Design Objective:

The Versatile Painting Solution is designed to provide painting assistance for a client with Cerebral Palsy. Painting is an art form that requires very fine motor skills in order for artistic control and expression. If the motor skills of the artist are too unrefined, then his artistic expression is limited. Fortunately, the average paintbrush can be replaced with a new brush that enhances painting ability by minimizing the necessary movements.

An average brush requires a palate of paint in which to be dabbed in, as well as finely controlled grip in order to apply the paint. This simple system does not is not optimal for an artist with Cerebral Palsy. The acts of dabbing a brush in a palate and applying brush strokes with a thin wooden brush require a disproportional amount of time and effort for the artistic benefit. By optimizing a more effective painting system, our client can paint more quickly and easily.

The Versatile Painting Solution consists of a motorized paint brush which contains and dispenses paint. It is lightweight and is held by the wrist using an attachment. The paint colors and brush sizes are interchangeable so that different size brushes can be used to increase painting precision. The Versatile Painting Solution Brush makes the following improvements over standard painting and has been optimized in respect to the following areas:

- Attaches to the wrist (no gripping necessary)
- Capable of paint flow against gravity
- Multiple paint colors can be used
- Bristle sizes can be changed to enhance painting precision
- Lightweight
- Minimal Noise
- Stores and saves unused paint
- User controlled paint flow

The Versatile Painting Solution also consists of a shoulder support to help optimize the biomechanics of the seating of the artist. If there is no system of support, the client will lean to the left of the wheelchair and remain in a position which is difficult for painting. By providing a shoulder support vest, the artist can paint for extended periods of time from a wheelchair without experiencing fatigue from difficult positions. The shoulder harness will mount to the back of the wheel chair and to the side of the frame, and will be adjustable to a wide variety of sizes to increase support or decrease tightness. Many support systems constrain blood flow and cause lack of feeling. This system includes a timer with an alarm that mounts to the wheel chair and will remind the client that his limbs are under support and be used to advise him to change the position before complete feeling is lost. This alarm will also notify the aids and remind them of the circulatory inhibition that can be caused by a support system.
The support itself is designed in order to promote circulation. The vest can be adjusted to any tightness so that circulation will not be compromised during use. In addition to the vest, a supplementary system of lateral supports is included in order to aid in torso positioning. This relieves pressure points which can be caused by system consisting of a single vest. By minimizing pressure and vest tension, tissue irritation is reduced. The cushioning and cloth covers are important aspects of this support since they provide enhance comfort and ergonomics. These overall functions combine to increase the precision of painting for the artist and help to enhance and maximize artist expression. The Versatile Painting Solution Support System provides the client with the following benefits:

- Comfort
- Stability
- Adjustability
- Promotes circulation
- Reduces length of movements

The integration of each of these devices enhances the artists control over his extremities and art supplies, which in turn maximizes artistic expression. Each of the Versatile Painting Solution devices will also abide by a set of global design objectives, which includes the following:

- Safety
- Durability
- Reliability
- Versatility
- Ease of Use
- Ergonomic Design

➤ The Versatile Painting Solution Brush

• Design Overview:

The Paintbrush that is incorporated in this painting system is pictured in figure 1.1. It includes the following parts and features in order to accommodate an artist with limited mobility and motor skills.
1.) **The linear actuator-**

The paint flow will be driven against gravity through the utilization of a linear actuator. The actuator weighs only 119 g which is a key advantage in this design. The shaft that will need to be housed in the same tube as the paint has a width of .551 inches. This will fit into the 1 inch tubing that will contain the paint. The screw length is 4 inches. This also is sufficient for the low volume of paint that is required. With tubing with inner diameter of 1 inch the maximum volume will be as follows:

\[ V = \frac{\pi}{4}(1\text{in.})(4\text{in.}) = \pi \text{ in cu.} = 51.5 \text{ mL} \]

An artist’s tube of paint contains 120 mL of paint. So a 50 mL capacity is more than sufficient for a painting session.
The actuator requires a 12 V supply with .18 A of current. It only consumes 4.2 W of power. This is also a desirable quality in design. Low power consumption is an important requirement that will increase usage time and battery life.

The actuator will be housed in economical PVC piping in order to provide safety. The housing will be just over 4 inches long to accommodate the screw’s maximum retraction. The diameter will need to be greater than the maximum width of the actuator which is 1.11 inches. Important dimensions are visible in figure 1.2.

