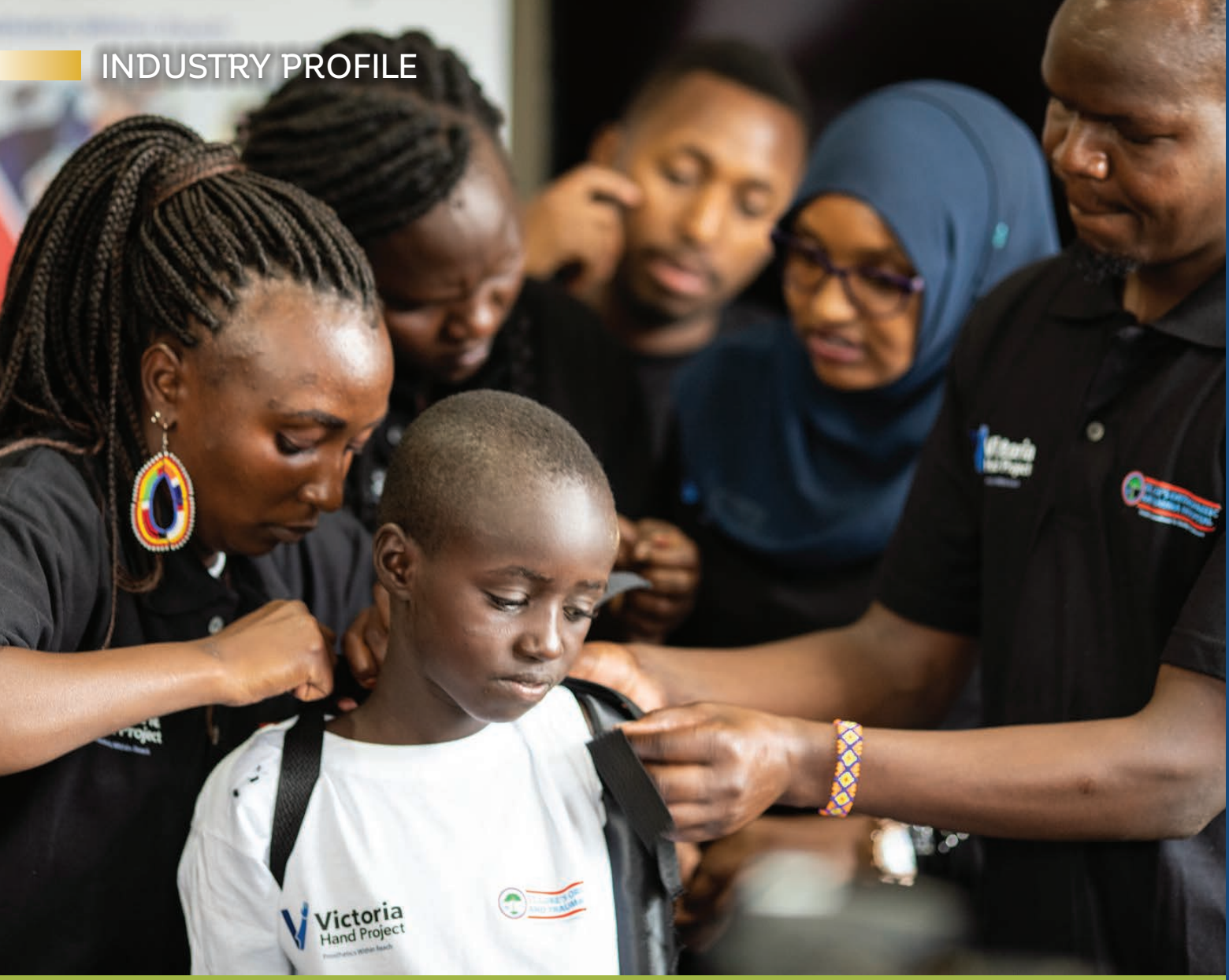


Photos courtesy of Victoria Hand Project

Victoria Hand Project

IMPACTING AMPUTEES IN NEED WORLDWIDE

By Jeff Tiessen

In 2010 a 7.0 magnitude earthquake struck the country of Haiti bringing with it devastating damage. The Haitian government's official death count was more than 300,000, making the earthquake's aftermath one of the worst natural disasters in recorded history. Thousands more were injured.

