Abstract

There is a need for a device to aid someone in lifting an object of reasonable size and shape. This device must reduce barriers that prevent persons with disabilities from entering or advancing in the workplace. This device may assist a broad range of disabilities which include, but are not limited to, persons with upper limb loss, persons with bad backs, little people, and the elderly.

This report details the design process for our team. Our research, interviews, and observations are detailed throughout the first few sections. The report addresses how we came up with our needs statement and how we narrowed our search.
1.0 Introduction

1.0.1 Context

The official definition of a disability is “anything that disables or puts one at a disadvantage” (Dictionary.com, 2007). In 2002 there were 51,235,000 disabled people in America which is 18.1% of the population. Of this, 25,597,000 are in the working age (21 to 64 years old) with only 14,313,000 or 55.9% maintaining stable employment. 18,289,000 of the 25,597,000 disabled working age have experienced employment problems related to their disability; and 10,877,000 have been unable to work at a particular job due to their disability. This data demonstrates the large number of people who face severe adversities in the workforce due to a disability (Steinmetz, 2007).

1.0.2 Purpose

As defined by the NISH, the purpose of the design project is to facilitate disable persons in integration into the workplace. There are numerous disabilities all with different limitations that pose problems when disabled individuals try to enter into a workplace. Our project will help those individuals with to move into the workplace and allow them to explore areas of work which they might have been restricted from in the past.

NISH is a national nonprofit agency whose mission is to create employment opportunities for people with severe disabilities by securing Federal contracts through the AbilityOne Program, formerly Javits-Wagner-O’Day (JWOD), for its network of community-based, nonprofit agencies (NPAs).

The purpose of the NISH National Scholar Award for Workplace Innovation & Design is to encourage college students to design creative technological solutions to barriers that prevent people with disabilities from entering or advancing in the workplace. We will be participating in this competition. Up to three awards are given annually:

First place – $10,000
Second place – $5,000
Third place – $3,000

A matching prize will be awarded to the sponsoring department for each of the design winners.

1.0.3 Scope

Team ME Too will place all our time, energy, and resources into creating a device to assist the disabled in the workplace. We will contact as many customers as needed to clearly identify our customer base and we will examine their problems to select a need area. After a need area and a customer are selected that customer will work side by side with us throughout the year to continually improve our project.
1.0.4 Objectives

1) Identify a customer.
2) Identify customer needs.
3) Capture customer requirements.
4) Narrow to one need.
5) Narrow to one concept.
6) Develop the concept based on customer requirements.
7) Manufacture concept.
8) Test concept.
9) Evaluate concept.
10) Implement Concept.

1.1 Initial Needs Statement

There is a need for assistive technology devices that reduce barriers that prevent persons with severe disabilities from entering or advancing in the workplace. Devices are needed to address environmental accommodation, functional assistance, and mobility issues for people with cognitive disabilities, developmental disabilities, and physical impairments (vision, hearing and mobility).

[NISH National Scholar Award for Workplace Innovation and Design]

2.0 Customer Needs Assessment

We decided on our initial customer needs through research, interviews, and observations. These items are described in this section through tables, outlines, and customer surveys. The customer surveys and interviewing outlines will appear first, followed by our conclusions of required needs.

2.0.1 Interview Outlines

Team ME Too interviewed numerous potential customers. These persons with various disabilities described the problems they encounter in the workplace on a daily basis. The interviewees included the following people:

a) Daniel Bohner – Has been without his left arm his entire life.
b) Gary Wycal – Farmer who lost both legs.
c) Eric Mailloux – Little person.
d) Patients from a rehabilitation clinic at the University of Illinois

Appendix A.1 shows the customer needs outline, lists of questions, surveys, and observation plans.
Upper Limb Loss:

General Statistics:
1) According to the LIMBS FOR LIFE FOUNDATION, "Every Week 2,996 People Lose a Limb."
2) 50,000 new amputations every year in USA based on information from National Center for Health Statistics
3) Existence of 350,000 persons with amputations in USA, 30% have upper limb loss
4) 30-50% of handicapped persons do not use prosthetic hand regularly
5) About one in every 2000 new born babies will have some form of a limb deficiency

Specific Need Statements:

1) Need for a device to aid someone in lifting an object of reasonable size and shape

Reasons for the Need:
1) Person with one arm has difficulty grasping and lifting specifically large objects which would require two hands to hold on two sides.
2) Interviewee: “lifting large boxes is difficult because I don’t have another arm to support or pin the box (on opposite sides) to lift it” – Dan Boehner

Specific Statistics:
1) 7.7 million people between the ages of 15-64 have difficulty lifting 10 lbs (Census 2002)

Requirements:
1) Must lift up to 40 lbs
2) Must lift to chest height
3) Must be comfortable
4) Lightweight
5) Must lift an object with a volume of about 8’ cubed
6) Durable – long fatigue life
7) Inexpensive < $50-75

Customer Ideas/Concepts:
1) Strap lift built into vest
2) Dolly aid
3) Mechanical Load Lift assist

2) There is a need for a device to aid people with only one hand to type as fast as someone with two hands.

Reasons for the Need:
1) In order to keep up the pace of work to compete with people who type with two hands.
2) Interviewee: “Yes, I would be interested in a keyboard that caters to people with one hand.”

-Requirements:
   1) Must enable typist to type 50-70 words per minute
   2) Inexpensive < $100
   3) Durable
   4) Ergonomic
   5) Should not be much bigger than a normal “qwerty” keyboard

-Customer Ideas/Concepts:
   1) One handed keyboard
   2) Keyless keyboard

http://www.aboutonehandtyping.com/statistics.html

Lower Limb:
Interview with local farmer Gary Wycal, October 20th, 2007, by Darin Cook

Specific Need Statements:
   1) There is a need for a lift to raise the operator up and into farm equipment.
   2) There is a need for a device to work the foot controls of equipment.
   3) There is a need for mobility in the field (off-road).

Reasons for the Need:
   1) Cannot easily get into any of his equipment, uses a 2X6 to slide up and in.
   2) Has lost both legs and uses a board to depress the clutch of his tractor.
   3) His wheelchair sinks into the ground when he is out doing work in the field or at home.

Requirements:
   1) Has to be raise a max of 8 ft and over approximately 4 ft.
   2) For all of his equipment the pedals must be depressed 1-12 inches.
   3) Weighs 230lbs, must not sink in soft mud, gravel, etc.

Customer Ideas/Concepts:
   1) A lift that is universal for all equipment, a lift that attaches to equipment.
   2) A lever system, air actuated system, electrical system that can be calibrated depress the pedal as much as it is told to.
   3) A wheelchair with larger diameter tires that have an off-road type tread.
Short Stature:

General Statistics:

1) Achondroplasia is the most common type of dwarfism and occurs in 1 in about 25,000 births [1].

Specific Need Statement:

1) **There is a need for little people to access ATM’s, Bank Counters, Hotel Counters, and Elevator Buttons.**

   **Reasons for the Need:**
   1) Short stature and that ATM’s, Bank Counters, and Hotel Counters are designed for average height people.

