# ENGINEERING TECHNOLOGY MONITOR

NOVEMBER 2013

Compiled by Subeesh A C

Technical Information Centre

# US Army experiments with crowdsourcing equipment design

By C.C. Weiss

The Combat UE-1 vehicle is one design being explored through ArmyCoCreate.com

The US Army Rapid Equipping Force (REF) is experimenting with internet-based collaboration. With the help of the crowdsourcing gurus at Local Motors, it has launched ArmyCoCreate.com, a website designed to let soldiers, designers and engineers collaborate on identifying soldier requirements and designing prototypes to address them.

REF is a division of the Army that works to rapidly address the ever-evolving issues facing soldiers in the field. Formed in 2002 to support operations in Afghanistan, REF works with industry, academics and other parties to help soldiers overcome obstacles.

ArmyCoCreate is an experimental website designed to further that mission. It works as a sort of broader version of REF's expeditionary lab program in Afghanistan. These labs are open for soldiers to stop in and discuss problems they're experiencing in the field.

"When we have our labs in theater, soldiers come up to the labs and the labs have capability to reach back to a lot of scientists and engineers," Gary Frost, REF Deputy Director for Futures, tells us. "What we wanted to do with the co-creation piece is engage more of the soldiers so that we can get more than just maybe one perspective. This is a process that we can get online and we virtually have access to thousands of soldiers, or any number of soldiers, at any given point."

Local Motors' Rally Fighter

REF partnered with Local Motors in August to develop the experimental crowdsourcing platform. Local Motors was chosen not because REF is looking specifically for vehicle solutions, but because of its wealth of experience and resources in crowdsourcing. In addition to hosting its own Forge online community, which has designed vehicles like the Rally Fighter, Local Motors has also collaborated with DARPA on military design through the Experimental Crowd-derived Combat-support Vehicle (XC2V) Design Challenge.

REF launched ArmyCoCreate last month and will trial the website for several months to see how online collaboration can be put to work toward its greater mission. The community is open to the public and free to use. Soldiers who are currently deployed or have been in the past identify problems, and the community brainstorms solutions and discusses and fine-tunes designs.

"Soldiers are living and breathing the fight, day-in and day-out, so they have the best ideas for new capabilities to solve their most urgent challenges," says Sergeant First Class, Adam Asclipiadis. "We need to connect those ideas with the people who can make innovations a reality."

The ArmyCoCreate trial will operate in a four-step process: problems, solutions, project and prototypes. The first step is identifying the problems that soldiers experience in the field. The community will be able to vote on these problems in order to push them further along. The solutions stage is all about brainstorming and creating sketches and graphics of potential solutions to the identified problems or to problems that have not been identified specifically.


The next two phases involve the pursuit of the best idea. REF will ultimately select a project to pursue and then post more specific necessities, such as size, weight, power, operation and endurance guidelines. From there, community members will work on specific aspects of the project in order to create a final design that fits the bill.

In the final prototyping stage, the goal will be to rapidly create a prototype version of the design. REF will host two week-long "Make-a-Thons" at the Maneuver Center of Excellence (MCoE) Fort Benning with the goal of using 3D printing equipment to prototype the design. Those will be held December 9-13, 2013 and January 13-16, 2014.

REF opted to keep the time frame on the trial period tight because it wants the potential system to develop solutions within 90 to 180 days. That will, of course, vary depending upon the nature of the project, but it's aiming for an average idea-to-solution turnaround time of no longer than six months.

After the trial period is over, REF will evaluate ArmyCoCreate on a variety of criteria, including "community participation levels, the ability to refine and properly articulate requirements, and the capacity to create a manufacturable, virtual design." It will then decide whether and how to proceed with a more permanent crowdsourced model. It also plans to look through the other ideas generated by the site and possibly pursue additional projects.

While the current trial is limited to unclassified projects, REF isn't ruling out using a similar system for classified projects.

"Once we do this, and review it, and decide whether or not this is a good fit for the REF, then we would look in the future, and we've already, you know, thought about, how we could do this on what we call the high side, which would be our secure net," Frost says.

The photo gallery shows a couple of the designs that have been posted on the ArmyCoCreate website.

# Crashing rockets could lead to novel sample-return technology

By Brian Dodson

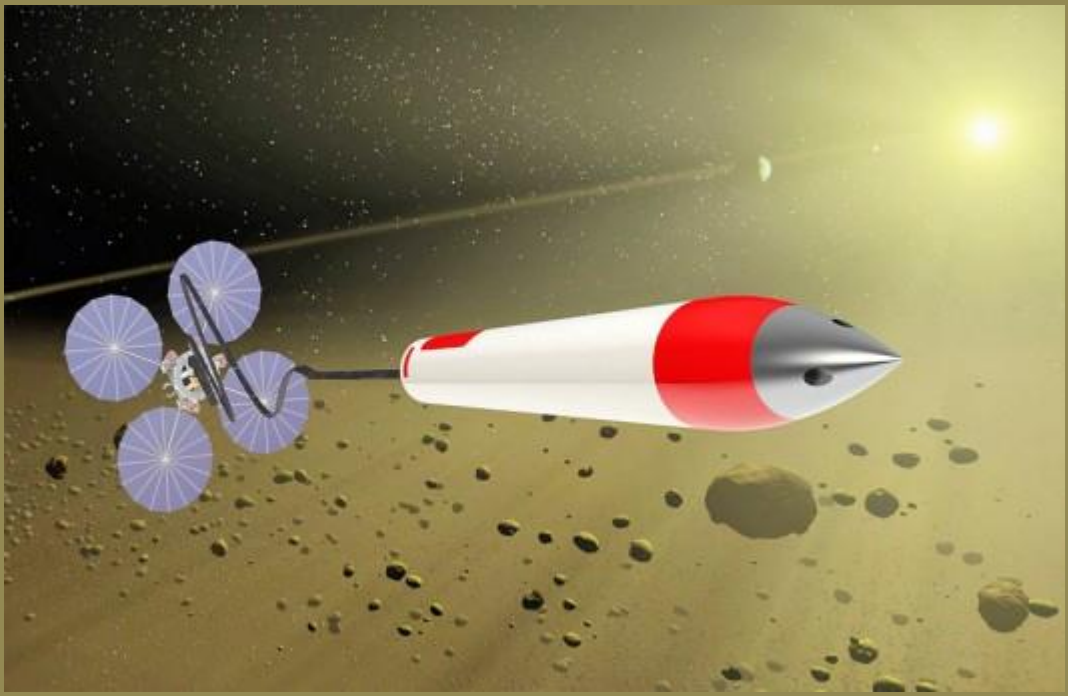
Is it supposed to look like that? In this case, yes

The terms "auger in" and "lawndart" refer to rather exciting and decidedly dangerous methods of recovering a rocket, during which the screaming rocket buries its pointy end deep in the ground. Such over-enthusiastic landings provided a group of research students from the University of Washington (UWash) the inspiration for a new approach to collecting samples from hostile environments, such as the crater of an erupting volcano or a melting nuclear reactor.

UWash offers an upper-level undergraduate class called Rockets and Instrumentation. Taught by Professor Robert Winglee as a "hands-on course for the development of rockets and their instrumentation," the essence is to design and build a high-power model rocket with a science package and telemetry capability. At the end of the quarter, the class participants take their finished rockets to a firing range for the ultimate test.

While most of the rockets perform well, there is the occasional problem. After seeing a number of sub-optimal landings (of the lawndart variety) over the years, Prof. Winglee began to wonder if something useful could be rescued from the remarkable ability of rockets to bury themselves deep in the ground.

He conceived what is now the Sample Return Systems for Extreme Environments (SRSEE) project, for which he obtained NASA support through the Innovative Advanced Concepts program (NIAC). The basic concept is to collect and recover physical samples by deliberately crashing rockets into the material to be sampled. SRSEE is being carried out in partnership with Robert Hoyt's Tethers Unlimited. The project is currently at Phase II, which brings with it roughly US$500,000 of support over an 18-24 month period.



A rocket will impact and bury itself in a surface. In the process, ports on either side of the nose cone collect samples of the material near the surface. These samples will be collected in an interior capsule that can be removed from the rocket, using a method such as pulling on a tether. The tether would be attached to a recovery vehicle, perhaps a balloon or helicopter if working in an atmosphere, or a rocket-propelled vehicle in space, which would reel in the capsule to recover the sample. This hard impact sampling system would be far simpler than an attempt to make a soft landing in treacherous situations.

In space, there is another approach to pulling the tether, which is to put a spacecraft into a very slow (perhaps a foot per second) pass by the object to be sampled, and fire the sampling rocket before reaching the point of closest approach. When the spacecraft and the object, each following their own slightly different trajectories, drift apart, the tether will pull the sample capsule from the lawndart sampler.

In recent tests at Black Rock desert in Nevada (see video below), rockets were fired into the ground from a kite at an altitude of 3,000 feet (915 m). The test altitude was not high enough, as the rockets struck the ground while still under full thrust. However, they had broken the sound barrier, and components of the system survived the supersonic impact.

The next round of tests will begin at a higher altitude, and impact speeds of Mach 2 are expected.

# EVA electric taxi can travel 200 km on a 15-minute charge

By Ben Coxworth

The EVA taxi prototype on display at the Tokyo Motor Show

Given how many miles taxis put in per day, the concept of electric taxis is certainly appealing. That said, one problem is the amount of time that their batteries can take to recharge – most cabbies won't want to shorten their work day or do a split shift, in order to juice up their cars. With the EVA taxi, however, they wouldn't have to. The prototype vehicle can reportedly get enough of a charge in 15 minutes to travel 200 km (124 mi).

EVA was created via the TUM Create project, a collaboration between Germany's Technische Universität München and Singapore's Nanyang Technological University. The 200-km figure is based on typical Singapore taxi-driving patterns, with the air conditioning turned on.

