3D-PRINTED MOBILE ASSISTANCE PLATFORM (MAP) FOR REHABILITATIVE ROBOTICS

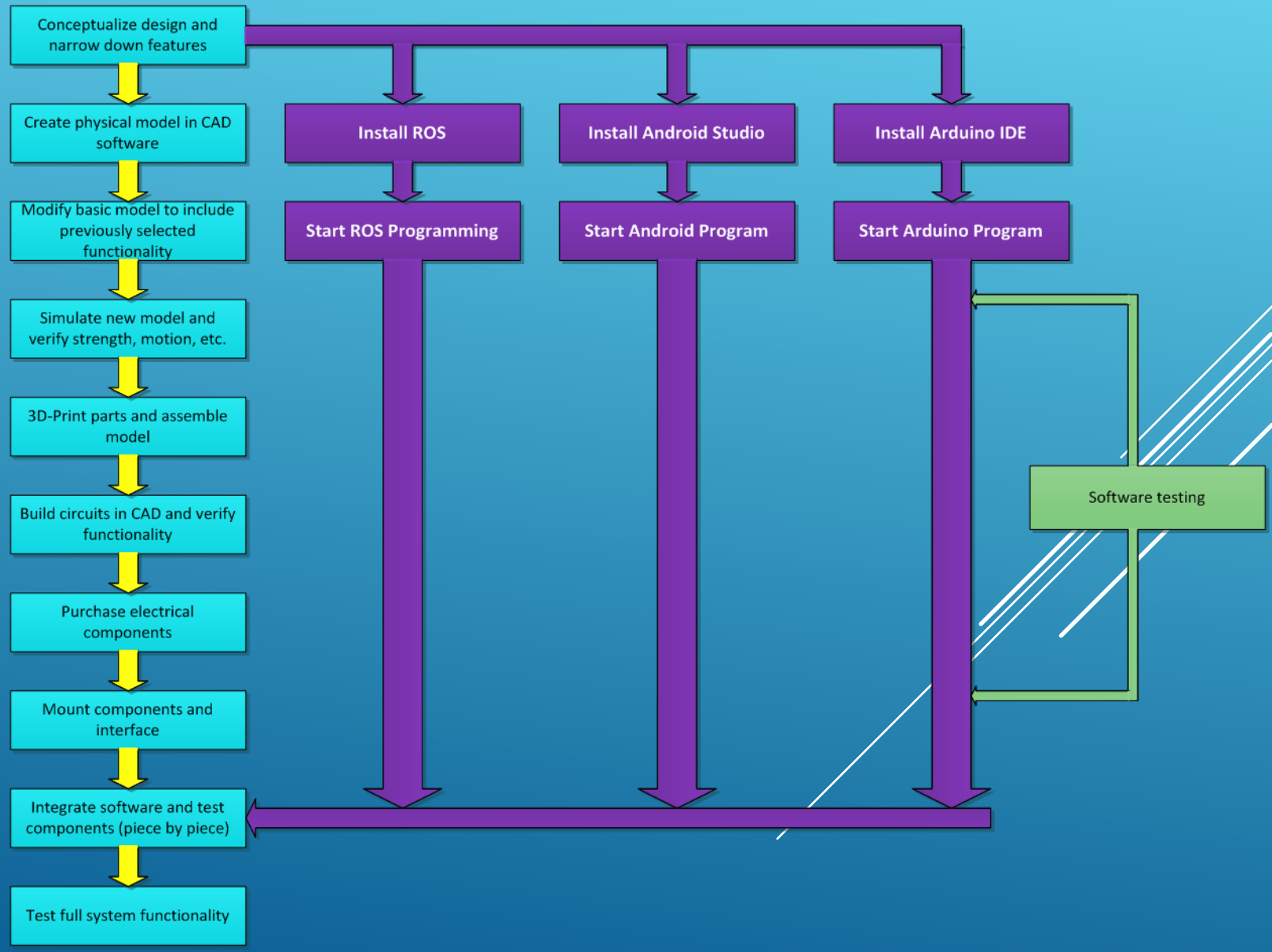
Dr. Patrick Benavidez
(presenting for Eric Wineman)

DESIGN FLOW OF CUSTOM ROBOTS 1

- **Before anything starts, choose the essential hardware and software to use**
- **Picking core components is necessary for the following design process**
- **If components change during the design process, that's okay…but you might have setbacks in your schedule**
- **Also, have an idea of how you are going to build your robot (3D Printing, CNC, etc.)**

DESIGN FLOW OF CUSTOM ROBOTS 2

- **Ideally perform hardware and software design concurrently**
- **Undertake individual unit testing for functionality**
- **Integrate units piece by piece then execute combined testing**
- **Combine all prior integrated pieces into functional platform**
- **Execute platform testing**



WHY A WALKER?