   **Requirements:**
   1) A device to elevate little people such as a step stool
   2) Height needs range on a personal basis from about one foot to much larger with 2-3 feet being sufficient to help most.

   **Customer Ideas/Concepts:**
   1) A light weight easily maneuverable step stool with wheels.

2) **There is a need for an assistive device to help little people button and unbutton buttons.**

   **Reasons for the Need:**
   1) Short fingers, arthritis, missing fingers, or missing hand.

   **Requirements:**
   1) Must be able to button any size button with a hand the size of a child’s.

   **Customer Ideas/Concepts:**
   1) No specific improvement ideas in this area currently.

3) **There is a need for little people to access lawn equipment such as a push mower or a riding lawn mower.**

   **Reasons for the Need:**
   1) The handle bar for a push mower is too high about (4ft.) needs to be made shorter on an individual basis.
   2) The pedals for the riding lawn mower cannot be reached.

   **Requirements:**
   1) To modify the handle for push mower lower but still keeping feet away from mower deck and blades. (different for every person)
   2) Develop pedal extensions for a riding mower similar to auto versions.

   **Customer Ideas/Concepts:**
   1) Developing solutions for various types of lawn mowers, push, riding, etc. to make them more usable for little people.
4) There is a need for an improved gripper/retriever device.

Reasons for the Need:
1) Lack of gripping power and range of gripping pads (2) when opened.
2) Trouble reaching and retrieving items from far away.
3) Inability to lift heavier objects.

Requirements:
1) Make gripper open wider or adjustable span, currently only 4”, 6-8” would be better.
2) Make gripper grip strong enough to pick up a large coffee cup which is about 2 lbs, and other items requiring a larger clamping force.

Customer Ideas/Concepts:
1) Modify a gripper with a clamping force adjustment like a vice grip, that can be retracted easily when larger/heavier objects are being picked up.
2) A gripper with more than two pads, an integral hook and foldable/retractable design. See pictures of existing product.

5) There is a need for more affordable, customizable automobile pedal lifts.

Reasons for the Need:
1) These items are very expensive and only have specific height ranges, especially for foreign vehicles and customizable on a personal basis.

Requirements:
1) A Rugged, sturdy design for daily use that does not affect drivability.
2) Similar size to stock pedals.
3) Corrosion resistant and provide a comfortable driving position.
4) Be able to be removed easily so other drivers can use the vehicle.

Customer Ideas/Concepts:
1) A cheaper version of what is currently available with modifications on a case to case basis for comfort and feel.
Figure 2.0 Summary of Survey Results from Rehabilitation Specialist at the University of Illinois. Appendix A.2 shows a copy of the Survey Sent to a Rehabilitation Specialist Working at the University of Illinois

<table>
<thead>
<tr>
<th>Disability / Time Disabled</th>
<th>Age</th>
<th>Employed</th>
<th>Tough Tasks at Work</th>
<th>Everyday Tough Tasks</th>
<th>Ever Been Discouraged From Job</th>
<th>Any Possible Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse myelitis, spinal cord injury, paraplegia - 21 years</td>
<td>34</td>
<td>Grad Student</td>
<td>No</td>
<td>Difficulty cooking in apartment because of the apartment size, and the fact that can’t reach the higher shelves</td>
<td>Yes, could not be hired at library because couldn’t reach top shelves.</td>
<td>Environment to be more accessible</td>
</tr>
<tr>
<td>T4 Spinal cord injury - 21 years</td>
<td>older</td>
<td>Head coach of men’s and women’s volleyball teams at U of I</td>
<td>Has trouble lifting things and things just generally take longer.</td>
<td>Bathing child and reach objects higher up.</td>
<td>Only naval officer training, obviously couldn’t complete the tasks.</td>
<td>None</td>
</tr>
<tr>
<td>T11/T12 complete paraplegic - 16 years</td>
<td>23</td>
<td>Office of Campus Life at U of I as grad assistant</td>
<td>carrying/moving heavy boxes or equipment, cannot pick up heavy objects from ground</td>
<td>Lifting heavy objects, especially from the ground.</td>
<td>No</td>
<td>None</td>
</tr>
<tr>
<td>T7 paraplegic - 7 1/2 years</td>
<td>24</td>
<td>Not employed</td>
<td>Worked at GAP and couldn’t reach the clothes on top shelf and couldn’t navigate the cramped stock room.</td>
<td>Not really</td>
<td>No</td>
<td>Market to change views on the disabled.</td>
</tr>
<tr>
<td>Spina bifida - lifetime</td>
<td>40</td>
<td>Alumni relations and development at U of I</td>
<td>None</td>
<td>None</td>
<td>No</td>
<td>Better aircraft lifts for the disabled.</td>
</tr>
<tr>
<td>Spinal Tumor - 19 years</td>
<td>20</td>
<td>Will be a personal trainer</td>
<td>None</td>
<td>Can’t reach high things.</td>
<td>No</td>
<td>Improve claw thing.</td>
</tr>
</tbody>
</table>

2.0.2 Customer Evaluated Needs

Figure 2.1: Customer Needs Based Off Interviews, Observations, and Research

<table>
<thead>
<tr>
<th>Needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>There is a need for a device to aid someone in lifting an object of reasonable size and shape.</td>
</tr>
<tr>
<td>There is a need for a device to aid people with only one hand to type as faster.</td>
</tr>
<tr>
<td>There is a need for a lift to raise the operator up and into farm equipment.</td>
</tr>
<tr>
<td>There is a need for a device to work the foot controls of equipment.</td>
</tr>
<tr>
<td>There is a need for mobility in the field (off-road).</td>
</tr>
<tr>
<td>There is a need for little people to access ATM’s, Bank and Hotel Counters, Elevator Buttons.</td>
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<tr>
<td>There is a need for an assistive device to help little people button and unbutton buttons.</td>
</tr>
<tr>
<td>There is a need for little people to access lawn equipment.</td>
</tr>
<tr>
<td>There is a need for an improved gripper/retriever device for little people’s hands.</td>
</tr>
<tr>
<td>There is a need for more affordable, customizable automobile petal lifts.</td>
</tr>
</tbody>
</table>

Figure 2.1 shows a list of different needs that are expressed as so by the disabled community. These suggestions were found by issuing surveys, watching videos, and by one on one interviews.