The vehicle gets the most out of one charge due partly to its lightweight carbon fiber reinforced polymer (CFRP) monocoque body, along with a unique thermal management system that keeps the 450-volt 63-Ah lithium polymer battery from overheating when charging rapidly.

It also utilizes an overhead air conditioning system, in which cooling air is delivered to each passenger individually. This means that power isn't wasted cooling the entire cabin, or cooling seats with no passengers in them. Additionally, the AC gets a break thanks to a separate system that sucks heat and moisture away from passengers through the seats.

Other features of the EVA taxi include a front passenger seat that folds forward to reveal an integrated child seat, and an onboard smartphone-accessible system for entertainment, booking and digital payments.

The 5-door prototype has four seats, a 0-100 km/h (62 mph) acceleration time of 10 seconds, and a top speed of 111 km/h (69 mph). It is currently on display at the Tokyo Motor Show.

## U-CAT robotic sea turtle set to explore shipwrecks

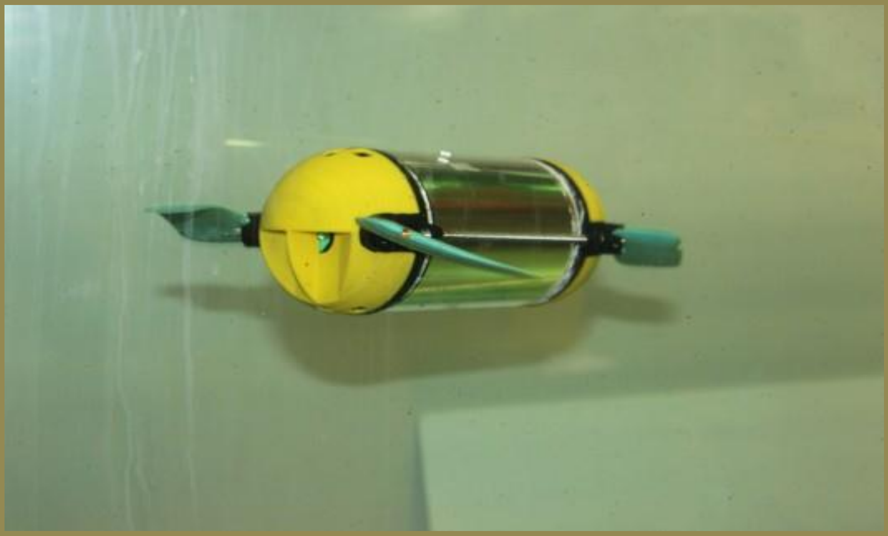
By Ben Coxworth

Tallinn University of Technology researchers Asko Ristolainen and Taavi Salumäe watch the U-CAT robot in an aquarium

When was the last time you heard about a sea turtle getting stuck in a shipwreck? Never, that's when. Although that's partly because stuck turtles rarely make the news, it's also due to the fact that they're relatively small and highly maneuverable. With that in mind, the European Union-funded ARROWS project has created U-CAT – a prototype robotic sunken-ship-exploring sea turtle.

Just like a real turtle, U-CAT has four independently-driven flippers that allow it to move up and down, forward and backward, and to pivot on the spot. Propellers would let it do those same things, although they'd also churn up much more visibility-limiting silt in the process.

U-CAT is autonomous, so it doesn't require a control cable that could get snagged or tangled. It also has an onboard video camera, which records video that can later be used to visually map out the inside of the shipwreck.



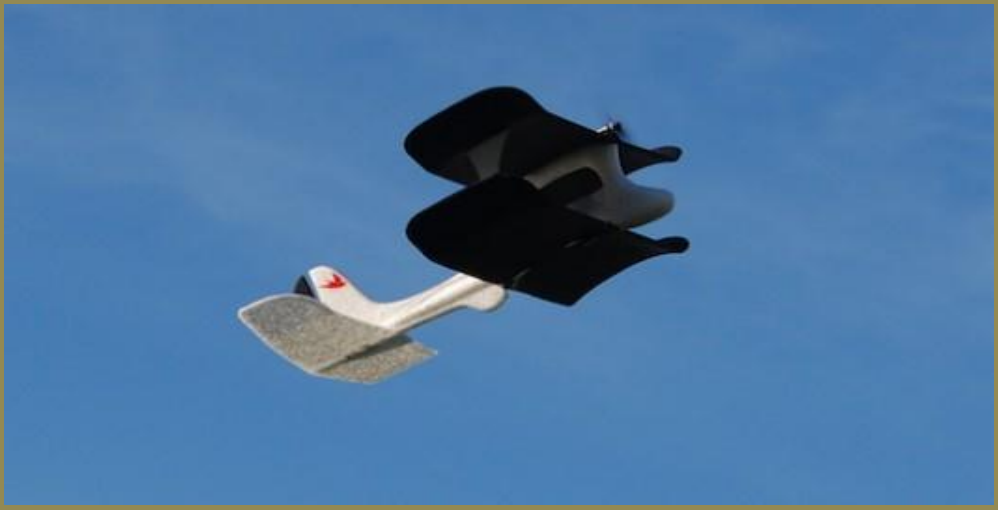
Plans call for the technology to be tested at underwater archeological sites in the Mediterranean Sea and the Baltic Sea. The idea is that U-CATs could ultimately be used in conjunction with other underwater robots that are too large to enter wrecks, and too expensive to risk losing within them.

Once they get into regular service, U-CATs might not be the only robotic turtles in the sea. Scientists from the ETH Zurich research group are developing a roboturtle of their own, known as naro-tartaruga.

The U-CAT prototype can be seen in action in the video below. If you're interested in seeing it first-hand, its public premier will be taking place this weekend at the London Science Museum's Robot Safari exhibit.

## "World's first" smartphone-controlled SmartPlane takes off

By Darren Quick



The SmartPlane can be controlled by tilting the connected iOS device

Parrot's AR Drone quadcopter has been strutting its smartphone-controlled stuff for a few years now, but fixed wing remote controlled aircraft have been a little thinner on the ground – and in the air. TobyRich, a German company specializing in smartphone-controlled gadgets, has now launched its SmartPlane, which it calls "the first smartphone-controlled airplane in the world."

Although the developers of the PowerUp kit that adds smartphone control to a paper plane might dispute TobyRich's claims, the SmartPlane is the first complete package we've come across in terms of a smartphone-controlled RC plane. Built from expanded polypropelene (EPP), the aircraft itself is durable and lightweight, with the engine and propeller offset inside the plane's nose to reduce the chance of damage even in head-on collisions – although an extra propeller is included if a hard landing proves too hard.

The lithium-polymer battery that powers the aircraft is also extremely light, adding just 1 g (0.03 oz) to the weight of the plane. TobyRich says the battery will provide over five minutes of flight time at full throttle, but up to 30 minutes is possible as long as there is plenty of soaring and gliding involved. Recharging the battery via the included microUSB cable takes about 15 minutes.

The SmartPlane connects to an iOS device via Bluetooth Smart (aka Bluetooth low energy), which gives it a range of up to 60 m (200 ft). The plane can only be paired to one device at a time, with a white LED on the plane indicating its connection status. The plane's firmware is also automatically updated wirelessly to ensure the latest version is always onboard.

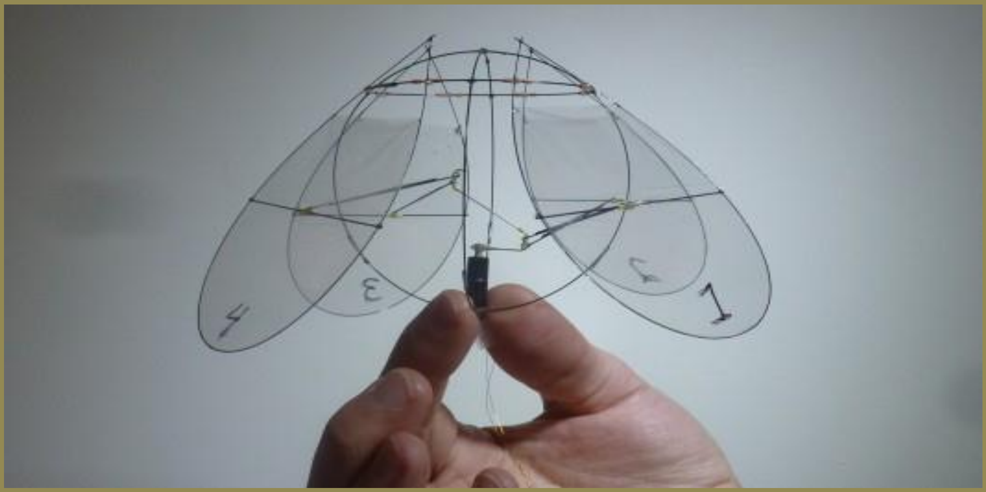
The use of Bluetooth Smart (and the fact it doesn't have a camera) means that, unlike the AR Drone that connects via Wi-Fi, the SmartPlane can't relay video back to the controlling iOS device's display. What users are provided is an artificial horizon that dominates the bulk of the display with a throttle touch slider below surrounded by gauges indicating remaining battery charge and signal strength. The SmartPlane's 256-level proportional rudder is controlled by tilting the iOS device.


TobyRich says the plane has been designed to stay in the air at low speeds to make it possible to fly indoors without "laser-sharp reflexes." The controller app also includes a FlightAssist feature that automatically makes adjustments and corrections to help stabilize the plane's flight.