- **In 2050, approximately 37% of the population is predicted to be composed of elderly people [6]**
- **Without any disabilities, the average cost from year 70 until death is around $136,000**
- **Reduce cost with an affordable platform**
- **Increase safety while remaining connected**
- **Allow elderly to act independently by providing obstacle avoidance and navigation**
- **Integrate with home cleaning/support systems**

DESIRED FEATURES OF A MOBILE WALKER

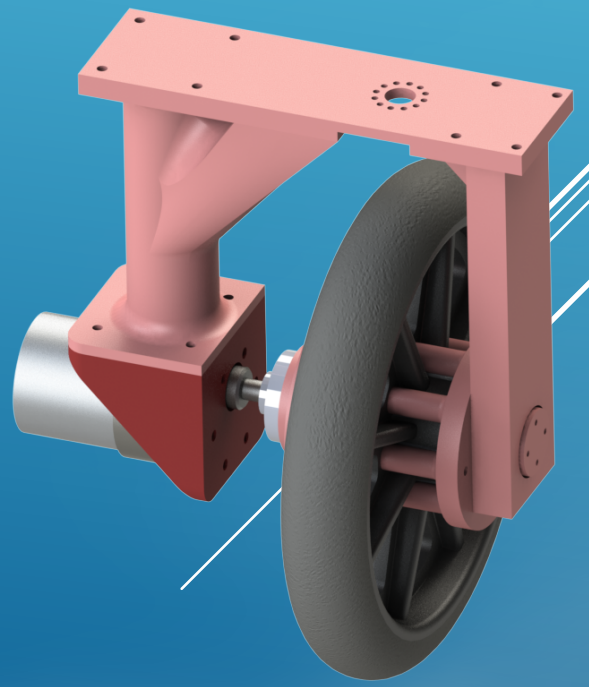
- **Be safe to use**
- **Provide powered motion for the elderly**
- **Simple to use interface for control**
- **Open-source for easy development**
- **Provide navigation and obstacle avoidance**
- **Integrate new design techniques**
- **Ascetically pleasing to elderly**
- **Auto-charging capability**
- **Be able to remove obstacles or pick-up objects**

IMPLEMENTED FEATURES OF MOBILE WALKER

- **Uses Robot Operating System to make the software Open-Source**
- **Uses Android Studio to allow application development for Android tablets**
- **Powered motor drive so the elderly do not have to push the walker**
- **Powered steering to allow easy turning**
- **Utilizes ODROID (mini-pc) for computation and future development**
- **Integrated Kinect for future development of feature recognition, mapping, and navigation**
- **Main interface is through a touch-screen Android tablet for easy management**
- **Simple joystick control for moving the walker**
- **Has electronic part files for more 3D-Printing or future manufacturing**

MECHANICAL DESIGN SOFTWARE

- **SolidWorks was chosen as the design software for the Mobile Assistance Platform for the following reasons**
- **Allows 3 dimensional visualization of parts**
- **Provides a simulation suite**
- **Compatible with ROS for navigational simulation/implementation**
- **Exports files suitable for 3D printing**
- **Customizable interface and units (IPS, MGS, etc.)**
- **Provides support and training**
- **Provides realistic rendering for demonstration purposes**
- **Design analysis features**
- **Produce manufacturing documents**



MECHANICAL DESIGN

- **A model of the walker without modifications was first created**
- **Parts were designed to meet with the objectives for the mobile assistance platform**
- **Once the parts were designed, they were placed into an assembly and simulated**
- **Once results were verified, the parts moved on to be 3D printed**

Original Model

First Prototype

Second Prototype

Functional Prototype

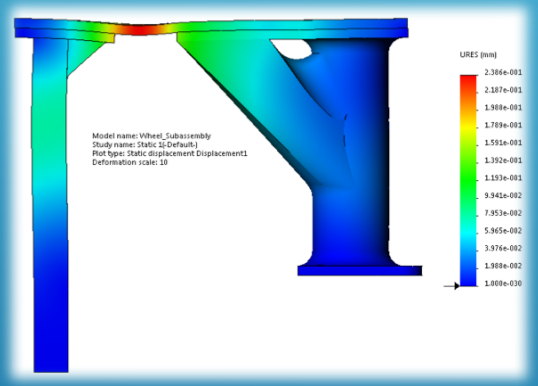
MECHANICAL SIMULATION 1

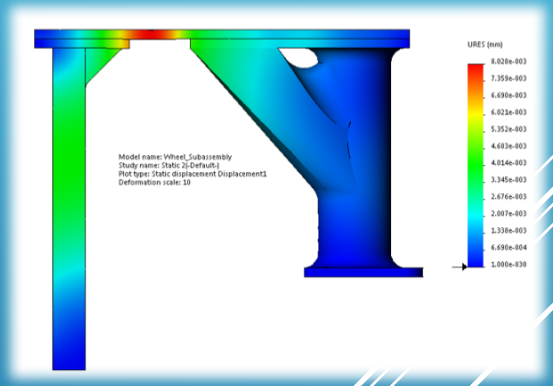
Do I need to simulate?