Good job collecting and evaluating the customer needs.
### 2.1 Weighting of Customer Needs

#### Figure 2.2: Customer Needs Weighting Table

<table>
<thead>
<tr>
<th>(Weighting)</th>
<th>Reaching High/Heavy Things</th>
<th>Lawn Mower Accessibility</th>
<th>Lifting Larger Objects</th>
<th>Getting into Small Equipment</th>
<th>Pedal Operation</th>
<th>Farm Mobility</th>
<th>Reaching Low Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>2</td>
<td>1.6</td>
<td>2.2</td>
<td>1.1</td>
<td>2.7</td>
<td>1.4</td>
<td>2.4</td>
</tr>
<tr>
<td>Knowledge</td>
<td>2</td>
<td>1.4</td>
<td>1.3</td>
<td>1.2</td>
<td>1.7</td>
<td>1.3</td>
<td>1.6</td>
</tr>
<tr>
<td>Need</td>
<td>3</td>
<td>1.4</td>
<td>2.3</td>
<td>1.2</td>
<td>1.7</td>
<td>1.9</td>
<td>1.8</td>
</tr>
<tr>
<td>Mfg.</td>
<td>1</td>
<td>1.6</td>
<td>2</td>
<td>1.3</td>
<td>2.4</td>
<td>1.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Interest</td>
<td>2</td>
<td>1.9</td>
<td>2</td>
<td>1.3</td>
<td>1.7</td>
<td>2.3</td>
<td>2.2</td>
</tr>
<tr>
<td>Totals</td>
<td>16</td>
<td>20</td>
<td>12</td>
<td>19</td>
<td>17</td>
<td>20</td>
<td>18</td>
</tr>
</tbody>
</table>

#### Figure 2.3: Customer Concepts Weighting Table

<table>
<thead>
<tr>
<th>(Weighting)</th>
<th>Lawn Mower Assist</th>
<th>Tractor Lift</th>
<th>Offroad Wheelchair</th>
<th>One-Hand Keyboard</th>
<th>Keyless Keyboard</th>
<th>Gripper Assist</th>
<th>Strap Lift</th>
<th>Little People Pull Cart</th>
<th>Cabinet Access</th>
<th>Standing Wheelchair</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>2</td>
<td>2.6</td>
<td>2.9</td>
<td>2.6</td>
<td>1.7</td>
<td>1.9</td>
<td>1.3</td>
<td>1</td>
<td>1.9</td>
<td>1.8</td>
</tr>
<tr>
<td>Scope</td>
<td>2</td>
<td>1.3</td>
<td>1.4</td>
<td>2.1</td>
<td>1.8</td>
<td>1.9</td>
<td>1.8</td>
<td>2.4</td>
<td>1.6</td>
<td>2.1</td>
</tr>
<tr>
<td>Knowledge</td>
<td>2</td>
<td>1.3</td>
<td>1.6</td>
<td>1.8</td>
<td>2.7</td>
<td>3</td>
<td>1.6</td>
<td>1.1</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>Need</td>
<td>3</td>
<td>1.4</td>
<td>1.4</td>
<td>2.6</td>
<td>1.7</td>
<td>2.1</td>
<td>1.8</td>
<td>1.8</td>
<td>1.6</td>
<td>2</td>
</tr>
<tr>
<td>Mfg.</td>
<td>1</td>
<td>1.8</td>
<td>1.9</td>
<td>1.9</td>
<td>2.6</td>
<td>2.7</td>
<td>1.6</td>
<td>1.1</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td>Interest</td>
<td>1</td>
<td>1.4</td>
<td>1.3</td>
<td>2</td>
<td>2.3</td>
<td>2.7</td>
<td>2.3</td>
<td>2.4</td>
<td>1.9</td>
<td>2.3</td>
</tr>
<tr>
<td>Totals</td>
<td>18</td>
<td>19</td>
<td>24</td>
<td>22</td>
<td>25</td>
<td>19</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>21</td>
</tr>
</tbody>
</table>
2.1.1 Analysis of Weighting Tables

We narrowed our search to one need area based on our analysis of weighting tables of customer needs and concepts. Figure 2.2 shows the results of our analysis of customer needs. The rating system is based off of low numbers being a good rating (1) and higher numbers mean the subject is question receives a poor rating (3). The weighting factors on the left are present to make the aspect stand out in accordance to it’s level of importance in our project. These numbers were chosen by the entire group. After each group member completed the decision matrix, the results were averaged and collected to give the present figure. As shown, the need which scored the best/lowest is the need for lifting larger objects.

When we evaluated the customer generated concepts the same way in Figure 2.3, the results were much closer together. The lawn mower assist, which would help a lower limb disabled person in and out of a riding lawn mower, little people pull cart, and standing wheelchair all scored very well. The problem with each of these arises when the customer base is considered. Each concept has plenty of customers, but not nearly as much as the strap lift assist would have. The strap lift assist could be a universal tool meant for the disabled with one arm, but it could also be used by people with two arms to help carry the load. Though the strap lift did not score as low in the interest area as the others, every person in the group had good ideas on how to design it. Not to mention it would be relatively cheap to manufacture, and it definitely goes along with the NISH needs statement. This gave us plenty of room to work and an area to let our minds soar to produce a product not like anything else on the market for able bodied persons with one arm loss.

Based on our analysis and discussion, we have decided to move forward with the general need of lifting large objects. This need area may pertain to people with upper limb loss, people with bad backs, little people, or the elderly.

3.0 Revised Needs Statement and Target Specifications

There is a need for device to aid someone in lifting and carrying an object of reasonable size and shape. This device must reduce barriers that prevent persons with disabilities from entering or advancing in the workplace. This device may assist a broad range of disabilities which include, but are not limited to, persons with upper limb loss, persons with bad backs, little people, and the elderly.

3.0.1 Target Specifications

The following customer requirements and target specifications were developed by discussion and recommendations with Daniel Bohner, who has been missing his left arm since birth. The requirements and specifications were also developed via testing in the lab and simulated lifting of heavy and large objects. Testing was completed with one arm tied behind the back to simulate an upper limb loss. Customer needs appear first (Table 1) followed by our target specifications (Table 2), and last metrics are presented (Table 3).
Table 1: Customer Needs

<table>
<thead>
<tr>
<th>#</th>
<th>Need</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The device provides a mean for ergonomic lifting</td>
</tr>
<tr>
<td>2</td>
<td>The device is lightweight</td>
</tr>
<tr>
<td>3</td>
<td>The device is inexpensive</td>
</tr>
<tr>
<td>4</td>
<td>The device accommodates various body sizes</td>
</tr>
<tr>
<td>5</td>
<td>The device supports heavy objects</td>
</tr>
<tr>
<td>6</td>
<td>The device is comfortable for prolonged use</td>
</tr>
<tr>
<td>7</td>
<td>The device accommodates various object sizes</td>
</tr>
<tr>
<td>8</td>
<td>The device transports objects long distances</td>
</tr>
<tr>
<td>9</td>
<td>The device is easy to get in and out of</td>
</tr>
<tr>
<td>10</td>
<td>The device is durable</td>
</tr>
</tbody>
</table>

Table 1 is a list of needs specified by potential customers.