Magdala Lundy was at school when the earthquake struck. Trapped underneath the debris of the building for three days, she was rescued from the rubble, injured but alive. The injury led to gangrene and the amputation of her right forearm. She lived for a year without a prosthetic limb and struggled to take care of her children. Many negative looks were directed her way from fellow Haitians. Magdala needed a prosthetic device that was both functional and cosmetically appealing, and affordable.

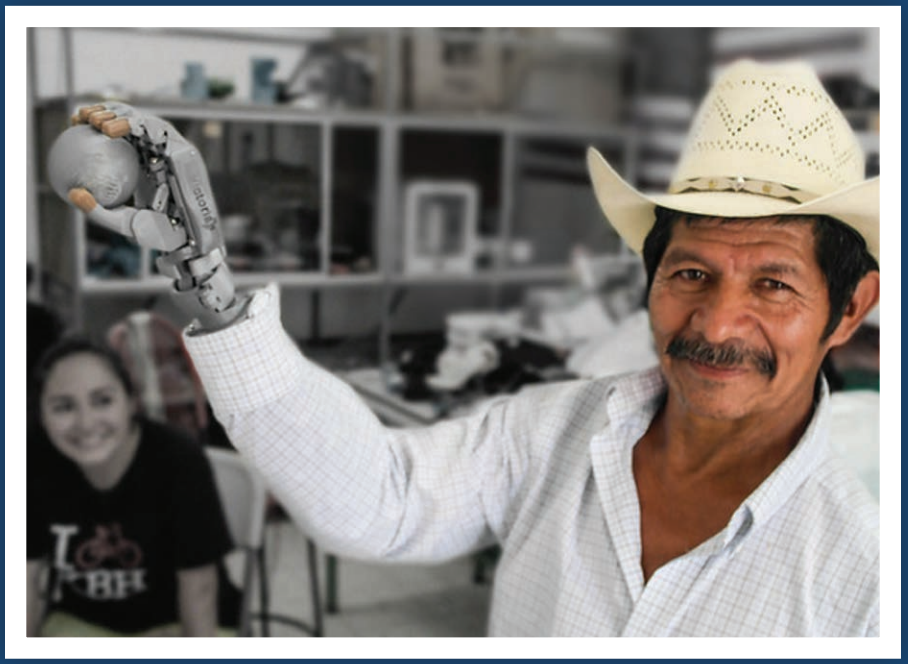
Isabel lives in Guatemala. He lost his arm in a work accident 12 years ago. Having a prosthetic hand was vital to Isabel as he needed to continue to work and provide for his family. He was one of the first amputees to work with the Victoria Hand Project. He was the first to be fitted with the Voluntary Open device, and wears it proudly, astounded at its functionality and appearance and how lightweight and versatile it is.

Magdala received a hand from the Victoria Hand Project (VHP) as well. Manufactured in Port-au-Prince by one of four 3D printers donated by the VHP, Magdala was provided with the help she needed with tasks she couldn't do with a cosmetic hand like grabbing objects, dusting, washing clothes, and getting dressed. The appearance of her Victoria Hand also helped to improve her body image and her comfort level in public. Stories like these accompany each hand that the VHP provides.

The Victoria Hand Project is a British Columbia-based charity working with medical clinics in 11 countries around the world, including Canada. Its mission is to produce affordable 3D-printed prosthetic devices for those who otherwise would go without because of cost, lack of government coverage, or lack of infrastructure to produce the devices. The VHP donates the 3D printing equipment and scanning computer software to partner clinics and educates and trains prosthetic practitioners on its use.

Led by Chief Executive Officer Michael Peirone, the VHP started as a research project at the University of Victoria to test the viability of 3D printing for prosthetic hands. Initial trials were done in Guatemala to get feedback from clinics and amputees. "I was an undergraduate student in bio engineering during those first trials and thought the technology was fascinating," Peirone remembers. "It's amazing how these devices can be made around the world and help people who don't have access. I volunteered with the VHP throughout my undergraduate degree and started full-time as soon as I graduated."

