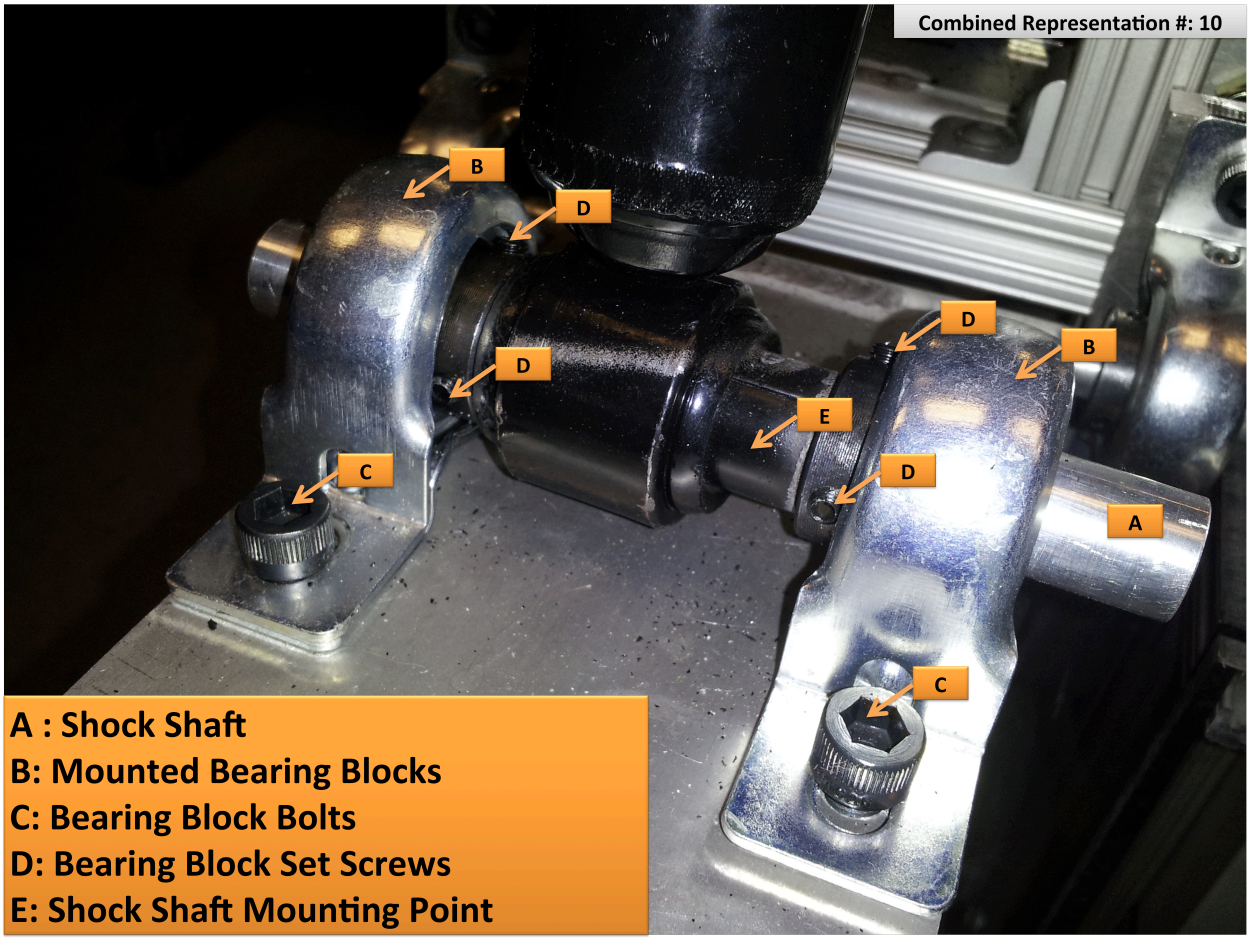
Combined Representation #: 7

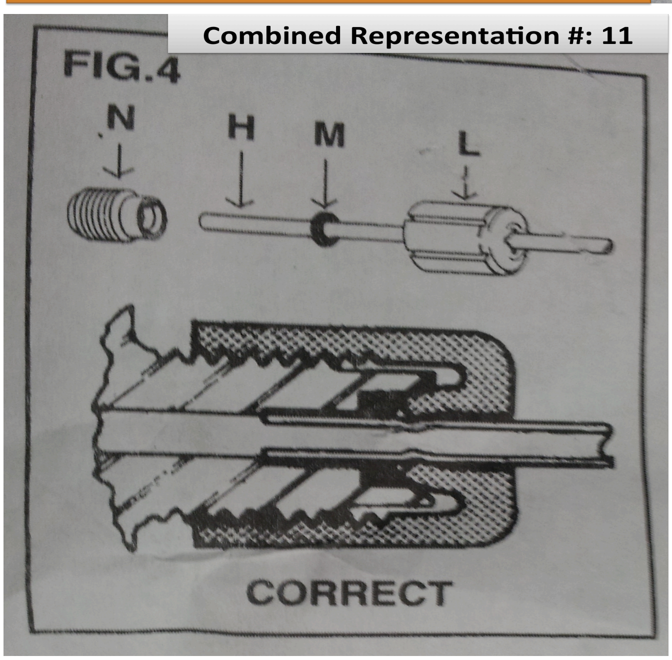


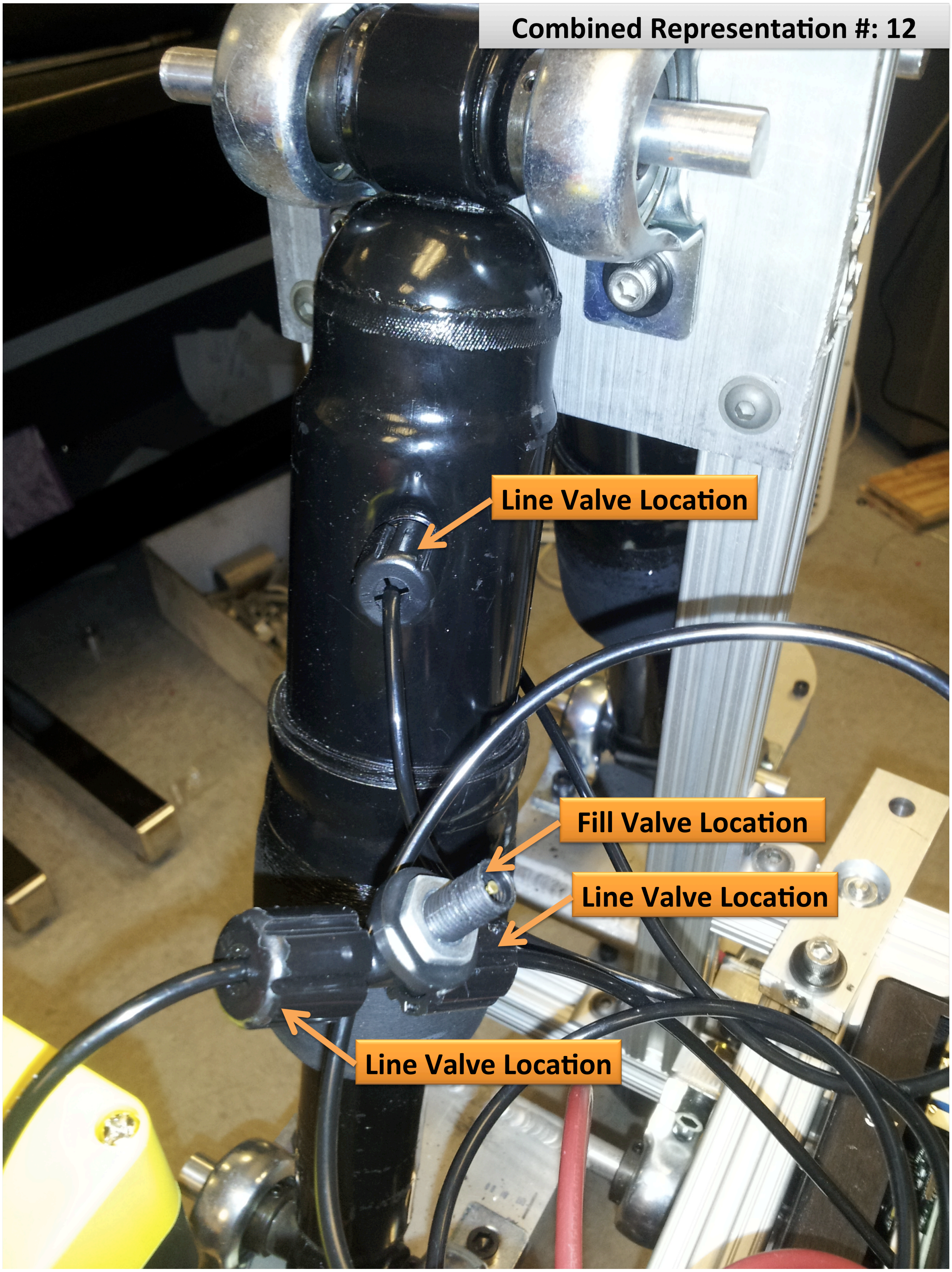
Combined Representation #: 8



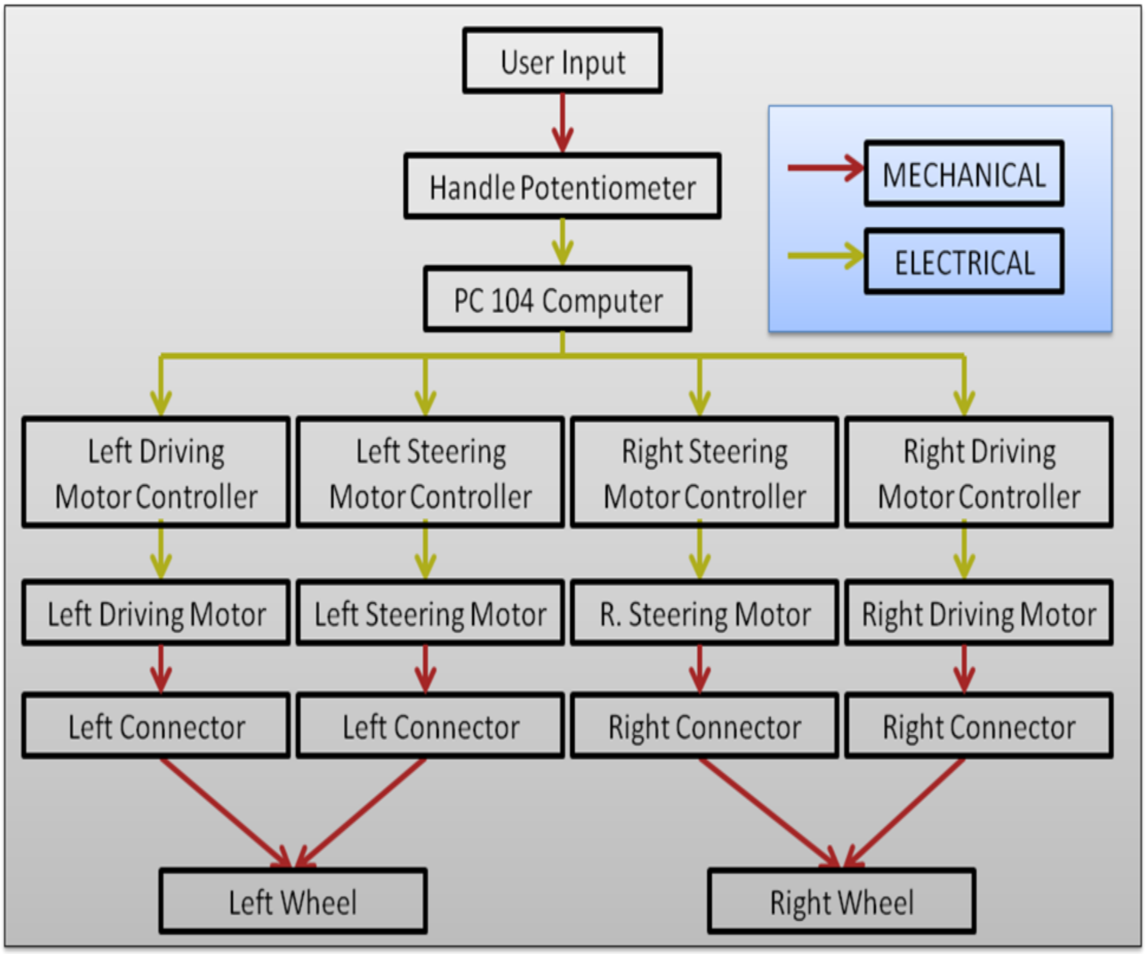

Combined Representation #: 9
Component #: 18
D
C
Component #: 19
Component #: 20
B
E
Component #: 21
Component #: 17
D
A
F
Component #: 14
G
Component #: 22
Component #: 11
GROUP 1
Soft Grip Handle
A : Stopper Bolts
B : Depth Adjustment Bolts
C : Width Adjustment Bolts
D : Rear Vertical Attachment Bolts
E : Handle to Bar Attachment Bolts
F : Rear Lower Attachment Bolts
G : Rotation Bolt


Combined Representation #: 10
B
D
D
B
D
E
D
C
A
C
A : Shock Shaft
B: Mounted Bearing Blocks
C: Bearing Block Bolts