What kinds of simulation can be performed?

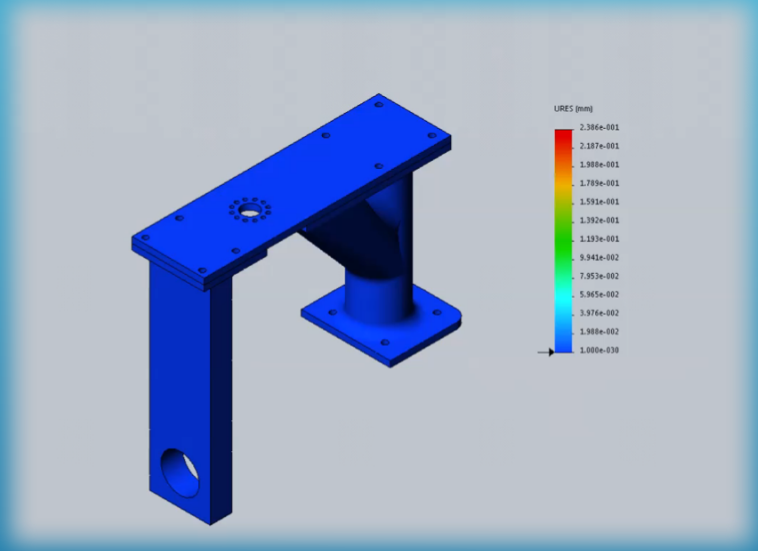
- **Static**
- **Thermal**
- **Frequency**
- **Buckling**
- **Drop Test**
- **Fatigue**
- **Nonlinear**
- **Linear Dynamic**

What kind of tests should I do?





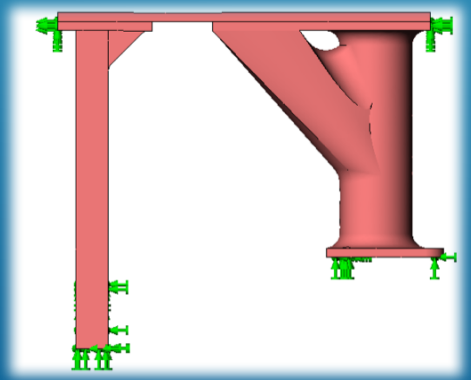
MECHANICAL SIMULATION 2

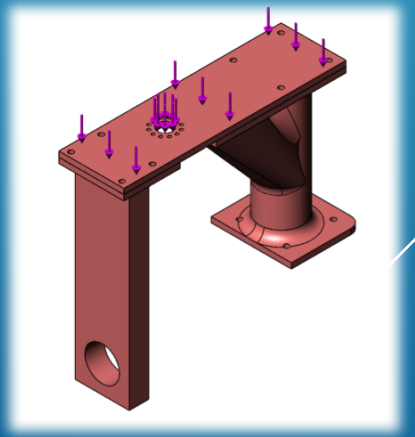


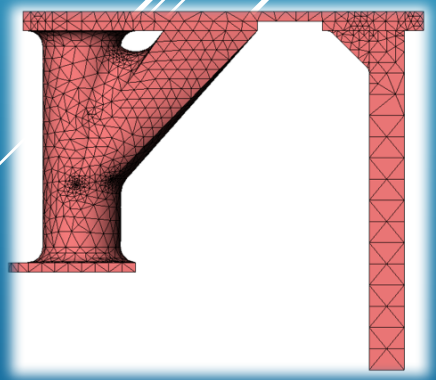
Mechanical simulations were executed

- **Material was assigned to a part**
- **Fixtures were added to faces of a part**
- **Load was calculated and added to assembly**
- **Simulation was executed and results were evaluated**
- **Was the assembly strong enough?**

Weight of an average man = 185 lbs.
(~ 84 Kg)
Leads to a down-force of 823.2 N on the assembly







3D-PRINTING 1

- **What is a 3D printer?**
- **What types of 3D printers exist?**
- **Why should I use a 3D printer?**
- **Which kind of materials are available?**
- **Major benefit is a savings in time and money**

3D-PRINTING 2

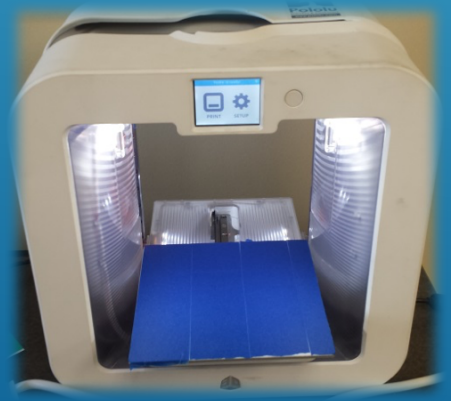
Cube 3D Printer

Printer Specifications:

- **Build Volume: 152.5 x 152.5 x 152.5 mm**
- **Material: ABS and PLA**
- **Heated Bed: No**
- **Layer Resolution: 70 to 200 microns**
- **File Format: .cube3**
- **Wireless: Yes**

Additional Features:

- **Automated Calibration**
- **Enclosed Printing Cartridge**
- **Dual Extrusion**
- **Wash-away Supports**



UP BOX 3D Printer

Printer Specifications:

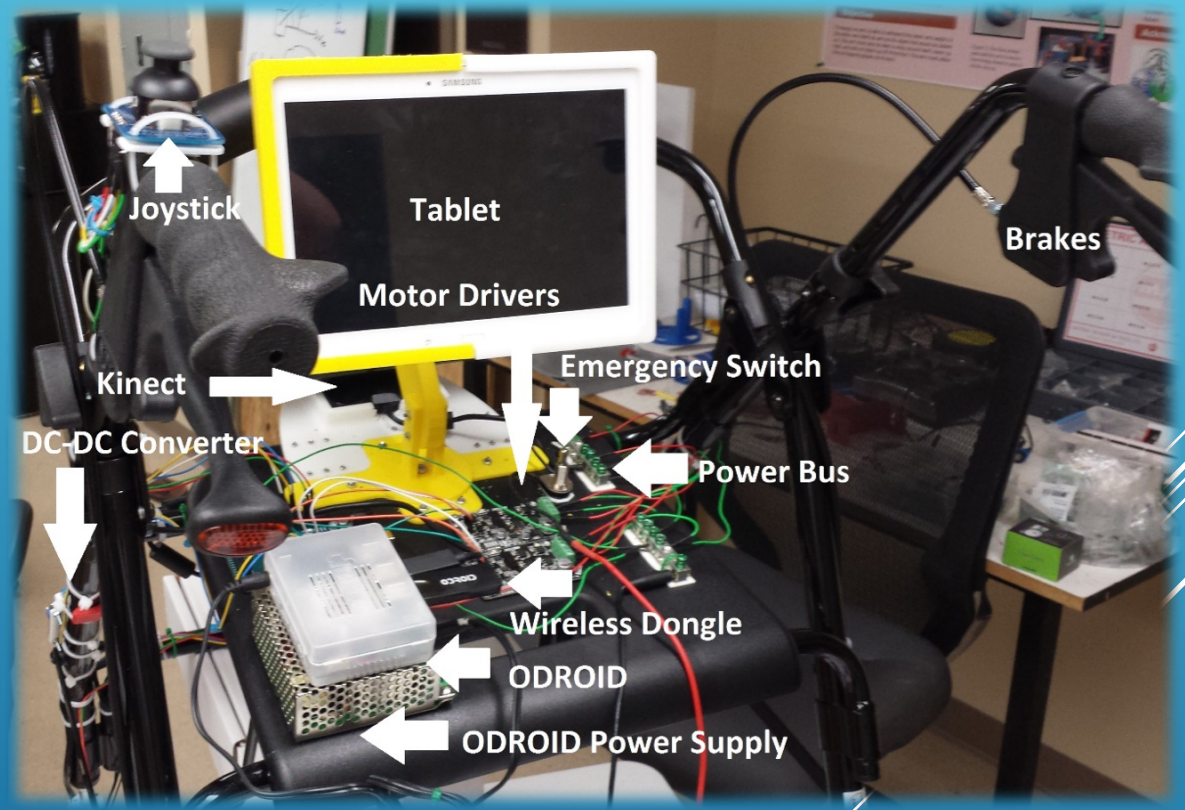
- **Build Volume: 255 x 205 x 205 mm**
- **Material: ABS and PLA**
- **Heated Bed: Yes**
- **Layer Resolution: 100 to 400 micron**
- **File Format: .stl, up3, upp**
- **Wireless: No**

Additional Features:

- **Hepa Air Filter**
- **Fully Enclosed Printing Volum**
- **Automated Calibration**