The linear actuators manufacture’s offer many resolutions for travel per step. For this application, the paint flow needs to be finely controlled. Refer to Block Diagram 1 for details. A small resolution of .000125” per step will be implemented. Depending on thrust, the speed of this motor will vary between 25 and 1100 steps per second. Relevant calculations can be found in the technical section.

Figure 1.2: Actuator Dimensions

2.) Non-threaded connectors-

Non-threaded connectors will provide an interconnection between the linear actuator and the paint containers. The pipe coupler is made of polypropylene which provides resistance to chemicals. It provides fast and leak-proof connection that is appropriate for chemicals. Once the adaptor and coupler are secured to each end the cam arms can be pulled down to lock assembly. The connector is made of glass filled polypropylene with EPDM gaskets, and 304 stainless steel handles and is compatible with 1 inch diameter piping. The non-threaded quality is an important feature in our design because it promotes ease of use and a reliable connection that will function when in contact with paint.
3.) **The paint containers**

The paint containers will be produced in large quantities. A minimum of eight will be produced to provide a large palette. The containers (figure 1.3) will be interchangeable via the coupler. They will be made of a rigid 1 inch ID butyrate tubing. This material was chosen because of its strength and chemical resistance over long periods of time. Each container will be fitted with a tightly sealed disk that will serve as a plunger that will be compressed with the actuator. The disk will achieve this seal with a rubber ring that will contact the tubing. The tube will contain notches at the end to prevent the plunger from being removed. The end of the brush tapers with a removable nozzle.

The nozzle is removable in order to allow the paint to be refilled. Here a threaded connector may be utilized as this connection will not to be changed frequently. Inside the end of the nozzle will be covered with a polypropylene screen with 1000 micron pores. This screen will aid in controlling undesirable flow that will result from gravity. Since the nozzle is removable, it will be able to be cleaned if paint dries in the container. Over the end of the nozzle, a threaded connector holding the brush filaments will be attached. These brush connectors will be interchangeable. The brushes will be constructed in various sizes to increase painting precision and versatility.

*Figure 1.3: Paint container*
4.) **Power supply**-

The linear actuator requires a 12 V power supply. This will be accomplished by using a 12 V rechargeable battery. This is convenient and does not require making additional purchases to keep the brush in operation.

Integration of the wheelchair battery as a power source is also a possibility. Very little amounts of power are needed only sporadically. With specifications to the client’s wheelchair as well as the actual actuator power consumption, the practicality to this idea in design will be further explored. The paintbrush’s power consumption cannot exceed our clients daily power needs for operation of his wheelchair. The option of using either a battery or the wheelchair would be the most ideal design pending the results of experimental electrical analysis.

5.) **Switch Controls**-

Connected to the power supply will be a single pull, double throw switch. This will be the first component in controlling the motion of the linear actuator. This switch will consist of three positions; up, off, and down. When in the up position, the actuator will have the ability to extend. In the off position, now power will be sent to the actuator, therefore, it will not be able to move. In the down position, the actuator will retract. This switch will be rated at a 15 AMP max, therefore, will not be a weak point of the circuit. It will also provide momentary action without spring return to off.

This single pull, double throw switch will connected at one end to the power supply (12 V battery) and at the other end to a variable switch (pressure sensitive switch). This will allow the user to manipulate the flow rate of the paint, based on the pressure placed on the switch. This switch will have a five inch diameter and can be pressed anywhere over those five inches. A three ounce minimum pressure will be needed to activate the switch, and the switch will have a 6 foot cable, so that it can be controlled by any part of the body, whether hand or foot.

This variable switch will then be an input to the microprocessor. The microprocessor with control the on and off function, the direction, and the step frequency of the linear actuator. These functions will be controlled by digital pulses created by the microprocessor.

