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WIN!



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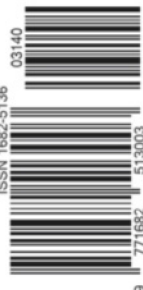
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10 TECH TERMS FOR 2014



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- BLACK KNIGHT TRANSFORMER
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Go Further

March 2014
Vol 12. no 8

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TO KNOW



On the cover: The erosion of privacy is an issue that affects all of us. Our resident expert tells you what to do about it. Keyhole image: iStockphoto
This page: This outrageously different flying machine is the AT Black Knight Transformer, billed as the world's first roadable VTOL (vertical take-off and landing) aircraft. It's intended for use as an autonomous rapid response ambulance for evacuating wounded soldiers from the battlefield. Picture: Advanced Tactics

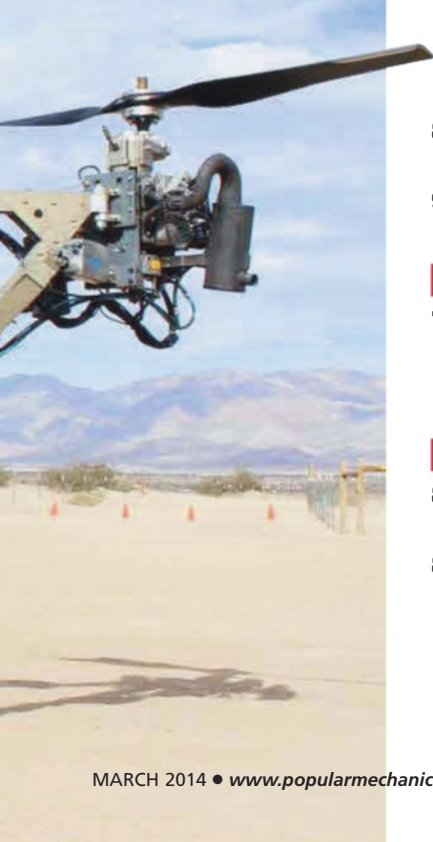




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WIN!



5 TomTom Start 20 GPS navigators with lifetime maps for Southern Africa. For entry details, visit our Web site at www.popularmechnics.co.za



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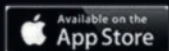


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HOW ALIVE ARE YOU?



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INVASIONS OF PRIVACY: IT'S TIME TO FIGHT BACK

We don't want to scare you unnecessarily, but you need to know that a lot of digital information that you regard as strictly private is accessible to people who may not be very nice.

PM's Davey Alba, who describes himself as a "proud technophile", confesses that for all the attention he pays to technology, he has never worked particularly hard at protecting his data – until now. After interviewing security professionals, cryptographers, computer science researchers and other clever people, he decided it was definitely time to change his ways.

Interestingly, the top suggestion from all these experts was to move from proprietary to open-source software. He installed encryption software on his phone and laptop, abandoned Google in favour of a new search engine and downloaded an anonymising bundle called Tor to hide his identity – and that was just for starters.

This month's cover story focuses on the erosion of privacy and explains how you can fight back, using technology, clever software and a generous dollop of common sense. How far would you go to protect your privacy? Do you believe it's worth taking those extra steps, no matter how tedious, to protect information that no one else has the right to see? Send us your thoughts.

Next up – a story about a strange quantum mechanical phenomenon inherent in many particles, including electrons, called *spin*. You may not be familiar with the term, but be assured that it's about to become a lot more common as physicists and engineers explore its potential applications across a huge range of gadgets. Says writer Jon Cartwright: "Now it (spin) is poised to march into other parts of our digital gadgetry, bringing smaller, faster and more flexible calculating machines – and perhaps even one that can mimic that most powerful of all number crunchers, the human brain."

In another thought-provoking article, we present "10 tech terms for 2014". You may be familiar with muon tomography, bioprinting, organ-on-a-chip

and in-memory computing, but what you probably *don't* know is that in February 2011, the Internet officially ran out of IP addresses (and yes, we know that new devices were still able to connect). As Alex Hutchinson says, it's time to shift from the creaky 32-bit IPv4 system developed in the 1970s to the hugely accommodating 128-bit IPV6 system. Would you believe 340 trillion trillion addresses?

Moving along, we visit the Sywell Aerodrome, about 120 km north of London, for a close encounter with magnificent men and their flying machines. This rural airstrip is the setting for one of the quirkiest aviation

competitions on the calendar, the Icarus Cup. Restricted to human-powered aircraft, it produces some amazing designs – such as the frail-looking *Betterfly*. This ultra-light (40 kg), pedal-powered aircraft was built and piloted by David Barford, a highly determined seat-of-the-pants engineer who didn't hesitate to cannibalise the wheels from his daughter's childhood bicycle to er... get it off the ground. Read "The

improbable flying machines of Sywell" and marvel at human ingenuity.

Finally, we take a look at the rich and varied assortment of gadgets from the annual International CES event in Las Vegas, cultural centre of the United States (just kidding) and a mecca for anyone who cares about cool – and in some cases, seriously odd – consumer technology. Consider the Urb-e folding electric scooter (we'd really like one), the Blaze Laserlight (promising a real advance in cyclist safety) and – this one fits neatly into the "odd" category – the Parrot Jumping Sumo, described by its creators as half robot, half insect. Wi-Fi controlled via your smartphone or tablet, it rolls, turns and jumps with reckless abandon. Naturally, we like it.

Alan Duggan

aland@ramsaymedia.co.za



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Winning letter

TIME FOR CLARITY

Your article, "The now delusion" (January issue) refers. In school, physics students are asked to sketch a displacement-time graph for any moving object. Is this not an effort to, as mentioned in the article, "stand outside" a given event? One end represents where the event is initiated and the other, where it ends. You can look at the event as a whole, outside of time.

Physicists, mathematicians and philosophers are at odds over how to interpret the passage of time. Special Relativity dictates that a stationary observer and a moving observer (moving at close to the speed of light) will not agree on when a particular event took place. If we accept the "growing block" theory in support of cosmologist George Ellis, how would a third observer, standing outside of space and time, observe not only the given event, but also the light travelling from the event?

The time dilation is caused by light having a finite velocity, and light originating from the event reaching the two observers at different times. The observer outside of space and time would, however, be able to see a "slice" of time where the actual event happened, but light from it has not yet reached either observer. Another, slightly advanced "slice" would show light reaching the stationary observer, and yet a different "slice" depicting light reaching the moving observer. The event happening, the stationary observer seeing it happen and the moving observer seeing it happen, are three different moments to the observer standing outside of time and space. We must remember that light takes a determinable time to reach any observer at any distance from its origins.

What would we see if we zoomed in on a particular "slice" somewhere between the event happening and it being observed? Would we see individual photons frozen in time, or perhaps a set of waves and interference patterns as wave-particle duality suggests? Simultaneity in the Universe is achieved only by a hypothetical observer outside of time and space, viewing it as a growing block, with an indeterminable future! Any observer inside space and time is biased by his velocity and position relative to an event.

ROUX WILDENBOER
VIA E-MAIL

Write to us, engage us in debate, and you could win a cool prize; this month's best letter wins a thoroughly desirable Oregon Scientific ATC9K action cam worth R3 499. This boldly styled instrument comes with a built-in g sensor and Full HD reproduction, with 5 MP stills capability. USB connectivity and an ATC9K app allow you to manage recordings on both PC and Mac; besides that, there's an HDMI connector. For more information, contact Oregon Scientific on 011-805 1996 or visit www.oregonscientific.co.za

Send your letter to: Popular Mechanics, PO Box 180, Howard Place 7450 or e-mail popularmechanics@ramsaymedia.co.za Please keep it short and to the point. Regrettably, prizes can be awarded only to South African residents.

Philosophical dead end?

I'm with Professor Ellis. There's no point in talking about an observation point "outside" time because we can never be in such a position and have no way of knowing whether such a vantage point can exist. At best, this is nothing more than a philosophical exercise; at worst, it's a dead end into which some very clever physicists are wandering with no apparent purpose.

In his latest book, *An Appetite for Wonder*, Professor Richard Dawkins says: "If the second dinosaur to the left of the tall cycad tree had not happened to sneeze and thereby fail to catch the tiny, shrew-like ancestor of all the mammals, we should none of us be here." Although Dawkins was talking about the potentially world-changing consequences of seemingly insignificant events, I believe that imaginary dinosaur's sneeze represents an example of Nature's glorious unpredictability. A block Universe in which all events are "cast in stone"? Not a chance.

Against that, I'm happy to embrace the "many worlds" hypothesis, in terms of which every quantum possibility can and does exist. In one of these universes, of course, I have an entirely different view of time (and possibly, though not probably, green hair and scales).

T OSBORNE
MORNINGSIDE

Let's keep it real

The letter from Clive Belsham ("Power play", January issue) refers. In order to resolve our energy needs, and to provide a meaningful solution, we should forgo the concept of a singular value to energy. By this I mean that energy delivered at a specific time and place, in the form required, has a specific value. Currently, the electrical metering systems are not able to charge variable rates, and the utilities charge an average cost to consumers. This creates the impression that all energy is equally valuable.

Not so. The concept of selling energy into a grid at times of low demand for the benefit of the individual at a cost to everyone is a political manipulation, not an engineering concept. Simply moving the problem does not solve it. If the scenario were to be modified, and the energy were sold on the basis of supply-and-demand value, the home owner could be incentivised to modify his consumption patterns, or the supplier would be able to make the storage of energy, stated to be "expensive", financially viable. If, for instance, the batteries of the home owner's electric car were used as a storage medium, ena-

bling him to sell power at time of high price (high demand), it could incentivise the migration to electric vehicles.

Even this scenario is an over-simplification. If the electrical grid becomes a multi-load of supply and demand points, how is the stability of the grid guaranteed? The utility (grid operator) has no control over the variables. This is the so-called smart grid, a futuristic concept that we must pursue to facilitate intelligent interaction between suppliers and consumers.

It is difficult to visualise a practical system where the energy storage and generation capability is not 90 per cent in the hands of the utility that manages the power flow. Hence the home owner's meter will only move "backwards" at the desire of the utility – which is okay if he is fairly compensated for the real time-value of that energy.

We need to utilise the energy at our homes, but we also need to take responsibility to store and use it intelligently ourselves. We should also avoid migrating the energy unnecessarily – that is, use solar heat as heat, stored in water, as is done in solar geysers.

In South Africa, we have an unbalanced grid, with supply concentrated. That is why caution must be used when adding additional capacity and demand. We should not create illusions, either. The new generation of container-sized nuclear plants is not yet available. When they *do* become available, they will not be in the form of a bin that you place on the corner and the lights go on. They will be fully fledged power plants subject to all the regulatory and supervisory obligations. They will have a cost to build and maintain.

If our energy comes from systems that earn their income at a "real" value of energy, the winning concepts will float to the top and pipe dreams will be recognised for what they are. Let us keep it real, and not for political showcasing.

ANDREW ROSSOUW
VIA E-MAIL

And another reality check...

Clive Belsham's interesting letter questioned Eskom's motives for not allowing us to sell excess power back to the utility. Eskom's main challenge at this stage is the morning and evening peaks, which occur at a time when the solar energy sources cannot really boost the spinning reserve. Eskom's "batteries" are the large hydro pumping schemes such as those in the Drakensberg and at Palmiet, and they are well under way with the Ingula facility. Power that consumers can sell back to Eskom is not of



Buck was there first

There's a remarkable similarity between the "new" spaceship featured on the cover of your January issue and the craft that transported the 1950s science fiction character, Buck Rogers. Great mag!

ROD KRUGER
DURBAN

much use unless Eskom can store it easily.

The other problem with selling back power is the possible issue with power harmonics (noise) generated by inverters used alongside solar installations. If these installations are not carefully specified, it can lead to serious issues on the power network (transformers overheating, etc).

There are already such systems available in Gauteng but they will set you back about R80 000 per household, which is still prohibitively costly. As for the pebble bed nuclear reactor, Eskom researched this concept for years and eventually abandoned the idea, probably due to its implementation cost.

My suggestion: fit direct-current (LED) lights and run your entertainment system from a DC system with one large deep-cycle battery, leaving the geyser on 230 volts with a solar water heating system as a backup. If you then also use a gas stove, you are quite well protected against blackouts.

ARTHUR BURGER
VIA E-MAIL

Starting them young

What a great idea it is to show kids how to use tools ("10 tools every kid should learn to use", January issue). Having spent a lifetime in the retail hardware trade, it pains me to see how many young people are barely able to change a light bulb, let alone replace a tap washer. Our education

system has failed the youth in many ways, not least in the teaching of hand skills. Long gone are school workshops where basic skills are taught. Even if these workshops didn't produce budding Chippendales, at least they taught some useful hand skills.

You proudly mention the DIY abilities of the PM staff: there's a good chance that these skills were learnt from a mentor somewhere along the line. Everyone should do woodwork. It uses a renewable resource, it provides great satisfaction and it enables you to make things that are really useful.