Table 2: Target Specifications

<table>
<thead>
<tr>
<th>Metric #</th>
<th>Need #'s</th>
<th>Metric</th>
<th>Units</th>
<th>Value</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1, 5</td>
<td>OSHA requirements</td>
<td>Y/N</td>
<td>Y</td>
<td>Spec</td>
</tr>
<tr>
<td>2</td>
<td>2, 6</td>
<td>Total weight</td>
<td>lbs</td>
<td>&lt;10</td>
<td>Criteria</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>Material and manufacturing cost</td>
<td>US $</td>
<td>&lt;70</td>
<td>Spec</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>User age</td>
<td>years</td>
<td>&gt;15</td>
<td>Criteria</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>Payload capacity</td>
<td>lbs</td>
<td>&gt;50</td>
<td>Spec</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>Continuous use</td>
<td>hours</td>
<td>&gt;8</td>
<td>Spec</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>Payload size</td>
<td>cubic ft</td>
<td>&gt;8</td>
<td>Spec</td>
</tr>
<tr>
<td>8</td>
<td>6, 8</td>
<td>Payload carrying distance</td>
<td>ft</td>
<td>&gt;50</td>
<td>Criteria</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>Time to get into device</td>
<td>sec</td>
<td>&lt;60</td>
<td>Criteria</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>Lifetime</td>
<td>years</td>
<td>&gt;5</td>
<td>Spec</td>
</tr>
</tbody>
</table>

Table 2 is a list of metrics linked to the specific customer needs. Each metric is given a unit to quantify it. Also, the actual target specifications specified by us with their type are listed. A spec is a must have value and a criteria is something that would be nice to have, but not a must. These specifications were calculated through feasibility tests and research on the topic.
Table 3: Metrics Linked to Needs

<table>
<thead>
<tr>
<th>Need</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>provides a mean for ergonomic lifting</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>is lightweight</td>
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<tr>
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<td>is easy to get in and out of</td>
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</tbody>
</table>

Table 3 shows visually which needs each metric is linked to.

These requirements and specifications are deemed sufficient but are subject to change as team ME Too progresses forward with our project.
4.0 External Search

Organized below is a summary of our external search. This section includes information gathered from numerous sources about the design problem and process. Sources include library, internet, patents, and observations of actual products. An extensive patent search was conducted to help determine what current technology current products are using. The main focus of the patent search was on the utility patents, not the cosmetic patents.

4.1 Benchmarking

Benchmarking was done both before and after we narrowed our search to one need area. Findings from before and after are shown below.

4.1.1 Initial Needs Statement Benchmarking

In our external research we’ve come across some currently manufactured products that access the needs of some of our initial needs and design ideas. The products address farming/agricultural lifts, one handed keyboards, keyless keyboards, lawn mower assistance, strap lifts, standing wheelchairs, and a pull cart/step stool. Some of the initial findings are shown below. Descriptions are kept to a minimum because they are no longer applicable to our revised needs statement. Website links to the products and images that appear in this section of the report are placed near the images.

The devices that appear below are Keyboards give ideas for opportunity in helping persons with hand / arm loss or very limited hand function gain the ability to type on a computer in an office setting. The first image in figure 4.1-#1 of devices shown above are typical layouts for one handed keyboards for left or right handed persons that are ergonomically designed to promote fast typing. The second image in figure 4.1-#2 is geared toward persons with limited hand / finger mobility.

Figure 4.1-#1 – Single Handed Keyboards
http://www.enablemart.com/Catalog/One-Handed-Keyboards/Maltron-One-Handed-Keyboard
Figure 4.1-#2 – Touch Spin Keyboard
http://www.enablemart.com/Catalog/Alternative-Keyboards/orbiTouch-Keyless-Keyboard

Figure 4.1-#3 – Coach Tractor Lift
http://www.coachlift.com/farm-equipment-lifts.htm
4.1.2 Revised Needs Statement Benchmarking

Our revised and most recently updated need statement is roughly as follows: In the area of assisted lift devices we will focus on building a system for a person with one arm or an arm deformity with only one working arm / hand to lift objects by themselves. This system as defined thus far will be composed of a vest with a strap. Included within this section are various products currently available in the area of assisted lift devices. Included with each http://shannahanergotech.com/lift_assists.htm

The first four figures below Shannahan Ergonomics and Technology below depict pneumatic and vacuum assisted lifting devices. These devices provide ideas of what is currently available within industry but are not very feasible for our project in terms of portability, and personal use. While the Vacuum lifts can handle up to 4000lbs per manufacturers specs this is outside the scope of our project. Figure four gives good ideas for clamping and lifting cylindrical objects which may be incorporated into our design features.

Figure 4.1.2 - #1 – Pneumatic Lift #1

Figure 4.1.2 - #2 – Vacuum Lift #1 - JumboSprint

Figure 4.1.2 - #3 – Vacuum Lift #2 - JumboErgo
Figures #5 and 6 below depict two Globalindustrial.com wheeled hand trucks with modifications that may make it easier for a person with only one working arm to operate. These items do not allow the object to be lifted off the ground easily, or provide adequate ways of placing items onto the carts.
Figure #7 depicts a person wearing a webdevices.com construction harness. This manufacturer also produces lanyards, hooks, straps and other devices that can be sourced to build our vest/strap apparatus. We also may be interested in modifying existing construction harnesses to aid in lifting of objects.

**Figure 4.1.2 - #7 – Construction Harness**

Figure #8 below shows Lifting Straps from bodybuilding.com where hooks are used to grasp around an object for lifting of weights. This is one adaptation for the usable arm of the individual to be able to grip around an object or hook it in on one side and have additional lifting devices on the other side of the body. This type of hook allows great amounts of weight to be hung from the hand with little grip effort. Cheap at about $15.

**Figure 4.1.2 - #7 – RD Millenium Hooker II Lifting Straps**

Figures 8 and 9 show the Handi-Straps ergonomic lifting harness and the grip attachments that can be used along with the harness. This device is used by police, fire fighting and rescue personnel to carry stretchers and items in the field. Additionally this device can be used to make the lifting of heavy object much easier. This is currently the closest product available to our desired concepts, it costs $75 for the harness and the grip attachments and seems very adjustable, comfortable and versatile as we desire our product to be.
Crane lifting straps bear some resemblance of what will be necessary for our vest / strap lifting device. Therefore included below in figure #10 is a yellow string lifting strap from yellowslings.com. This type of lifting strap will be used in order to lift objects safely, prevent ripping and tearing and clamp onto other straps or the vest in some way.
4.2 Applicable Patents

Summarized below are a few applicable patents we found when researching our revised needs statement. A description of each patent is provided as well as an evaluation.

4.2.1 Harness For Lifting Heavy Objects

With the need area being lifting devices, U.S. Patent #4280645 “Harness for lifting heavy objects” was chosen because of its similarity to one of the general product types that have emerged as possible solutions within this need area. This particular device allows the lifting of much larger, heavier objects than otherwise possible. Pictures of the design of this device show that the weight is distributed across the shoulders allowing the individual using it to lift the item under power of their legs in the vertical direction. Stabilizing the object may be difficult with this apparatus and some major modifications would be necessary to allow a person with only one arm or limited use thereof to lift large objects. Some ideas for development of this apparatus include, additional straps, strap attachments higher up on the arm so the forearm down can be used easier, metal plates and conforming strap/rods to wrap around and tighten down upon the object to be lifted. Patent Drawing Appears Below:
4.2.2 Lanyard operated sternum breakaway buckle with vertical position adjustment

**Patent number:** 7107657  
**Filing date:** Oct 21, 2002  
**Issue date:** Sep 19, 2006  
**Inventor:** Frank A. Howell  
**Primary Examiner:** Victor Sakran  
**Attorney:** Samuels, Gauthier & Stevens

This patent is applicable to our Senior Design Product because the sternum buckle could be used in some way to attach a strap type lifting device to the upper body. This system would allow for ample adjustments between body size and figure. It would also act as a breakaway buckle for safety purpose (i.e. the load becomes unstable, unsafe, or the strap system must be released in an emergency situation).

