# Implementing a system for 3D printing prosthetics and orthotics

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## Problem Statement

The ROCK team is working in collaboration with CURE International in Kijabe, Kenya to implement a 3D printing system in the orthopedics department. The department asked for this system to help handle the high volume of patients seeking care. A 3D printing system will allow employees in the orthopedics department to see and treat a greater volume of patients as well as potentially cut long term costs.

## Current Need

There are 40 million amputees globally, but only 5% of these have access to prosthetic assistive devices (World Health Organization, see Fig 1).

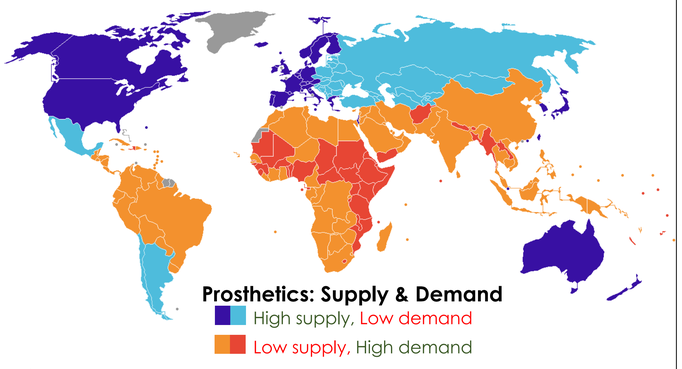


***Figure 1*** *– The gap between global supply and demand of prosthetic devices.*

CURE International works to fill this gap by supplying charitable health care services to high-need communities. Their hospital in Kijabe, Kenya is their longest-running hospital and was Africa's first orthopedic pediatric teaching hospital. Their orthopedic workshop supplies prosthetic and orthotic devices to approximately 100 patients per month.

Our team witnessed their amazing work first hand during summer 2016 and summer 2017 (Fig 2) site team trips.

***Figure 2*** *– The summer 2017 site team with Simon and Shadrack from the CURE Kenya orthopedic workshop. (photo credit: cure.org)*

## System Design

CURE Kijabe asked us to design a 3D printing system that helps them shorten the time it takes them to make prosthetics and orthotics while also lowering the cost (Table 1).

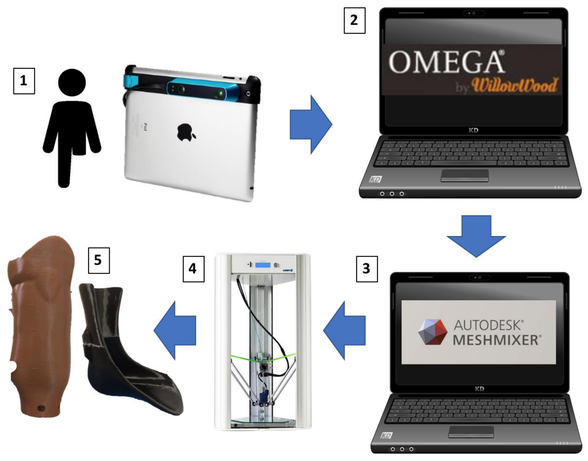


*Figure 3 - Results from the compression testing*

| Design Criteria | |
|---|---|
| Unit Cost | < $25 |
| System Cost | < $5000 |
| Manufacturing Time | < three days (current standard) |
| Compatibility | Must be compatible with current prosthetic parts used in Kenya |
| Safety | Failure load must be > 750 lbs |

*Table 1 – Design criteria for the 3D printing system to be implemented at CURE Kenya.*

As shown in the figure above, the system we have designed consists of (1) a 3D scanner, (2) the rectification software Omega, (3) adjustments in open-source computer-aided design (CAD) software MeshMixer, (4) the DeltaWASP 20x40 3D printer, and (5) evaluation of the safety and patient satisfaction of the print.

## Installation & Safety Testing

The 3D printing system was installed at the CURE international hospital in Kenya during the summer 2017 site team (Fig 4).

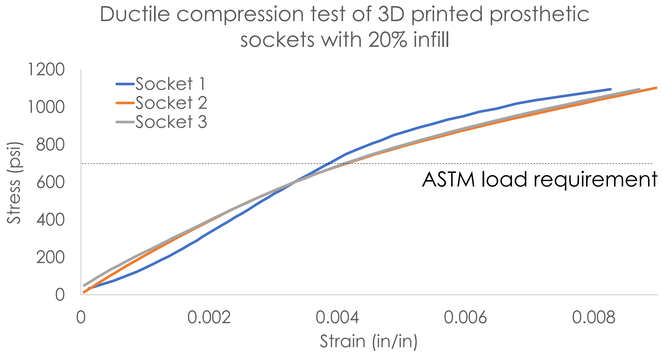


*Figure 5 - -Results from the compression testing*

A compression test was conducted according to modified ASTM and ISO standards to ensure safety of our prosthetic sockets. We found that the socket **did not fail when tested to 1200 lbs, well beyond our design criteria of > 700 lbs** (Fig 5).

A SolidWorks finite element analysis model of the socket has been created to understand heterogeneity of stress distributions (Fig 6).

*Figure 4 - One of the technicians (Shadrack) holding a printed prosthetic socket next to the 3D printer.*

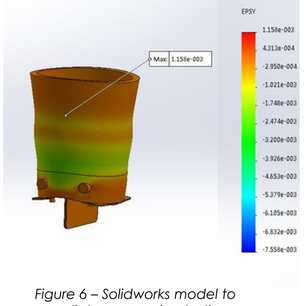


*Figure 6 – Solidworks model to predict compression testing*

## Reducing Costs & Expanding Capability

The current cost of our system is $15,000, largely due to the cost of one software, OMEGA. To reduce system cost, we are working to replace OMEGA with a cheaper software. A wrist brace we made using free programs (Meshmixer and Blender) is shown in Figure 6.

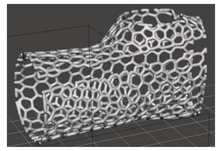

*Figure 6 – Wrist splint created in free software*

The team is also working to expand the printing capabilities of the system to orthotics and upper-limb prosthetics. We have created and tested a system for printing a two-piece Ankle Foot Orthotic, used to treat dropfoot (Fig 7, 8). We are also working towards a system for printing prosthetic hands.

*Figure 7 – Version 1 of our 3D printed Ankle-Foot Orthotic tested on a team member.*

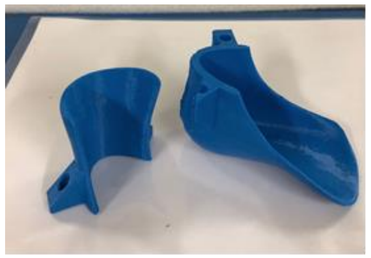

*Figure 8 – Version 2 of our 3D printed two-piece AFO. New design is more comfortable and sturdy.*

## Upcoming Site Team Trip

Most of the ROCK team will be traveling to Kijabe, Kenya from May 25 to June 9, 2018 (Fig 9). We will continue to train the technicians at the hospital and grow our relationships with them.

*Figure 9 – The current team.*

## Acknowledgements

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## More Information

Project Report: https://bit.ly/2KfR3ip
CURE: www.cure.org

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