

# Rachel Kremen

## Robotic Insect Takes Off

Researchers have created a robotic fly for covert surveillance.

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*A life-size, robotic fly has taken flight at Harvard University. Weighing only 60 milligrams, with a wingspan of three centimeters, the tiny robot's movements are modeled on those of a real fly. While much work remains to be done on the mechanical insect, the researchers say that such small flying machines could one day be used as spies, or for detecting harmful chemicals.*

*"Nature makes the world's best fliers," says Robert Wood, leader of Harvard's robotic-fly project and a professor at the university's school of engineering and applied sciences.*

*The U.S. Defense Advanced Research Projects Agency is funding Wood's research in the hope that it will lead to stealth surveillance robots for the battlefield and urban environments. The robot's small size and fly-like appearance are critical to such missions. "You probably wouldn't notice a fly in the room, but you certainly would notice a hawk," Wood says.*

*Recreating a fly's efficient movements in a robot roughly the size of the real insect was difficult, however, because existing manufacturing processes couldn't be used to make the sturdy, lightweight parts required. The motors, bearings, and joints typically used for large-scale robots wouldn't work for something the size of a fly. "Simply scaling down existing macro-scale techniques will not come close to the performance that we need," Wood says.*

*Some extremely small parts can be made using the processes for creating microelectromechanical systems. But such processes require a lot of time and money. Wood and his colleagues at the University of California, Berkeley, needed a cheap, rapid fabrication process so they could easily produce different iterations of their designs.*

*Ultimately, the team developed its own fabrication process. Using laser micromachining, researchers cut thin sheets of carbon fiber into two-dimensional patterns that are accurate to a couple of micrometers. Sheets of polymer are cut using the same process. By carefully arranging the sheets of carbon fiber and polymer, the researchers are able to create functional parts.*

*For example, to create a flexure joint, the researchers arrange two tiny pieces of carbon composite and leave a gap in between. They then add a sheet of polymer perpendicularly across the two carbon pieces, like a tabletop on two short legs. Two new pieces of carbon fiber are placed at either end of the polymer, as a final top layer. <sup>1</sup> Once all the pieces are cured together, the resulting part resembles the letter H: the center is flexible but the sides are rigid.*

China take on our problem? One sector's hazardous waste is another's gold mine. In among the toxins that make our computers work are valuable metals, such as gold, silver and platinum.

Many developing nations are all too happy to pluck them out for far less than it would cost to recycle them in richer countries.

For a country like Canada, which has a growing problem with electronic waste, a cheap, export solution can look very appealing.

According to Duncan Bury, head of product policy for Canada's National Office of Pollution Prevention, this country produced 158,000 tonnes of electronic waste in 2002.

"We estimate that if nothing is done . . . that number will increase to 206,300 tonnes by the year 2010," Bury said.

"There are toxic components there. There's lead, there's cadmium, there's poly-brominated flame retardant. If one can avoid having them released into the environment that's what we should be doing." Yet Environment Canada doesn't track the export of electronic waste because, despite all the toxins, the government agency doesn't generally consider it hazardous. So it gets shipped to whichever country will process it at the lowest price.

Post-doctoral research fellow Alastair Iles argues that it's cheaper to send our electronic waste overseas because we can't see the hidden costs. Iles has worked with the University of California at Berkeley and as an environmental lawyer in Australia.

"The costs of worker protection and safer recycling facilities are not factored in," he said. "We don't know if there are worker or environmental laws being enforced overseas, and we can't see the conditions that recycling happens in. We can't see all the workers in Asia who may be forced to work on ewastes because of poverty."

Actually, we can catch a glimpse. Basel Action Network, an environmental watchdog group based in Seattle, Wash., visited China in 2001 and returned with telling images of children sitting on heaps of electronic waste. They are now posted on the organization's Web site.

"The kids are playing in them like they are sand piles," said Basel Action Network coordinator James Puckett.