BRIAN JOLLY
brianjolly@strandhardware.co.za

Let's build it locally

I loved the Lazzarini Jet Capsule featured in your "Upgrade" pages (January issue). It's compact and stylish, with amazing all-round vision and (apparently) lots of cabin space. However, I assume it will never be available in this country, and even if it is, the price will probably be stratospheric. All of which leads to my question: why doesn't a South African yacht builder produce something similar? All you need is a nicely rounded glass fibre shape that integrates hull, deck and cabin – hardly an impossible ask for an established boat builder.

BRETT MASON
CAPE TOWN
PM



1982 We've always loved weird and wild concepts, even if some of them pushed the boundaries of credulity. Witness this design for a gargantuan steam-powered submarine – decked with massive oak beams and sheathed in plywood – to transport 54 000 tons of super-chilled natural gas from Alaska to eastern Canada or Europe *under the polar ice cap*. According to writer Robin Nelson, this was a “dead-serious” proposal from a group of marine architects, engineers and planners who had already produced fleets of nuclear submarines and LNG (liquid natural gas) ships.



1956 Clinton Hull of Santa Ana, California, came up with the brilliant idea of spreading a sheet of plastic under Junior's high chair to collect spilled (or in some cases, thrown) food, making the dining area easy to clean. Personally, we might have been inclined to use a high-pressure hose or at the very least, a stern lecture.

1936 This PM advertisement described how George Jackson froze in horror when he realised he was sharing his camp bed with a deadly copperhead snake. Fortunately, one of his companions was armed with an Eveready torch, which he cunningly used to “hypnotise” the reptile while George scrambled to safety (and then, quite understandably, fainted from the shock). The advertisement makes it clear that *fresh* Eveready batteries are the way to go.



1947 We revealed that soothing music calmed nervous patients of New York dentist Dr Herbert Weinstock. He connected earphones to a radio, allowing his patients to listen to music “loud enough to drown the awesome whirr of the burs and drills”. Yes, but was it loud enough to drown their screams? **PM**

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Edited by
JENNINGS BROWN
and
ALAN DUGGAN

Lunar laser

AN EXPERIMENT AROUND THE MOON
HERALDS THE NEXT GENERATION OF
SPACE COMMUNICATIONS.

BY JOE PAPPALARDO

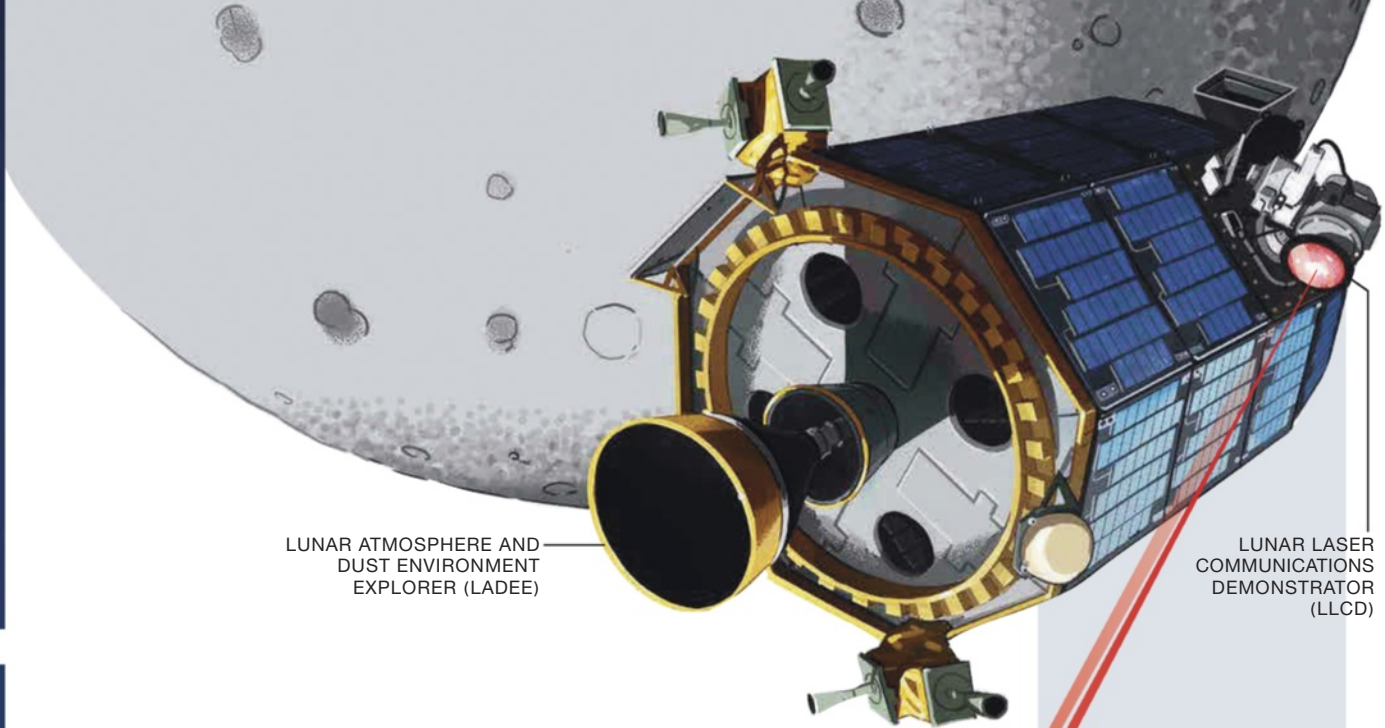
The future of space communications may come at the speed of photons instead of radio waves. Researchers for the first time have communicated with a spacecraft using a laser system.

In late October last year, the Lunar Laser Communications Demonstrator (LLCD) beamed data at 622 megabits per second – orders of magnitude faster than the current rate – back from the spacecraft, which was in lunar orbit. Don Cornwell, mission manager at Nasa's Goddard Space Flight Centre, said that the LLCD "has →

GROUND STATION,
WHITE SANDS,
NEW MEXICO

TRANSMITTING
TELESCOPES

RECEIVING
TELESCOPES



LUNAR ATMOSPHERE AND DUST ENVIRONMENT EXPLORER (LADEE)

LUNAR LASER COMMUNICATIONS DEMONSTRATOR (LLCD)

→ been extremely successful, beyond expectations”.

During the test, the LLCD sent a string of binary code from the satellite orbiting the Moon to a ground station in New Mexico. It was the fastest download rate between the Moon and Earth. For scale, Nasa says that the spacecraft that’s carrying this laser experiment would take 639 hours to download an average-length HD movie using the standard S-band radio. LLCD could download the same film in less than 8 minutes.

The next step for laser space communications will occur closer to home. In 2016, the Laser

Communications Relay Demonstration (LCRD) will hitch a ride into space on a communications satellite, where it will orbit Earth. In 2017, the LCRD will begin beaming 1,25 gigabits per second of test information from a ground station to the satellite and back to Earth to another ground station. The test spacecraft will be in orbit for two to five years, operating 24 hours a day, to prove the system is robust enough for commercial use. If it is, the test could open up new avenues of big-data-information exchange at the speed of light.

GROUND STATION, WHITE SANDS, NEW MEXICO

HOW IT WORKS

1

READY

The spacecraft positions itself in the Moon’s orbit so the Lunar Laser Communications Demonstrator (LLCD) points at Earth.

2

AIM

An on-board detector scans for a signal from the ground terminal, telling LLCD where to aim its laser.

3

FIRE

A 10 cm laser beam travels 383 000 km from the spacecraft orbiting the Moon to White Sands, New Mexico. Coded test information is transmitted at 622 megabits per second.

WHY LASERS?

Laser wavelengths are 10 000 times shorter than radio wavelengths, delivering much more data than even the best modern radio system, yet using less power. On the ground, collecting antennas can be smaller, easier to build and cheaper to maintain.

LASER

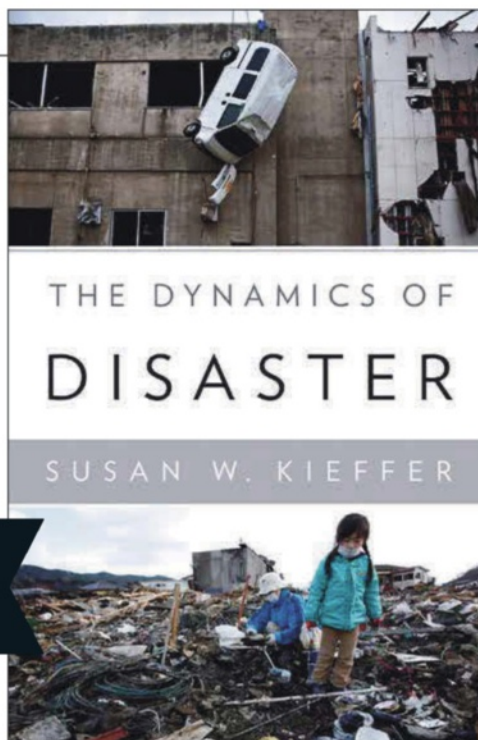


RADIO



TECH WATCH





60-SECOND GENIUS

Susan Kieffer, geologist, planetary scientist, author

IN HER BOOK, *THE DYNAMICS OF DISASTER* (WW NORTON & COMPANY), KIEFFER EXPLAINS WHAT VARIOUS LARGE-SCALE NATURAL DISASTERS HAVE IN COMMON AND DESCRIBES THE UNSEEN PROCESSES CHURNING BELOW OUR FEET THAT CAUSE THEM.

Q: Should we rebuild big cities after disasters?

A: We need to learn what we did wrong in the first place and then address truly tough questions: should we rebuild New Orleans post-Katrina, knowing that another Category 5 hurricane there is inevitable? Should we be living on active earthquake faults, knowing that another magnitude 9 is inevitable, or on coastlines prone to hurricanes or tsunamis? In our world, the answer is unlikely to be no. So, if we are going to live there anyway, then we need to know why we suffered and see what we can do to remediate it.

How is a stealth disaster different from a natural disaster?

Stealth disasters are typically caused by humans but involve the natural systems and processes that support us. They have a much longer time scale for onset – decades or even centuries. Because of this, we tend to not notice them, or find it convenient to ignore them. With the exception of climate change, they typically don't receive much press coverage. Other examples of stealth disasters are rising sea level, ocean acidification, pollution of our ground and surface waters, erosion and poisoning of soils. Stealth disasters, however, don't have to be inevitable. We could apply what we've learnt from natural disasters and then take decisive, timely action, which could do a lot to change the course of stealth disasters.

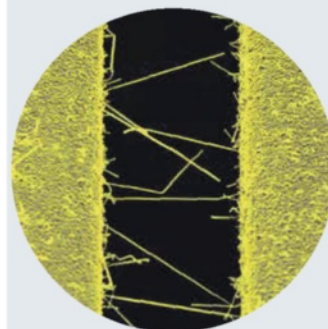
Will advances in technology ever help us prevent disasters?

We're not likely to change how Earth unleashes its energy on any significant scale, but we can change our preparedness and response to natural processes. Evolving technology can give scientists more and more sophisticated tools for investigating the causes of disasters. With that information, we can better forecast the next disaster and provide timely and universal warnings to the public. – AS TOLD TO

ALYSON SHEPPARD

News Brief

Tin whiskers



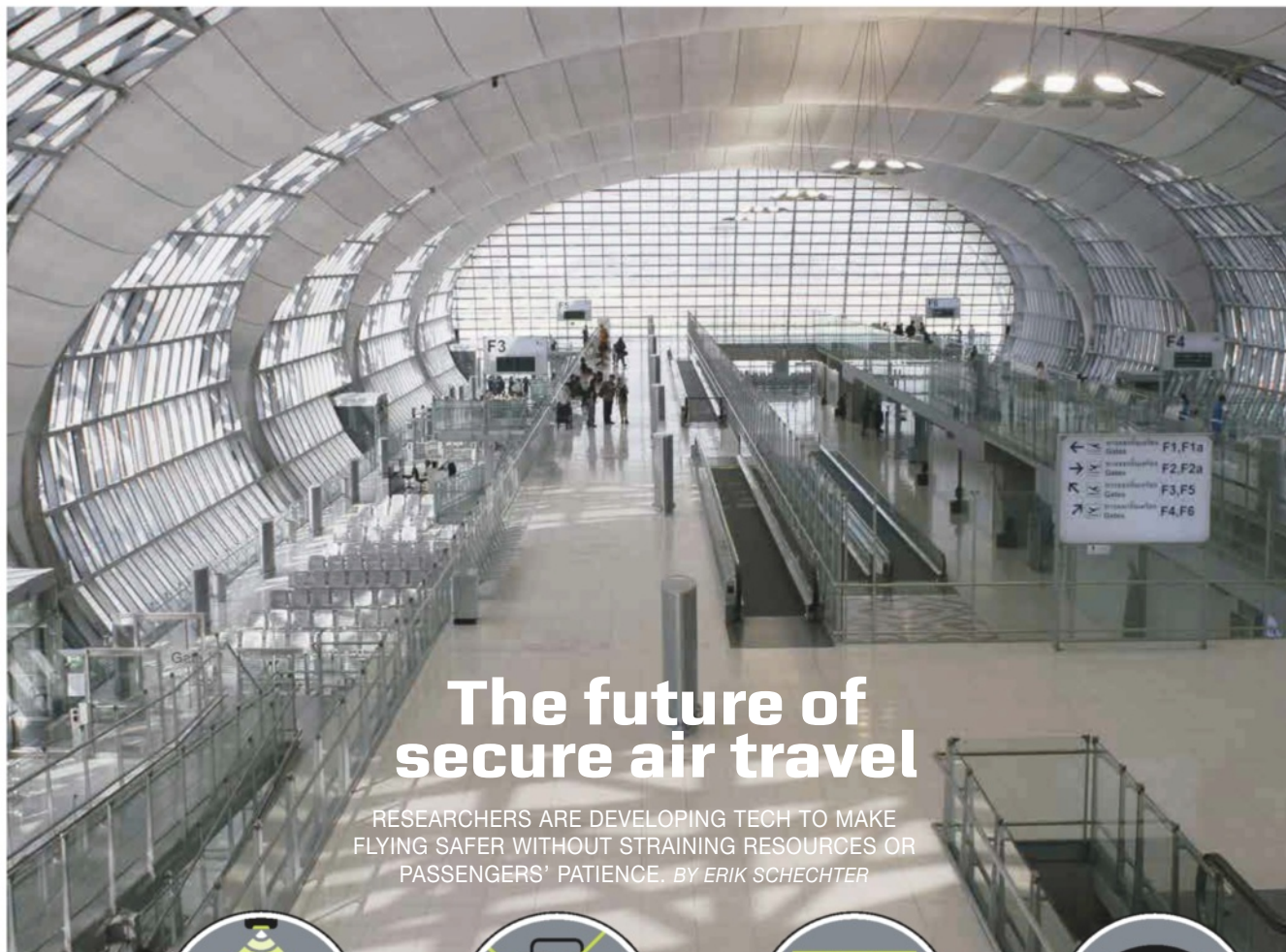
THE PROBLEM

The move to eliminate lead from solder (an alloy used for its low melting point) over the past decade was good for the environment but bad for short-circuits. Lead-free tin solder has the strange habit of growing "whiskers" – filaments that extend, causing shorts. Tin whiskers led to a diode failing at a nuclear plant in Connecticut in 2005.