This would also be applicable to a strap lift system in ways other than strapping across the sternum. It could be used as a breakaway strap on the lifting strap to release the loads in an emergency situation. Besides an emergency situation it could be used to attach and detach when the load is either being picked up or sat down. This buckle could prove to be useful in many ways for a strap lift system.

4.2.3 Backpack With Lumbar Support

Plate Patent #7028873

This patent shows a good example of a lumbar support mechanism that could possibly be implemented in an assistive lifting apparatus to help prevent lower back strain or injury. The lumbar support plate in this patent is adjustable, giving more or less support when needed. The adjustable mechanism can be operated with the use of one hand. The lumbar support also provides an anchor point for any shoulder straps or harnesses.
4.2.4 Device and Method For Wireless Lifting Assist Devices

This patented device assists a person in vertically lifting objects of unspecified weight. It is essentially a winch attached to the ceiling. A glove worn by the operator controls the motor by sensing the force applied by hand to the object that is to be lifted. The desired result is that the object feels lighter and the operator retains manual control of the objects position (limited in the horizontal plane).

The concept of this patent can be adapted for use by disabled persons whose lifting demands are not necessarily significant. It could be made to be portable and have a pulley that is easily positioned in space. A more simple strategy to control the assist would likely be employed. The method for which the cable is attached to the object would need to accommodate a wide array of sizes, shapes, and weights.

http://www.google.com/patents?id=TvkMAAAAEBAJ&dq=lifting+assist
4.2.5 Ergonomic Lift and Transport Harness

Patent Number: US 6,257,633 B1
Patent Date: Jul. 10, 2001
Inventor: David L. Katz

Background

This invention is designed to ergonomically help a person lift heavy objects. It is specifically designed to force the load onto the chest, shoulder, and arm muscles of the user, as opposed to the knees and lower back. The arched shoulder pieces are padded to add comfort for the user, and the entire device is made of a hard plastic or light metal so that it is not too heavy for the user. The lifting device can be folded up at various hinged joints to allow it to be transported easily or stored in a smaller space.

To allow the load to be lifted with the person’s upper body, moveable handles are attached to the front of the harness. The user pushes down on the handles to pivot the harness on their shoulders and allow the load to be picked up. The handles can be adjusted once the load is lifted to make it as comfortable for the user as possible. In Figure 1, the device is shown with a hook (38) for lifting, but other accessories, such as a mechanical grip, may be attached instead of (38) to aid in other lifting applications.
Evaluation

This invention applies to our need area in the fact that it facilitates the lifting of heavy objects with the upper body, but with minimal use of the hands/arms. There are several key things about this invention that should be applied to the design of our device:

1.) The device is *ergonomically designed* to prevent lower back and lower limb injuries. The design of our teams lifting device definitely needs to take ergonomics very seriously to prevent user discomfort and/or injuries; ergonomics will become even more important for our group because our customers will have some kind of disability. The above invention also has padding where the heaviest parts of the load will push against the body.

2.) The device was designed so that it was *lightweight*. Whether our lift device is a solid material, such as the plastic or light metal suggested in this patent, or some kind of harness, it must be lightweight to accommodate to the user and allow them to lift the maximum loads possible.

3.) The device is *collapsible* and can be easily stored or carried. Reducing bulkiness and facilitating easy transport, while still maintaining the functional requirements of a product, is an important key to consider during our conceptual design process.

While the invention is rather simple and handy, there are some areas of concern and areas of possible improvement:

1.) The invention is *made entirely of rigid materials* to aid in the lifting process, but a rigid base material will not be as comfortable as a more flexible material. Accessories that are actually attached to the load (like the hook in Figure 1.) could be made of something that could be formed to the individual object being lifted. This could be advantageous when trying to lift or move odd shaped loads.

2.) *It is unknown what the recommended load limits are* for this lifting device, and how comfortable lifting such heavy loads are for the user.

3.) Lifting things from the user’s backside is most likely based on ergonomics, but it is probably *not the most convenient or easiest way to lift objects*, especially when many things need to be moved. If our group could design a front loading device it would save the user time and make our product more convenient to use.
4.3 Applicable Standards

All info for this section was retrieved from the osha.org website under occupational lifting guidelines. Summary of proper lifting was originally for teens in the workplace but the same guidelines can be applied for every worker lifting objects.

Do:
- Keep your head up and back straight and bend at your hips.
- Bring the load as close to you as possible before lifting.
- Lift with your legs, not your back.
- Shift your feet to turn.
- Keep the load directly in front of your body.
- Try to perform lifts at waist height with your elbows in close to your body.
- Limit lifting by hand. Use mechanical lifts or get help.
- Stay fit to avoid injury.

Don’t:
- Lift heavy loads (35 lbs or more) get help.
- Reach across something to lift a load.
- Lift bulky or uneven loads.
- Reach to the side or lift while twisting.

Research that has been done by OSHA suggests that some of the reasons for the onset of back pain and injury arise from the following.

- Reaching while lifting.
- Poor posture—how one sits or stands.
- Stressful living and working activities—staying in one position for too long.
- Bad body mechanics—how one lifts, pushes, pulls, or carries objects.
- Poor physical condition—losing the strength and endurance to perform physical tasks without strain.
- Poor design of job or work station.
- Repetitive lifting of awkward items, equipment, or (in health-care facilities) patients.
- Twisting while lifting.
- Bending while lifting.
- Maintaining bent postures.
- Heavy lifting.
- Fatigue.
- Poor footing such as slippery floors, or constrained posture.
- Lifting with forceful movement.
- Vibration, such as with lift truck drivers, delivery drivers, etc.
4.4 Applicable Constraints

There are very few internal constraints on this need area. Space and budget are not an issue due to the small size and minimal material used in the proposed concepts. A small conflict of limited expertise could arise in the area of sewing; all proposed concepts use fabric and will most likely involve sewing. Also, health and safety become a concern when external constraints are looked at. OSHA has a lot of data in regards to the strain upon and injuries to the lower back.

Our need area involves lifting objects so strain to the lower back is a big issue. Our designs will have to follow OSHA regulations in regards to the lower back. This could limit our concept ideas and call for drastic changes in designs. Also, the safety of a user must be considered in regards to the load falling. Our designs must take into account how secure the load will be when lifted. These constraints will most likely call for design changes and additions to the concepts. This could take more time and cost more than expected.

4.5 Business Opportunity

Our primary objective is to provide persons with one working arm/hand with a device composed of a vest with a strap that will aid in lifting objects. This device will allow these persons to lift objects in the workplace which they previously were unable to do. As shown in section 4.1.2 above for our revised need statement benchmarking, there are no known products in existence that fit this exact need. While products exist in construction, safety harnesses, and rescue lifting harnesses, none of these are tailored to persons with one working arm. We believe that we will be filling a niche market and providing our product to enable as many persons as possible at a low cost (less than $100) as defined in our current customer requirements and specifications.

