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A Grand Challenge? Maybe Not

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... but the problem posed by America's half-million homeless is ripe for engineering solutions.

When the management of an apartment building in London implanted spikes in the pavement to fend off would-be loiterers in 2014, a public petition with 130,000 signatures prompted the city to order the spikes removed. No such public outcry is heard in the U.S. capital, where bus benches are short and curved with notches to deter sleepers, made of metal that gets extra cold in the winter and keeps people from sitting too long.

At home and overseas, American engineers regularly apply their problem-solving skills to improving the human condition. But when it comes to one of the most pressing social problems in the nation's cities—our homeless population—the most visible examples of engineering are often ones that deprive them of comfortable places to rest and sleep. These range from “no-sit benches” that you can only lean against to strategically placed rocks embedded in flat surfaces and fences put up to

block homeless encampments. Daily impediments reinforce what some homeless people see as a callous attitude on the part of authorities. “They think everyone has forgotten about us, no one cares about us, so they think they can do whatever they want to us,” says Rachel Higdon, 26. A former writer and vendor for *Street Sense*, a Washington, D.C., newspaper written and distributed by the city’s homeless, Higdon lived on the streets for over two years, during which time she was often forced from her sleeping spots by law enforcement officers.

In 2016, the U.S. Department of Housing and Urban Development counted 549,928 people experiencing homelessness in the United States. Around 68 percent of them had some form of shelter, in the form of “emergency shelters, transitional housing programs, or safe havens,” but the remaining 32 percent were “unsheltered.” Advocates for the homeless believe that the numbers are higher than reported because the population is so difficult to count.

While homelessness is as old as poverty, it became acute in America in the early 1980s. “A big part it was the rollback of support for affordable housing programs and mental health programs,” says Andrew Hening, director of homeless policy for San Rafael, Calif. “Local communities had no idea how to think about the problem.”

The causes are complex and usually interwoven with the rising cost of housing, education, and medical care; falling wages; mental health and addiction problems; and a lack of family or institutional support, as can happen to teens who age out of the foster-care system. “Believe me, you don’t have to be uneducated or a ne’er-do-well, an alcoholic or a drug addict or anything like that to be homeless,” says Ken Martin, a 63-year-old *Street Sense* vendor, who found himself homeless as a result of business reversals. “It can happen to anybody. If you don’t have a support system and you have an illness hit, that can be that.”

Engineering programs that explore solutions for the homeless are more the exception than the rule. Students see more advantage in international experiences than in helping to solve domestic problems, says Juan Lucena, director of humanitarian engineering at the Colorado School of Mines. “You want something that beefs up your résumé. You can say that you went to sub-Saharan Africa or you went to Latin America—you can claim some form of international experience. That’s going to help you on your résumé. If you say that you went downtown and you worked with the homeless community that lives in the underpass of the highway, that’s not sexy. The students know that, and it’s unfortunate.” Jon Leydens, coauthor with Lucena of *Engineering and Sustainable Development*, says he “realized that engineers with the best of intentions sometimes fail to engage people who are

homeless—neglecting critical steps in the contextual listening phase.”

Avoidance of Shelters

Listening would expose a range of problems that often seem insurmountable to people experiencing homelessness. Warmth is only one piece of the puzzle. Existing shelters are often rife with theft, bedbugs, unhygienic conditions, violence, and sexual assault. Many people would rather be on the street than in a shelter. “A lot of people don’t want to go into them because they feel freer outside,” says Higdon. “It actually feels safer outside sometimes.” In his five years on the street (and 14 years on D.C.’s waiting list for subsidized housing), Martin says, he spent only two nights in shelters. Shelter or no, the homeless are almost always sleep deprived and dehydrated, he says.

Kevin Passino, professor of electrical engineering and director of Ohio State University’s Humanitarian Engineering Center, is among those who have listened. His textbook *Humanitarian Engineering: Advancing Technology for Sustainable Development* contains several sections discussing homelessness and a range of technologies that can help. There’s low-hanging fruit, like low-cost, portable tent shelters made of local materials. Students can also work on affordable ways to light and heat the tents, where standard camping equipment may not be appropriate. “You need to engineer things so it’s sort of people-proof,” he says. Take candles for example—they’re light, cheap, and produce heat and light, but someone might roll over at night and kick it. “A homeless woman told me one of her best friends burned to death.”