Peirone admits that as a biomedical mechanical engineer he had his sights set on pursuing surgical robotics. But it was those first trials in Guatemala that captured his interest and imagination. As an intern, he also travelled to Nepal to help set up a centre and train staff. "Just seeing the transformation in some who refused to show that they're missing a limb to becoming more confident and outgoing is



"This project gives people, wounded soldiers, hope that this is not the end. This is a great hope for people who have lost a limb."

– Andriy, Ukraine

what instilled the VHP as a career mission for me," shares Peirone. "I think that's what draws so many student volunteers to us from around the world," he adds. "When we ask what makes them want to work with us, the answer is often, 'Well, I want to do engineering but I want to give back too'."

Peirone's first experience as a VHP volunteer is a testament to that. "The participants in the research study in Guatemala, like Isabel, asked to keep their test devices because they never had a prosthetic device," explains Peirone, "and that's what led our founder and UVic [University of Victoria] to spin the research project into a nonprofit organization."

The VHP's founder is Dr. Nick Dechev, an Associate Professor in the Department of Mechanical Engineering at UVic, and former Biomedical Engineering Program Director. Dechev's research focuses on developing innovative solutions to enhance the lives of individuals with disabilities, particularly in the field of prosthetic and orthotic devices.

Driven by advances in rapid prototyping technologies – 3D printing, 3D scanning, and 3D computer-aided design – the VHP uses these technologies to provide low-cost prostheses to those facing limited access to prosthetic care.

The concept for the device actually originated at the University of Toronto in the early 2000s, where Dechev was a Master's student. He created an electric, motorized terminal device that was groundbreaking at the time because it employed something called adaptive grasp. The motorized fingers moved semi-independently. When one finger made contact, the others would continue to close for a more natural grasp around an object.

Dechev brought the device to Victoria when he began working as a professor of mechanical engineering. And it wasn't until years later, when some of his students discovered his abandoned project and suggested desktop 3D printing, that the project was revived.

Dechev was resistant to the idea at first. But a trial with a 3D printer on campus was promising enough to provide grant funding for the redesign of his electric hand.

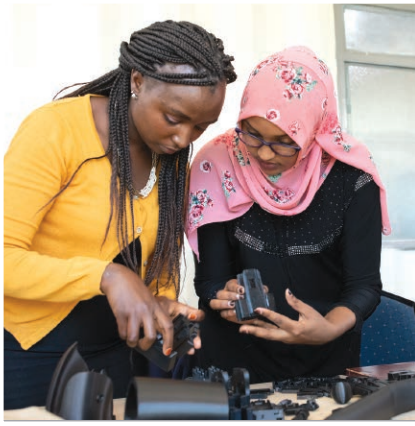
With the new 3D-printed style, the manufacturing cost went from a projected $5,000 per device in the early 2000s to only $100 to $200 USD today. With that, and in collaboration with the Denver-based Guatemala Range of Motion project, the first testing and trials began.

The VHP's 3D-printed prosthetic system has itself evolved over the years, with thousands of hours devoted to engineering design and testing. There has been on-going consultation with Canadian, U.S., and international prosthetists, as well as feedback from hand recipients, to inform the design direction. With that input, the VHP has developed a range of prosthetic arm systems. And with the help of its volunteers, the small team continually works to improve fit, appearance and function.

"Research, training and fundraising are all things that push us everyday but the primary driving force behind what we do is the recipients of our devices," states Peirone. "People like Lewis, a 21-year-old Kenyan film student who lost his arm from an electrical injury. Lewis was really self-conscious about people staring or judging him and would always try to cover his residual limb with a jacket. Receiving a prosthetic arm helped him adjust. It helps him with daily tasks like cleaning, cooking, and washing dishes. And it has helped him succeed in school too, with handling the camera equipment more efficiently. Most importantly, his confidence has been boosted which has helped his

"I will use my new hand to write and do other chores. I will use [it] to wash clothes and do so many other activities. The hand feels normal."

– Ijabu, Kenya



healing journey tremendously. And, he has hand-painted his device to be like tattoos which he's quick to show off!"

Peirone continues: "The impact on children's lives is so important too." Like Ijabu from Kenya who is 15 years old now. When she was eight, a boil developed complications and she had to have her hand amputated. When some people started making fun of her, she didn't go to school for a year. Receiving the Victoria Hand allowed her to write and do chores more easily and be much more independent.