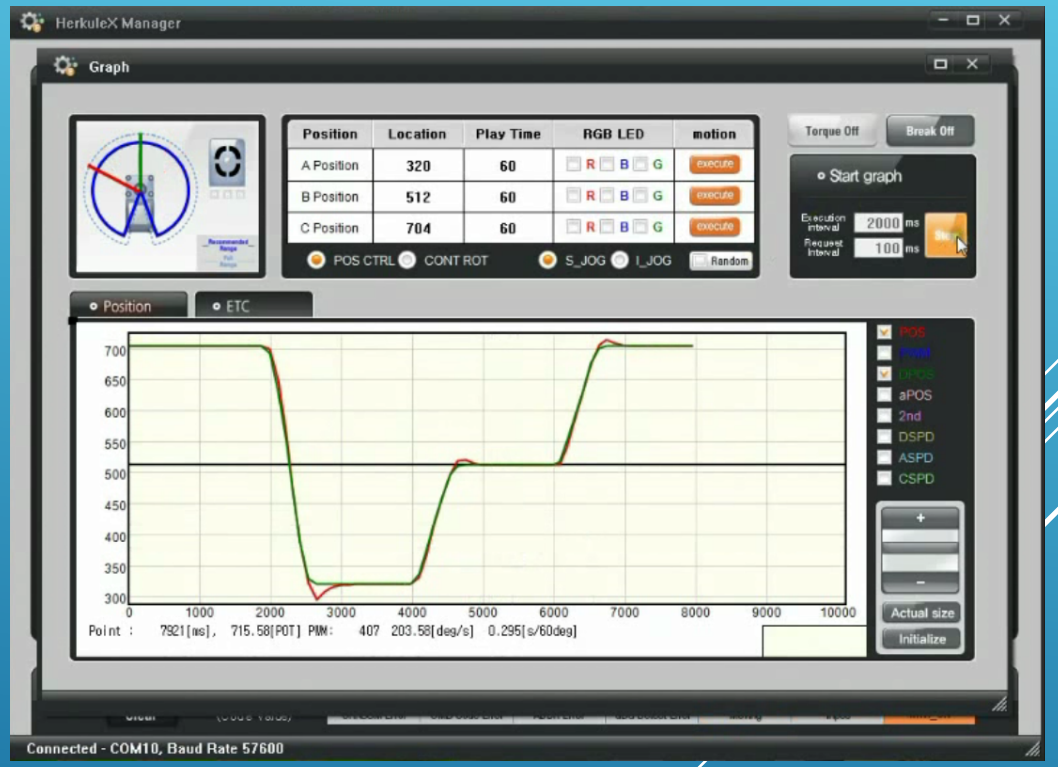
ELECTRICAL DESIGN (HARDWARE)

- Walker has power turning and steering
- Controlled via a joystick interface (swappable)
- Touch-screen tablet interface
- Microsoft Kinect for sensing
- ODROID for processing
- PID Controllers in each servo for controlling angular position