As stated above, the primary customers for this device are individuals with one working arm/hand who desire to lift objects such as boxes with less effort and greater personal/physical safety. Secondary customers include companies where persons with arm deformities are currently working that seek to help their employees be able to perform simple lifting tasks that were previously not possible given their condition. Some secondary customer ideas include shipping and receiving companies where lifting and moving objects is necessary such as UPS, FedEx, DHL, or other company’s warehouses, storehouses. Additionally the construction industry could benefit because possible adaptations to construction harnesses for lifting items. Next, persons with back problems and any other industry where people may possibly have the need to lift items that were previously not feasible for them are possible customers. Finally, any company, industry or person desiring to increase personal lifting power, stability, safety and time efficiency are potential customers.
5.0 Concept Generation

OK, but some more text discussing the concepts would be helpful.

Below are selected concepts of interest. The following concepts could all be used as an assisted lifting device.
Torso belt to displace weight to hips (similar to squat belt)

Straps attach to torso belt

Quick Release Buckles

Back Strap

Forks to hold weight

Same as other side if needed

Shoes to go around object

Dane Turk
5.1 Problem Clarification

The need to lift objects requires few energy transfers. The static energy of the resting object must be transferred into the kinetic energy of the lifting motion by means of the user. Whatever the device ends up being it must be able to be operated by the physical ability of the person using it. Our needs statement states that our targeted audience is a person with only one functional arm/hand. The energy used to operate the device will have to be provided by the functional hand or by means of the shoulder or some other form of motion.

Another aspect to the lifting problem is the problem of carrying the object once it is lifted. Very rarely is the object being lifted in the general proximity of the end destination. To cope with this, the device must also allow the user, with the defined limitations, carry the object to its final destination, without causing the user physical pain or the possibility of prolonged damage to the body.

5.2 Concept Generation

A variety of concept generating techniques were summarized and presented to the group for consideration. In the end, the use of sketches and brainstorming, in particular, 6-3-5 brainstorming was used to generate most of the concepts. 6-3-5 brainstorming is a process where 6 group members take approximately 5 minutes to generate 3 concepts, and then the papers are passed around the circle and the process repeated with modifications or upgrades to the original concepts. The group used this philosophy with somewhat of a modification; we had 7 members start drawing just one concept for about 5 minutes and then passed them on to the next person. The concepts could be sketches, words, or a combination of both. There was no talking allowed during the brainstorming session, which led to greater diversity since every one interpreted the previous ideas a little bit differently. After the papers were passed around for four iterations, there were 7 solid concepts which had multiple modifications and extras which improved upon the original concept.

The final drawings were all put together and with each concept, the original illustrators describe the idea and function of his concept. After the original illustrator was finished describing the concept, each person who added or changed something on the concept described the purpose of the change and what new it brought to the concept.

As the discussion progressed, certain repeated ideas were made note of. Some of the ideas were voted out for lack of feasibility or benefit to the customer. The best ideas within the separate remaining concepts were then combined into the final concept.

5.3 Initial Screening for Feasibility and Effectiveness

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<tr>
<th>Rating system</th>
<th>1- good</th>
<th>2- average</th>
<th>3- poor</th>
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<tr>
<td><strong>6-3-5 Method Drawings 1-8 as follows</strong></td>
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<tr>
<td>Rating</td>
<td>3</td>
<td>6</td>
<td>4</td>
</tr>
</tbody>
</table>
I suggest putting these drugs in the Appendix, only including those that were selected or combined into the final concept.

- Drawing 1 -

Vest

- pinned to hooks
- don't dig into body
- metal rings
- can use eyebolt type attachments as well

Strap

- green so ring sits in and ties so it is secured

attach hooks to rings.

Different straps

- adjustable length
- take loop in adjustable length
- metal ring
-Drawing 2-

Side

Lift Arm

Steering Assist Needed For One ARM

Have front piece flip down w/ a fold down for storage

foot Switch so box can be picked up w/ one arm and then won't have to move cart.

Top

Have it fold in half and handle
-Drawing 3 -

- Operating button to fasten/close shelves
- Make changeable for use on other side (same with hook attachment)
- Adjustable strap?
- Why not make one piece? Easier to get on?
- Attatch loop strap to hoop around object and attach here
- Shelves retractable, able to move upward and downward
- Make belt wider for better back support
- Small shelves to rest objects on
-Drawing 4 -

Attach scissors at waist and have hook/other piece to assist on side w/ no limb.

Make attack up here

add some way to adjust lengthwise of tifiers

Soft rubber end pieces to aid in picking up fragile things.
LIGHT WEIGHT PORTABLE HOIST

Need to develop way to wind

Folded to size of load frame

Assisted winch always pulls in slack

(ADJUSTABLE TENSION IN CABLE)

Folding legs

Hoist: retracts cable when button is pushed. Already exists in most machining plants or loading docks.
Harness system

Buckles for attachments

Attachments that will tighten on their own

Attachment w/ single loop

Length should be adjustable

Have buckles cross for better leverage on side w/ no limb.

Back brace support
Put on opposite side where it can be used as a second hook.

Metal bracing to distribute load throughout vest.

Adjustable to keep tight around operator.

Fits around one end of box or corner of box.

Cancel make this a fully system so that things can be lifted with stops.

Make straps adjustable or have multiple straps w/different lengths.
-Drawing 8-

Drawing of a person carrying a bag, with labels for a "Smoking Bad," "Boo0000," "Strap," and "Front." Additional notes include "Lockable Winch for Length," "Release for Strap," "Hook in back," and "Catches to rest box on?" There are also notes on adding a strap to the bitter, with suggestions for making it longer or adding a webbing, and considerations for spring-loaded hooks and support.
6. Concept Selection

6.1 Data and Calculations for Feasibility and Effectiveness Analysis

To research feasibility and effectiveness several steps were taken. “Lifting guidelines provided by the Occupational Safety and Health Administration (OSHA) suggests that a weight over fifty pounds should require a second person” (OSHA). Objects should be carried between mid-thigh and mid-chest, which is sometimes referred as the “Power Zone” (OSHA). The guidelines are based off of techniques for able bodied persons. Here is a list of Manual Handling Tasks provided by OSHA.

- Material handling tasks should be designed to minimize the weight, range of motion, and frequency of the activity.
- Work methods and stations should be designed to minimize the distance between the person and the object being handled.
- Platforms and conveyors should be built at about waist height to minimize awkward postures. Conveyors or carts should be used for horizontal motion whenever possible. Reduce the size or weight of the object(s) lifted.
- High-strength push-pull requirements are undesirable, but pushing is better than pulling. Material handling equipment should be easy to move, with handles that can be easily grasped in an upright posture.
- Workbench or workstation configurations can force people to bend over. Corrections should emphasize adjustments necessary for the employee to remain in a relaxed upright stance or fully supported seated posture. Bending the upper body and spine to reach into a bin or container is highly undesirable. The bins should be elevated, tilted or equipped with collapsible sides to improve access.
- Repetitive or sustained twisting, stretching, or leaning to one side are undesirable. Corrections could include repositioning bins and moving employees closer to parts and conveyors.
- Store heavy objects at waist level.
- Provide lift-assist devices, and lift tables.

