

New wheelchair gets its first real-world test

Grad student's device aims to meet the needs of millions of people in the developing world.

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February 18, 2010

The U.N. Development Programme estimates that less than 1 percent of the need for wheelchairs in developing countries is met by local production, partly because small workshops can't exploit economies of scale to be profitable. Moreover, the wheelchairs that are available aren't designed for people who must push themselves over rough roads and muddy walking paths often encountered in the Third World. As a result, millions of people must rely on others to carry them or be stranded inside their homes.



The Leveraged Freedom Chair
Photo - Photo courtesy of Amos Winter

What is needed is an affordable device that can carry users comfortably and efficiently off-road, but is also small and maneuverable enough to use indoors. Amos Winter, a PhD candidate in mechanical engineering, along with a team of undergraduates and international design collaborators, has designed such a device, which he describes as performing like a combination of a desk chair and a mountain bike — "something you can comfortably sit in all day and maneuver around the office, but also use to efficiently commute to and from work." Constructed from widely available, cheap bicycle parts, the Leveraged Freedom Chair (LFC) features two large levers attached to a bicycle drivetrain that helps the chair power through mud and over rocky paths.

Winter recently returned from East Africa, where he spent three weeks in January surveying six disabled people who had tested prototypes of the LFC. Using feedback from the four-month trial, as well as a \$50,000 grant he recently received from the Inter-American Development Bank ([IADB](#)), Winter is currently tweaking the LFC design in anticipation of advancing it to large-scale production, which would provide local manufacturers with the tools to produce 500 to 1,000 units per month.

According to the U.S. Agency for International Development, 20 million people in developing countries require wheelchairs; Winter estimates that 70 percent of those people live in rural areas where regular wheelchairs simply don't work. He has been studying the problem of wheelchair production in Third World countries since the summer of 2005, when he traveled to Tanzania on a public-service fellowship and saw firsthand how wheelchairs that rely on hand-rim propulsion are too difficult to use on rough terrain and for long-distance travel. He also learned that hand-powered tricycles are too big to use indoors and usually have only one gear. His solution "for people who grew up in a village where they were literally dragging

themselves to school” is the LFC.

By pushing two levers located on each side of the LFC, a user can change mechanical advantage by simply moving hand position in order to go fast on flat ground or to produce enough torque to travel over sand or through mud. The removable levers hook into a bicycle drivetrain that has been converted to work on a wheelchair and is made entirely of bicycle parts that can be found throughout the developing world. This means that the LFC can be made and repaired anywhere one has access to a hacksaw, welder, drill and vice.

Freedom to move around

Winter has been developing the design ever since the concept won the MIT IDEAS Competition in 2008, partly in conjunction with a [wheelchair design class](#) he teaches at MIT's Mobility Lab. Winter founded this lab in 2007 so MIT students could collaborate with local manufacturers and experts from the developed world to produce mobility aid technologies.

One of those experts is Matt McCambridge, a designer for [Whirlwind Wheelchair International](#), a San Francisco-based nonprofit that produces durable, low-cost wheelchairs in developing countries.

McCambridge likes the simplicity of the LFC design, but says he has been most impressed with the intentionally slow, methodical implementation of the LFC. He praised Winter for conducting user testing early, “rather than inventing something in the lab, then using donor money to make thousands of them and forcing them on disabled people who really have no option but to smile and say, ‘thank you.’ ” McCambridge believes that Winter’s process should produce solid results that grow slowly.

The implementation began last summer, when Winter launched his first trial in East Africa with collaboration from the [Association for the Physically Disabled of Kenya](#). He and Mario Bollini '09, Danielle DeLatta '11, Benjamin Judge '11 and Harrison O'Hanley '11, spent a month in Kenya building eight prototypes of the LFC. Each chair cost slightly less than \$200 to make, which Winter said is roughly the price of a regular wheelchair in Kenya. Weighing about 65 pounds, or five to 10 pounds more than a regular wheelchair, the LFC was customized for the trial participants, who range in age and live near varied terrain in Kenya, Tanzania and Uganda. Winter returned to Africa with MIT senior Tish Scolnik four months later to interview the participants and test the efficiency of the LFC for each user.

What they learned from the “phenomenal feedback” is that although the LFC is more efficient than a regular wheelchair for plowing through mud and over big stones, it is still too wide and heavy. Winter will make the chair lighter by lowering the seat four inches and shifting the wheels back two inches, which will eliminate the need for the bulky mounting brackets that are currently used to attach the rear wheels to the chair.

‘My little angel machine’

In addition to reducing the width and weight, Winter will focus on improving the LFC for indoor use so that it functions just as well as a normal wheelchair when the levers are removed. He uses the desk chair/mountain bike analogy to describe how the LFC is intended to be used all day. Although someone might spend many hours each day sitting in a desk chair, it would be horrible to use that chair to commute to work, especially if the commute involved dirt roads. Similarly, while the mountain bike would be great for the commute, it would be awkward and uncomfortable to sit on all day at the office. “What we have now is an LFC that is great off-road and is comfortable to sit on, but is still too big to comfortably use

indoors,” Winter said.

With the trial results, guidance from manufacturing collaborators and help from a group from his design class, Winter will use the IADB grant to design a new prototype and produce about 30 chairs for another trial that will begin in August in Guatemala. One crucial goal of the trip is to develop the manufacturing equipment that will be used to build the chairs for large-scale production, which Winter hopes will begin in 2011.

Until then, he continues to review the feedback from the East African users, including Abdullah Munish, a Tanzanian spinal injury survivor who lives in a hilly town with rough roads and who has tested various wheelchairs over the past decade. Munish said that in terms of capability and functionality, the LFC is “number one” compared to other wheelchairs.

“It is strong and stable in African terrain, and you can travel long distances and uphill without using too much energy,” he told Winter. “I would say that we have [a] life saver ... I just call it my little angel machine.”