THE SOLUTION

Lockheed Martin developed a printable nanocopper solder paste that isn't subject to whiskering. Copper conducts electricity 10 times better than tin solder does, but its melting point of over 1 090 degrees makes it too hot to use on circuit boards. Researchers found that working with copper nanoparticles – less than 10 nanometres across – dropped the melting point to less than 204 degrees, making a perfect nanocopper solder.

– ALEX HUTCHINSON



The future of secure air travel

RESEARCHERS ARE DEVELOPING TECH TO MAKE FLYING SAFER WITHOUT STRAINING RESOURCES OR PASSENGERS' PATIENCE. BY ERIK SCHECHTER



DISTRIBUTED CHEMICAL SENSORS

The US Naval Research Laboratory is developing a sensor that can track trace amounts of chemicals in explosives. The tiny sensor, called Silicon Nanowires in a Vertical Array with a Porous Electrode (SiN-VAPOR), is superior to dogs in terms of analysis: it can describe in detail what it's detecting. Christopher Field, lead researcher on SiN-VAPOR, sees it eventually paired with other technologies such as CCTV cameras and facial-recognition software to create a checkpoint-less airport.



FASTER EXPLOSIVE-TRACE DETECTION

Finding explosive traces is a time-consuming process involving wipe-downs and residue analysis. Michigan State University researchers came up with a faster method that uses a low-power laser. The system fires two pulses at a target, one in resonance with chemical frequencies found in explosives; the other, a control pulse, slightly out of resonance. A reaction in only the non-control pulse indicates the presence of explosives. It's efficient and could be used in X-ray machines.



LONG-RANGE IRIS ID

Researchers continue to extend the range of iris-identification scans. Current systems must be 30 cm or closer to a person's face to "enroll" an iris in a database. In 2010, PM reported on an experimental eye scanner that works at 4.9 metres. Now, the Carnegie Mellon University CyLab Biometrics Centre has built a device that can perform high-quality scans from almost 12 m in 3 to 6 seconds. Airport security officers could use the device to quickly confirm passenger identities.



GOLD-COATED PILOT GLASSES

It's a criminal offence to flash a laser pointer at an aircraft, but that hasn't stopped some miscreants from trying to blind pilots with them. In 2012 alone, there were 3 482 laser incidents, according to America's FAA, and South African pilots have also reported a number of incidents. University of Central Florida scientist Jayan Thomas has developed eyeglass lenses with gold nanoclusters that block high-intensity light. The glasses would work against all laser wavelengths while allowing colours and eye-safe light to pass through.

TECH WATCH

Invisible skyscraper

Pasadena-based firm GDS Architects' new building in Incheon, South Korea, is guaranteed not to be an eyesore. Last August, the South Korean government granted approval for Tower Infinity, a 450 m-tall invisible skyscraper. The Infinity will be built near the Incheon International Airport, but Tower Infinity will be located outside of aviation corridors and will have standard aviation-warning lights.

While cities such as Dubai and Shanghai are competing for the status of building the biggest skyscrapers, the Infinity seeks to be the most novel. "Instead of symbolising prominence as another of the world's tallest towers, our solution aims to provide the world's first invisible tower to showcase South Korean innovation," says GDS's principal designer, Charles Wee. – WILL DIETRICH-EGENSTEINER

HOW IT WORKS

1 A series of 18 optical HD cameras are placed at three levels along the tower's height.

2 The six cameras at each level take live feeds of the surrounding views, then the images are digitally processed, scaled, rotated and merged to form one panoramic view.

3 Rows of LED screens opposite each camera then project the view on to the glass facade, blending the tower seamlessly into the skyline.

CAMERA CAPTURE ZONE

TECH WATCH



Navy SEALs may soon be able to hide from enemy night-vision goggles by emulating squid. The skin of the common pencil squid (left) is imbued with a protein, called reflectin, that changes colour and reflects wavelengths of light, enabling it to "disappear". University of California, Irvine, engineers are testing a reflectin-based coating that appears black at wavelengths between 700 and 1 200 nanometres. The properties can be adjusted by applying a chemical trigger, so the coating vanishes when viewed in infrared. The goal is to incorporate reflectin in fabrics to make camouflage that adjusts to various backgrounds and lighting. – AH

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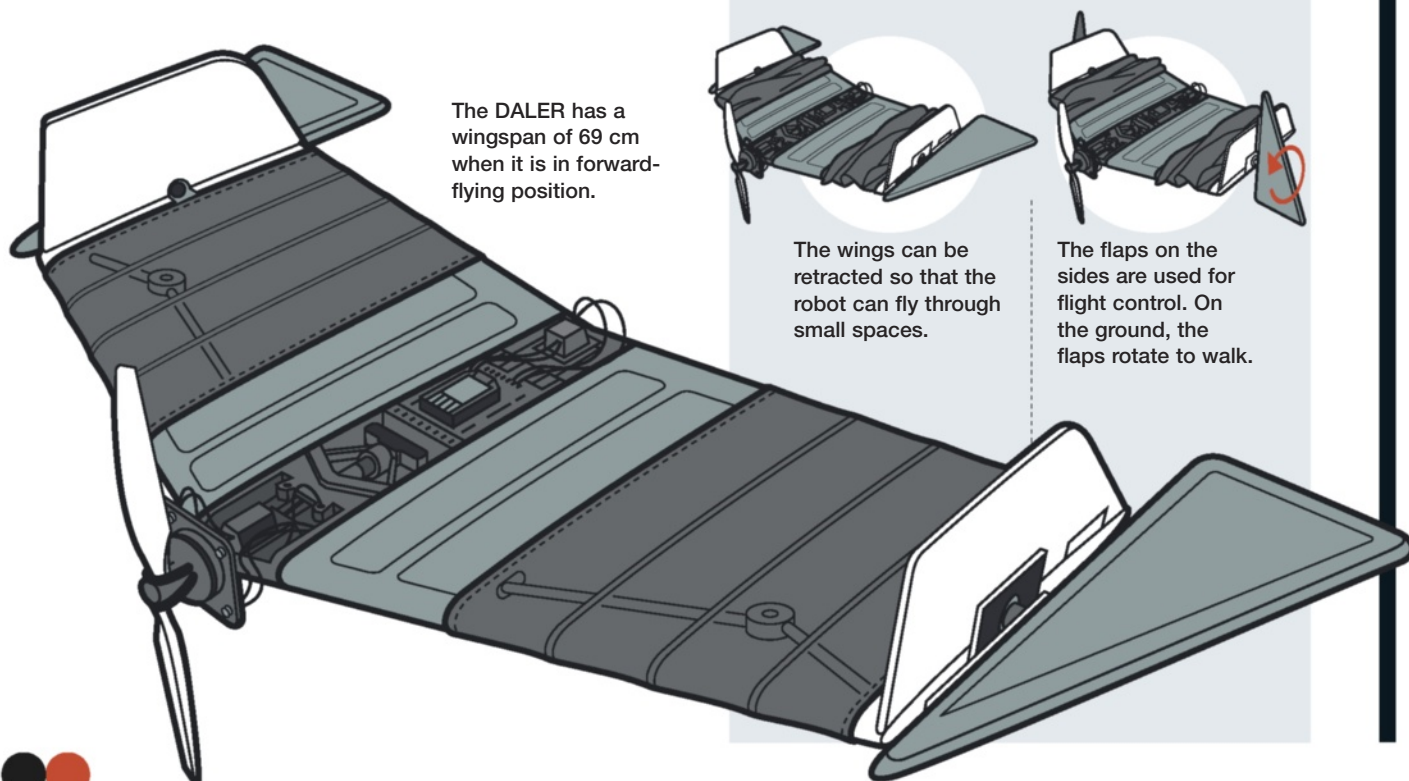


VIDEO > Visit www.popularmechanics.co.za to catch the DALER in action.

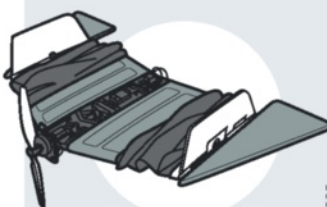
HEY, NICE WHEGS

The flying, crawling bat bot

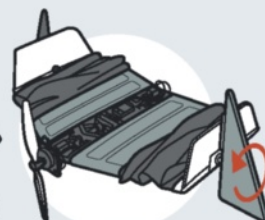
During search-and-rescue missions, it's ideal to have robots that can fly through tight spaces and walk over rough terrain. The DALER (Deployable Air Land Exploration Robot) can do both. Developed by researchers at the Laboratory of Intelligent Systems in Lausanne, Switzerland, the robot can reduce its wingspan and turn the ends of its wings into "whegs" – a cross between wheels and legs – to propel itself across rocky terrain at speeds of about 15 cm/second. This adaptive morphology avoids the added weight that would be required to incorporate separate air and land locomotion systems. – AH



The DALER has a wingspan of 69 cm when it is in forward-flying position.



The wings can be retracted so that the robot can fly through small spaces.



The flaps on the sides are used for flight control. On the ground, the flaps rotate to walk.



TECH WATCH

MEANWHILE, ON THE INTERNET

Blogged today, gone tomorrow

From the Arab Spring to the death of Michael Jackson, the first draft of modern history is recorded on Twitter and other social media platforms. But how long do the messages last? Hany SalahEldeen and Michael Nelson, computer scientists at Old Dominion University in Virginia, have been studying the lifespan of Internet content to determine how much of this content will be available to historians in 100 years, or even 100 days. – AH

PM

20%

The amount of content linked to Twitter that has been saved in public archives within one year of posting.

11%

The amount of content linked to Twitter that has disappeared within one year of posting.

0,02%

The amount of the remaining content disappearing every day after the first year.

ILLUSTRATIONS BY PHIL LAUGHLIN

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POLAR CYCLE

Extreme three-wheeler takes on South Pole

British adventurer Maria Leijerstam, 35, has braved savage conditions to become the first person to cycle to the South Pole from the edge of the Antarctic continent. Maria raced two men for the title and arrived at the pole hundreds of kilometres ahead of her nearest rival. It took her ten days, 14 hours and 56 minutes to complete the 640 km expedition.

Despite starting days later than her competitors, Maria made quick progress on her recumbent trike, designed specifically for the challenge by UK firm Inspired Cycle Engineering (ICE). The custom-made trike is stable and aerodynamic, which allowed Maria to focus her energy on progressing through the gale-force winds and hazardous terrain.

Its design is based on a standard ICE Sprint recumbent trike, with modifications to ensure it could tackle the challenge ahead. It features an aircraft-grade steel frame selected for strength and fatigue resistance, 11,5 cm-wide snow tyres for superior traction, and gearing that allowed Maria to climb 1-in-3 gradients.

The ability to climb hills with relative ease meant that Maria could take a shorter route to the pole than her competitors. Maria was able to ascend the Leverett Glacier, despite strong headwinds and deep snow, to reach the polar plateau. She said afterwards: "The polar cycle is amazing. It's completely stable even in extreme wind, and I can take it on long, steep climbs that would be difficult to tackle on a bike."



VIDEO > Watch the White Ice Cycle expedition documentary preview at www.popularmechanics.co.za



WHITE ICE CYCLE/RYAN EDY



DERRINGER ELECTRIC

Retro-styled charmer recalls heyday of board track racing

Best known for its range of custom-built, board track-inspired motorised bicycles, Californian company Derringer has now come up with a classically styled and seriously cool bike that runs on battery power. As the company tells it, the Derringer Electric can be used for anything from daily commuting to weekend cruising and everything in between.