The following equation was provided by the National Institute for Occupational Safety and Health (NIOSH). The NIOSH came up with an equation to evaluate the recommended weight limit (RWL) for a given lifting task. The NIOSH equation for RWL is the following:

\[ \text{RWL} = LC \times HM \times VM \times DM \times AM \times FM \times CM \]  

(1)

The multipliers for equation (1) are shown below in Figure 6.1. The frequency and coupling multipliers can be determined by using the tables provided in the Appendix A.3 of this report.
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<thead>
<tr>
<th>Variables</th>
<th>Metric</th>
<th>English</th>
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</thead>
<tbody>
<tr>
<td>Load Constant</td>
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</tr>
<tr>
<td>Horizontal Multiplier</td>
<td>HM</td>
<td>(25/H)</td>
</tr>
<tr>
<td>Vertical Multiplier</td>
<td>VM</td>
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</tr>
<tr>
<td>Distance Multiplier</td>
<td>DM</td>
<td>.82 + (4.5/D)</td>
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<tr>
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<td>AM</td>
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</tr>
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<td>FM</td>
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</tr>
<tr>
<td>Coupling Multiplier</td>
<td>CM</td>
<td>Appendix B.1</td>
</tr>
</tbody>
</table>

**Figure 6.1: Equations and Constants for Recommended Weight Limit Equation**

The NIOSH lifting model assumes the following conditions, which were provided by OSHA:

- Lifting task is two-handed, smooth, in front of the body, hands are at the same height or level, moderate-width loads (i.e., they do not substantially exceed the body width of the lifter), and the load is evenly distributed between both hands.

- Manual handling activities other than lifting are minimal and do not require significant energy expenditure, especially when repetitive lifting tasks are performed (i.e., holding, pushing, pulling, carrying, walking or climbing).

- Temperatures (66-79°F) or humidity (35-50%) outside of the ranges may increase the risk of injury.

- One-handed lifts, lifting while seated or kneeling, lifting in a constrained or restricted work space, lifting unstable loads, wheelbarrows and shovels are not tasks designed to be covered by the lifting equation.

- The shoe sole to floor surface coupling should provide for firm footing.

- Lifting and lowering assumes the same level of risk for low back injuries.

- Using the Guidelines in situations that do not conform to these ideal assumptions will typically underestimate the hazard of the lifting task under investigation.

- This calculation will become important to further research when refining the product in later stages. For now, simple assumptions are made in defining a specific task: To enable a person of average height and strength the ability to lift an 8 ft³ (2 ft x 2 ft x 2 ft), 50 lb object from the floor with one arm. From there, the person should be able to place the object at a position that is at least waist high.

These assumptions can be used to explore the feasibility of a vest with a strap as a lifting assist. It is not necessary to define “waist height” due to the relative position of the vest to the waist. The strength of the fabrics used and the force applied to the person using the vest are examined in the following.
First, the assumption that the material of the vest or strap will never be subjected to loads greater than the weight of the object to be lifted. It is geometrically impossible to support a load at any point and have the reactionary force greater than that of the load. A quick glance of available materials reveals that our assumed weight of 50 lbs is well within the strength limits of straps and cloths that would cost much less than the $100 target price limit of the product. It is also likely that vest would be reinforced by metal as appropriate.

Second, it can also be assumed that the person would never be subjected to a force greater than the load by the same logic. This leaves the maximum moment of resistance placed on the back about the hip.

Assuming that the object’s weight is evenly distributed and its force is directed vertically, the maximum moment, \( M = r \times F \), would equal half of the maximum radius multiplied by the maximum weight. Taking a box of 2ft x 2ft x 2ft, it longest horizontal radius would be from corner to corner of a horizontal surface of 2ft by 2ft.

\[
r_{\text{max}} = \sqrt{(2\text{ft})^2 + (2\text{ft})^2} = 2.828 \text{ ft}
\]

\[
\frac{1}{2} r_{\text{max}} = 1.414 \text{ ft}
\]

Multiplying the maximum load of 50lbs and the assumed radius 1.414ft gives a moment of 70.7 ft·lbs. This is of course considering that all vertical resistance is applied through the strap from the shoulder. More research is necessary to determine if this is an acceptable value, although rough preliminary trials suggest that it should be.

6.2 Concept Screening

Concepts were generated using the 6-3-5 method with prior discussion. Concepts were generated and improved by everyone in the group. Each concept was screened based on feasibility and effectiveness. Our final concept is a combination of many sub-system level concepts. Each sub-system level concept was evaluated and combined into a final system level concept set for development.

Team ME Too understands that goal of this process is not to select the best concept but to develop the best concept. Below are several factors that helped us to develop the best system level and sub-system level concepts with respect to the customer.

Feasibility and Effectiveness of Final Concept:

The best sub-system level concepts were as follows:

1. Vest Concept
   - Easy to make, can also be purchased for less than $20-$30 from our research
   - Vest will most likely be side-entry.
This will enable the user to place the vest over his head from the side and enable a one clip fasten after initial adjustment on the 1st wear. Fasteners are still under investigation but most likely and plastic clip in fastener will be used with more Nylon webbing at $0.38/ft.

- Vest will enable user to move comfortably as if he was not wearing a vest at all.
- Vest may require sewing training if we decide to make it. Otherwise very little training will be required to manufacture/purchase/operate.
- Vest will not be time consuming to put on.
- One size fits all adjustable vest can be worn by old/young/large/small people.
- Vest will fit over any regular or work clothing.

2. Strap Lift Concept
   - 1” Nylon strap or webbing may be purchased for $0.38/ft
     - We would need about 4 ft or $1.52 per strap
   - Strap must have metal ring at the end.
   - Very little training will be required to operate.
     - Can be purchased at a hardware store for less than $1.
   - Nylon will be easily operated and slid under box based on our testing.
   - Strap will not be time consuming to place under the object based on testing.
   - Strap may help user lift boxes on to a dolly for mass transport.
     - This would provide compatibility with existing solutions.

3. Retractable Cord
   - Sturdy, lightweight retractable dog leashes can be purchased easily for less than $10, based on our research.
     - It may be necessary to take the leash apart and only use the retracting mechanism and manufacture a new outer casing to attach to the vest. More work will be done with this over winter break.
   - Very little training will be required to manufacture/purchase/operate.
   - Retractable cord will not be time consuming to operate based on experience.
   - Locking mechanism may be adjusted to allow for “chin-locking.”
     - This enables hands-free lock-ability of the length of the strap or cord.

4. Metal Supports
   - Supports may be manufactured with aluminum or stainless steel. They will be only a few inches wide and long, and cost will not be an issue with them.
   - No training required to manufacture/operate.
   - Resources/Materials are readily available for manufacturing.
   - Supports would provide a resting place for the object for long distance carrying.