The SmartPlane retails for €69 with free shipping within Germany. Buyers in the UK and Switzerland need to pony up an extra €12 for postage with TobyRich looking to extend availability to other regions. The SmartPlane app is available as a free download from the App Store

## Prototype "flying jellyfish" takes to the air

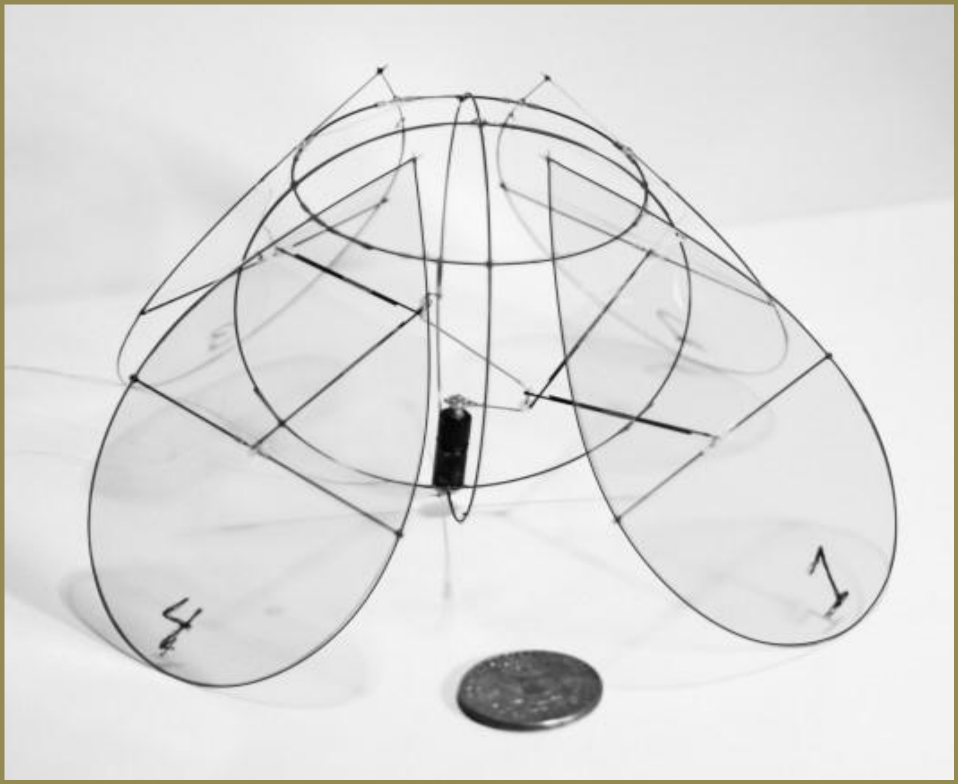
By Ben Coxworth



New York University's flying jellyfish

What could be better than a jellyfish-inspired machine that swims underwater? Well, how about one that flies in the air? A group of scientists from New York University have created just such a contraption, and it could have big implications for tiny flying robots.

Ordinarily, flapping-wing MAVs (micro aerial vehicles) require some sort of automated flight control system, that allows them to respond instantaneously to things like wind gusts. The problem is, besides being difficult to develop, these systems require physical hardware that adds unwanted weight and complexity to the tiny aircraft.




The NYU machine, however, is able to remain stable simply by virtue of its design. Created by Dr. Leif Ristroph, it consists of four wings that are arranged "like the petals of a flower," that flap at a rate of 20 times per second. When rising or falling, its motions do indeed resemble those of a pulsating jellyfish. Once hovering in place, its actions are more like those of a moth.

So far, it still relies on an external hard-wired power source, and it can't be steered. Nonetheless, it's considered a promising proof-of-concept model, that could one day lead to centimeter-sized surveillance, search-and-rescue, or reconnaissance flying robots.

# Mitsubishi adapts EV batteries for Super Giraffe robot

By Jason Falconer


The MHI-Super Giraffe can handle 15 degree slopes and works for 5 hours on a rechargeable battery

While the world watches anxiously as the Tokyo Electric Power Company (TEPCO) begins its most dangerous operation yet in the ongoing clean-up of the damaged Fukushima Daiichi nuclear plant, large Japanese corporations continue to design and build robots to help go where people cannot. Mitsubishi Heavy Industries (MHI) has built a new remote-controlled robot called the MHI-Super Giraffe, which has an extendable arm capable of reaching up to 8 m (26 ft), and borrows battery technology from Mitsubishi Motor's electric vehicles.

The Super Giraffe (Global Innovative Robot Arm For Future Evolution) weighs 4 tons and moves at a maximum speed of 6 km/h (3.7 mph) on flat ground. Though not the most agile robot, it can handle up to 15 degree slopes. It's powered by a rechargeable Lithium-Ion battery adapted from Mitsubishi Motor Company's electric vehicles (specifically the i-MiEV), and can work up to 5 hours on a single charge.

It gets its name from a five-step telescopic ladder connected to a 7-axis robot arm, which can be used to reach otherwise inaccessible areas. Crucially, this arm can be equipped with modular tools weighing up to 20 kg (44 lb) to perform different tasks inside the plant. Operators will be able to open or close valves, inspect pipes for leaks, cut through metal and concrete, and decontaminate an area, all from the safety of a wireless control station. The company says it will release the design plans so that other companies can help develop modules for the robot to expand its capabilities.

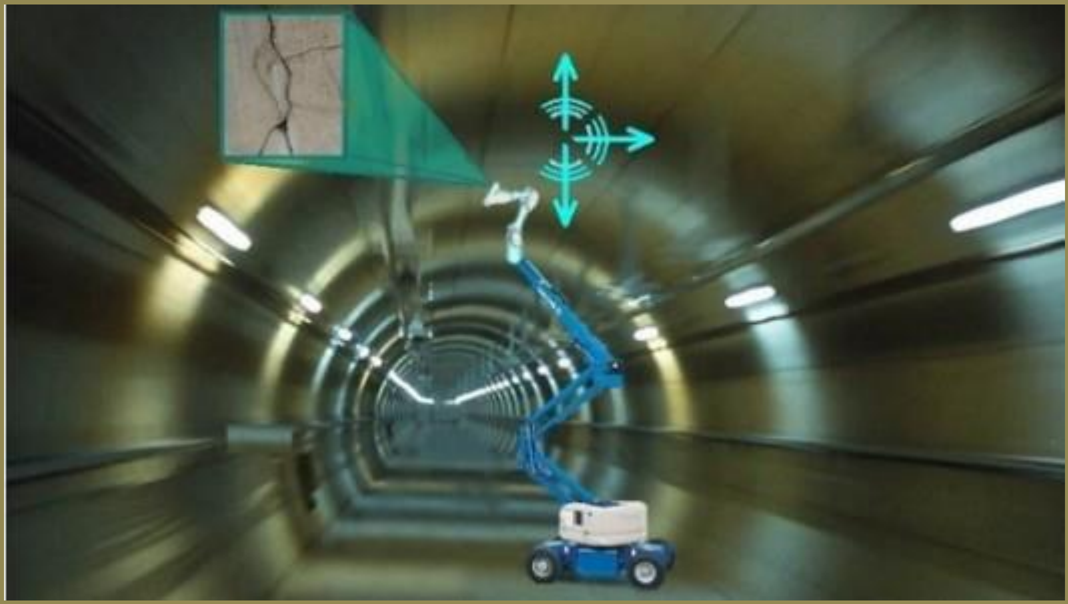
Another cool feature are its four outriggers, positioned on the four corners of the robot's body, which extend out like legs to help stabilize it whenever its arm is extended. A sensor inside the robot calculates its center of gravity at all times, and sounds an alarm if it starts to tilt too far in any given direction.

The robot was developed alongside examples from Toshiba, Hitachi, Honda, and Cyberdyne as part of the New Energy and Industrial Technology Development Organization's "Research and Development Project for an Unmanned Disaster Response System". It joins Mitsubishi's smaller nuclear inspection and maintenance robot, the MHI-MEISTeR.

Yesterday TEPCO began the delicate process of removing fuel rods from the damaged Fukushima reactor number 4. The company is using a remotely-operated crane to lift the rods out of their compartments and into water-tight containers for transport to a different storage pool on site. It's considered one of the most dangerous operations in the clean up, since the delicate rods (which are 4.5 m / 15 ft long and weigh 300 kg / 660 lb) are normally only moved by computer control.

## ROBINSPECT project developing a tunnel-inspecting robot

By Ben Coxworth



The proposed ROBINSPECT robot

For anyone who worries about being caught in a cave-in, you'll be glad to know that tunnels such as those found in subways or mountain roads are regularly checked for structural degradation. These tests are typically performed using the naked human eye, and require the tunnel to be closed to use for as long as the process takes. With this in mind, the European Union ROBINSPECT program is now developing a robotic tunnel inspection system, that should be both quicker and more thorough than human inspectors.

At the heart of the system will be a semi-autonomous robotic unit, consisting of a small unmanned vehicle with a crane mounted on top of it. On the end of that crane will be a robotic arm, containing multiple sensors.

The whole setup will move down the length of a subway, motorway or other tunnel, conducting a complete inspection in one pass. Along with cracks, faults such as rust stains, corrosion, and exposed reinforcements will also be sought out.

At a rate of about one meter per second, the robot will use its computer vision system to rapidly acquire rough 2D images of every inch of that tunnel's walls. When cracks meeting certain minimum criteria appear in those images, the robot will proceed to stop and obtain more detailed 3D images. At this point, ultrasound and lasers will also be used, to ascertain the exact width and depth of the cracks.

Human operators will still be able to remotely issue basic commands such as Advance and Stop, although the robot itself will be able to "learn" both from its own findings, and from accessing an online database compiled by human tunnel inspectors. This will allow it to notify its operators, when it does come across flaws that need attention.

It is hoped that when the three-year project is completed, the finished robot will result in increased safety (both for tunnel users and inspectors), shorter tunnel-inspection closure times, and financial savings as less human workers will need to be paid, and for less hours.

A working prototype is expected to be ready by next year, at which point it will be tested in the London underground, three underground stretches of the Egnatia highway in Greece, and some experimental tunnels in Switzerland.