Features include chromoly construction, pistol-shaped dropouts, hydraulic disc brakes from German manufacturer Magura, and a twist-grip throttle that's said to provide intuitive control similar to that of a motorcycle. The lithium-ion battery resides in an enclosure inspired by the fuel tanks from vintage board track racing motorcycles and the motor controller is concealed in a vented enclosure.

The bike is propelled by a brushless hub motor built into the rear wheel. The motor is wound for high torque, delivering vigorous acceleration and impressive hill-climbing ability. Signature Series 52V bikes are also available with a geared hub motor that employs a planetary gear set to reduce size and weight; these are aimed at customers looking for compactness rather than raw power. Signature and Bespoke series bikes also feature a Cycle Analyst E-bike computer that allows riders to tune the bikes to their individual power needs (up to 2 000 and 2 800 watts respectively). We like it.



DERRINGER



AT BLACK KNIGHT TRANSFORMER

It flies, it drives, it saves lives

A small American aerospace company called Advanced Tactics has released details of a strange concept called the AT Black Knight Transformer, billed as the world's first roadable VTOL (vertical take-off and landing) aircraft. It's intended for use as an autonomous rapid response ambulance for evacuating wounded soldiers from the battlefield, says the company, and will also be able to transport cargo – with or without a pilot on board.

Explains Advanced Tactics: "The patented AT Transformer technology combines the capabilities of a helicopter, such as the ability to take off and land anywhere, with the capabilities of an off-road vehicle. The first technology demonstrator, the AT Black Knight Transformer, completed driving tests in December 2013 in Southern California and is scheduled to fly in early 2014."

The low-cost vehicle will be capable of carrying two passengers and their gear, and will be transportable in a CV-22 Osprey cargo hold.



VIDEO > Visit www.popularmechanics.co.za to catch the AT Panther scaled prototype – which also leverages the AT Transformer technology – take flight in June 2013.



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KAWASAKI J CONCEPT

Meet an outrageous shape-shifter

Unveiled at last year's Tokyo Motor Show, the Kawasaki J concept is a strikingly different form of transport that's not easy to describe. Is it a futuristic sportsbike, a sort of trike thing, or neither of these? Either way, we think it hits the spot, at least in terms of over-the-top design.

From the little we know about the J concept, we can reveal that when it's switched from Sport to Comfort Mode, the riding position is elevated and the front wheels separate, at which point you are able to carve your way through corners with breathless ease. Steering is by way of levers attached to the front wheels (so you were expecting a joystick?). Power is provided by a nickel-metal hydride (NiMH) battery pack.

Ready to place your order? Hold your horses. Experience suggests that this kind of concept, clearly the work of designers who allowed their creative fervour to overwhelm their common sense, is unlikely to reach the production line. **PM**



VIDEO > Catch the Kawasaki J concept shape-shifter in action at www.popularmechanics.co.za

KAWASAKI



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HYOSUNG X-5 250 SPORT

Pocket rocket

Some bikes just rev everyone's engines right from the get-go. Take Hyosung's new X-5 250 Sport. Whereas your average 250 barely manages to maintain highway speeds, on its track debut at the Korea Road Race Championship the X-5 250 took first place in the 250 class. Launched the same month at Italy's Milan show, it went on to take Europe by storm.

Its powerplant is a liquid-cooled, DOHC 4-valve single-cylinder with maximum output of 21,2 kW at 8 500 r/min and 26,1 N.m at 7 000 r/min. Tech features include fuel injection, 6-speed gearbox, single disc with 4-piston calliper up front and single disc with 2-piston calliper on the rear, upside-down front suspension, and dual side aluminium swing arm with striking gas-charged hydraulic rear monoshock (which is preload adjustable). Its exhaust is artfully tucked away like you'd expect to find on a works Moto GP machine. Price: about R36 000. Contact the Cayenne Group on 011-244 1900 or visit www.cayenne.co.za





SONY DEV-50V BINOCULARS

See and shoot

Previously, a busy day in the field usually meant packing your spotting scope, binoculars and digital camera with bulky telephoto lens. Happily, those days are over. With Sony's new DEV-50V digital recording binoculars you can observe wildlife close up, grab 20-megapixel photos and shoot smooth, steady HD video... all without having to carry extra gear.

Unlike with ordinary binoculars, there's no need to keep focusing manually as your scene changes. Speedy, precise autofocus makes sure everything stays pin sharp – even when zooming or when your subject's moving fast. Electronic viewfinders featuring a newly developed hyper-gain function enhance visibility in low light conditions, helping you to see clearly as dusk falls. Two completely separate image sensors and processors (a pair for each lens) means you can shoot cool 3D footage as well.

Apart from being 30 per cent lighter than predecessor, the DEV-50 is also splash- and dust-resistant, making it a great travel companion. Other features include HDMI output, GPS (without map display) and dioptre adjustment. Price: about R20 000. Contact Sony on 011-690 3555 or visit www.sony.co.za



LIFESAVER WATER PURIFICATION BOTTLE

Clean water to go

Going without food for a day or two might do us pampered urbanites a lot of good. Cut out clean drinking water, however, and your body's headed for trouble, fast. The über-convenient 750 ml Lifesaver Bottle 4 000 UF features a replaceable filtration cartridge that removes all bacteria, viruses, cysts, parasites, fungi and other water-borne pathogens from up to 4 000 litres of water without any need for chemicals, power or UV light.

Using it is a breeze. Fill it up from any stream, pond or muddy puddle, give it a few pumps, then drink. A pre-filter protects its membrane from debris and a carbon filter reduces chemical residue, endocrine-disrupting compounds and metals. Plus, the bottle's pneumatic pressure allows you to direct a jet of cleansing water into wounds to prevent infection. Price: about R2 100 for the bottle and around R1 600 for replacement cartridges.

Contact Lifesaver Systems on 011-027 9555 or visit www.lifesaverafrica.co.za

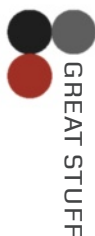


TP-LINK UNIVERSAL WIRELESS N RANGE EXTENDER

Give it a boost

Perching uncomfortably on a corner of your bed to access the weak Wi-Fi signal from a distantly located router is for the birds. Instead, rather plug TP-Link's wall-mounted 300 Mbps Universal Wireless N Range Extender into a nearby electrical socket and you're good to go in comfort. This device allows you to extend coverage and improve signal strength of existing wireless networks to eliminate dead zones, without breaking the bank. Thanks to its Ethernet port, you can use it to connect wired devices such as smart TVs and gaming consoles to your home wireless network. Price: about R450. Contact LinkQage on 0860 538 869 or visit www.linkqage.co.za





TOSHIBA QOSMIO X70

Hybrid performer

Advanced PC users and gamers looking for a machine that delivers the goods when working with graphics-intensive software are bound to appreciate Toshiba's latest mobile performer, the Qosmio X70. Its 1 TB 6,4 cm hybrid drive combines the speed of Solid State Drive (SSD) with the high capacity storage of a hard disc drive. As a result, it's said to deliver around three times faster read and write times than current models kitted out with normal 1 TB 5 400 r/min hard drives. Equipped with up to 32 GB RAM, it can be specced with Hybrid Drive options providing up to 2 TB of on-board storage.

Speed is also a feature of the connectivity side, with gigabit Ethernet and wireless capabilities for faster upload/download, LAN gaming and faster transfer speeds with USB 3.0 ports. Visuals are taken care of by a 3D-enabled Full HD 43,9 cm display. Standard DVD movies can be up-converted to nearly Full HD quality (it comes with a Blu-ray disc player), and there's an HDMI port to feed content to your TV. Prices start at around R21 000. Contact Mustek on 011-237 1000 or visit www.mustek.co.za

WD MY CLOUD PERSONAL DRIVE



On a cloud of your own

Most tech-savvy homes have to deal with the headache of thousands of digital files scattered across multiple computers and mobile devices. Here's one solution: WD's My Cloud personal cloud drive (once connected to the Internet) lets users share files, stream media and access content from anywhere in the world. Not only are there no monthly fees, but you can feel secure knowing that your data remains in your home under your family's exclusive control.

Set-up is said to be a matter of minutes, after which users can easily connect their computers and mobile devices via free desktop and mobile apps. A gigabit Ethernet connection and dual-core processor should make transferring files blazingly fast. Available in 2 TB, 3 TB and 4 TB capacities, it also features a USB 3.0 port, allowing you to connect an external hard drive and expand capacity even further. Prices start at around R1 800 and go up to about R2 700. For more information, visit www.wd.com



SKIL FOX 3-IN-1 MULTI SANDER

Smooth operator

Sanding a workpiece by hand, although undeniably worth the effort, can hardly be described as a fun activity. Skil's multi-sander, the Fox 3-in-1 (model 7220), looks set to make your DIY jobs a little easier from now on. Combining a random orbital sander, orbital sander and delta sander in one handy tool, it can be used to sand stairs, tables, doors, window frames, roofs, furniture, cars and even boats.

A brake prevents you from scratching surfaces when using the random orbital sander. Two speed settings allow for controlled material removal (low speed) or regular sanding (high speed). The delta tip can be rotated in three positions to help preserve the life of the Velcro connection and sanding paper. There's also a dust box and vacuum cleaner connection to help keep your work area clean. The sander weighs a modest 1,3 kg, so holding it above your head for extended periods shouldn't pose a problem. Price: about R830. Contact Skil on 011-651 9858 or visit www.skileurope.com/za



VICTORINOX CYBER TOOL 41

Just fix it

Just because you're a computer geek doesn't mean you can't have a cool multitool. The Victorinox Cyber Tool 41 was designed specifically with PC and electronic specialists in mind. Besides the standard stuff you'd expect from a Swiss Army knife (think large blade, wood saw, can opener, wood chisel and much more), it also comes with the tools you need to fix computer hardware on the fly. For starters, there's a bit wrench, with a bit case containing 5 mm and 4 mm hex sockets, #8, #10 and #15 Torx bits, #2 Phillips bit, #0 and #1 Pozidriv bits). In addition to this, you get a 4 mm flathead and mini screwdriver, a ballpoint pen that doubles up as a DIP switch setter, a wire stripper, wire cutter and wire crimper. Fortunately, it's not all work and no play: reward yourself by popping a refreshing frosty using the all-important bottle opener attachment. Price: about R1 100. Contact iWarehouse on 0861 123 7467 or visit www.iwarehouse.co.za



GREAT STUFF



ZARTEK RECHARGEABLE LED WORKLIGHT

Let there be light

Whether you're into DIY projects, outdoor adventure or saving lives as an emergency responder, if you can't see what you're doing, you're operating blind. Zartek's Rechargeable LED Worklight ZA-440 has myriad uses and is a true go-anywhere device: shock- and rainproof, it weighs less than 1 kg. An array of 48 bright LEDs provides a flood beam of 225 lumens and illuminates areas up to 40 m wide. Its rechargeable 2 400 mAh lithium-ion battery is good for four hours of continuous use from a single charge. and it can be operated directly from AC or DC power sources. Price: about R550. Contact Zartek on 011-640 2460 or visit www.zartek.co.za

RED-E PREMIUM EDITION POWERBANK



Premium power

Portable power packs for gadgets may have been around for a while, but the new RED-E Premium Edition 6 000 mAh PowerBank – with its ability to charge up to three devices simultaneously – definitely does stand out from the crowd. Apart from being able to charge smartphones and other

compatible devices via its built-in micro USB cable, it also features two additional USB outlets for added convenience. A 4-LED power indicator helps you identify how much charge is left, and there's a built-in USB plug for charging. Its lithium-polymer battery is said to take between 6 and 7 hours to charge fully. Price: about R700. Contact Omnico on 021-691 0110 or visit www.omnico.co.za



GREAT STUFF



CANON POWERSHOT N100

Both sides of the story

Most cameras tell only half of the story: namely, what you're looking at. Canon's latest concept camera, the PowerShot N100, is completely different. Featuring two cameras – one front and one rear facing – this baby not only captures what you see through the lens, but also your reaction to it when you press the shutter to capture either video or stills.

It uses Canon's Smart Auto technology and 58 scene options to automatically determine the best settings for capturing the perfect shot – from sunsets to smiling babies. You'll never miss a moment either, thanks to the inclusion of Canon's Hybrid Auto feature, which captures four seconds of movie footage before you press the shutter to take a still image.

The new Story Highlights mode helps you tell your story without any need for editing. That's because it automatically edits all your clips into one video album for you to review and share. And when using Canon's CameraWindow app you can even control its zoom, flash, shutter and self-timer via your smartphone.