Tags and stickers found on some of the scrapped equipment pointed to Canadian companies. Puckett estimates that 50 per cent of the electronic waste observers saw was from the United States, with another 20 per cent from Canada. A printer found in Guiyu, China carried a tag from the Canada's Department of National Defence.

The tag on the Hewlett-Packard printer read, "No Longer Required Return to Supply."

The team also found piles of broken, leaded glass in irrigation ditches and large mounds of assorted scrap beside rivers — ideal circumstances for toxins to leach out and poison the environment.

Basel Action Network activists returned to China last April and found similar scenes of environmental mayhem, where poor labourers burn circuit boards and insulated plastic wires on open fires with little more than a handkerchief to protect them from the fumes.

These are the real costs of electronic waste export, Basel Action Network activists argue, and we're sticking poorer nations with the bill. "What they are doing is a global environmental injustice," Puckett said. "They are disproportionately injuring a certain portion of the world with an environmental hazard simply because they are poor."

If it is illegal to export electronic waste to the developing world, Puckett asks, "Why is it still coming in?"

Iles said he believes part of the reason lies in the convoluted journey electronic waste often takes.

"Shipping e-wastes through many middlemen and to Singapore, the Philippines, and then China makes it very hard to track where e-wastes end up," said Iles. Repeated hand-offs of waste shipments also make it hard to determine who is responsible for sending the waste overseas in the first place.

"Some entrepreneurs have made a business out of finding the loopholes in the Basel Convention," said University of Toronto environmental policy professor Pierre Desrocher. "There's always a way around if you want to get these materials delivered to India."

Perhaps the biggest loophole in the Basel Convention is the definition of hazardous waste. As with any international treaty, the specific terms of the Basel Convention are rather complicated. Determining what, exactly, qualifies as hazardous waste can be challenging. Basically, there is a list of things that are not considered hazardous, and a list of things that are if they could exhibit certain qualities. The Basel Convention treaty states that waste that is "capable, by any means, after disposal, of yielding another material, e.g., leachate, which possesses any of the characteristics listed above," including toxicity should be considered hazardous.

Environment Canada doesn't quite see it that way, though.

Lyne Monastesse, a manager at the federal department's transboundary movement branch, said it only considers electronic waste hazardous if it is displaying hazardous characteristics at the time of export.

"For the computer to have the characteristic where it will leach, it has to be broken," said Monastesse. "We have to look at the state of the waste when it leaves the country."

Basel Action Network activists argue that Canada's is not an accurate interpretation of the international agreement. They note that under the Basel Convention a computer doesn't have to be leaching (leaking) toxins at the time of export: something is deemed hazardous if it could leach toxins at any point after disposal. Other developed nations have interpreted the Basel Convention the same way as the activists. A 1999 guidance paper from Environment Australia found that while there was some ambiguity in the wording of the treaty, component testing indicates that cathode-ray tube (CRT) computer monitors and the vast majority of printed circuit boards should be considered hazardous waste under the agreement.

"It is true that these listings are open to some national interpretation," said Puckett. "But not wild deviation."

Monastesse admitted she does expect electronic waste shipped from Canada will be broken up once it reaches its destination and she said that at that point it has to be handled properly. Other developed nations interpreted the Basel Convention to incorporate a broader perspective, including Australia and the U.K. Environment Australia found testing indicated CRT monitors and the vast majority of printed circuit boards should be considered hazardous waste under the Basel Convention.

Regardless of the Basel Convention definition of hazardous waste, some nations — including China — have forbidden the import of electronic waste. Signatory parties to the treaty are supposed to abide by these national bans. Yet Canada's waste still turned up in China in 2001. Asked how that happened, Monastesse said Environment Canada didn't know about China's ban.

"We have to rely on the mechanism of the Basel Convention (for notification)," she said.

Monastesse said she didn't know how much of Canada's electronic waste has been exported. There's no need to keep track, she said, unless it's leaching toxins at the time of export. Only then would it require a permit, according to Monastesse. No such permits have been issued.