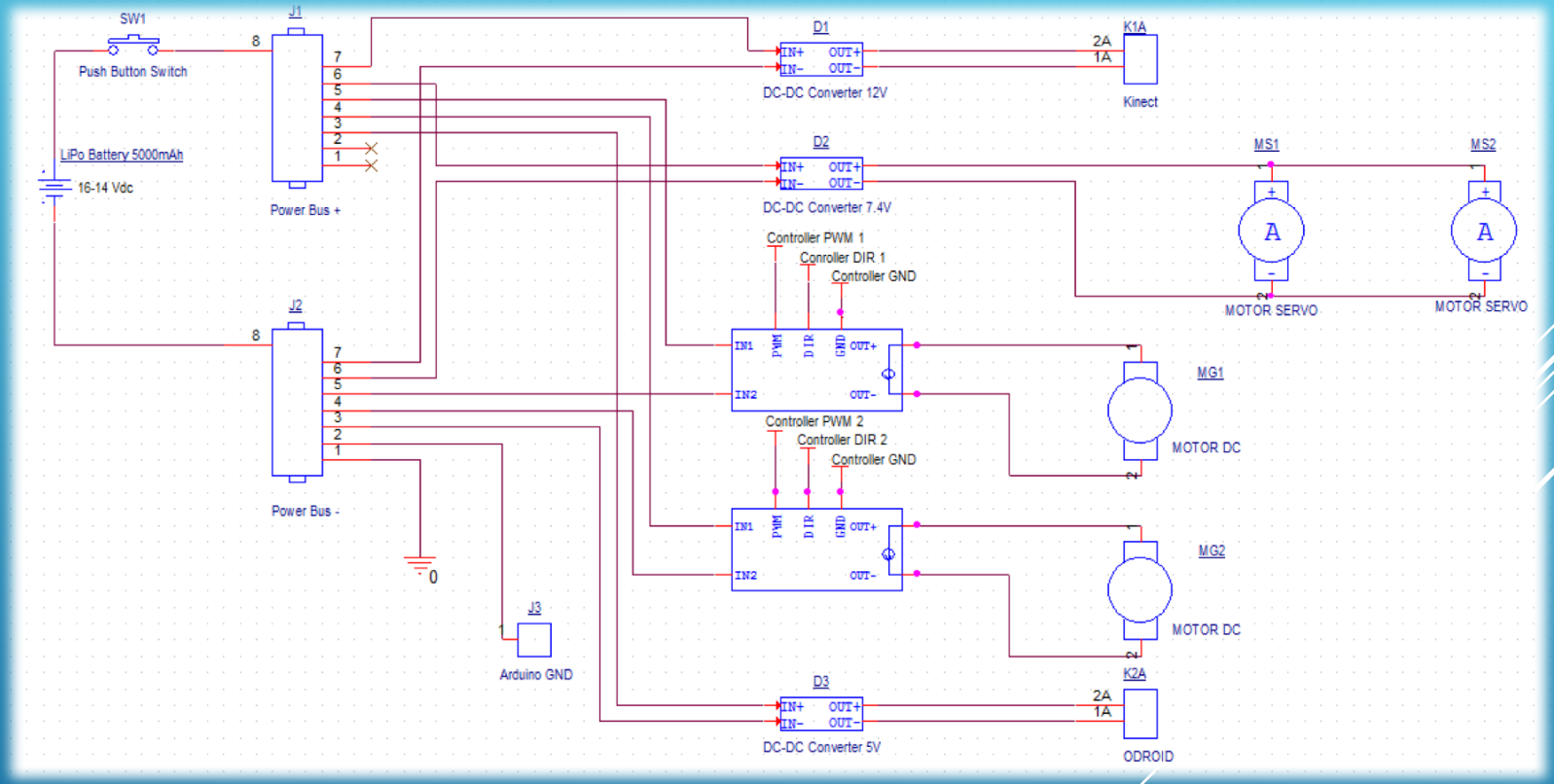
BENEFITS OF SMART SERVOS

- **Ease of control for angular position and speed**
- **Tunable PID in each servo**
- **High torque**
- **Custom response time**
- **Can daisy chain servos**



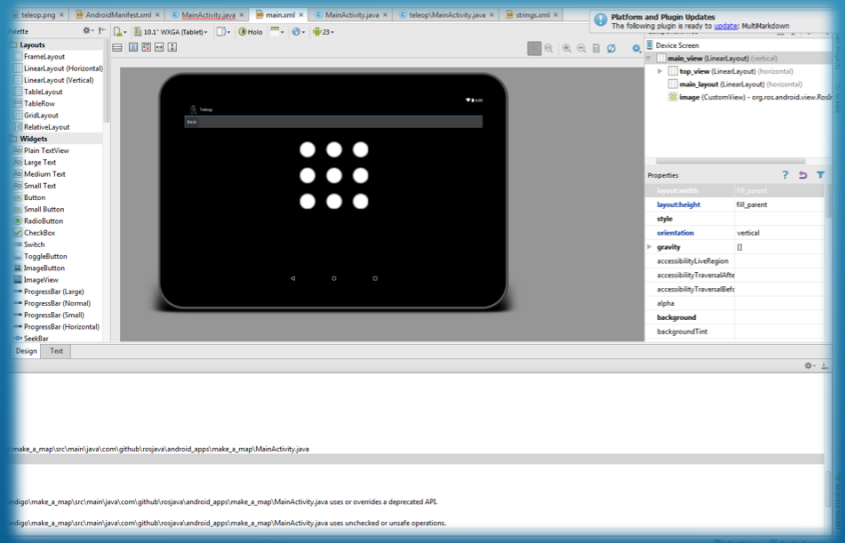
POWER SYSTEM

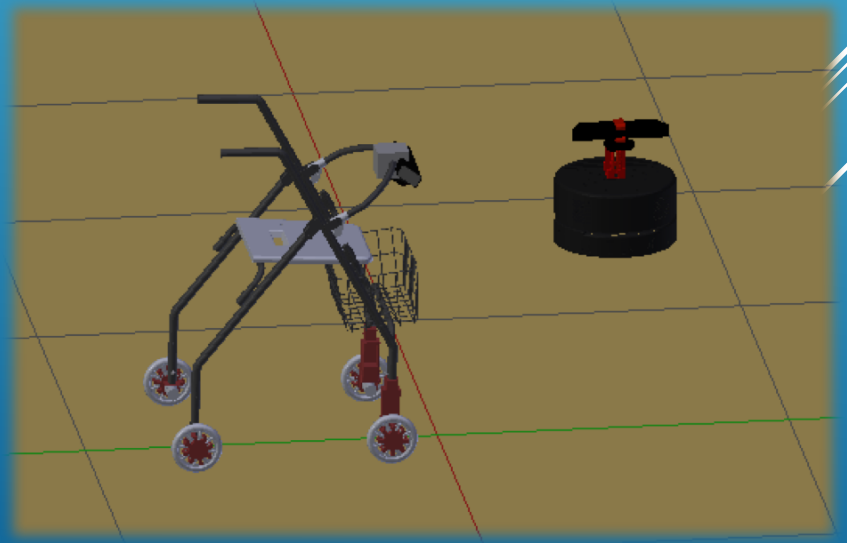
- **Features a 5V, 7.4V, and 12V bus**
- **Expandable to power more systems**
- **Integrated quick-stop switch for emergency**
- **Can be net-listed to create a PCB**
- **Improves appearance for elderly**



ELECTRICAL DESIGN (SOFTWARE)