Other features include the company's proven DIGIC 6 processor, 12,1 MP CMOS sensor, 25 mm ultra-wide angle lens with 5x optical zoom and Wi-Fi connectivity. Price: about R5 100. Contact Canon on 012-675 4900 or visit www.canon.co.za



WACOM INKLING DIGITAL SKETCH PEN

Digital doodler

If you prefer to start your artwork the old-fashioned (you know, tactile) way before committing it to the digital realm, then maybe Wacom's Inkling digital sketch pen could be for you. This nifty gadget allows you to sketch with a ballpoint pen on any paper. Each stroke is recorded electronically and everything can be imported as vector artwork into your graphics application of choice for further editing. At the click of a button you can record layers to separate your preparatory work from your final drawings, too. Even better, the pen boasts over 1 000 levels of sensitivity to deliver exactly the type of stroke you need. Its receiver can store hundreds of high resolution sketches before you transfer them to your Mac or PC. Price: about R1 800. Contact The Gadget Shop on 012-346 2726 or visit www.thegadgetshop.co.za



UP MINI 3D PRINTER

Grow your own

Hobbyists and other can-do types wanting to manufacture their own models or components should check out the UP Mini 3D

printer. It's capable of "growing" any manner of things out of tough ABS plastic (the same stuff used to make LEGO blocks). It features a build footprint of 120 x 120 x 120 mm, and comes with a heated build table and chamber to prevent your creations from warping.

Thanks to the included software, models too large to fit inside the chamber can be easily sliced into several components and then glued together once printed. Moving parts such as bearings can be manufactured in one hit.

Double linear bearings on both axes help ensure consistent build quality throughout the entire print process. Tools are supplied to facilitate maintenance and self-service, and the unit's software includes STL files for printing its own spare parts. The STL 3D layout and printing software is compatible with most CAD packages. Price: about R13 000. Contact 3D Printing Systems SA on 014-597 3327 or visit www.3dprintingsystems.co.za **PM**



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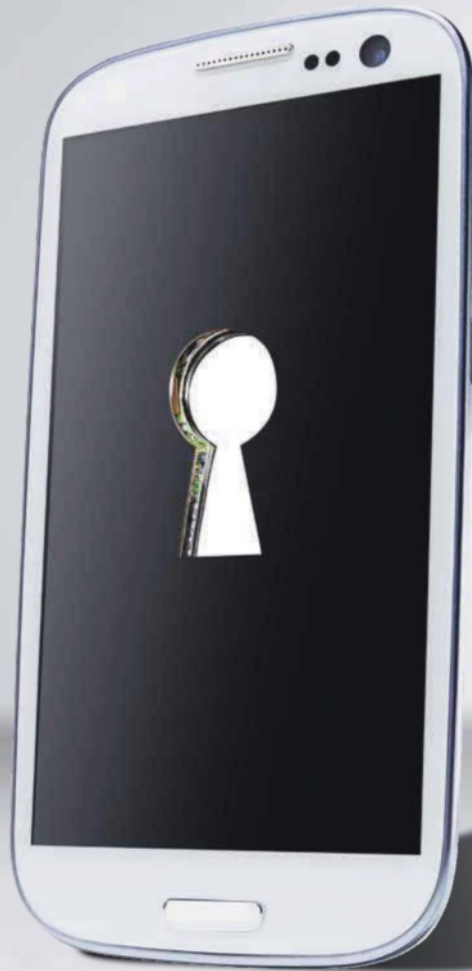
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THE DIGITAL SPIES ARE WATCHING YOU –
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BUT THE BATTLE'S NOT
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BIG CATEGORIES OF
PERSONAL TECH,
AND HOW YOU CAN
SECURE THEM.



IT'S TIME TO FIGHT FOR YOUR

P R I



PRIVACY, WE SAY, is about to come roaring back. No, it's not too late. Yes, we know that Google monetises both our e-mails and our search histories. It's true that data brokers market our personal dossiers, listing everything from our favourite blogs to our old parking tickets (identity thieves must love it). And NSA leaker Edward Snowden really did prove the paranoids right: the United States government spies on everyone.

Now, we agree that security agencies have a vital responsibility to track terrorists, but that mission can't require all citizens to live in a surveillance state. Feel you have nothing to hide? That assumes the data will always be used to defeat terrorists, not to monitor activists, let alone to stalk ex-girlfriends – yes, NSA employees have done that. Here's the other side to the privacy-is-dead argument. You can fight the privacy erosion that technology has enabled using tools that technology provides. And when you protect your data – using encryption and other tools – you incidentally bolster the argument that security is the norm. At least it should be. Privacy is not dead but simply suffering from neglect. It's your job to revive it.

BY DAVEY ALBA

PHOTOGRAPH BY TERU ONISHI
PROP STYLING BY SARAH GUIDO

TECH: WEB BROWSERS

TO DO: DEFEAT TRACKING SOFTWARE

Web browsers work in two directions: You use them to learn about the world, and snoops use them to learn about you. The sheer number of identifying files, or cookies, downloaded on to our computers can surprise even jaded digital natives. Many cookies are helpful – keeping you logged in to a service, for instance – but others exist purely to help marketers target their sales pitches. An online tool maintained by the Network Advertising Initiative can reveal who is collecting information on you; a browser we tested was being tracked by 82 firms, with names such as AppNexus, Criteo and Datalogix.

Cookies can be cleared, but new methods for tracking online use will be harder to circumvent.



TYPOGRAPHY BY SINELAB

For instance, some companies use browser fingerprinting, which looks for distinctive patterns of computer settings, such as installed fonts and time-zone details, to home in on a user's identity. Google and Microsoft are also working on a new form of cookie-less identification: unique IDs with tracking that reaches beyond the desktop and into the user's browsing activities on smartphones and tablets.

Google's system could potentially be used to tie together data across all its products – Gmail, the Chrome browser and Android phones. In addition to tech firms, the US government can monitor your digital trail through your browser. Among last year's revelations: the NSA has tapped into the fibre-optic cables that make up the Internet's backbone, and, through the Marina metadata application, the agency can track an individual's browsing history, social connections and, in some cases, physical locations.

Routine fix: To practise good browser hygiene, regularly clear your cookies and your browser cache. There are a number of browser add-ons that can shrink the deluge as it pours in. For instance, Adblock Edge blocks ads and third-party trackers. The Disconnect add-on lets you see and prevent otherwise invisible tracking of your browsing history. (Both add-ons work with Firefox and Chrome; Firefox is preferable because it's an open-source browser.) **Extreme fix:** Organising resistance to a totalitarian state and need real anonymity? Download the Tor Browser Bundle. Tor has become famous as a secure way for activists, journalists and, yes, some criminals to browse the

Web. Tor bundles your data into encrypted packets and directs it through a worldwide volunteer network of more than 3 000 servers, hiding your location and making your data more difficult to read along the way.

There are two downsides to Tor: first, it's slow, because your data is sent through at least three relays, with each relay donating different amounts of bandwidth to Tor users. Second, merely downloading it can draw government scrutiny. The NSA has reportedly developed a system called FoxAcid to insert eavesdropping applications into the machines of Tor users. However, the agency admitted in a leaked Snowden document: "We will never be able to de-anonymise all Tor users all the time." A virtual private network (VPN) adds a different kind of protection by encrypting all outbound computer communications. Combine Tor with a VPN and you've got even tighter security.

TECH: SOCIAL NETWORKS

TO DO: RAMP UP PRIVACY SETTINGS

In 2011, an Austrian law student named Max Schrems asked Facebook to provide all the data it had collected on him, taking advantage of an obscure provision in a European data-protection law passed in 1995. Schrems initially received only a fraction of his data. He protested, and eventually a CD showed up at his door that held a 1 222-page PDF, which included employment information, relationship statuses, pokes, old chat conversations and geotagged photos – most of it information that Schrems thought he had deleted.

Such data is being monetised by tech companies in increasingly invasive ways. Google's Shared

E-ZPass tags capture a car's location data at toll plazas. In the US, the information can be used in civil court cases such as divorces. Tag readers can also be used to monitor traffic flow along any road.



PRIVACY MAKEOVER

HOW POPMECH TECH EDITOR DAVEY ALBA TRIED FOR TOTAL DIGITAL SECURITY.

PROUD TECHNOPHILE – that’s how I’d describe myself. I’ve built a 3D printer from mail-order parts. I once tracked down an iPhone thief using sneaky digital tools. My smartphone, at last count, has 303 apps. But testing seemingly every digital product released has a downside: it means I have bigger privacy vulnerabilities than most people. And for all the attention I pay to technology, I’ve never worked particularly hard at protecting my data – I always used default privacy settings and the same, sloppy online tools most people choose.

No longer. After interviewing dozens of computer science researchers, cryptographers and security professionals, and learning how easily digital snoops can access personal data, I decided to change my ways. Every expert’s top suggestion: use open-source software, because the NSA works with tech companies to weaken encryption in proprietary software. “It’s much harder to build in back doors in open-source,” Matthew Green, a computer security expert at Johns Hopkins University, told me. “The eyeballs are on it.”

I switched to Mozilla Firefox and jettisoned my

Googling habit in favour of a new search engine, DuckDuckGo. I downloaded Tor, an anonymising browser bundle that hides your identity – it’s slow but worth using if you’re on an open Wi-Fi network. Right now, I am locked in to an iPhone contract, but next time I’ll go with Android, which is open-source. So far, so easy.

Next, I set about installing encryption software on my laptop and phone. Honestly, I’d never even heard of some of the tools my sources recommended – with names like Cryptocat, Autistici/Inventati and GNU Privacy Guard. Downloading a secure instant-messaging client was a cinch. So was adding plug-ins to my browser to block tracking by ad companies.

However, it took me an afternoon to wrestle PGP (Pretty Good Privacy) encryption into my e-mail, partly because I insisted on learning how to encrypt my Facebook messages, too. I started

using a password manager, then promptly forgot the long master password I’d created. But I worked through the mishaps and felt much more secure once I was done.

But there was a rub: privacy is a lonely world. I had an encrypted phone service and text messaging – and no one to talk to. The first time I fired up my secure texting app, Silent Text, I had exactly one contact on my list: Bruce Schneier, the cryptographer who’d recommended it. But rather than give up, I started cajoling my friends into enabling encryption on their own systems so that we could communicate. (I probably have lots of invisible new friends, too. The NSA reportedly flags people who download encryption software – I imagine I’m now on the agency’s radar.)

Is increased security worth the trouble? I say yes. Realistically, it may be hard to adopt some of these tools, the ones that require your friends to sign up as well. But if there’s ever been a time to advocate for privacy technology, this is it. Downloading encryption tools sends a clear message that you’re not okay with digital snooping. All kinds of organisations are spying on us, with minimal permission or oversight. We don’t have to make it easy for them.

ILLUSTRATIONS BY AMANDA LANZONE



DIGITAL SAFETY ZONES

Where do you land along the privacy spectrum? Side with the easy-going online libertines and you'll never have to remember another password – but everyone from spambots to NSA spooks will have their way with you. Join the Luddite camp, avoiding all digital entanglements, and you'll be safer but isolated. Most of us will be happiest somewhere in the middle. Choose wisely, digital dweller.

The man with no secrets – at all

Security level: 1 

Profile: You're a digital exhibitionist – and an identity thief's perfect target.

Digital tech: One password to rule them all (last four of your Social Security number should do it); unsecured Wi-Fi; phone Password Lock set to Off.

Social networks: Facebook, Snapchat, Pinterest, Twitter, Instagram – you name it. Privacy settings? What are those?

Commerce: The more retail loyalty programs you can join, the better you like it.



Endorsements feature, for instance, allows the company to include a Google Plus user's name and photo alongside ads being shown to his social contacts, if the original user had indicated some interest in the product. And potentially such data could also be pored over by recruiters, cybercriminals and stalkers.

Routine fix: Use strong privacy settings on each of your social networks, placing limits on who can see your posts. To block tracking software associated with the Share buttons on many Web sites, install Disconnect, an extension that disables such widgets. Also, log out of social networks when you're finished, and routinely clear cookies. **Extreme fix:** Opt out of social media – invite your friends to a barbecue.

TECH: CARS

TO DO: GET USED TO IT

In early 2012, a tinkerer with the Internet alias Puking Monkey hacked a plastic "moo cow" toy to

sound an alarm every time his E-ZPass was read. This RFID-enabled device is used to pay bridge and highway tolls throughout much of America's East. But during a test drive in July 2013, the cow lit up and wailed in Manhattan, even when the car was nowhere near a toll plaza. The unseen E-ZPass readers had been installed to help monitor traffic flow – but that didn't pacify the hacker. "If non-toll tracking is benign," asks Puking Monkey in an e-mail, "why is it not disclosed when you sign up for an E-ZPass?"

There are ways to avoid that kind of tracking. But American motorists can't do too much about the really big guns of automotive surveillance: the tens of thousands of automatic number-plate scanners deployed across the United States. In Grapevine, Texas, to give one example, 14 547 vehicles were photographed in one day, and up to two million plates are currently stored in a database. Most US law enforcement agencies can still set their own policies on the use and retention of the data (it varies by state); many have no policy at all.

In addition to all this, cars are themselves data-

ILLUSTRATIONS BY AMANDA LANZONE

You floss nightly – and clear your web cache

Security level: 2 

Profile: Sure, you know the NSA and Target are both listening in. Creepy? Sort of. You'll take precautions – but you're not giving up Scramble With Friends just to make a point.

Digital tech: For Web browsing, privacy add-ons (for example, HTTPS Everywhere, Disconnect); for e-mail, two-step verification and strong passwords; WPA-encrypted Wi-Fi.