## Review: Estes Proto X nano quadcopter

By Jonathan Fincher

It's actually a little startling to pick the Proto X up for the first time, because it isn't much bigger than some insects you might find in your backyard

You may have noticed that we enjoy our quadcopters here at Gizmag, from the GPS-equipped Phantom 2 Vision to the palm-sized 1SQ V-cam. Recently though, we had a chance to try out a somewhat unusual style of quad in the form of the tiny Proto X from Estes. It may not have a laundry list of features under its belt, but the Proto X does hold the distinction of being the smallest quadcopter we've ever reviewed ... by a huge margin

### What's in the box

The Proto X costs US$39.99 and comes ready to fly with its own controller right out of the box.

Inside the package, you'll find:

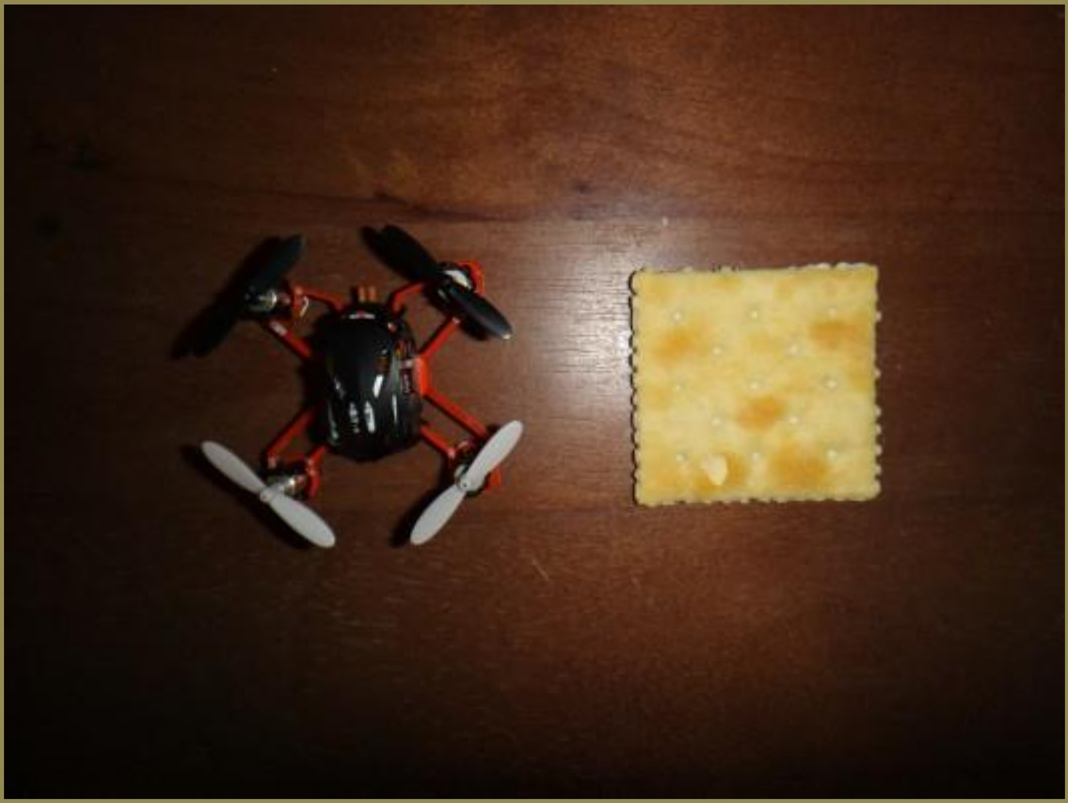
- the Proto X quadcopter
- 2.4 Ghz radio transmitter
- USB charging cable
- four replacement rotor blades
- instructions

The only necessary components missing from the box are two AAA batteries, which are needed for the transmitter. However, fitting them into the controller and charging the quadcopter via USB are the only steps needed before the Proto X is prepared to take off.

**A pocket-sized UAV**

I really can't stress enough how incredibly tiny this quadcopter is. It's actually a little startling to pick it up for the first time, because it isn't much bigger than some insects you might find in your backyard.

Estes claims it's one of the lightest quadcopters in the world with a weight of 0.4 oz (11.3 g). Measuring from the tip of the rotor blades, each of its four sides is approximately 2.5 in (6.4 cm) long. Even the frame by itself is just 1.8 in (4.5 cm) on each side, giving it almost the exact same footprint as a typical saltine cracker.



The included radio transmitter is built to match, measuring a little over 3.5 in (8.9 cm) wide and 2.5 in (6.4 cm) wide, making it look vaguely like a shrunken video game controller. Even put together, the copter and transmitter are compact enough to fit inside a regular pants pocket.

## Piloting a bug

Due to its size, flying the Proto X feels like guiding a large bug, right down to the faint buzzing noise it makes. If it weren't for the LEDs that light up when it's switched on, it would be difficult to keep track of it at a distance. My haphazard attempts to take photos of it in flight with an ordinary digital camera made me sympathize with anyone who's tried to record a UFO.

Once you get used to following it though, it flies about the same as a full-sized model. The controls are straightforward – left stick for altitude and rotation, right stick for direction, plus a couple buttons to adjust the trim – and an internal gyroscope keeps it flat while in the air. Hovering in place takes a bit of practice though, since the slightest breeze will knock it off course and the bundled transmitter can be difficult to use (more on that later). I've spent a couple hours flying it and still have trouble keeping it perfectly still in mid-air, though it's not too hard to guide it in the basic direction I want it to go.

The box and instructions say it's intended for indoor use, so that's where I flew it most, but I did take it outside once just to see how it would handle. After a gust of wind blew it far away after it had barely lifted a few feet off the ground though, I understood why the manufacturer had made that call. It might fare better on a nicer day, but in my area, this isn't exactly the time of year to find out.

On a full charge, the Proto X can remain aloft for approximately 10 - 15 minutes. When it's about to run out of power, the LEDs near each rotor will begin to flash rapidly, at which point it has about a minute left of flight time before it slowly floats to the ground and stops. To maintain the quadcopter's balance, its 3.7 V 100 mAh LiPo battery is secured inside the plastic body, so unfortunately you can't extend that flight time by swapping batteries. Once the battery is drained, it takes about 30 minutes to completely recharge it.

**Made for small hands**

The main hindrance when piloting the Proto X though is the controller itself. Holding the transmitter feels like holding a child's toy, especially if you have larger hands. There's really no comfortable way to grip both thumbsticks at once without folding the rest of your fingers awkwardly out of the way. I understand the designers probably didn't want to ship a regular-sized transmitter with the nano copter, but even just a couple extra inches in width could have made the controls much less cramped.

The trim buttons are also located in spots that are difficult to reach when controlling the quadcopter simultaneously. Adjusting the trim usually involves landing, pushing the button for the desired direction, taking off again to see if it worked, and repeating until it seems to be hovering correctly. The controller also doesn't have trim buttons for the copter's rotation, just for the direction it flies, which could have been useful at times.

**Tough little bug**

Because of its size, I thought it might need to be treated delicately when I first pulled it out of the box, but the tiny Proto X quad seems to be just as durable as its larger brethren. Crashing at full speed into walls, dropping straight onto a hardwood floor from as high as the ceiling, and even ricocheting between a chair's legs did nothing to faze it. The worst damage it suffered was when a rotor blade popped off during a crash, which was easy enough to retrieve and put back in place.

At one point when it was hovering in place, my dog actually leaped up and snatched it right out of the air. He released it almost immediately, and I made sure to get him out of the room before flying it from then on, but the quadcopter still came out of it without even a scratch. I doubt it would survive being stepped on or dropped off a building, but it's still nice to know it can survive a few mishaps during regular use.

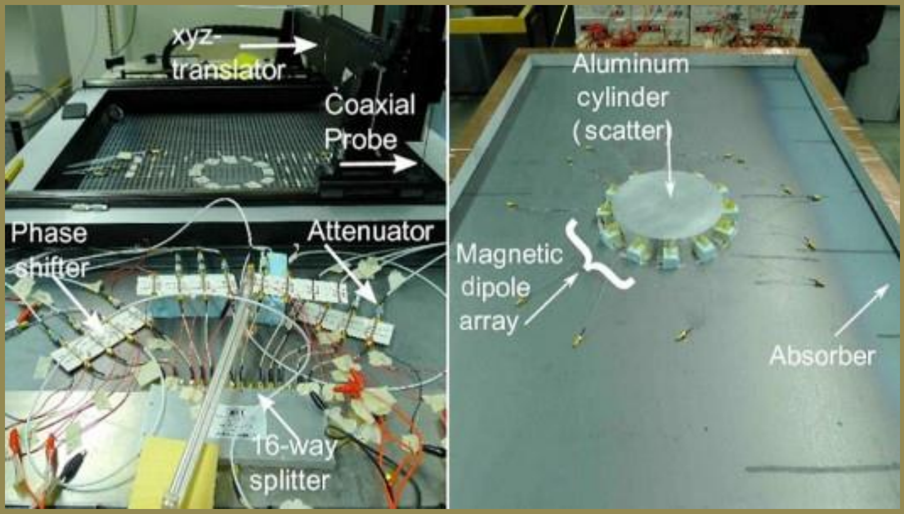
**Overall impressions**

Aside from its novelty size, there aren't too many standout qualities to speak of on the Proto X. It doesn't have a camera, it can't perform any fancy tricks, and it's not really designed to be reprogrammed or customized. That said, for the price, it is a simple and dependable quadcopter that's easy enough for beginners to pick up. If you're looking for an R/C quadrotor with a myriad of features, then the Proto X is not going to cut it. However, if you're just looking for a tiny quad that you can fly around your living room or office for fun, then it should fit the bill perfectly.

Since Estes is a subsidiary of Hobbico, the Proto X quadcopter is available right now from its retailer, Tower Hobbies, if you want to try it out for yourself.