D: Bearing Block Set Screws
E: Shock Shaft Mounting Point


Combined Representation #: 11
FIG.4
N
H
M
L
CORRECT


Combined Representation #: 12
Line Valve Location
Fill Valve Location
Line Valve Location
Line Valve Location

Part 3 – Functional Diagram



Part 4 – Major Components

Major Component	Model Number	Manufacturer	Quantity	Cost	Comments
Driving motor & wheels	EC82M244632WLGBR	Motion Tech	2	$212.50	purchased from eBay
Steering motors	317767	Maxon Motors	2	$775.00	
Mounted bearing blocks	5913K610 & 5913K620	McMaster	8 & 8	$11.00	
Thrust bearings	SKF-9060	Nice	20	$3.50	purchased from Reid supply
Motor mount assemblies			2	$220.00	custom made by Group 17
Caster wheels	2652T52	McMaster	2	$33.50	
Air shocks	MA785	Monroe	2	$64.00	purchased from amazon
Handle assembly			1	$300.00	custom made by Group 17
Batteries	70115690	Power Sonic	2	$116.00	purchased from Allied
Motor controllers	CBT005A	AMC	2		provided by CISCOR
Computer	PC-104		1		provided by CISCOR
Potentiometers	pot10kbmono	Futurelec	2	$0.50	

Part 5 - Assembly Instructions

Leg Assemblies

Caster Leg Assembly

As Combined Representation 1, shown below, shows, four major components that make up the caster leg assembly. These four components are as follows: Component #1, caster leg upper attachment, Component #2, the caster leg, Component #3, caster leg lower attachment, and the caster wheel. Components #1 through #3 are permanently fixed together as they are both press fit and welded together. The caster wheel simply bolts onto the bottom of Component #3.

These components will already be assembled with locking nuts and it is highly recommended that any modification to this assembly utilizes only locking nuts as the vibrations from the caster wheel could very well shake nuts loose. This caster leg assembly is only made for a specific size wheel, eight inches, and mounting height so any modification to the height of the caster wheel will cause the entire walker to not sit level. The four holes on component 1 mount to the modular mounting locations found on Component #24. The nut used to attach these components should as well be a locking nut for the reasons stated above.