Combined, these four sub-system level concepts will provide an effective solution to the problem. Our final concept will sufficiently fulfill all of our customer requirements and target specifications. If implemented well, this product will enable persons with upper limb loss to lift heavy or large objects in the workplace just as a non-disabled person would.
6.3 Concept Development, Scoring and Selection

The team members had many concepts that needed to be discussed and developed. The first development process involved sharing each individual’s concepts/ideas with the rest of the team. The concept selection process used was the 6-3-5 Brainstorming Method. Each team member had the chance to draw their idea on a piece of paper, and then the papers were rotated to the next teammate where they added additional modifications to each drawing. The brainstorming activity ended when everyone had the chance to modify each drawing. All of the drawings were placed on the whiteboard for everyone to see. Each teammate took a moment to review them individually. Next, the originator of their drawing explained their idea in detail to the group using their drawing as a reference. Then those that improved or modified it explained their addition and why. After all of the drawings were reviewed the group soon realized that many of the ideas were relatively the same and could be combined into one concept. From here, the concepts were narrowed down to three main concepts, a vest with lifting strap, a portable crane, and a dolly lifting device. The group discussed the differences and benefits of the three concepts to determine which would be most feasible and accomplishable. At this point, the group voted to select the concept that would be used. The group unanimously decided on a final concept consisting of a vest with lifting straps and a back support.

The concept of a vest with a strap is as simple as it sounds. The biggest obstacle for a one armed individual to do is to pick up objects from the group. The obvious problem is not having their other limb to assist in lifting an object like able-bodied persons. To compensate for this, a strap can be used to lift and support an object opposite the good arm. The strap could have a number of different attachments that could hook directly to the vest including a metal loop or swivel hook. The individual would use their arm to place the strap around one corner or side of an object. Once the strap is in place, the individual would then latch the strap to the vest and grab the other side of the object and simply stand up. The strap actually supports most of the weight making the strain on the arm significantly less. However, lifting an object that is out in front of the person puts strain on the shoulders and lower back.

The strap would be attached to a vest that the individual would be wearing. The vest could be a full vest of solid material, or could simply be straps such as a climbing harness. The lifting strap would be attached to the vest in a position that puts the least amount of strain on the individuals back when lifting. Also, the back of the vest could have a rigid back support for additional support. This support could be in the form of a thick belt around the waist similar to a weight lifting belt or a plastic piece that takes the shape of the lumbar. The vest must be easy for the individual to change into and out of. This would most likely be determined by where the strap attachment point would be and how the strap would be attached to the vest. For example, if the vest is zippered, the placement of the zipper would have a big impact on the ease of use. The vest could also be buttoned up or even use Velcro.
Appendix A: Interviewing Guidelines

A.1 Template for Customer Needs Assessment Based on Interviews

Lower Limb (example):

General Statistics:
- XX% of Americans have lower limb disabilities
  - Severe
  - Not Severe
- Number of lower limb disabled people that are employed
- Etc. (Any statistics that cover your general area)

Specific Need Statements:
1) There is a need for people with a lower limb disability to climb into their farm equipment

  Reasons for the Need:
  - Because... (Comment and quotes from interviewee on personal experience)

  Specific Statistics:
  - XX% of Americans with lower limb disabilities have trouble climbing steps
  - XX% of American farmers have lower limb disabilities

  Requirements:
  - Has to go from seated position up 5 feet into the piece of equipment
  - Has to lift a minimum of 300 lbs
  - Etc. (Need Many More Requirements!)

  Customer Ideas/Concepts:
  - A type of lift for a tractor
  - A swivel seat in the tractor
  - Etc. (Any Ideas the Interviewee has)

2) There is a need for people in wheelchairs to reach elevated places (standing up)

  - Reasons for the Need:
  - Specific Statistics:
  - Requirements:
  - Customer Ideas/Concepts:

3) Etc.
A.2 Survey Sent to Rehabilitation Specialist Working at the University of Illinois

1. What is your disability? How long have you been disabled?

2. How old are you?

3. Are you currently employed? If so, what do you do? If not, what would you like to do?

4. Are there any tasks at work that you have trouble completing because of your disability?

5. Have you ever been discouraged or excluded from a job because of an inability to complete the required task/s? Please explain.

6. Is there anyway that some sort of device could help you be more employable or join the workforce? If so what would it be?

7. Is there any basic task that you have trouble doing in your day to day tasks (not work related)?

Thank you for your time
Appendix B: Relevant tables

B.1

Figure B.1.1

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<th>Frequency Multiplier Figure</th>
<th>( \text{F} )</th>
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<th>&gt; 1 but &lt; 2 Hours</th>
<th>&gt; 2 but &lt; 8 Hours</th>
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† Values of \( \text{V} \) are in inches.

‡ For lifting less frequently than once per 5 minutes, set \( \text{F} = 2 \) lifts/minute.
**Figure B.1.2**

<table>
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<tr>
<td></td>
<td>V &gt; or = to 30&quot; then CM = 1.00</td>
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1. For containers of optimal design, such as some boxes, crates, etc., a "Good" hand-to-object coupling would be defined as handles or hand-hold cut-outs of optimal design.

2. For loose parts or irregular objects, which are not usually containerized, such as castings, stock, supply materials, etc., a "Good" hand-to-object coupling would be defined as a comfortable grip in which the hand can be easily wrapped around the object.

1. For containers of optimal design, a "Fair" hand-to-object coupling would be defined as handles or hand-hold cut-outs of less than optimal design.

2. For containers of optimal design with no handles or hand-hold cut-outs or for loose parts or irregular objects, a "Fair" hand-to-object coupling is defined as a grip in which the hand can be flexed about 90 degrees.

1. Containers of less than optimal design or loose parts or irregular objects that are bulky or hard to handle.

2. Lifting non-rigid bags (i.e., bags that sag in the middle).

**Coupling Multiplier Figure**
Appendix C: Relevant Sources

Below is a list of references not fully referenced in the report.

Below is a table which shows what the team members will be doing over break to continue research and work on our project.

<table>
<thead>
<tr>
<th>Name</th>
<th>Task</th>
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<tbody>
<tr>
<td>Chris</td>
<td>Continue to talk to customer and observe him in his work and home environments</td>
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<tr>
<td>Darin</td>
<td>Investigate the material type and cost of straps used in similar applications</td>
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<tr>
<td>Jared</td>
<td>Look for old vests we can use to start testing and prototyping and investigate different styles of vests/harnesses</td>
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<tr>
<td>Kirk</td>
<td>Take apart retractable dog leashes and other similar devices to see how the inner workings can be used on our project</td>
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<tr>
<td>Joe</td>
<td>Investigate other similar technologies for the retractable strap.</td>
</tr>
<tr>
<td>Mike</td>
<td>Investigate buckles and latches which may be used to make the strap length adjustable</td>
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<tr>
<td>Dane</td>
<td>Will look into expanding the customer base</td>
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<tr>
<td>Dave</td>
<td>Will look for old vests and research vest styles along with Jared</td>
</tr>
<tr>
<td>Dan</td>
<td>Research lumbar/back support for the vest</td>
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