## Two research groups create active invisibility cloaks

By Brian Dodson



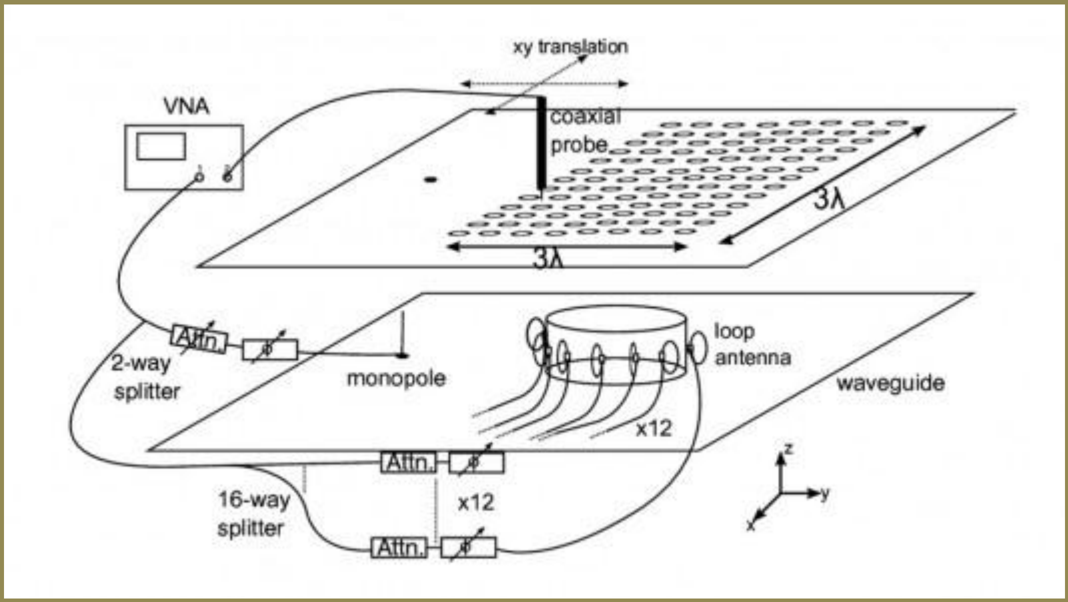
View of the equipment supporting an active invisibility cloak and the cloak itself

Sometimes everything can seem to happen at once. The new game in town is active invisibility cloaks (AIC), which use electronics and antennas to generate a cloaking field to hide an object. Two types of active cloaks have just been revealed (excuse the pun). While being impressive feats of technology, such cloaks could easily be defeated in practice.

Earlier this week, a research paper from Andrea Alu's group at the University of Texas demonstrated that any passive invisibility cloak (e.g., one just depending on the properties of metamaterials) would not only fail to achieve invisibility under broadband illumination (for example, white light), but would actually cause the cloaked object to stand out more strongly than when it is uncloaked.

A natural question to ask is if there are any other possibilities. In fact, there are. An active cloak uses sensors, electronics, and antennas to actively generate an electric field near the surface of the cloak that interferes destructively with the radiation scattered from the cloak and contents. This electric field will be called a cloaking field. In the past few days, Professor George Eleftheriades' EE research group at the University of Toronto has revealed a working model of an active cloak, while Prof. Alu's group has worked out a new approach for making active cloaks.

In essence, if the cloak transmits the exact opposite of the light being scattered from the cloak, it will appear as if there is no object there. Even the shadow behind the cloak, which results from the illumination that is scattered from the front of the cloak, is removed. Such a cloak is as broadband as the sensors, electronics, and antennas can handle.




Schematic of the University of Toronto active invisibility cloak

Sounds good, but what's the catch? Turns out there are two catches. First, to successfully use an active cloak you need to characterize the light that is scattered from the target. Until this is known, the cloaking field required to cancel out the scattered illumination can't be determined. Second, you can't design your cloaking field from local measurements at the site of the antenna.

Measurements from around the cloaking device are needed before the signals to be sent to the antennas can be properly calculated and generated.

Both of these requirements cause a response delay, the time interval between first sensing a source of illumination and the cloak's generation of an effective cloaking field. Even given infinitely fast electronics, the response delay is going to be similar in size to the time it takes light to cross the longest dimension of the cloak.

An example of where an active cloak would function quite well is to hide from a Doppler radar system. The Doppler effect tells us that light scattered off a moving target changes in frequency by an amount proportional to the relative speed between the source of the waves and the target. A change in speed of 15 m/s (34 mph) will change the frequency by one part in ten million.

Fourier analysis tells us that it takes time to notice so small a change in frequency. In particular, to be able to detect that 15 m/s change in speed, a 10 GHz Doppler radar would have to have a pulse containing ten million oscillations to be sure we would notice that one of them was missing. As a result, the pulse would have to be about a millisecond in length.

Given that the Doppler radar has a sensitivity set to measure a pulse a millisecond long, it won't notice that an active cloak takes a handful of nanoseconds to sense the pulse, and generate an effective cloaking field for the target. The portion of the pulse that is not effectively cloaked is simply too short to be detected.

What sort of cloaking job is difficult for an active cloak? It is when the radar (also including light) avoids sending out any pattern or similarity which can be predicted by the cloak's electronics. As the cloaking field cannot be generated until the pulse is sufficiently understood to erase its scattering from the cloak, any foreknowledge of the radar pulses makes the job of generating a cloaking field easier.

Assume that the radar illumination takes the form of pulses having constant interval, frequency, strength, and shape. In that case, the cloak's electronics could learn that each pulse is the same, so it only needs to pump out a predetermined cloaking field at the fixed pulse interval to cloak the target. This does assume that the target doesn't change shape or position – unlike the passive metamaterial cloaks, the external fields do penetrate into the region containing the target. Accordingly, we want to avoid giving the cloak such cues.

Arguably the worst case is if the illumination appears at random intervals, the short pulses have randomly varied frequency, width, and shape, and the wavelength is short compared to the volume that is being cloaked. These characteristics accomplish the befuddlement of an active cloak in separate ways. Clearly, by avoiding random intervals the cloak cannot initiate a cloaking field in advance of the arrival of an illumination pulse – even it it knows the shape of the pulse in advance, it doesn't know when the pulse will arrive, causing an unavoidable and perhaps lengthy response delay.

Similarly, if the pulses have different nominal frequencies, the cloak will take some time to detect what the frequency is, and figure out an appropriate cloaking field. If the pulses have different widths, they will include different bandwidths of frequencies around the nominal frequency. This is very confusing, as you may have to monitor the entire pulse to see if there are hidden signals within it.

This brings us to the effect of pulses of variable shape. If the pulse has a constant intensity save for a narrow region at the middle of the pulse, there will appear a short burst within the pulse where the frequency spread of the pulse suddenly increases. This cannot be prepared for, so an active cloak cannot effectively hide a target from such a doctored pulse – some of the scattered signal (or an improperly matched cloaking field) will leak out of the cloak, making it visible. Remember that the cloaking field, if not properly matched to a scattered field, is roughly as easy to detect as would be the scattered light from the object; if they were not the same size, the one couldn't erase the other.

To sum up, the Achilles heel of an active cloak is its response delay – it cannot respond to randomly changing radar pulses quickly enough to effectively cloak a target from detection. To reduce the ability of a radar to find a cloaked object is likely possible, to achieve perfect cloaking is not. What we still have to learn is how closely an active cloak can approach perfection against an attack which is random in several different directions. At this point, however, the new active cloaks are not, as many in the media are announcing, "an invisibility cloak that works." At least not in my book.

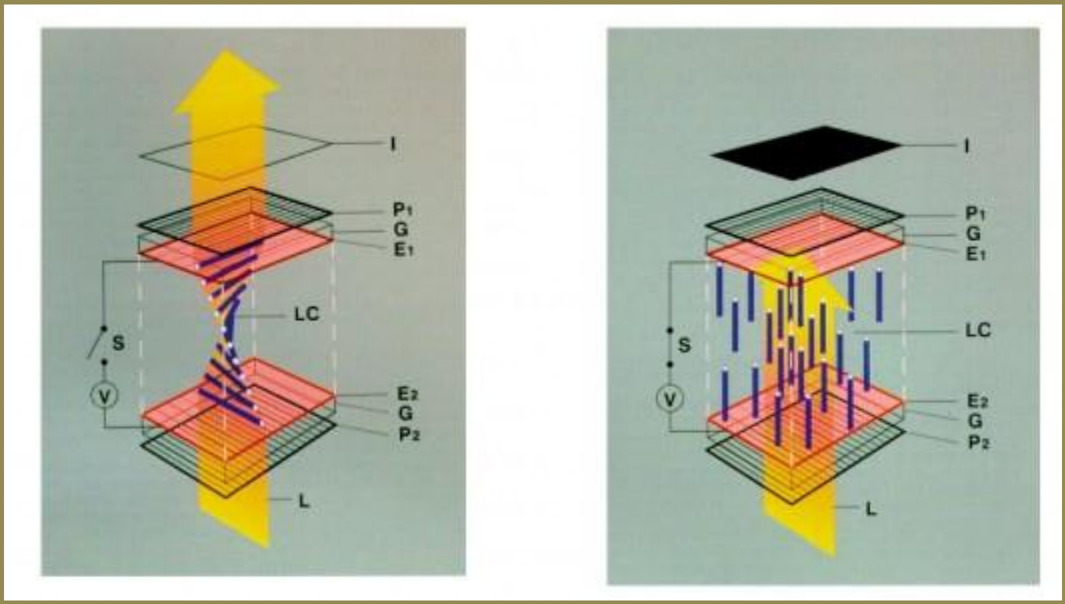
## How to build a "stealth" computer display

By Brian Dodson

Stealth LCD monitor showing a Rubik's cube through polarizing sunglasses

Computer monitors have become larger and larger over the decades, making it easier for passersby to read sensitive information or activities over one's shoulders. An additional layer of security (and fun) can be added to your computer's LCD display by following the lead of Brusspup, a well-known online illusionist and computer artist. Just remove your display's outer polarizing filter, and use polarizing sunglasses to view your display.