- **Robot Operating System (ROS) and associated packages**
- **Android Studio**
- **Arduino IDE**
- **Cadences' OrCAD Capture**
- **Cadences' OrCAD PCB Editor**



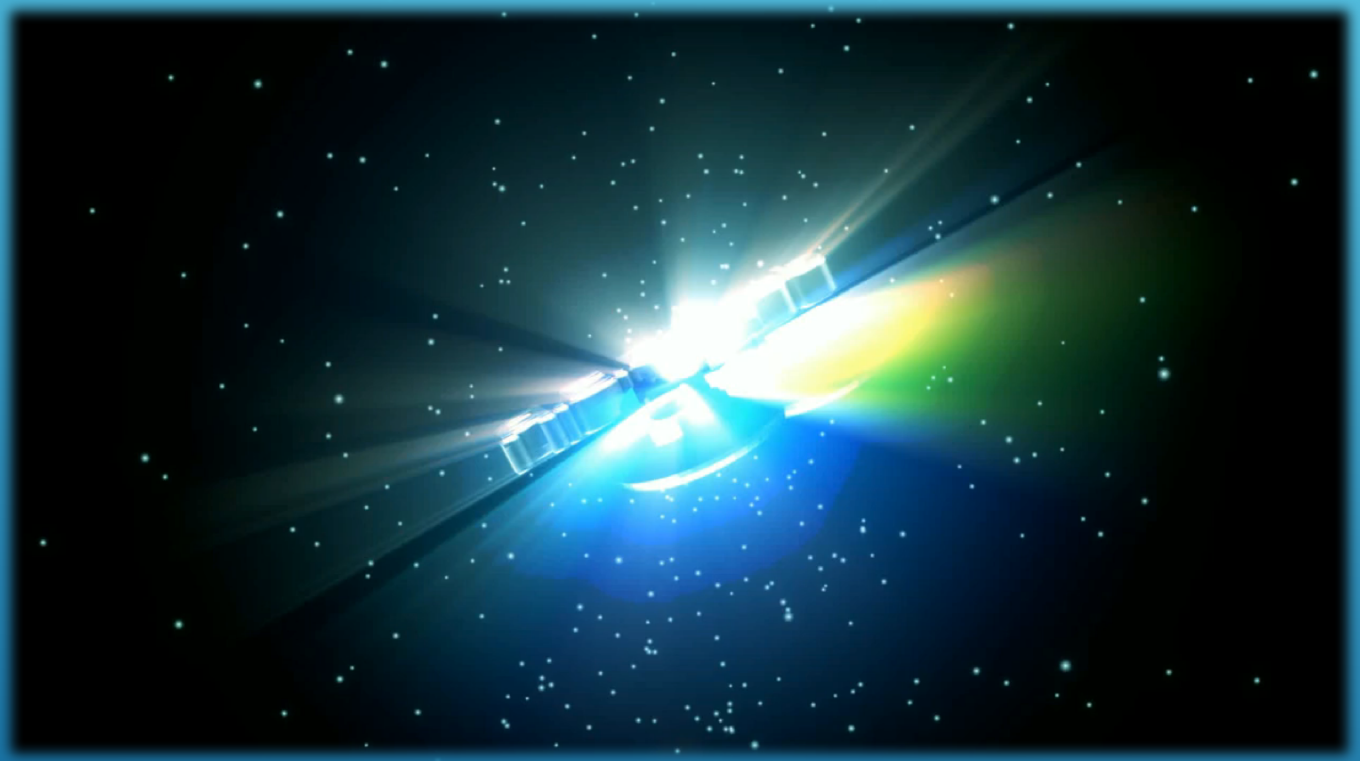


COSTS

- **The prototype was created for less than $1,000**
- **Less than Dynamaid at $3,500**
- **Surpasses cost of similar assistive platforms**
- **ARM = $26,000**
- **Overall cost excludes the user tablet**
- **Cost may increase during actual build (attributed to tooling costs, part cost would decrease though)**