It's possible that electronic waste that Canada does consider hazardous — material that is broken down and releasing toxins — is all being dealt with here at home. But with an intricate network of waste exporters it's also possible that it's slipping out of Canada undetected, perhaps mixed in with all that electronic waste Canada considers safe for export.

In a lengthy paper on the impact of computer waste in Asia, Iles notes that a ban such as China's may be ineffective because of corrupt local governments and "quasi-governmental town and village enterprises" that are more than happy to take on the scrap anyway.

"The problems of computer wastes are clearly known to Asian governments and many recyclers, residents, and activists," writes Iles. "Yet e-waste regulation and enforcement differ across the region and within large nations such as India and China."

For the last 10 years, many nations have sought to strengthen the Basel Convention with an outright ban on the export of hazardous wastes intended for final disposal from countries that are members of the OECD (Organization for Economic Co-operation and Development) to non-OECD countries.

The Basel ban amendment would be completely separate from bans made by individual nations such as China against the import of certain hazardous wastes. The amendment would act as an overarching ban, in fact, blocking the import of all hazardous wastes to any non-OECD nation. The Basel ban amendment has never taken effect, however, because Canada and a handful of other developed nations have opposed it.

Puckett said Canada has in fact been the most outspoken nation against the ban, acting as a mouthpiece for the United States, which never signed the Basel Convention in the first place. The Canadian government argues there are good reasons for opposition.

"If a developing country wants to invest in a recycling facility, we don't believe it's the role of the OECD states to not allow them to develop this capability," said Monastesse of Environment Canada.

Even if they don't want to deal with wealthier countries' cast-offs, some developing nations do have needs of their own to consider.

China, which manufactures and consumes a lot of electronics, needs to develop an electronics recycling industry to deal with domestic e-waste.

This sentiment is more than just a wealthy-country delusion. Even in developing nations, there are those who oppose the Basel ban amendment.

Kate O'Neill, author of *Waste Trading Among Rich Nations: Building a New Theory of Environmental Regulation* and professor of environmental science, policy and management at the University of Southern California at Berkeley, said progress on the ban is very slow in part because many non-OECD nations feel their recycling facilities are up to snuff and that they shouldn't be lumped in with countries such as China that have poor environmental records. Others argue that an export ban goes against basic economics.

Barun Mitra is the director of a non-profit, public-policy think tank in New Delhi, India called the Liberty Institute. Mitra is a supporter of India's growing recycling industry. He said it makes good economic sense for India to recycle the electronic waste of the developed world because it provides the country with a cheap source of materials, such as valuable metals, that can be used in other products. A Basel Ban would interfere with the free trade of these raw materials that we call waste.

"Free trade is the most effective way to optimise resource utilization and improve economic efficiency," he said.

"We in India do not have enough computers and other electronic products. These products would be just lying and polluting the environment at the end of their life. By importing similar products from richer countries, our recyclers are able to reach economies of scale and make extraction of resources from these dead products economically viable. As a result, environmental stress in India is lowered, as it is in the exporting countries."

Mitra further argues better environmental practices can only come through increased consumption, which stimulates the demand for great efficiency, because that's when those gains start to make economic sense.

"Environmental quality, just like any product quality, is a value-added product," he said. "One has to be able to afford it."

In the wake of December's tsunami, few people in Asia will be thinking about the problem, at least for a few weeks.

But it seems clear that in the long run, if the Asian recycling industry props up national economies, people in those countries will be able to afford more electronics.

Theoretically, manufacturers would make more money, which could be spent on safer recycling facilities. But the real world provides plenty of reality checks. Canada's signature on the Basel Convention regulating export of hazardous waste to poor countries means little since Canada deems much of the material non-hazardous.

Environment Canada seems happy to hand off the problem — as long as it's well packaged and shipped elsewhere.