One way Lucena tries to encourage empathy in students is through homework problems. “Imagine if you’re trying to teach your students heat transfer principles. Instead of teaching in an abstract way, you teach about heat transfer that happens to homeless people when they sleep in the streets,” he says. “The minute they begin to see the application of engineering to what is a very basic human need—the need to stay warm at night—they begin to get it and appreciate it very much.”

Beyond comfort, health, hygiene, and storage for belongings top the list of things that people on the street need. It’s difficult for the homeless to stay on schedule with their medication, something Passino says technology could help fix. Mental health and other medical problems are rampant in the homeless community, and anything—like an electric scheduling system—that might help them gain access to medicine and remember to take it on time every day would be massively helpful, he says, but “you run into a problem of money to operate these systems.”

“Carrying stuff is a problem,” says Martin. “I have a bad back.” Train and bus stations did away with long-term storage lockers out of security concerns. Martin and Higdon both reported hiding their belongings out of sight in black plastic trash bags, but said that people would sometimes find them and throw them away. At the same time, “you can’t drag all that stuff to a job interview. They’re not going to hire you. Heck, they’re not going to let you in!” says Martin. He and Higdon would both like to see engineers come up with homeland-security-compliant public lockers where they could store their stuff for 24 to 72 hours, possibly centralized at the places where they receive their services.

Some useful technology already exists. Martin, for instance, wears a rechargeable battery-powered Milwaukee jacket that houses five heating elements to help keep him warm and aid his circulation. These jackets currently go for upwards of \$200 from Home Depot. His was a gift, but such innovations can be life-saving, “if they could find a way to make this affordable.”

Access to clean bathrooms—or any bathroom access at all—poses a significant hurdle. Public restrooms are becoming rare. Shop owners don’t want to let the homeless use their restrooms to clean up, Martin says, “but then they complain that we smell bad.” For many people, it’s a choice between going to the bathroom or going to jail for public urination. Because of that, many will simply forgo drinking water so that they don’t have to go. This leads to extreme dehydration and kidney conditions, Martin says.

One solution to this is the “Portland Loo,” a low-cost public city toilet that locks for privacy, is easily cleaned, and has outdoor faucets that anyone can use even when the toilet is occupied. Portland, Ore., adopted the design and has a loo stationed every eight blocks. This benefits tourists as well.

Higdon says that hygiene was one of her greatest difficulties. “I was one of the few who used SOME’s,” says Higdon. So Others Might Eat (SOME) is a Washington, D.C., homeless service center that opens daily for bathing. The catch is that it’s open for only 45 minutes each morning for women. “You only had three showers and 25 women trying to take a shower. Not everyone would get to shower. A lot of people were embarrassed to go or couldn’t get there when they were open.” A San Francisco organization, Lava Mae, had a different approach: retrofitting old buses into public showers that can traverse the city in search of the people who most need them.

Obtaining feminine hygiene products can be especially hard, Higdon notes. That’s where Betty Stearns comes in. Stearns recently received her degree in aerospace engineering from the University of Southern California’s Viterbi School of Engineering. She’s now in training at IBM as a sales engineer.

and will eventually work with the public sector in the company's education division. "I loved aerospace engineering, and airplanes are really cool," she says, "but at the end of the day, they already exist and fly, and only rich people can have them. I wanted to help the community."

Before she left school, her Lotus Cups menstrual cup design took second place and a \$10,000 prize at the Min Family Engineering Social Entrepreneurship Challenge. Her company sales pitch reads, "You're on the second day of your period with no access to a tampon or a way to clean up. How are you going to go to a job interview?" This encapsulates the cleanliness conundrum that many homeless women face.