And Isaiah, who lives in a region where temperatures go up past 40 degrees. Sadly, Isaiah would spend his day wearing a heavy jacket to hide his shame. When he got his arm, it was a really happy moment for him and his dad, and the VHP team too."

To make those stories happen the VHP provides foreign clinics – although it has partners in Canada and the U.S. too – with 3D equipment and teaches clinicians how to make the devices themselves, rather than shipping products in bulk to under-developed countries. The goal is low-cost, highly functional, durable prosthetic arm systems that can be built on-site in countries worldwide.

3D printing allows for manufacturing of parts in small batches, without the need to inventory hundreds of different parts. Printing on-demand parts means less supply-chain disruption, fewer shipping and import fees, fewer delays, and enables on-site service and repair in hard-to-reach places in the world.

"That's why we give our partners the equipment, so they can manufacture it in-country," explains Peirone. "It improves accessibility. It allows for better customization. And then if somebody needs upgrades or minor repairs, that can be done directly in their community."

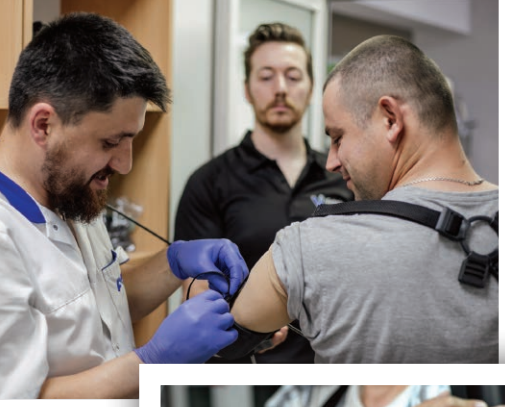
On-site, on-demand 3D printing enables the rapid replacement of worn out or broken parts which reduces downtime for individuals. This ensures that people travelling to the clinic receive care and maintenance right away which minimizes wait times without their device.

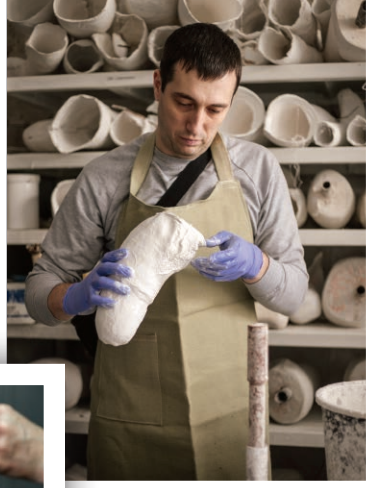
"Isaiah speaks to the significance of this," Peirone continues. "He's just 10 and growing, and has to have frequent adjustments made to his socket. But he never wants to send his device back to our clinical partner in Kenya. He doesn't want to go without it because it helps him at school and with everything he does. That's very touching to hear."

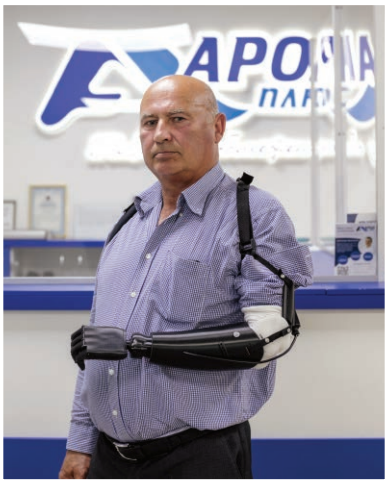
VHP-developed software aids prosthetists in the workflow and socket creation too. By partnering with local clinics in this way, the VHP's approach ensures quality care and builds in-country capacity. To date, the VHP's support has provided over 400 Victoria Hand prosthetic arms worldwide, while training over 50 clinicians in Cambodia, Canada, Egypt, Guatemala, Haiti, Kenya, Nepal, Pakistan, Uganda, Ukraine, and the United States.

Back at home in Victoria, when international clinical partners share recipient feedback that warrants a design change, the VHP engineers go to work on it in Canada. They build it, test it and then push the new designs (as digital files) via the software to partners. The VHP collaborates with the University of Victoria's Engineering Faculty to perform extensive testing on all 3D-printed parts before deployment.