A liquid crystal display (LCD) depends on liquid crystals that can rotate the polarization axis of light as it passes through. Here's how an LCD display works. An LCD pixel is made up of numerous layers, but must include a pair of linear polarizers and a thickness of nematic liquid crystal with transparent electrodes that can apply a voltage across the liquid crystal.




On the left side of the figure above appears an LCD pixel with no applied voltage. Light L is coming up from beneath, usually from a set of LEDs in newer displays or CCFL (Cold Cathode Fluorescent Lamps) in older ones. The light is polarized horizontally by horizontal polarizer P2, then passes through a liquid crystal LC. While the pixel can apply a voltage across the liquid crystal through transparent electrodes E1 and E2, on the left the voltage is switched off.

The thickness of the liquid crystal is set so that it rotates the polarization of the light by 90 degrees in the no voltage state. This converts the horizontally polarized light leaving polarizer P2 into vertically polarized light ready to enter vertical polarizer P1. Finally, the light passes through P1, and appears as a bright pixel.

What happens when there is an applied voltage across the liquid crystal is shown in the right hand of the figure. The voltage causes the liquid crystal's rodlike molecules to line up with the applied field. In that configuration there is no structure to alter the polarization of the light, so the light leaving the liquid crystal is still horizontally polarized. This light cannot pass through the vertical polarizer P1, so this appears as a dark pixel. As the level of the voltage is changed, the pixel can let any amount of light pass through, from bright to dark.


Interesting things happen when one changes the orientation of the final polarizer. Shown above is an inexpensive calculator with an LCD display that normally displays dark numbers on a white background. The outer polarizer has been removed, and replaced after turning it 90 degrees. The display now shows white numbers on a dark background. If you trace the light through the figure on how an LCD display flows, but replace the vertical polarizer P1 with a horizontal polarizer, you will see why this happens.

As mentioned earlier, Brusspup specializes in optical illusion. He noticed that if you completely remove polarizer P1, an LCD display shows essentially uniform illumination with a varying pattern of polarization over the screen. However, as the human eye is not very sensitive to the polarization of light with which it sees the world, an LCD display from which the final polarizing film has been removed appears to be bright and featureless.

Now if you wear vertical polarizing filters over your eyes, you will once again see the original image and the image is not visible to anyone not wearing polarizing glasses. Brusspup, understanding the theory, decided to make such a stealth display.

He began with the materials shown above: a used LCD display costing US$20 from a pawn shop, a roll of linear polarizing film, scissors with which to cut the film, the frame of a pair of glasses, a small screwdriver to pry off the bezel of the display, and hobby knifes to cut and remove the outer polarizing film from the LCD display. we'll briefly go through his conversion procedure, but more details appear in the video.

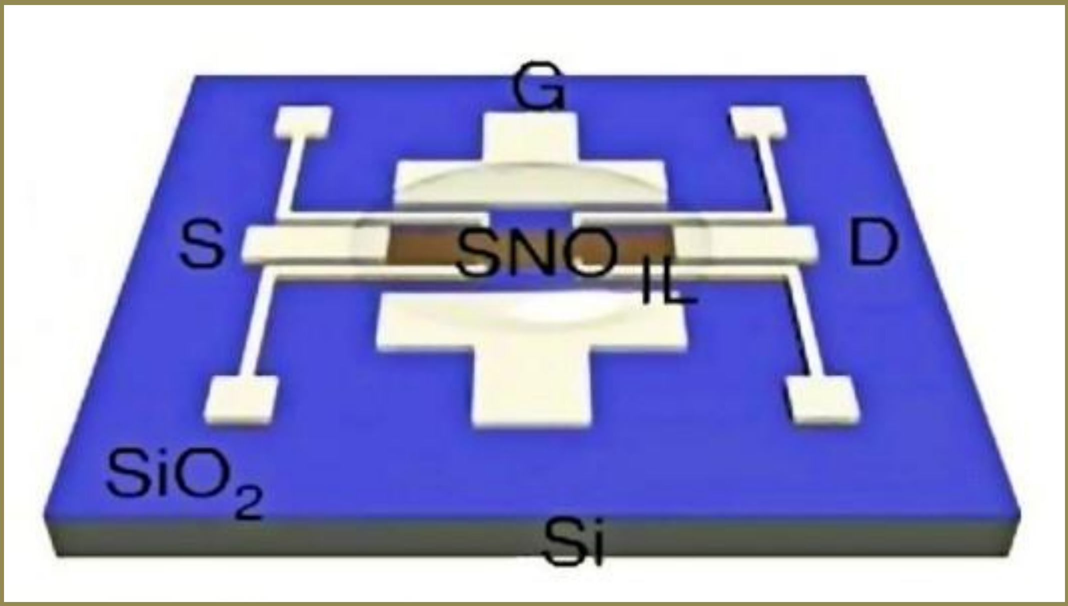
In the photo above, Brusspup has removed the bezel of his second-hand LCD display, cut the edges of the outer polarizing filter, and has removed the polarizing filter by careful scraping and prying using a chisel-like hobby knife. At this point, he installs properly oriented polarizing filters (made from the film) in place of the lenses in the glasses frame. That's all that is needed; the display is bright and blank to anyone not wearing the polarizing glasses, but appears completely normal with the special glasses.

It is actually a bit easier if you own a pair of polarizing sunglasses. These have polarization filters to cut down on the glare of reflected light, which under most circumstances requires vertically polarized glasses. These will work fine to view most converted LCD monitors, although an occasional example may show a negative image.

Brusspup has provided us with some amusement, and an interesting demonstration on how LCD displays work. While it's obviously not advisable to try this experiment on an expensive LCD monitor, there are likely to be many with an old monitor laying about that could be used for such maker-style fun.

## Harvard scientists develop a transistor that learns

By Brian Dodson




Schematic of the ionic liquid-gated SmNiO3 synaptic transistor

In a development that may enable a wholly new approach to artificial intelligence, researchers at Harvard University's School of Engineering and Applied Sciences (SEAS) have invented a type of transistor that can learn in ways similar to a neural synapse. Called a synaptic transistor, the new device self-optimizes its properties for the functions it has carried out in the past.

One of the more remarkable features of the human brain is it gets better at whatever it does. While your first day on an assembly line may be full of fumbling and confusion, in a week or two you will find yourself seemingly on autopilot, performing the set of required tasks without much mental effort. After a few months, you will respond automatically when a part comes through damaged or improperly oriented. Plasticity is the name for the brain's ability to change its own structure through thought and activity.

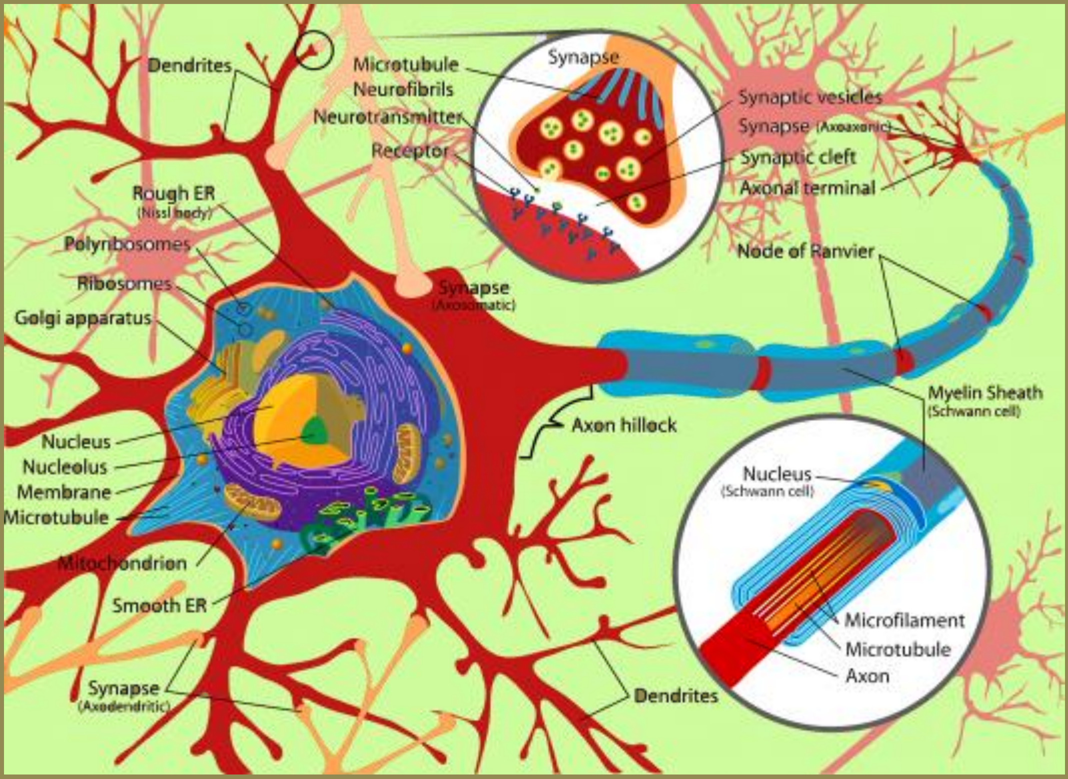
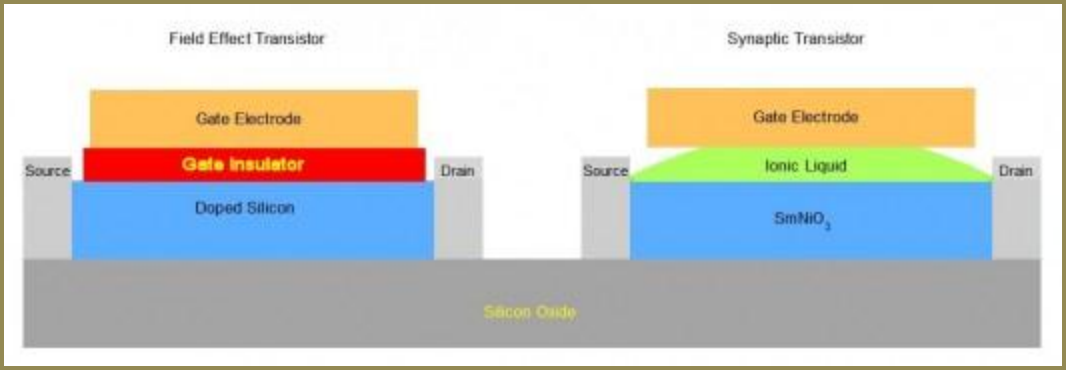



Diagram of the key features of neurons and synapses in the brain (Image: Mariana Ruiz Villarreal)

Most of this plasticity results from changes in the 100 trillion or so synapses, or interconnections, between brain cells. One of the ways through which sets of behaviors are reinforced, or learned, is called spike-timing dependent plasticity, or STDP.