Social networks: All networks, but with strong privacy settings and a password manager.

Commerce: Amazon Prime, baby... you can't give up everything.

Paranoid? No, realistic

Security level: 3 

Profile: They laughed at your talk of government surveillance, but that was before Edward Snowden. Who's paranoid now?

Digital tech: VPN (virtual private network), OTR (Off The Record) instant messaging for laptops and Silent Circle for mobile phone calls; PGP (Pretty Good Privacy) e-mail encryption.

Social networks: Offline only – you meet your buddies at the Def Con Hacking Conference.

Commerce: No loyalty cards; you give "Jenny's Number" (XXX-867-5309) to shop assistants to look up "your" account.

Welcome to the encrypted zone

Security level: 4 

Profile: You're a CIA agent or democracy activist in a totalitarian state. Or maybe you just think like one. Welcome to the privacy rabbit hole.

Digital tech: Air-gapped computers (meaning no Web connection) for sensitive files; burner phones; the Tor bundle with VPN. Open-source technology.

Social networks: Offline only. Immediate family, trusted members of your doomsday-prepper network.

Commerce: Cash, barter in MREs... or bitcoins.

Living off the grid, under a rock

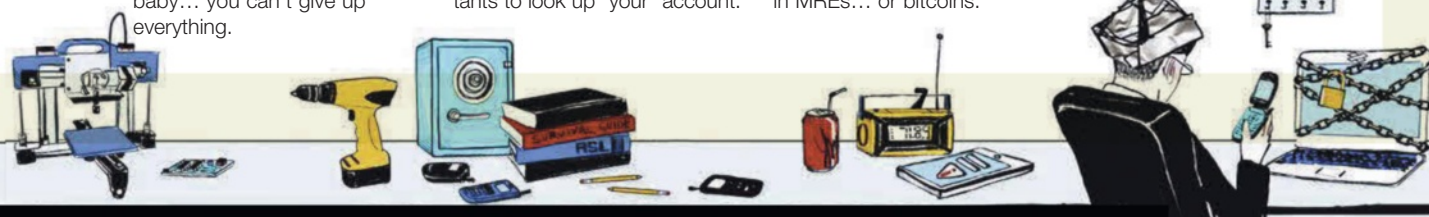
Security level: 5 

Profile: You don't want to worry about digital snooping – ever. So you've gone offline.

Digital tech: Does finger painting count? Absolutely no computers.

Social networks: Other woodland creatures, your reclusive aunt.

Commerce: Cash, foraging for edible roots.



sharing devices – electric cars can upload data to their manufacturers, and connected services such as GM's OnStar and the Ford SYNC infotainment system send information to the cloud. But the most widespread in-car device is the event data recorder (EDR), which tracks seatbelt use, speed, steering and braking, among other bits of vehicle data. This data comes into play during accident investigations. Ninety-six per cent of cars built in 2013 have the devices; they will be required in all new cars sold in the US from September.

Routine fix: You can store RFID devices such as an E-ZPass in a read-prevention holder until you get to a toll booth. Or simply pay cash – though that option is going away on some roadways. There's a lot of chatter about techniques to defeat number-plate cameras, but it's unclear whether these are legal or even effective. **Extreme fix:** When it comes to black boxes in cars, the best approach is to know your legal rights – or, better yet, just to drive safely. Really hate being watched? Buy an old car that predates black boxes.

TECH: INSTANT MESSAGING TO DO: CLEAR OLD CHATS

Instant messages seem fleeting, but they're not. The messages are stored, at least briefly, on the IM service provider's servers unless you delete them – on your machine and your partner's. And unencrypted messages are vulnerable to interception as they travel from your device through your ISP's network to your IM service provider (Google, AOL, Yahoo, Microsoft or whomever) and then out to your friend's computer.

But does anyone actually snoop on IM conversations? Well, the US government does, for one. Snowden leaks reported in July last year revealed the existence of XKeyscore, an NSA program run in co-operation with security agencies in New Zealand and Australia that, among other things, lets agents surveil IM correspondence, often in real time.

Routine fix: Delete your chat records, in case anyone gets hold of your phone or laptop. You can

stop recording future chats by changing the settings in your IM client.

Extreme fix: The gold standard in IM encryption is OTR, or Off The Record (not to be confused with Google's proprietary Off The Record chat feature, which isn't secure). OTR uses "perfect forward secrecy", which means a fresh set of encryption keys is created every time one partner in the chat sends a new batch of messages. Note: even participants in the chat won't be able to review old messages. As Ian Goldberg and Nikita Borisov, the designers of the OTR protocol, explained in an e-mail: "The only record of the conversation is your memories."

TECH: E-MAIL

TO DO: TURN ON OPTIONAL SECURITY TOOLS

The content of your e-mails can be less revealing than the metadata – the record of which contacts you correspond with and how often. Through a program called Stellar Wind, the NSA logged metadata on e-mail communications for 10 years, and from 2007 to 2011, the data included bulk information on Americans. In a separate effort, the government agency has been scooping up hundreds of millions of contact lists from around the world, at a rate of 250 million people a year.

One piece of fallout from that spying has been the shuttering of two services that until recently offered a high level of protection – not just against the United States government but also against repressive regimes and criminal organisations. Ladar Levison, the owner of Lavabit, a Texas-

based secure e-mail service, closed down operations in August after he was asked to hand over the encryption keys that protected his site to the FBI, which would have given the government access to all user data. The FBI said it was just interested in Lavabit's most famous user, Edward Snowden – but refused Levison's offer to provide access to that account only.

A few hours later, the encrypted communications company Silent Circle announced that it, too, was closing its e-mail operations because, although the messages sent through its service were encrypted, e-mail protocols – SMTP, POP3 and IMAP – leave user metadata open to spying. "We decided that our e-mail service was too much of a risk for us and our customers," Silent Circle's Jon Callas says. "While it might have been a good idea six months before, it wasn't a good idea in a post-Snowden world." The companies have since teamed up to develop a new service, called Dark Mail, meant to secure both the content of an e-mail and its metadata – the encryption will work only among Dark Mail users.

Routine fix: Ordinary e-mail protocols make it impossible to hide metadata information, but there are ways to secure the content of your messages. Check that you're using the common Internet security protocols, SSL and TLS, when you're on Webmail. (The browser's address line will start with https, and a small padlock appears.) If you're using a desktop mail client, make sure you're connected via SSL/TLS over IMAP or POP; otherwise, your e-mails are being sent in cleartext and can be read by outsiders.

Also, turn on two-factor authentication, a security feature offered by the three big e-mail services, Gmail, Yahoo and Outlook (see our DIY Tech article, "5 E-mail myths debunked", for additional routine e-mail-security measures).

Extreme fix: People who truly need to guard their communications use PGP (Pretty Good Privacy) when they e-mail each other. Every user has a pair of cryptographic keys, a public encryption key and a private decryption one. The public key is widely distributed, while the private key is kept by the owner. A sender encrypts his or her note with the recipient's public key, transforming it into gibberish. Since only the sender and receiver hold the keys, no one in the middle – including the e-mail service provider – can decode the message. PGP doesn't hide the metadata, though, and everyone you communicate with has to be using PGP for it to work.

ADIKAMDAR,
ELECTRONIC
FRONTIER
FOUNDATION



"TOO OFTEN, THE DISCUSSION ABOUT PRIVACY DIGRESSES FROM THE ISSUE OF CONTROL. PEOPLE DESERVE THE POWER TO KNOW WHAT'S GOING ON, AND TO SAY NO OR SET LIMITS ON WHO CAN USE THEIR DATA. MAKING SURE GOOD CHECKS ARE IN PLACE IS SOMETHING THAT WE, AS BOTH CITIZENS AND CONSUMERS, CAN AND SHOULD FIGHT FOR."

TECH: MOBILE DEVICES

TO DO: DELETE OLD APPS

There's no need to invent the ultimate citizen-surveillance device: it already exists, and it's called the smartphone. Police departments have been investing in IMSI catchers (that's short for International Mobile Subscriber Identity). These devices insert themselves between mobile devices and cell towers – the technology can be used to identify participants at a demonstration and even access their conversations. Hackers can build or buy the devices, as well. Additionally, law enforcement agencies can easily subpoena third-party companies for user data; in 2011, cellphone carriers responded to an astonishing 1.3 million demands for subscriber information. The companies handed over text messages, caller locations and other information, in most cases without the knowledge of the user.

Brick-and-mortar retailers are also making use of cellphone-location data: some chains have started experimenting with using phones to track individual shoppers as they move through the store. And many mobile phone apps can transmit location data, contact lists and calendar information back to their developers. Lose an unlocked phone and, of course, you give up access to your contact lists, e-mails, chats and everything else that resides on your phone.

Routine fix: First, delete the apps you don't use – fewer apps means fewer robotic spies.

Extreme fix: Silent Phone can encrypt phone calls (about R100/month, iOS and Android) – both parties need to be subscribers. There are also secure apps for IM chats and Web browsing. Prepaid (aka "burner") phones are relatively safe from snooping because they aren't tied to an

account. And if you're worried about IMSI catchers at your next political rally, just leave your phone at home.

TECH: WI-FI

TO DO: USE ENCRYPTION

We all know that browsing on an unsecured network is just asking for someone armed with cheap network-analysing software to tune in by vacuuming the 802.11 data packets flying between your machine and the Wi-Fi router. That can happen in Starbucks – or in your home. Last September, a federal appeals court ruled that Google could be held liable for civil damages for eavesdropping on homeowners' Wi-Fi networks while using the company's camera-carrying Street View cars. Google says it was all a misunderstanding: the Wi-Fi data was being used to pinpoint precise locations where GPS signals were spotty.

Routine fix: Most wireless Internet access points come with WEP (Wired Equivalent Privacy) or WPA (Wi-Fi Protected Access) to let you encrypt the messages between your computer and your access point. Use WPA if possible; it's the stronger technology. In addition to protecting data, turning on encryption gives Americans, at least, legal protection against hackers under the Wiretap Act, which Congress passed in 1968 and last amended in 1986 through the Electronic Communications Privacy Act (ECPA). If you don't make any attempt to secure your data transmissions, US law assumes that your intention is to run a public network. Here in South Africa? Don't hold your breath.

Extreme fix: Combine a virtual private network with the Tor bundle and you're as safe as you can be – well, almost. Want even better security? Don't use Wi-Fi at all.

PM

Burner phones, pre-paid devices that aren't tied to a specific account and allow people to switch numbers frequently, can be useful tools for the highly cautious.



Number-plate readers (left), mounted atop police cars and along city streets, scan up to 1 800 licence plates per minute, keeping track of virtually every car on the road.





SCIENCE • BY SETH LLOYD

New question from the *Edge*

DO WE OWE OUR EXISTENCE TO A GIANT COW?

Once a year, we feature short, thought-provoking essays from a Web site called *Edge*, described by the UK's *Guardian* newspaper as "a forum for the world's most brilliant minds". Contributors are asked to respond to a different question each year; this year's question is:

"What scientific idea is ready for retirement?" Seth Lloyd, professor of quantum mechanical engineering at MIT, thinks it's time to retire the Universe. Here's why...

I know. The Universe has been around for 13,8 billion years and is likely to survive for another hundred billion years or more. Plus, where would the Universe retire to? Florida isn't big enough. But it is time to retire the 2 500-year-old scientific idea of the Universe as the single volume of space and time that contains everything.

Twenty-first century cosmology strongly suggests that what we see in the cosmos – stars, galaxies, space and time since the Big Bang – does not encompass all of reality. Cosmos, buy the condo.

What is the Universe, anyway? To test your knowledge of the Universe, please com-



plete the following sentence. The Universe:
(a) consists of all things visible and invisible – what is, has been, and will be.
(b) began 13,8 billion years ago in a giant explosion called the Big Bang, and encompasses all planets, stars, galaxies, space and time.
(c) was licked out of the salty rim of the primordial fiery pit by the tongue of a giant cow.
(d) all of the above.
(see correct answer below).

The idea of the Universe as an observed and measured thing has persisted for thousands of years. Those observations and measurements have been so successful that today we know more about the origin of the Universe than we do about the origin of life on Earth. But the success of observational cosmology has brought us to a point where it is no longer possible to identify the Universe – in the sense of answer (a) above – with the observed cosmos (answer b).

The same observations that establish the detailed history of the Universe imply that the observed cosmos is a vanishingly small fraction of an infinite Universe. The finite amount of time since the Big Bang means that our observations extend only a little more than 10 billion light years from Earth. Beyond the horizon of our observation lies more of the same, space filled with galaxies stretching on forever. No matter how long the Universe exists, we will have access to only a finite part, while an infinite amount of Universe remains beyond our grasp. All but an infinitesimal fraction of the Universe is unknowable.

That's a blow. The scientific concept, Universe = observable Universe, has thrown in the towel. Perhaps that's okay. What's not to like about a universe that encompasses infinite unknowable space? But the hits keep coming. As cosmologists delve deeper into the past, they find more and more clues that, for better or worse, there is more out there than just the infinite space beyond our horizon.

Extrapolating backwards before the Big Bang, cosmologists have identified an epoch called inflation, in which the Universe doubled in size many times over a tiny fraction of a second. The vast majority of space-time consists of this rapidly expanding stuff. Our own Universe, infinite as it is, is just a "bubble" that has nucleated in this inflationary sea.