Each prosthetic system is customized by selecting from dozens of possible components, including terminal devices (hands), wrists, sockets, and harness pieces, combined and customized to suit the unique needs of each person. Terminal device options are comprised of a voluntary close hand,

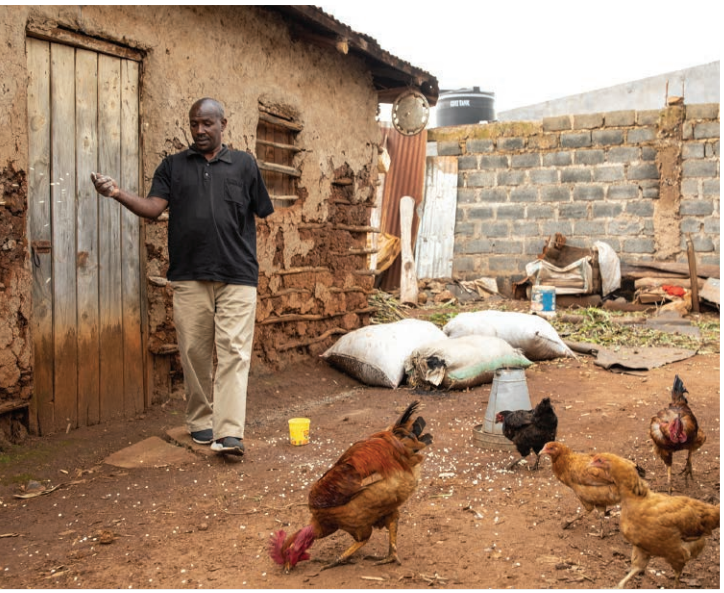






voluntary open hand, cosmetic-passive hand, and a paediatric hand. Amputees pick and choose features that work best for them and their lifestyle.

Presently, the VHP has focused its work primarily in Ukraine, fitting Ukrainian soldiers with prosthetic hands. With many prosthetic facilities destroyed by bombings, thousands of people were left without access to the care they required. Andriy is one such Ukrainian, waiting on a list for six months and counting for a traditional prosthesis.



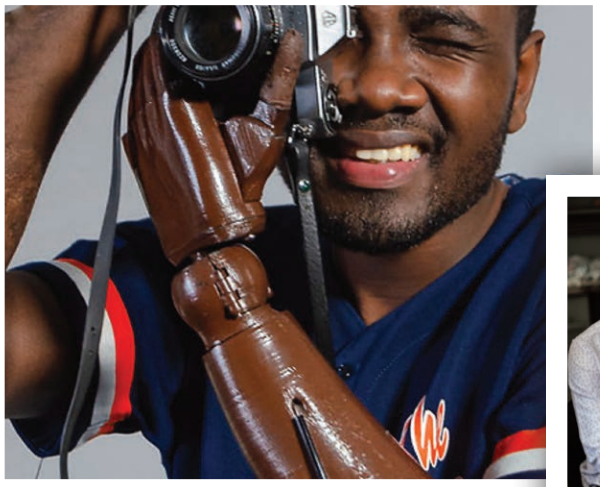
Andriy's life was profoundly changed by the invasion of Ukraine. When the war struck his country he, like many others, was called to defend his homeland. He had never before picked up a weapon. And during his courageous service he lost his arm in a mine explosion.

Subsequently, Andriy was among the first Ukrainian soldiers to receive an above-elbow Victoria Hand prosthetic arm. "For Andriy," tells Peirone, "this meant more than just functional recovery. It gave him the ability to hold both of his sons' hands again.

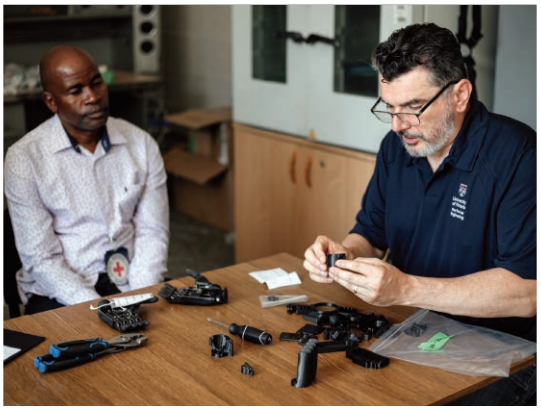
He and his wife Ivana have two young boys, and Ivana said that before Andriy got his device, their sons would fight over who got to hold their dad's one hand. After he received the device she reported that, 'Oh, now Andriy can hold both of our sons' hand at once.' It's very touching to hear things like that."