Her Lotus Cups design was inspired when, one day, a young homeless woman asked Stearns to buy her tampons. "I had never really thought about what homeless women might do in that situation, but I hadn't had to spend money on tampons in over a year [because she used a menstrual cup]." Existing menstrual cups are expensive and not necessarily easy to clean or use. Stearns's design uses ultrahydrophobic materials, allowing the contents to fall out easily. Not only that, but bacteria can't stick, either. "It's something to make it better and safer for homeless women to do because they don't have as much access to water and sinks to wash it and their hands."

It's still in the prototype phase. "There has been pushback from shelters because they don't like to think about women emptying blood in the bathroom toilets or sinks." Stearns and her team have instead been marketing more to low-income women with large families who can't afford to buy menstrual products for, say, their five daughters every month. They are working with the OB-GYN department at the University of California, San Francisco's medical school to make it better adaptable to women's different shapes. They're also working on FDA regulations and on finding more funding. Until then, they donate other menstrual cups to shelters and hold workshops on how to use them—because they can have a steep learning curve that turns some women off.

New Smartphone Applications

"The phone is a lifeline," says Silvia Figueira, associate professor of computer engineering at the University of Santa Clara and director of the Frugal Innovation Hub. "Some would pay for the phone before food. The phones actually enable them to get out of poverty. How do you get a job if you don't have a phone? How do you find housing?" A higher percentage of homeless people own smartphones than the rest of the population, it turns out—in part thanks to Obama Phone, the Obama administration's promise of free smartphones to the poor and homeless. But the device has

not been fully exploited.

Figueira got involved when she was approached by an organization called the Computer Technology Alliance (CTA) asking her help in making services for the homeless more accessible, once they figured out that most people on the streets had access to phones. The program is called Mobile for All. “We participated in that by developing applications that were uploaded to phones that were donated,” she says.

Figueira also started a hackathon that she called Hack for Homeless to write code for the application and think of other creative solutions that might help the homeless over a 24-hour period. It’s developed into a popular new initiative called Hack for Humanity, in which students tackle different humanitarian issues—the next one will center on disaster recovery. The event attracts up to 100 students each time.

With that many dedicated coders working all at once, the students were able to come up with some remarkable applications that connect people on the streets with vital services.

Figueira says that someone devised a way to help people handle the phones better, coding big buttons that were easy to see and understand. Another thing they created was an announcement tool. “The organizations have a hard time reaching out to people,” she says. “Let’s say you have a job fair tomorrow and you have to alert homeless people to that—how do you do that? We created an announcement tool that people registered for with their phone numbers” to receive word of available services. “This is being used by Sacred Heart and another organization called Downtown Streets Team.”

Figueira’s team also collaborated on another project in Oakland to connect young homeless women with medical services. “The problem is that the women have a high rate of STDs, but they don’t like to be found,” she says. The team developed a questionnaire tool for medical offices that would tell if a woman was at high risk and connect her with a doctor. The apps would also place women’s contact information in the medical system so they could receive needed information. With all of this technology at their fingertips, one of the greatest challenges for the homeless is keeping their phones charged. “There are no outdoor charging stations,” says Martin. “You have to develop a rapport with someone [at a shop] who will let you charge things.”

Housing First

The most obvious response to homelessness is, well—homes. “That’s the first thing. You want to end homelessness? Build homes. That’s the bottom line,” says Martin. “If we get people off the street and get them to bed, get them to rest, and let them heal—they’ll find the solutions themselves. You can’t keep people out and expect them to be well.” Dwellings need not be large, fancy, or complicated—anything with a locking door, a place to store some stuff, a couch that turns into a bed, a toilet and a shower. “Give them some comfort, a place to use the toilet and take a shower, that’s it. It’s not that much to ask for, and it would save lives. Just get them out of the elements.”

Housing First is a systems approach that offers shelter to the homeless without requiring that they be sober, medication-compliant, or employed. Those issues are addressed concurrently or even after people are housed. Andrew Hening employed the model with his HOT (Homeless Outreach Team) program in San Rafael 18 months ago. A recent M.B.A. graduate from the University of California—Berkeley, Hening says he became profoundly aware of homelessness through an interdisciplinary innovation course called “Reimagining Slums” that integrated engineering design and systems thinking. During the course, he mapped out the causes of chronic homelessness, such as ill health, debt, addiction, and jail time.