Often summed up by the aphorism "Cells that fire together, wire together", when neuron A repeatedly sends a signal across a synapse that causes neuron B to fire, the synapse will strengthen, in effect making that decision easier to make in the future.




The synaptic transistor developed at Harvard mimics this behavior. So how does a synaptic transistor work? As shown above, the synaptic transistor has a structure quite similar to that of a field effect transistor, where a bit of ionic liquid takes the place of the gate insulating layer between the gate electrode and the conducting channel, and that channel is composed of samarium nickelate (SmNiO3, or SNO) rather than the field effect transistor's doped silicon.

A synaptic transistor has an immediate response, and also a much slower response related to learning. The immediate response is basically the same as that of a field effect transistor – the amount of current that passes between the source and drain contacts varies with the amount of voltage applied to the gate electrode. The learning response is that the conductivity of the SNO layer varies in response to the STDP history of the synaptic transistor, essentially by shuttling oxygen ions between the SNO and the ionic liquid.

The electrical analog of strengthening a synapse is to increase the conductivity of the SNO, which essentially increases the gain of the synaptic transistor. Similarly, weakening a synapse is analogous to decreasing the electrical conductivity of the SNO, thereby lowering the gain.

Note that the input and output of the synaptic transistor will be continuous analog values, rather than more restrictive digital on-off signals. This gives the artificial synapses the flexibility to learn "more or less" how to perform a task, and then to learn how to improve its earlier performance.

While the physical structure of Harvard's synaptic transistor has the potential to learn from history, in itself it contains no way to bias the transistor so as to properly control the SNO's memory effect. This function is carried out by an external supervisory circuit that converts the time delay between input and output into a voltage applied to the ionic liquid that either drives ions into the SNO or removes them. In response, the synaptic transistors become self-optimizing within a circuit being subjected to learning experiences.

The gain of the device adjusts over time to more efficiently provide the average performance asked of them during training. The result is that when a large network of synaptic transistors is assembled, it can learn particular responses to "sensory inputs", with those responses being learned through experience rather than directly programmed into the network.

"The transistor we've demonstrated is really an analog to the synapse in our brains," says co-lead author Jian Shi, a postdoctoral fellow at SEAS. "Each time a neuron initiates an action and another neuron reacts, the synapse between them increases the strength of its connection. And the faster the neurons spike each time, the stronger the synaptic connection. Essentially, it memorizes the action between the neurons."

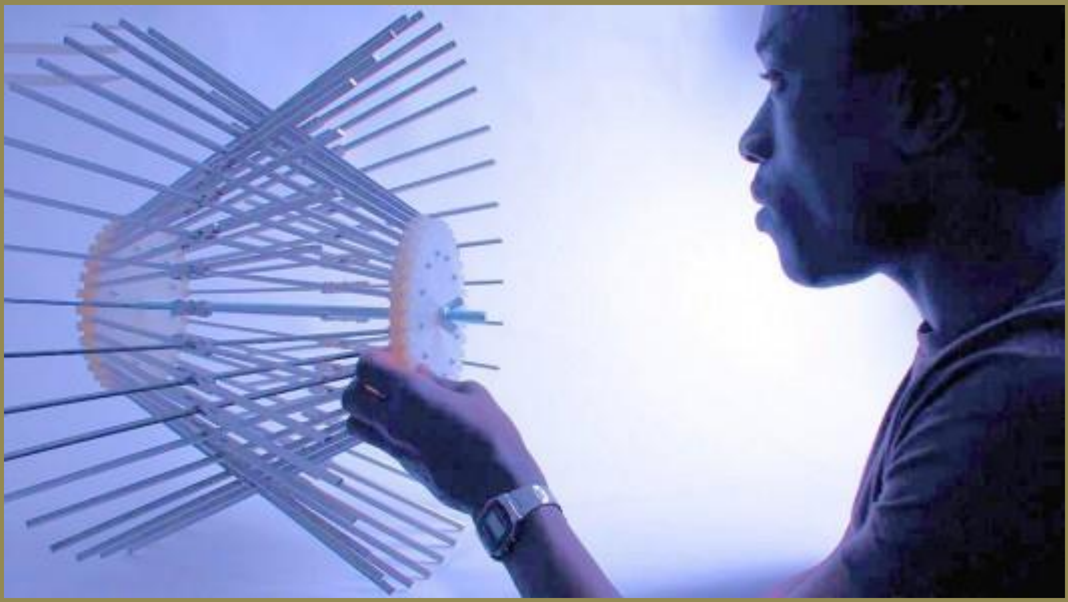
The synaptic transistor could mark the beginning of a new kind of artificial intelligence: one embedded not in smart algorithms but in the very architecture of a computer. In principle, a system integrating millions of tiny synaptic transistors and neuron terminals could take parallel computing into a new era of ultra-efficient high performance.

"This kind of proof-of-concept demonstration carries that work into the 'applied' world," says research team leader Professor Shriram Ramanathan, "where you can really translate these exotic electronic properties into compelling, state-of-the-art devices." Hopefully those SOTA devices can someday be assembled into SOTA learning machines.

A paper detailing the team's findings was published last month in Nature Communications