Driving Wheel Assembly

As shown in Combined Representation #2-#5, the driving wheel assembly is comprised of 3 main parts attached together and to the driving motor itself with 9 bolts (see Combined Representation #5, bolts labeled A and B). Component #5 through $7 are already press fit and secured with roll pins, thus there should not be any need to modify these components. Component #6 attaches to Component #5 with three bolts, labeled B in Combined Representation #5. These bolts must be tightened securely before use of the walker. Component #6 attaches to the driving motor with the use of 6 bolts. These bolts are labeled A in Combined Representation #6. It is also important to ensure these bolts are sufficiently tight before operating the walker. There really is no reason to disassemble any of these components unless a malfunction occurs.

Steering Motor Coupling

As seem in Combined Representation #6 and 6a the steering motor coupling is comprised of several components. Combined Representation #6a is the more important representation as there were some changes from the cad to the actual implementation. The main change occurred on Component #26 where an additional plate was added to the bottom so that it could be bolted, labeled B, as opposed to welded to the structure. This ensures that the structure hopefully will be maintain the ability to keep the steering motor in line with the contact patch from the driving motor. In the future it may help to remake Component #26 so that there is a tighter fit with Component #28. The bolted design allows for the wheel size of driving motor to change however additional holes may be necessary to drill into Component #7. The bolts labeled A in Combined Representation #6a provide the compressive forces to squeeze the entire steering motor assembly together. This compression force is transmitted from Component #27 to Component #24 through Component #29 and some washers that allowed for a perfect fit. The bolts labeled C in Combined Representation #6a bolt directly to the steering motor itself so keep the steering motor firmly in place.

Handle Assembly

As shown in Combined Representation #7 - #9, the handle assembly is comprised of roughly 30 components that interact with each other. Components #8-#11 are already either welded or bolted securely on, this subassembly should not be altered. Components #12-#14 are also bolted securely on, this subassembly should not be altered. Components # 17-#18 are welded together, this subassembly should not be altered. Combined Representation #7 shows an exploded view focusing on either the left or right handle shafts (as they are mirror images of each other). As seen in this representation it is important that everything in the handle assembly, whether it be the left or the right side, maintain a common central axis.

It is also very important to not mix up the components from the left side and the right side as although these components should be interchangeable they simply are not. The assembly of the handles is very straight forward and just bolts together. Very detailed assembly instructions can be found within the drawings themselves, just match up the tapped holes with the holes drilled for clearance. No modification is necessary to these handles at this time save for adjusting bolts B, C and F as shown in Combined Representation #9. These bolts are central to controlling the width, height, and depth of the walker.

Shock mounting

The Monroe air shocks have two different diameter shaft sizes, either Component #35 or Component #36. It is important to match these shaft sizes with the appropriate mounted bearing block and shaft. Each mounting location on the shocks requires two mounted bearing blocks, one on each side of the shaft mounting location. This is best seen in Combined Representation #10. The shock shaft itself (labeled A) does not necessarily have to have any precision fitting through these components, both the mounted bearing blocks and the shock mounting point itself, but the tighter the better. It may be helpful to align the set screws (labeled D) that hold the shafts through the mounted bearing blocks (labeled B) so that both sets of screws are available to the operator in an orientation that the shaft would normally lay in during operation. Some caution must be taken when mounting these mounted bearing blocks in their respective locations. The tightness of the bolts (labeled C) that attach the mounted bearing blocks directly affects the rotational resistance of the bearing itself. That is, a tighter mounting will result in more resistance to rotation of the bearing. With this in mind, since the nut cannot be tightened down too tightly, it is important to use locking nuts to prevent the nut from coming off during operation.

Using the pneumatic shocks

Monroe air shocks come with substantial literature on how to use their shocks and are fortunately very widely use d which means that your local auto shop can help with the installation and maintenance of these devices. The most important consideration is how the tubes connect to the actual valves. The exploded view of this is shown in Combined Representation #11. It is important to make sure that the line, labeled H, is inserted as deep as possible within the valve. The o-ring, labeled M, must then be compression fitted to the valve by tightening down with the cap, labeled L. If leaking occurs, try to either grease the o-ring slightly, insert an additional o-ring, or ensure that the line is sufficiently deep in the shocks. Some common locations for these line valves is shown in Combined Representation #12.These shocks should be filled through the fill valve location as shown on Combined Representation #12.