The microprocessor is then connected to the microstepping driver. The microstepping driver will operate and control the bipolar linear actuator. It will control the range of step from the linear actuator, from a full turn to an either of a turn, and it will also control the speed and direction of each turn (or step). The input voltage of the microstepping driver is from 3.0 to 5.5 V, therefore, a voltage
regulator will be used to drop the initial 12 V to the required voltage. The output voltage of the microstepping driver has a maximum of 30 V, therefore, the 12 V necessary to power the linear actuator can be achieved. The microstepping driver is then connected to the linear actuator to provide motion.
Block Diagram 1: Paint Release

1. Client Presses Forward Control Button
2. Actuator Activated in Forward Motion
3. Cartridge Plunger Compressed at ~0.006167 cm/s
4. Paint is Applied to Bristles at ~0.25 mL/s
5. Paint Supply Stops / Container is Empty
6. Cartridge is Removed Using Quick Release
7. Plunger in Cartridge is pulled to Refill Position
8. Supplementary Acrylic Paint is Added
9. Cartridge is Reattached to Brush by Closing Quick Release
10. Tip is Fastened Back onto Cartridge
11. Cartridge is Opened Using Torsion on Thread System
12. Cartridge is Reattached to Brush by Closing Quick Release
13. Appropriate Brush Size or Color Cartridge is Chosen and Applied
14. Brush Size or Color Settings are Inappropriate for Current Artwork
15. Paint is Applied to Canvas
16. 51.5 mL Acrylic Paint Enclosed in Brush
The Versatile Painting Solutions Shoulder Supports

- **Design Overview:**

The Shoulder support system that is incorporated in this painting system is shown in figures 2.1-2.2. It includes the following parts and features in order to accommodate an artist with limited mobility and motor skills. Figure 2.3 demonstrates the alarm system used to time repositioning.

1,4. Bracket mounts which attach to rails of wheelchair
2. **Hook mount which attach to the top of the chair and interconnect with the webbing.**

3. **Adjustable Support Members**

   The lateral supports will consist of adjustable interlocking support members which use the interlocking devices to hold the support in the optimal position. Height is the most important consideration for lateral supports. If they are mounted too low they will be inefficient. If mounted too high, they will be uncomfortable and actually reduce mobility. Proper position is the most important consideration when providing optimal comfort and function. The lateral supports will fulfill this by providing triaxial motion. This will maximize comfort and mobility for the user. The repetitive use and cyclic loading of the supports necessitate durable support members which will not be affected by fatigue. Stainless steel tubing will be used for this purpose. The two sizes will interconnect and allow for positioning adjustment of the entire system in two directions using a screw and flynut system to fasten the polymeric rods in their desired location.

5. **Support Cushion**

   The end of the support members will have a polyurethane polymer cushioning system, which will help to contour the body. The advantage of contouring is that the forces applied by the supports are delivered over a maximal area. By increasing the area of application, the weight of the user is distributed, therefore reducing uncomfortable pressure and irritation. The cushioning should have a memory feature in order to retain shape and strength. The housing for the cushioning should be tear resistant and have minimal abrasion properties in order to reduce skin and tissue irritation. Pyrell Polyurethane Open Cell Foam Sheets are used as cushioning. This polymeric cushioning system was chosen because it is capable of contouring to the body because of its deflection at small pressures (only .7 Psi yields a 25% deflection). The cushioning contours to the body for comfort purposes. It will dissipate the stress forces over the largest possible area.
Movement promotes good circulation. Many cerebral palsy patients remain stationary for long periods of time leading to discomfort. A timer will remind the artist to readjust the position of his arm. Since the support is providing stability, and the easel he uses provides movement, a timer is an appropriate accessory to this painting system. The timer that will be purchased is a simple egg timer that has magnetic mounting capabilities. This will allow it to be placed on the artist’s wheelchair or any other nearby metal structure. This timer will measure up to an hour at a simple twist of the dial. This timer is not battery operated and is made of steal ensuring a long and active life. The timer can be used to set a 15 minute reminder for our artist to reposition.

**The Versatile Painting Solution Brush**

- **Technical Analysis:**

*Calculation of Force for Desired Flowrate of .25 mL/s*

**Bernolli’s Equation**
*assume nozzle area reduced to 1/25 cm² with addition of mesh*
- $A_1v_1 = A_2v_2$
- $(.5*2.54)2\text{cm}^2*v_1 = (1/25\text{cm}^3)(.25 \text{mL/s})$
- $v_1 = .001974 \text{mL/s}$

**Figure 3.1: Reducer variables**

Poiseuille's Law of The Flow of Liquids Through a Tube Where:

- $l = 4 \text{ cm}$
- $r = 1.27 \text{ cm}$
- $p = F/A = \text{dynes per cm}^2$
- $c = 15 \text{ poises}$
- $v = v_1 = .001974 \text{ cm}^3 \text{ per second}$

Then:

$v = \pi r^4 p/(8cl)$

$F = 8cl/(vr^2)$

$F = 8*15*4/(.001974*1.27^2) = 1.5076 \times 10^{-5} \text{ dynes}$

$1.5076 \times 10^{-5} \text{ dynes} = 1.508\text{N}$

The paint in the brush exerts a force of 1.508 N on the plunger that is driven by the actuator. The coefficient of the plunger on the tubing needs to be found experimentally in order to obtain an accurate value. As long as the addition of the forces of the plunger remains less than 5 N then the motor will run at a maximal speed of 1100 steps/sec as specified by the manufacturer. With a linear travel of .000125" per step then
the linear actuator will move a maximum of .138 inches per second as shown in the following calculation.

**Stepping calculation:**

Travel distance/time = .000125”/step*1100step/sec = 0.138 in/ sec

**Battery Life Calculation:**

The manufacturer of this 12 V rechargeable battery specifies a 4 Amp Hour capacity. The Amp Hour rating tells you how much amperage is available when discharged evenly over a 20 hour period. The switches are serving as relays and are negligible in this calculation. The actuator requires 4.2 W.

- Height of Paint = 4 in
- Actuator speed = 1100 steps/sec
- Linear travel= .000125 in/step
- Paint consumption time = 4/1100/.000125 = 29 seconds

The battery life is as follows:

Life = Total Energy / Actuator Power Consumption
Life = (12V)(4*3600A/s)/(4.2W) = \textbf{41142 s/battery}

The actuator is only running for a fraction of a second to dispense the paint. When it is active it will draw .35 A which is low in comparison to a battery with a capacity of 4 Amp hours. Taking into consideration the reversal of motor upon every color change, the battery will completely empty after over 700 tubes of paint. This battery will need to recharge rarely unless the motor is run excessive to painting needs.

**Other variables which effect flow rate:**

Further data is required in regard to the rubber plunger (E-17, Figure 1.3). The friction of the plunger has not yet been included in flow rate calculations. The coefficient of friction is may need to be measured empirically. It cannot be calculated without knowing the normal force which will be created by the compression of the rubber. Since the fitting is a very inexpensive part, ones with different properties may be used to experimentally determine the frictional characteristics as well as the normal forces which are created by compression. Most dry materials in combination give friction coefficient values from 0.3 to 0.6. As the roughness of the surfaces increase, the force of friction will also increase proportionally.
Friction can be calculated using the following equation:

\[ F_f = \mu F_n \]

**Microstepping Driver and Translator**

![Schematic of the Microstepper Driver](www.allegromicro.com Dwg. PP-075-2)

*Figure 3.2: Schematic of the Microstepper Driver*
Figure 3.3: Block Diagram of the Microstepper Driver
Source: www.allegromicro.com Dwg. FP-050-3A

**Pin 3** → **Sleep**: Has the ability to shut down the entire system. Input from the microprocessor of 0 or 1.

**Pin 4/9** → **Out2A/Out2B**: Output to one portion of the motor.

**Pin 5/20** → **Load Supply**: The load applied to the linear actuator.

**Pin 10** → **Step**: Controls the step of the linear actuator. Input from the microprocessor of a square wave. Frequency affects the step.

**Pin 11** → **Direction**: Controls the direction of the linear actuator. Input from the microprocessor of either 0 or 1.

**Pin 12/13** → **MS1/MS2**: Controls the resolution of each step (full step to an 1/8 step). Both connected to ground.

**Pin 14** → **Logic Supply**: Required input voltage for the microstepper driver. Input from the voltage regulator of 5 V.

**Pin 15** → **Enable**: Controls the motor functions or either on or off. Input from the
microprocessor of either 0 or 1.