# Roadless wheel concept adjusts to all terrains

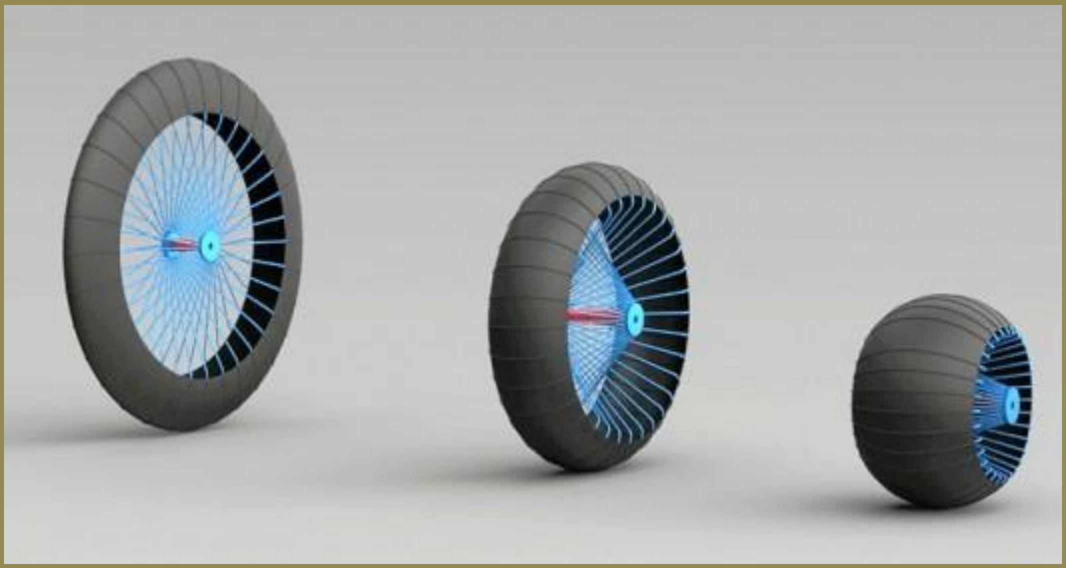
By Brian Dodson



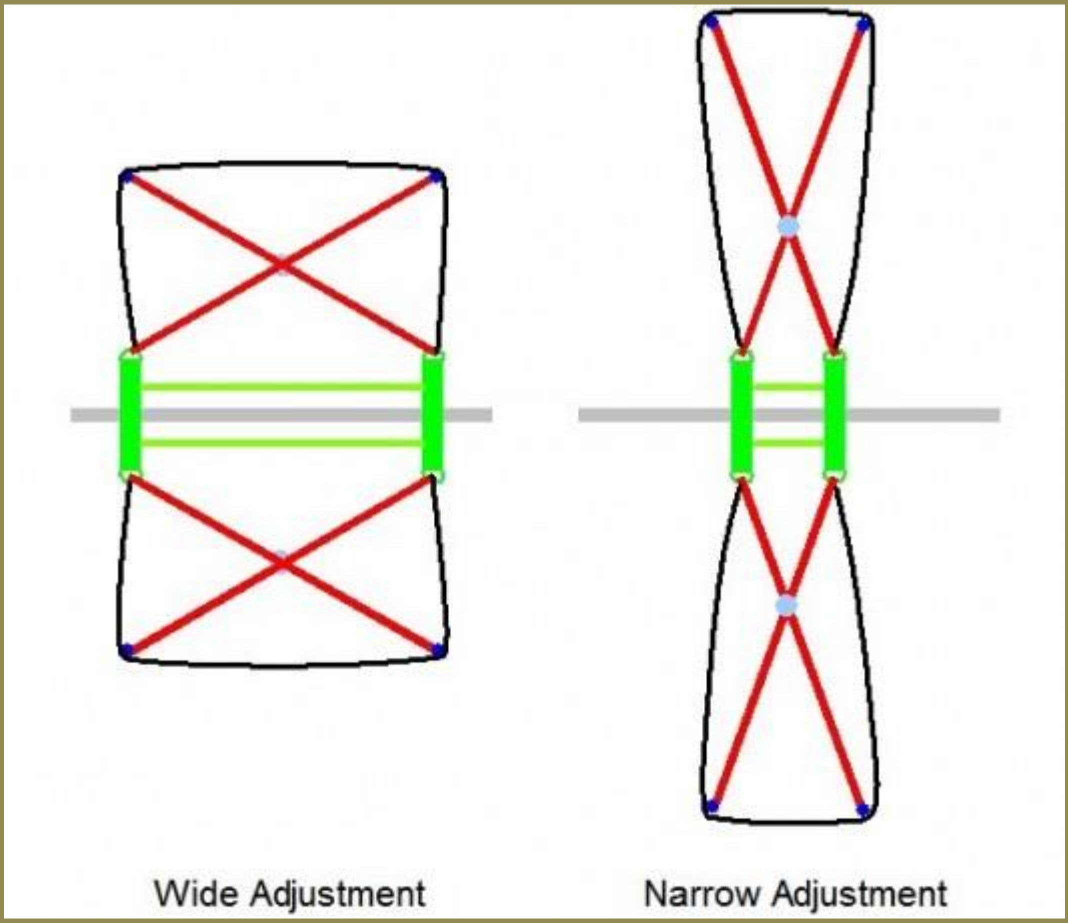
Design Engineer Ackeem Ngwenya contemplating the internal structure of his Roadless variable-aspect wheel system

Graduate student Ackeem Ngwenya has combined the 6000 year-old wheel with modern materials to develop a new type of all-terrain wheel assembly that switches from narrow to wide tread at the turn of a screw. His Roadless wheel system, while envisioned for rural applications in his native Malawi, has the potential to be as big a change to road (and off-road) transport as was the introduction of anti-lock braking.

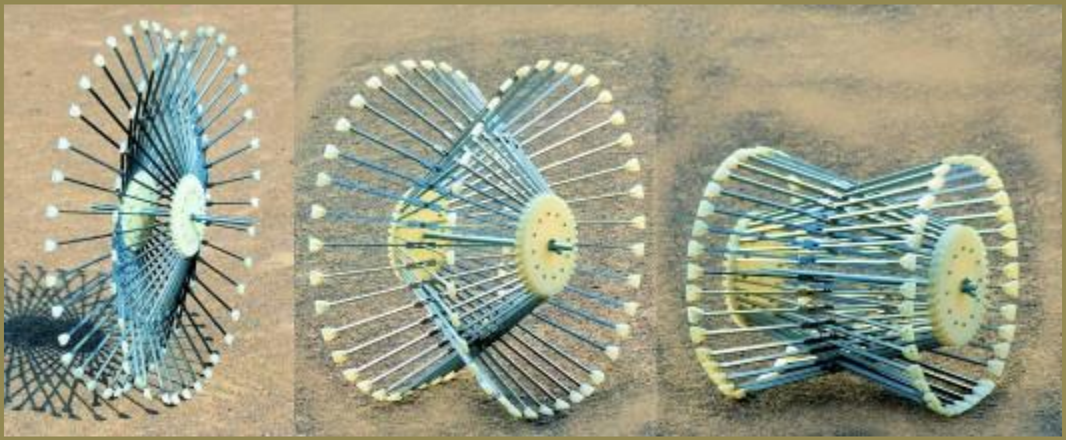
We've all done it. Before embarking on a long driving trip on smooth-surfaced interstate highways or other roads of national importance, we'll raise the tire pressure to boost the gas mileage a bit. Stuck in the snow, mud, or sand? Let some pressure out of the tires to increase the contact area, while at the same time increasing the chances that the now floppy tire will grab hold. However, the benefits of trying to change the aspect ratio of a tire by simply changing pressure are rather minor, and often associated with a significant loss in tire lifetime.



The Roadless wheel system attempts to throw out the limitations of a pneumatic tire by substituting a tread material wrapped around a pair of rod networks attached by an axle. The rods are adjusted using a mechanism reminiscent of a scissor jack.

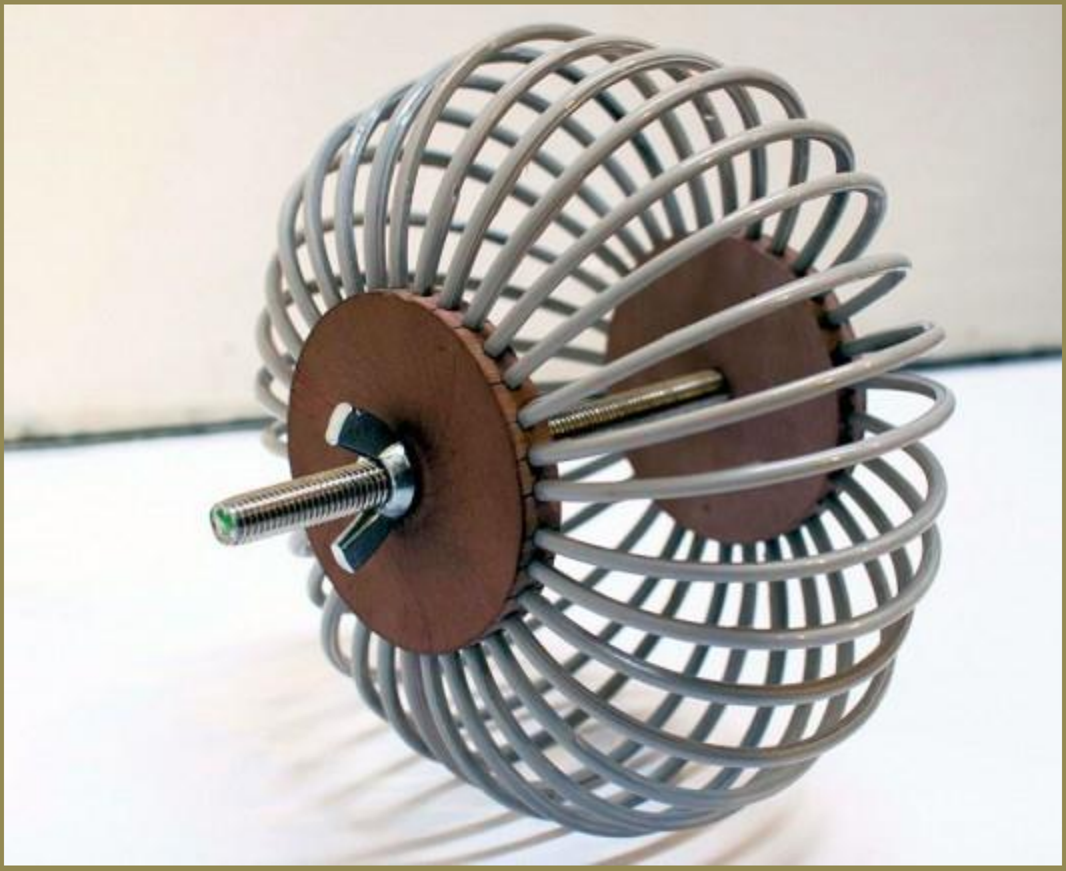



When the disks on which the rods are mounted are far apart, the wheel takes the form of a wide tire of small diameter. When the disks are moved close together, the wheel becomes a narrow tire of large diameter. The proximate rods from the two disks are mutually attached to a fixed bearing (light blue circle).



The tread of the wheel must be sufficiently compliant to adapt to the changing aspect ratio of the wheel, so is likely to be some form of elastomer.

Alternately, the wheel can include compliant members that directly form the shape and supporting mechanism for the tread, which can then be as simple as a sheet of rubber.



The video below tells the story of Roadless, and also shows more clearly how it adjusts to varying terrain. There are a host of variations of this basic idea, whose genesis was to make it easier for people living in rural Malawi to more easily deliver their goods to market. It does not seem likely that this concept will stop there.

## Gimball flying spherical robot takes collisions in its stride

By Darren Quick

The Gimball bounces off, rather than avoids obstacles

The Japanese Ministry of Defense (JMD) got the ball rolling, as it were, in 2011 when it unveiled its spherical air vehicle, which was followed by the Kyosho Space Ball and Puzzlebox Orbit in 2012. Now researchers at Ecole Polytechnique Fédérale de Lausanne (EPFL) in Switzerland have got in on the act with Gimball, a flying robot that takes crashing into obstacles in its stride.

Developed by Przemyslaw Mariusz Kornatowski and Adrien Briod from EPFL's Laboratory of Intelligent Systems (LIS), the Gimball prototype ditches the complex and heavy network of sensors most flying robots use to map a clear flight path for a spherical, elastic cage that allows it to bounce back from impacts and continue on its way.

Unlike the JMD's air vehicle, whose body is rigidly fixed to the exterior sphere, the Gimball features a double carbon-fiber ring that passively rotates in the event of a collision to allow the robot's gyroscopically stabilized body to stay vertically oriented. This allows it to quickly recover from impacts, a capability that was inspired by insects.

"Flying insects handle collisions quite well," says Briod. "For them, shocks aren't really accidents, because they're designed to bounce back from them. This is the direction we decided to take in our research."

The Gimball prototype has undergone testing in a Swiss pine forest. Weighing just 370 g (13 oz) and fitted only with a compass and an altitude sensor for navigation, the robot was able to maintain its course over several hundred meters while crashing into several trees along the way.

Like other spherical flying robots that are designed to operate where other robots can't, the Gimball has potential in exploration and search and rescue operations. The robot is fitted with a camera, which isn't used for navigation, but to relay images back to emergency personnel.