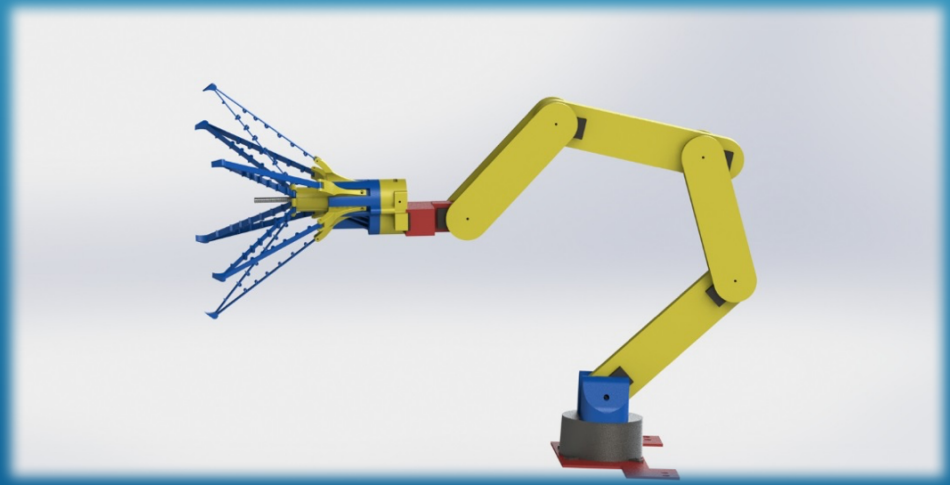
Item	Unit Cost	Quantity	Total Cost
Walker	$99.00	1	$99.00
Arduino	$36.98	1	$36.98
DC-DC Converter	$5.99	2	$11.98
Miscellaneous Wires	$29.99	1	$29.99
Male and Femle Wire Headers	$11.95	1	$11.95
Solder	$9.49	1	$9.49
USB to TTL Adapter	$7.38	1	$7.38
AA Arduino Battery Case	$5.99	1	$5.99
Heat Shrink Tubing	$10.49	1	$10.49
Force Sensitive Resistors	$6.95	2	$13.90
DC Motor Hub	$7.95	2	$15.90
DC Motor	$39.95	2	$79.90
Servo Motors	$132.00	2	$264.00
DC Motor Driver	$12.11	2	$24.22
Miniature Analog Joystick	$5.95	1	$5.95
Kinect Sensor	$69.99	1	$69.99
ODROID XU3	$99.95	1	$99.95
3D Printing Filament	$100.00	1	$100.00
Turnigy 5000mAh Battery	$42.06	1	$42.06
Battery Cell Checker	$3.92	1	$3.92
HXT 4MM to Banana Plug Adapter	$3.57	1	$3.57
Total Cost for Mobile Assistance Platform			**$946.61**

PROTOTYPE DEMONSTRATION



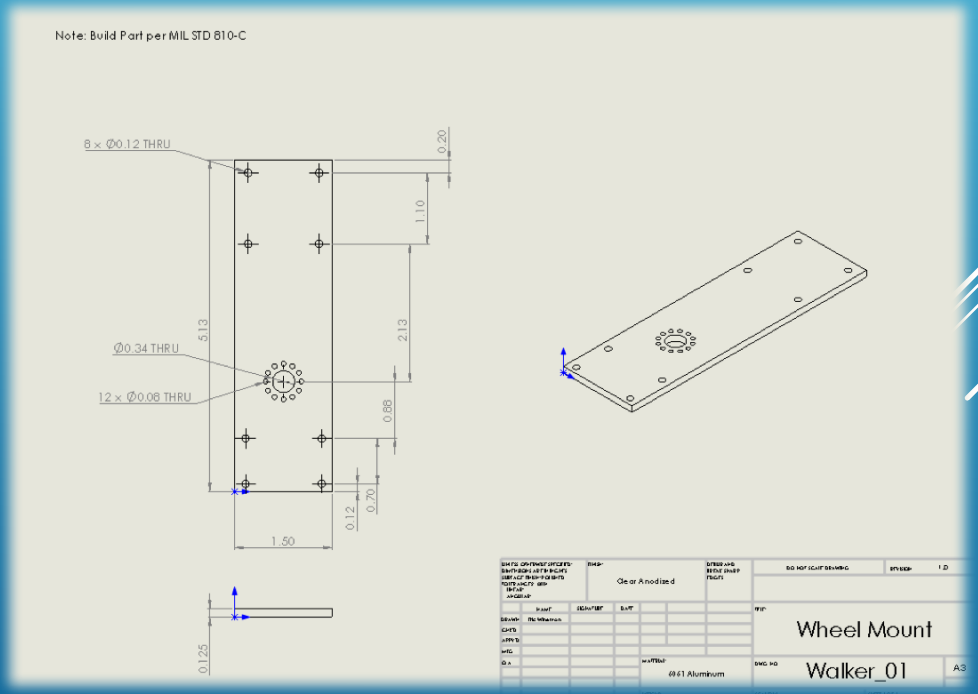
FUTURE WORK

- **Increase strength of wheel base for mobile wheelchair properties**
- **Make MAP aesthetically pleasing**
- **Add a robotic arm for object and obstacle manipulation**
- **Include ROS navigation package for navigation and SLAM**
- **Could have a health monitoring systems for emergencies**
- **Voice control**



CONCLUSION

- **Took a standard COTS walker and made a prototype Mobile Assistance Platform**
- **Minimal modifications to the walker frame**
- **Demonstrated conceptual model was valid**
- **Integrated Open-Source Software**
- **Electronic Part Files**
- **Manufacturing Ready**
- **Cost-efficient Design**



QUESTIONS?