In another bubble, electrons don't exist

It gets worse. The inflationary sea contains an infinity of other bubbles, each an infinite universe in its own right. In different bubbles, the laws of physics can take different forms. Somewhere out there in another bubble universe, the electron has a different mass. In another bubble, electrons don't exist. Because it consists not of one cosmos but of many, the multi-bubble universe is often called a multiverse. The promiscuous nature of the multiverse may be unappealing (William James, who coined the word, called the multiverse a "harlot"), but it is hard to eliminate. As a final insult to unity, the laws of quantum mechanics indicate that the Universe is continually splitting into multiple histories or "worlds", out of which the world that we experience is only one. The other worlds contain the events that didn't happen in our world.

After a two-millennium run, the Universe as observable cosmos is kaput. Beyond what we can see, an infinite array of galaxies exists. Beyond that infinite array, an infinite number of bubble universes bounce and pop in the inflationary sea. Closer by, but utterly inaccessible, the many worlds of quantum



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mechanics branch and propagate.

MIT cosmologist Max Tegmark calls these three kinds of proliferating realities the type I, type II and type III multiverses. Where will it all end? Somehow, a single, accessible Universe seemed more dignified.

There is hope, however. Multiplicity itself represents a kind of unity. We now know that the Universe contains more things than we can ever see, hear or touch. Rather than regarding the multiplicity of physical realities as a problem, let's take it as an opportunity.

Suppose that everything that could exist, does exist. The multiverse is not a bug, but a feature. We have to be careful: the set of everything that could exist belongs to the realm of metaphysics rather than of physics. Tegmark and I have shown that with a minor restriction, however, we can pull back from the metaphysical edge.

Suppose that the physical Universe contains all things that are locally finite, in the sense that any finite piece of the thing can be described by a finite amount of information. The set of locally finite things is mathematically well defined: it consists of things whose behaviour can be simulated on a computer (more specifically, on a quantum computer). Because they are locally finite, the Universe that we observe and the various multiverses are all contained within this computational Universe. As is, somewhere, a giant cow.

Answer to quiz: (c)

● Visit www.edge.org

PM

HOT RIDES
TOP TECH
TEST DRIVES

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MERCEDES-BENZ C-CLASS

MY, HOW YOU'VE GROWN

The new C-Class has grown 80 mm in the wheelbase and is 95 mm longer overall. That's not, as you might expect, simply because Mercedes has decided that bigger is better. It's our fault, apparently: Mercedes says the size increase reflects the fact that humankind is growing taller on average. Rear passenger room and boot capacity (now up to 480 litres) are the main beneficiaries.

Besides being bigger, Mercedes's mainstay model is smarter and more powerful, but also lighter and more





economical. Lightweight materials and techniques save up to 100 kg; aluminium's proportion of the car's weight has rocketed from 10 per cent in the predecessor to around half the total. Tweaked aerodynamics drop the drag factor to as low as 0,24, and there are thrifty new engines.

New driver assistance systems and optional air suspension give C-Class owners the ultra-refined feel of the flagship S-Class, too. The new car's comprehensive interior makeover combines styling cues from Merc sports cars with a totally new centre console that differs for manual or automatic versions.

The three engine variants available at launch – C 220 BlueTEC diesel and the two petrol models, C 180 and C 200 – will be joined soon after by a range that stretches from a new supercharged 1,6 diesel (outputs 85 to 100 kW) to a 245 kW six-cylinder petrol. Transmissions are either 6-speed manual or 7-speed auto.

A novel feature that is not very relevant for South Africa, but nevertheless worth noting, is "tunnel detection". The C-Class is the only car in this segment to offer this system, which uses the sat-nav map information and GPS location data to close the air recirculation flap automatically when the vehicle enters a tunnel, and to re-open on emerging from the tunnel. To crank up the well-being further, the Air-Balance option combines active fragrancing, air ionisation and more efficient filtration.

HONDA NC750X

THE SWISS ARMY KNIFE OF BIKES

In the space of two years, the NC700X carved a niche for itself as a capable commute machine. It featured a torquey engine and rugged looks with ergonomics and dynamics to match. For 2014, it gets a 75 cm³ engine capacity increase that changes the model designation to 750, twin balancer shafts, new exhaust muffler and taller gearing. Smaller, detail improvements are the icing on top.

Designed to be as capable commuting as it is touring, the NC750X features an innovative parallel-twin engine configuration that frees up space within the body of the motorcycle. There's room for a storage compartment that's big enough for a full-face helmet. The engine is profiled for punchy low- to mid-range performance, with the additional balancer shaft intended to counteract vibration at high revs. The new muffler design, to match the increased engine capacity, keeps a lid on undesirable noise while retaining the engine's pleasing beat. Thanks to the torque increase, with 6 per cent taller overall gearing, you get higher top speed and more relaxed highway cruising, too.



IN BRIEF

ENGINE	745 cm ³ liquid-cooled 4-stroke 8-valve, SOHC parallel 2-cylinder
OUTPUT	40,3 kW @ 6 250 r/min; 68 N.m @ 4 750 r/min
FUEL SYSTEM	PGM-FI electronic fuel injection
TANK	14,1 litres
ECONOMY	3,46 litres/100 km (M)
TRANSMISSION	6M (6-DCT optional)
KERB WEIGHT	219 kg (M)
SUSPENSION	Front – 41mm telescopic fork, 153,5mm stroke; rear – monoshock damper, Pro-Link swingarm, 150 mm travel



SUBARU WRX STI 225 POWERFUL REASONS WHY

There's a lot more to a high-performance car than sheer power. But it doesn't hurt to have a bit extra. Or, in the case of Subaru's hooliganmobile, a lot extra: the WRX STI's 225 kW output is said to be the best in its segment.

As we say, though, power isn't everything. You have to get it down on the road. So, Subaru's flagship performer gets a stiffer chassis with firmer springs, crisper steering (2,5 turns lock to lock) and active torque vectoring. In addition to this, the adaptive central differential can either be left to adapt its action automatically or can be switched to one of 6 settings manually. Drive characteristics such as throttle response can be matched to the situation using one of Intelligent, Sport or Sport Sharp mode.

As before, the car runs on the marque's trademark symmetrical all-wheel drive. Brembo brakes and beefy 245/40 tyres on 18-inch wheels complete the package.

Launched at the year's traditional automotive opener, the Detroit Show, the WRX gets aerodynamic goodies that include the characteristic boot spoiler and a rear diffuser. Aluminium, carbon fibre and high-tensile feature prominently in an effort to cut back on weight.

And yes, it will be coming to South Africa – albeit in limited numbers – during the course of the year.



IN BRIEF

ENGINE	2,5 l Boxer four-cylinder
OUTPUT	225 kW at 6 000 r/min; 393 N.m at 4 000 r/min
DRIVETRAIN	Symmetrical all-wheel drive, multi-mode centre diff, torque vectoring
TRANSMISSION	6M



VOLKSWAGEN DUNE

BEAST OF A BUG

They're calling it a near-production concept car. The Dune extends the "Cross" theme found on other models (such as the Polo) to the archetype VW, the Beetle. With a little twist: instead of roof rails, the Dune gets what have been dubbed "blades" on its back. There's a nod to the original in the side trim, which evokes running boards. Yet this Beetle is no mere dune buggy: under the bonnet growls a 157 kW turbo petrol engine that provides the ability to rocket from standstill to 100 km/h in 7,3 seconds.



AUTO INTEL





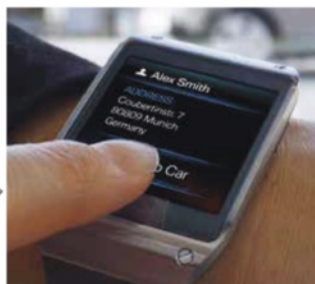
BMW AT CES

MEETING OF MINDS

MAYBE CONVERGENCE COULD BECOME A BUZZWORD AGAIN. RUBBING SHOULDERS WITH THE WORLD'S CONSUMER ELECTRONICS GIANTS AT THE ANNUAL LAS VEGAS TECH-FEST, THE CONSUMER ELECTRONICS SHOW (CES), BMW SHOWED OFF SOME OF ITS ADVANCED SYSTEMS, FROM AUTONOMOUS DRIVING TO CONNECTIVITY.

Automated driving. A new kind of research prototype for highly automated driving uses advanced control technology to demonstrate maximum safety up to the car's dynamic limit. The prototype vehicle highlights the effectiveness of a new generation of control systems on a closed-off track. What makes this system different from current "stability control" equivalents is that it operates proactively, rather than mitigating understeer or oversteer by selectively braking the wheels. According to BMW, it "actively intervenes in the direction-changing decision-making process". That means harmonising the electronically controlled steering, braking and acceleration.

Watch what you're doing. BMW is the world's first carmaker to integrate vehicle functionality with the [Samsung Galaxy Gear](#) electronic wristwatch.



Using the BMW i Remote App on the Gear offers information on the battery charge and available range of BMW i3 electric car. It also shows whether the windows, doors and sunroof are closed and allows users to send a navigation destination to the vehicle or adjust the on-board climate in preparation for a journey. It even responds to spoken commands via Samsung's speech recognition S Voice technology.

Park easy. With BMW's new Parking Assistant, easing into your chosen space requires nothing more than a button-push. Using inputs from ultrasonic sensors, in addition to controlling the steering, the new system has the ability to manage forward and reverse movement, with longitudinal and lateral guidance.

BMW 2 SERIES COUPÉ

A NEW TAKE ON COMPACT PERFORMANCE

It's been a decade that the 1 Series has carried the BMW flag in the compact sports segment. This new two-door adds a touch of exclusivity with the promise of the marque's traditionally sporty demeanour, with its rear-wheel drive configuration touted as a trump card. In fact, it's a stand alone successor to the 1 Series Coupé. As such, it has more in common with BMW's coupé line than with the sedans.

For instance, the 135 kW four-cylinder engine in the BMW 220i Coupe is making its debut in a compact BMW model. At the other end of the scale, the M235i Coupé's 240 kW six-cylinder in-line makes it the most powerful petrol-driven member of the BMW M Performance Automobile line-up.



A SMARTER BOLT

GM'S DATA BOLTS ARE THE KEY TO A NEW HIGH-TECH ASSEMBLY LINE. *By Matthew De Paula*

Engines are complicated and a lot can potentially go wrong during assembly: malfunctioning machines, faulty parts and, of course, human error. But at its factory in Tonawanda, New York state, General Motors has taken a high-tech approach to preventing and catching these problems. And it's all thanks to a humble little bolt.

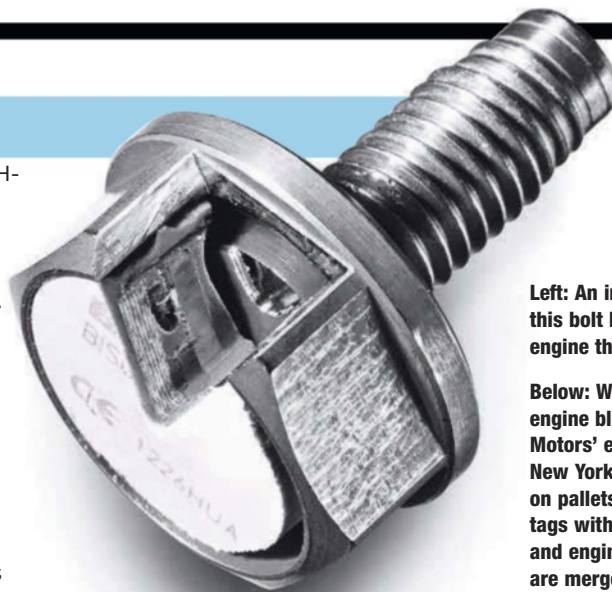
The 75-year-old factory recently underwent a R4 billion upgrade to start building a new line of six- and eight-cylinder engines. It's the first of the company's manufacturing facilities to implement a new track-and-trace system by using radio-frequency-identification (RFID) technology. GM has used RFID tags in its factories for more than 10 years to identify assembled engines, but now the company is attaching them directly to the cylinder heads and engine blocks using what it calls a data bolt. It's shaped like a regular bolt and is threaded on one end, but the head is hollow. Inside, secured with epoxy, are a memory chip (or RFID tag) and a coiled metal filament, which acts like an antenna.

As its name implies, the data bolt stores information – 2 kilobytes' worth, to be exact. That's a very small amount of data by modern standards (only a fraction of an MP3 audio file's 3 to 5 megabytes). But it's enough to record every single manufacturing process the engine block or cylinder head undergoes. And that is the key to the whole track-and-trace system: all of the data from each bolt gets uploaded to servers housed at the factory.

DOWN THE LINE

In total, there are about 50 different points throughout the production line where data gets transferred to and from the bolts. Just about every automated machine on the line has an RFID scanner to read the data bolt before it performs its task, and another RFID writer that logs new information on the bolt once the machine has done its job. If any of the machines on the floor do not complete their duties to perfection, the next machine in line can tell and will shunt any out-of-spec engine block or cylinder head off the line to be inspected by a worker.