HOT introduces displaced people one at a time to providers of medical and other services and employment counselors. “You’re coming up with a customized housing plan for how you’re going to support them. You address all their needs at once rather than make them find their own way through an impossibly complex system,” he says. Among HOT’s 20 occupants, there has been a sharp reduction in 911 contacts and a parallel drop in emergency medical transports.

Typically, homeless outreach efforts attempt to cater to different people in the same way, Hening says. “We often think, ‘Well, if we just had the right program in place, everything could be solved.’ But the reality is that everyone is so different individually, that their needs are so unique that what you really need is a better process.”

Aggies Without Limits (AWL), New Mexico State University’s humanitarian engineering club, is one of the few campus initiatives tackling a local homeless problem. Kenny Stevens, the club’s faculty adviser and professor of civil engineering technology, and Victor Meraz, a graduating senior in mechanical engineering technology, got involved when a local group, Community of Hope, approached them.

Working with the group starting in 2011, they helped turn what had been a squatters’ camp into a

tent city for the homeless. AWL students laid out the camp design and drainage system, and conducted a survey of the retention pond. The camp has a resident homeless mayor who oversees operations and a homeless police force that patrols the area. It's built to be transitional and rotate people into permanent dwellings so others can take their spot. It has a bathroom facility and 50 tent pads (for families as well as singles and couples). "It has about a 90 percent housing success rate and has placed around 500 individuals and families into permanent housing," says Stevens.

Two years ago, AWL switched its focus to Foxhole Homes, an organization that caters to homeless veterans. On 150 acres near Holloman Air Force Base, Foxhole Homes is building permanent individual 215-square-foot Earthship homes made from local mud and soils and recycled tires and bottles. Shops and business opportunities are planned. Meraz and his cohort made the CAD drawings for the first homes.

It hasn't been easy. "We've done projects in five different countries, and it's a lot easier to work in Nicaragua than it is to work in Alamogordo, New Mexico," says Stevens. With both Community of Hope and Foxhole Homes, the students have run up against bureaucratic red tape and local "not in my backyard" attitudes that work against them.

But like Ohio State's Passino, Stevens says that once students see that assisting the homeless means solving real engineering problems, they become enthusiastic. "It's been really nice. [Foxhole has] gotten the work they need, and students have gotten service hours out of it. Several students have gotten their senior projects out of it," says Stevens. "There's no shortage of students who want to give back. People—students especially—will do good things if you just give them a chance."

Students don't have to look outside their own campuses for opportunities to help. The homeless student population is alarmingly large. A 2015 California State University system study found that nearly 9 percent of its students had experienced homelessness. Community colleges have even higher rates—the Wisconsin HOPE Lab surveyed 33,000 students at 70 community colleges across 24 states in 2015. The survey revealed that "about half of community college students were housing insecure, and 13 to 14 percent were homeless."

In response, two mechanical engineers at the University of California—Los Angeles started Students4Students (formerly called the Bruin Shelter), which offers long-term free housing to up to eight students at a time. Luke Shaw, a Ph.D. student, and Louis Tse, a recent graduate who is now an engineer at NASA's Joint Propulsion Laboratory, modeled their effort on the Harvard Square

Homeless Shelter in Cambridge, Mass., established over 30 years ago. “At UCLA, we would see students sleeping in places where they really shouldn’t be, like the lounges and lecture halls and other common spaces,” Shaw says. “You see a lot of students showering in the gym, even though they clearly weren’t there to work out.” The shelter is funded as a student organization and through donations, sponsors, and grants. Now in their second season, they hope to expand—a good thing, because they have a waiting list 100 students strong. Shaw and Tse prove that engineers can help through altruistic desire, not just design.

By Jennifer Pocock

Jennifer Pocock is associate editor of Prism.

Design by Nicola Nittoli

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