Peirone remembers another Ukrainian man for something very different than Andriy's story. "When our partners were doing the initial casting of his limb and taking measurements, he was very stern, not really talking to anyone. We thought, 'Well, maybe he doesn't want to be here.' But when he was fitted two days later, his demeanor changed completely. He was so happy. After he left the clinic with his new limb he was back in no time with cake and chocolates and a bottle of whisky to say 'thanks'. These devices can be life-changing, and it's so rewarding just to be able to help."

Filled with rewards, the work that the VHP delivers comes with plenty of challenges too, of course. There is still resistance to the technology from some prosthetic traditionalists. "It's difficult when we have someone, as we have had here in Canada, who is very interested in the device but their prosthetist is not," Peirone shares. "For us at the VHP, we don't want to say, 'Okay, well, let's work with another prosthetist who is willing' because of that existing relationship. So, it's difficult in that sense. Whereas, outside of North America and Western Europe there is so much more need for these technolo-



"Since getting the Victoria Hand my life has tremendously improved. I am more confident. I learned how to accept myself. I learned how to do things I would do before." – Lewis, Kenya



gies because so many people who can't afford a device are turned away."

Another challenge for Peirone, and perhaps the most significant, is ensuring strength and durability in 3D-printed prosthetic applications as compared to traditionally manufactured devices. To optimize strength, the VHP devices are made using the FDM (Fused Deposition Modelling) method which is the successive addition of thin layers (0.4 mm to 0.6 mm) of molten plastic material to build the parts layer-by-layer. Then, various high-stress parts like wrists and elbows are reinforced with small threaded bolts. Additionally, laser-cut stainless-steel components are incorporated into the design to function as internal structural elements, like the bones in our fingers.

But then there are the many pros associated with the Victoria Hand, like decreased manufacturing times for one. "With 3D printing, you can produce a socket or a check socket while focusing on patient/client care elsewhere," Peirone explains. "Mind you, socket builds still begin with the prosthetist taking anatomical measurements and making a traditional plaster limb impression of the residual limb, creating a positive cast, rectifying it, and then 3D scanning the positive impression. The clinician's sense of tactile feedback for incorporating space in the socket is still part of the process for each amputee individually. But, it's 3D-printed overnight and fitted the next day."

Peirone also explains that for the clinician, this process reduces equipment needs since there is no need for oven heaters, vacuum systems, and trimming and grinding equipment for making traditional sockets. And it allows for complex shapes to be manufactured directly into sockets like connection points, cable guides, and wrist connectors. And components can be printed on-demand or ahead of time and kept in stock. "It's feasible," says Peirone, "that a Victoria Hand recipient could visit a clinic, be measured and cast, and receive a custom prosthesis the next day."

And of course, the low cost of these devices is an enormous benefit of 3D printing. Rapid prototyping allows for low-cost production. Materials for a complete VHP prosthetic system cost approximately $150 to $250 USD. The VHP provides stipends to partner clinicians and technicians, typically $150 to $250 USD to support their business and livelihood, bringing the total cost of a VHP system in the $300-$450 USD range depending on location and configuration.

The VHP's charitable model ensures that recipients who can not contribute even a little bit to the cost are not denied a device. And clinicians are always reimbursed for their time. But that provides another challenge in and of itself.

"As with any charity," Peirone acknowledges, "fundraising is a challenge. Getting the word out in communities across Canada is the objective but we also want to show donors how they're making a difference around the world. Ukraine has been our largest project so far. We're working in two clinics there and opening another in Kyiv. But it's front of mind for a lot of people and generates the most support. Our donors typically want to support Ukraine, but there still is need in places like Nepal and Kenya too."

Learn more at victoriahandproject.com. Donations can be made to the Victoria Hand Project at https://www.victoriahandproject.com/donate.