**Pin 16/21 → Out1A/out1B:** Output to one portion of the motor.

**Pin 22 → Reset:** Input voltage of 5 V.

---

**Microcontroller**

40-Pin PDIP

- MCLR/VPP
- RA0/AN0
- RA1/AN1
- RA2/AN2/REF-/CVREF
- RA3/AN3/REF+
- RA4/T0CKI/C1OUT
- RA5/AN4/SS/C2OUT
- RE0/PR/AN5
- RE1/WR/AN6
- RE2/CS/AN7
- VDD
- VSS
- OSC1/CLKI
- OSC2/CLKO
- RC0/T1OSO/T1CKI
- RC1/T1OSI/CCP2
- RC2/CCP1
- RC3/SCK/SCL
- RDO/PSP0
- RDI/SO
- RDI/SI
- RDI/SDA
- RDO/PSP3
- RDO/PSP4
- RDO/PSP5
- RDO/PSP6
- RDO/PSP7

---

*Figure 3.4: Schematic of pin configuration of the microcontroller*

Source: [www.microchip.com](http://www.microchip.com) Datasheet PIC16F874A

**Pin 2 → RA0/AN0:** Analog to digital conversion. Converts the pressure on the variable switch to a digital pulse wave.

**Pin 19-22 → RD0-RD3:** Provides digital pulse waves for output.

**Pin 33-40 → RB0-RB7:** Input for microprocessor.
The Versatile Painting Solutions Shoulder Supports

• **Technical Analysis:**

Since safety and reliability are the first and foremost design standards of the support system, a biomechanical static analysis has been performed to ensure that the system can sufficiently tolerate the forces imposed upon it by a user of up to 300lbs (136kg).

**Lateral Supports**

These diagrams presume the following

Assume:

• Shoulder height is approximate to the height of the back of the wheel chair
• The maximal angle which can be assumed by the torso of the user is a 180° degree bend at the waist induced by the extension of the *erector spinae* muscles of the lower back, which would invoke the largest force and can be used to estimate the maximum force that can be imposed on the shoulder harness.
• Assuming the largest user is 300lbs, an anthropometric data table yields a torso, arms, and head combined mass consisting of 67.8% of the total weight. The center of mass is 62.6% of the torso length from the greater trochanter

- Fs= Force of Support
- Wt= Weight of Torso
- Ft= Net Force of Torso
- Fc= Force of Wheel Chair
- X= Joint formed at Greater Trochanter and Pelvis
Figure 3.5 - Static Model at Upright Position (0°)

\[
\begin{align*}
F_s &= 0 \text{ lbs} \\
F_t &= 0 \text{ lbs} \\
W &= 203.4 \text{ lbs} \\
M_x &= 0, \quad F_s = 0
\end{align*}
\]
**Shoulder Support Harness**

These diagrams presume the following

Assume:

\[ M_x = (\text{Torso Weight} \times 0.678)(\text{Length} \times 0.626)(\cos 45) + (\text{Force of Support})(L) = 0 \]

\[ M_x = (300 \text{lbs} \times 0.678)(3 \text{ft} \times 0.626)(\cos 45) + (F_s)(1.5 \text{ft}) = 0 \]

\[ F_s = 254.7 \text{lbs} \]
• The maximal force invoked on the lateral supports is applied when the torso is bent to the side at a maximal angle approximate to 45° degrees.
• Assuming the largest user is 300lbs, an anthropometric data table yields a torso, arms, and head combined mass consisting of 67.8% of the total weight. The center of mass is 62.6% of the torso length from the greater trochanter

- \( F_w = \) Force Webbing
- \( F_t = \) Net Force of Torso
- \( W_t = \) Weight of Torso
- \( F_c = \) Force of Wheel Chair
- \( L = \) length

### Figure 3.7 - Static Model at Upright Position (0°)

\[ F_w = 0 \text{ lbs} \]
\[ F_t = 0 \text{ lbs} \]
\[ W_t = 203.4 \text{ lbs} \]
\[ F_c = 203.4 \text{ lbs} \]

\( _M_x = 0 \), \( F_w = 0 \text{ lbs} \)
Figure 3.8 - Static Model at Bent Position (45°)

\[ M_x = (L \times 0.678)(W_t \times 0.626)(\cos 45) + (F_w)(L)(\sin 45) = 0 \text{ ft lbs} \]

\[ M_x = (3 \times 0.678)(300 \times 0.626)(\cos 45) + (F_w)(3)(\sin 45) = 0 \text{ ft lbs} \]

\[ F_w = 127.3 \]
This data is used to determine the maximal forces that the user will apply to the supports. The shoulder support harness must consist of webbing that can support a maximal amount of 180.7 lbs, while the lateral supports should be constructed to support 254 lbs. These forces are not likely to occur, but could theoretically occur if the client adjusts his position to an extreme angle. By overestimating the maximal forces, safety can be improved and guaranteed. The components selected meet the specific force requirements to ensure safety while maximizing function.
### Parts List and Budget:

#### Tables 2.1-2.2 – Complete Shoulder Support Part List

**Table 2.1 Lateral Support System**

<table>
<thead>
<tr>
<th>Components</th>
<th>Cost</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrell Polyurethane Open Cell Foam Sheets (2sq ft.)</td>
<td>$9.49 per Sq. ft</td>
<td>Temperature Range: -40° - 225° F</td>
</tr>
<tr>
<td>Density:</td>
<td>2 lbs/cu. ft.</td>
<td></td>
</tr>
<tr>
<td>Compression:</td>
<td>25% deflection at .7 Psi</td>
<td></td>
</tr>
<tr>
<td>Thickness:</td>
<td>in.</td>
<td></td>
</tr>
<tr>
<td>Durable Cover Cloth (TBD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade 5 bolts (TBD)</td>
<td>8$ per 25</td>
<td>Strength: 120ksi</td>
</tr>
<tr>
<td>Steel Square 5/8 x 5/8</td>
<td>$18.95 per 3ft</td>
<td>Ultimate Strength: 58ksi</td>
</tr>
<tr>
<td>Yielding Strength:</td>
<td>36ksi</td>
<td></td>
</tr>
<tr>
<td>Mounting Screws (TBD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stainless Steel Tubing 2ft (5/8 in.),</td>
<td>Size: 5/8 in</td>
<td></td>
</tr>
<tr>
<td>Material: Stainless Steel – 304</td>
<td>Wall Thickness: .0350&quot;</td>
<td></td>
</tr>
<tr>
<td>Stainless Steel Fittings (TBD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVC piping 2ft (1/2 in.) (TBD)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2.2 Shoulder Support Harness**

<table>
<thead>
<tr>
<th>Components</th>
<th>Cost</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/4in Polypropylene Webbing 10ft.</td>
<td>4.00 per 10ft</td>
<td>Strength: 450lbs</td>
</tr>
<tr>
<td>Thickness:</td>
<td>.040 in.</td>
<td></td>
</tr>
<tr>
<td>Pyrell Polyurethane Open Cell Foam Sheets (2sq ft.)</td>
<td>(See table 1.1)</td>
<td></td>
</tr>
<tr>
<td>DB Single Lock Double Bar Buckle (4)</td>
<td>3.96$</td>
<td>Material: Acetal Nylon</td>
</tr>
<tr>
<td>Durable Cover</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cloth (TBD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------</td>
<td>-----------</td>
</tr>
<tr>
<td>Mounting Screws (TBD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSR Side Release Buckle</td>
<td>1.99$</td>
<td>Material</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acetal Nylon</td>
</tr>
</tbody>
</table>

### Table 2.3 Timer

<table>
<thead>
<tr>
<th>Components</th>
<th>Cost</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eva sola magnetic egg timer</td>
<td>$33.00</td>
<td>Alarm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sounds at set time</td>
</tr>
<tr>
<td>Attachment</td>
<td></td>
<td>Magnetic</td>
</tr>
</tbody>
</table>

---

#### Table 2.3 – Complete Paintbrush Part List

#### Table 2.4 Versatile Painting Solutions Brush Part List

<table>
<thead>
<tr>
<th>Part</th>
<th>Source</th>
<th>Pricing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear Actuator</td>
<td>Hayden Switch and Instrument</td>
<td>$150</td>
</tr>
<tr>
<td>Quick Disconnect Coupler</td>
<td>Industrial Plastic Pipe</td>
<td>$8.05</td>
</tr>
<tr>
<td>Quick Disconnect Adapters (8)</td>
<td>Industrial Plastic Pipe</td>
<td>$27.92</td>
</tr>
<tr>
<td>Butyrate Tubing</td>
<td>Polymer Plastics Corporation</td>
<td>$8.58</td>
</tr>
<tr>
<td>Rechargeable (12 V)</td>
<td>LSD</td>
<td>$39.00</td>
</tr>
</tbody>
</table>

Subtotal: $372