Mouting components to the 80/20

While the T-slotted 80/20 Aluminum is very versatile and easy to work with, there exist several considerations when mounting to or assembling the 80/20:The bolts used to attach components to the 80/20 rely solely on a surprisingly low frictional contact between the smooth aluminum and variably smooth nut surface. With this in mind the 80/20 mounting is not exceptional at resisting shear forces.The 80/20 is flexible, literally so following the following instructions is much to your advisability. Thus any distance over inches five, if you want the structure to stay alive, that will be subjected to even moderate loading must be supported, for the structure to not be contorted. It is important to continually check the mounting locations of the components to see if they potentially transported.

Part 6 – Operating Procedure

In order to offer ease in transition between current walker use and use of a more advanced robotic walker, the following procedures should be closely followed to allow for intuitive and safe operation of the walker.

1.) Confirm that the Monroe MA785 Air Shocks are pressurized to an optimal user-dependant psi. To inflate or deflate the shocks, connect the AK18 Air-line Kit and use an external compressor to fill the shocks through the T-jointed Schrader Valve. Proper connection of the AK18 Air-line Kit will allow for uniform inflation between two shocks. Once filled, detach the compressor line from the Schrader Valve and store the AK18 Air-line Kit onboard the walker **Do not remove the air-lines from the shocks after inflation as they will rapidly deflate and potentially cause serious injury or death**
2.) Verify that both driving motor clutches are unlocked to allow rotation within the wheels. To do so, locate the protruding lever on the driving motor and rotate inward to unlock (outward to lock). An ergonomic black cap is located at the end of the clutch level for indication and to avoid any potential hazards.
3.) Once successfully completing the first two steps, stand behind the walker at a comfortable distance and place both hands on the red handles. If the current positioning of the handles is unfit, adjust them to the preferred height, width, and depth such that maneuverability of the walker will occur with ease.
4.) Once the walker is calibrated and adjusted correctly in accordance to the user, assume standard walker function and operation. Use of the spring-driven handles will assist the user as they progress through such tasks; no additional calibration of the walker should occur beyond this point. The user should be able to project freely about the area of operation with ease as the control logic will provide added stability and safety within the walker.

Part 7 – Safety Information

Safety Information (electrical connection specifications, material hazards, etc)

The purpose of this senior design project was to create a research platform for further evolution and development. With this, there are a few facets within our design that must be discussed to preserve the safety and health of the operator. First and foremost is the overbearing total weight of our walker, equaling almost 200 pounds. If the walker is used incorrectly or a situation presented itself in such a fashion, the walker may topple over and potentially hit or pin down the user. This must be kept in mind during operation, as the slightest force incident on the walker's center of gravity may result in the entire system falling over. This hazard could occur as the walker traverses obstacles or travels on inclined planes with varying surface grades.

There are additional hazards existing within the system that must be discussed. Sharp edges and corners have been ridded of all burrs from machining, but are still hazardous if the user was to vehemently come in contact with them. Also, to fulfill the control logic requirement, multiple wires and electrical connections are mounted onboard the walker. All of the electronics have been housed within our walker, but our team designed the electrical components to allow for further development. However, since our design focuses more on the structural and mechanical means, there are a few wires and electronics that are exposed and may harm the user. Consequently, any water that would come in contact with the electrical components could short out and shock the user. This must be considered for further safety requirements of the walker. Additional components onboard the walker may endanger the user. Misuse of the air shock can be unsafe as it may not only cause the walker to collapse almost instantaneously, but will also present a danger when the internal pressure of the air shocks rapidly expel out of the fill valve and into the environment in which the user is present. Proper use of the air shocks will alleviate the possibility of this danger, but again, must still be mentioned to account for the occurrence of such dangers. Lastly, although it doesn't present an immediate danger to the user, appropriate disposal of the lead-acid batteries must be executed, as improper disposal can harm both the environment and the disposer.