Likewise, if a block or head gets pulled to undergo a gauge test for appropriate tolerances, but somehow gets left offline at the end of a shift, it can't be put back into the wrong place in the production process, which sometimes used to happen. "That has saved us a couple of times already," Peter Laskiewicz, a manufacturing process engineer for GM, says, "especially during launch, when you've got a lot of parts everywhere and are trying to understand where they go." Skipping a single process could crash one of the 30 new digitally operated milling machines that use computerised co-ordinates to hone surfaces and drill and top holes in the engine blocks and cylinder heads. Such mistakes can cost the company about R10 million apiece, Laskiewicz says.



Left: An internal RFID tag means this bolt knows more about your engine than you do.

Below: When the cylinder heads and engine blocks are joined at General Motors' engine plant in Tonawanda, New York, the engines are mounted on pallets that have their own RFID tags with which the cylinder head and engine block serial numbers are merged. By then, the assembly information recorded by the RFID tag in the data bolts has already been backed up to a central server for easy retrieval.

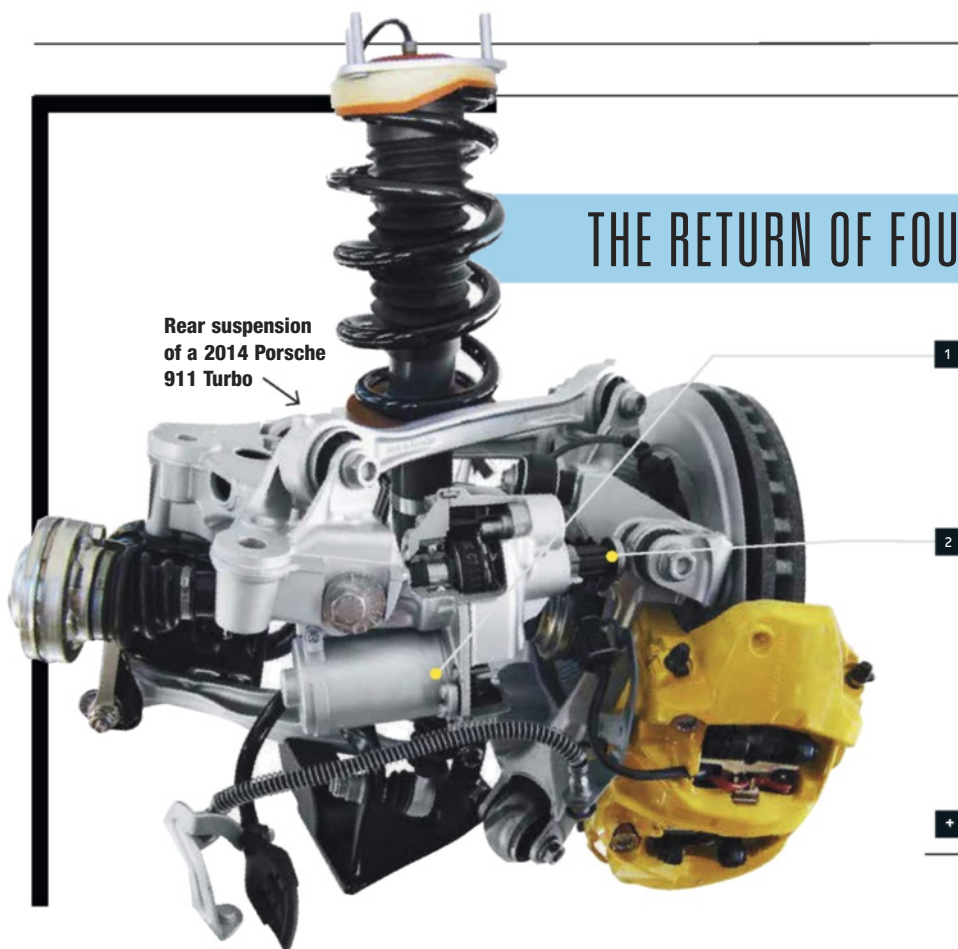


Once the cylinder heads are fully milled, they're attached to the block using a machine that screws down all 20 bolts at the same time. Here again, the RFID tracking is invaluable, allowing workers to tell whether each bolt was successfully installed. This is also critical, because some bolts require such a precise tolerance that they can only be torqued and retorqued a certain number of times. In the past, if a bolt attaching a bearing cap to an engine block got flagged for improper tolerance, for example, a worker could retry and sometimes get it to pass muster, even if it wasn't fully within spec. And that was an oil leak just waiting to happen.

Although quality control during the manufacturing process is the main goal of the new data-bolt RFID system, it is also proving to be a huge help in post-production troubleshooting. If a supplier notifies the factory of a bad batch of parts, it's easy to zero in on the exact engines on which they were installed using the database of information saved from the bolts. General Motors plans to implement the track-and-trace RFID system in other factories, but hasn't said when it will do so. Marc Brazeau is a director with AlixPartners, a global consulting firm with expertise in manufacturing processes. Brazeau says that what GM is doing is exciting and has the potential to spread to industries such as appliance manufacturing: "Four or five years from now you're going to see a lot of different types of applications."

THE RETURN OF FOUR-WHEEL STEERING

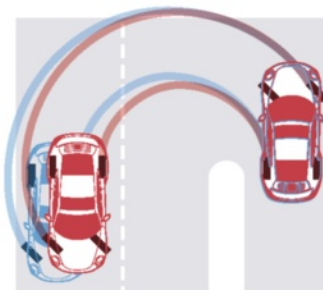
Rear suspension
of a 2014 Porsche
911 Turbo



Independent **electric motors** replace the convoluted steering gearbox in old four-wheel-steer systems. Each computer-controlled motor drives a separate toe link in and out via a belt-driven gear.

The **toe link** nudges each rear tyre to the right or left. Only a few centimetres of movement is needed: the maximum change at the rear is 2,8 degrees when moving in the opposite direction to the front wheels, and 1,5 degrees in the same direction.

TURNING RADIUS



At low speeds, four-wheel steer helps the **911 Turbo** U-turn in 10,6 metres, half a metre tighter than the **911 Carrera 4**.

During the late 1980s Honda led a wave of Japanese manufacturers that introduced four-wheel steering in some sports cars. Why steer all four wheels? At lower speeds, turning the rear wheels in the opposite direction to the front wheels results in a smaller turning radius and faster cornering responses. At high speeds, turning all four wheels in concert improves high-speed stability. The trend was short-lived, though, owing to the complicated mechanical systems and the sometimes scary handling. But with modern electronics, four-wheel steer is back. According to Porsche engineer Andreas Preuninger, the latest systems are so fast, you can't tell when they're working. Currently, Porsche uses four-wheel steering on the 911 GT3, 911 Turbo and 918 Spyder. Honda's Acura range offers a similar system on the RLX.

– Michael Austin

DATSUN CONCEPT

THE REVIVAL ROLLS ON

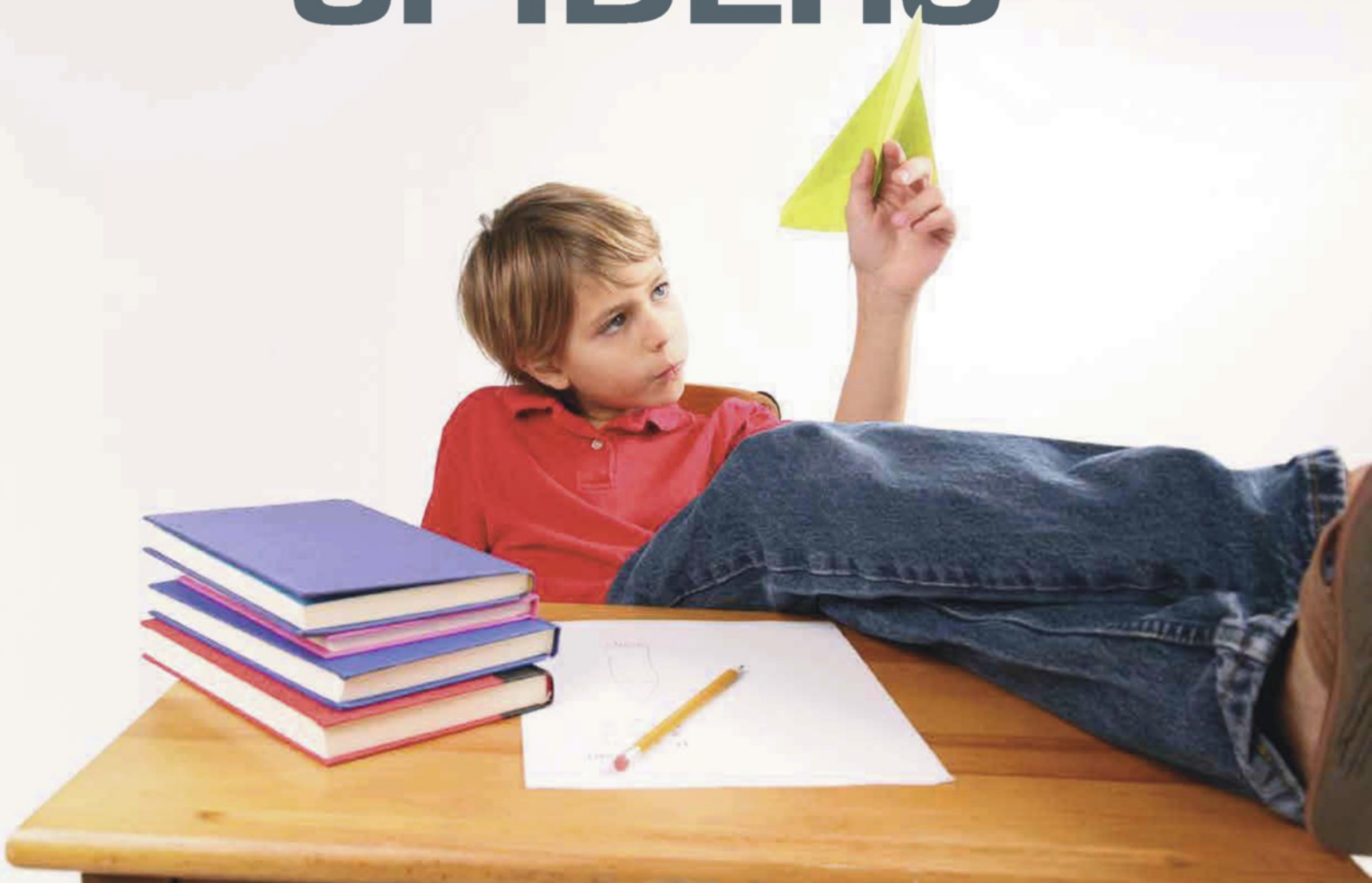
The revival of the Datsun nameplate continues apace with the news that parent company Nissan is fleshing out the line-up. Last year, nearly three decades after the name had been shelved, the Datsun Go compact came on stream, followed soon after by the Go+ wagon. Soon, we could also be seeing something with a bit more pizzazz, going by the concept due to have been shown at the Delhi Auto Expo (see artist's impression). The concept represents a possible direction for the future expansion of the Datsun line-up for up-and-coming young customers in high-growth markets, such as India, says Nissan. Other target markets include South Africa, Indonesia and Russia.

PM





**WHY
EDUCATION
NEEDS
MORE
RADIOACTIVE
SPIDERS**



WRITER SCOTT BARRY KAUFMAN SAYS THERE ARE EXTRAORDINARILY TALENTED AND CREATIVE INDIVIDUALS SITTING IN OUR CLASSROOMS, BORED OUT OF THEIR MINDS – AND WE NEED TEACHERS WHO CAN EXTRACT THAT POTENTIAL AND GIVE THEM A SAFE SPACE TO FIND THEIR IDENTITY. THINK SPIDER-MAN...

Consider Peter Parker. His childhood wasn't easy. Both his parents, Richard and Mary, were killed on a mission as double agents. Raised by his Uncle Ben and Aunt May in Queens, Peter spent most of his childhood without an identity.

Now, Peter was a good student. He had a real knack for chemistry, mathematics, mechanics, biology, physics and photography. But he lacked confidence, drive and self-belief. He was bullied constantly by the other students. He was lonely, shy and socially isolated. One day in high school, he attended a science exhibition about radiology. In a moment, something happened that forever transformed him.

He was bitten by a radioactive spider.

This changed everything. He suddenly realised he had all these powers. He was much stronger and quicker than he ever realised. He could climb walls effortlessly. He discovered he had finely tuned sense perceptions. He even used his extensive science knowledge to design a special kind of "liquid cement" that could shoot out of a "web-shooter".

With his newly discovered abilities, he immediately went for fame. But it went to his head and, when placed in a position to catch a thief, he did nothing. Later, he found out that the same thief had killed his Uncle Ben. If he'd done something earlier, his Uncle Ben would have survived. He realised that with great power comes great responsibility.

But in this moment he also realised something else: for the first time in his life, he had an identity. Who was he? He was *Spider-Man*.

Now more than ever, education needs more radioactive spiders – figuratively, of course. What we need is for more teachers to show students just how much possibility resides within them, and to then provide them with a safe space to find their identity.

Unfortunately, every single day, extraordinarily talented and creative individuals sit in our classrooms, bored out of their minds. What we must realise is that potential is not enough. Potential needs a catalyst, a reason for expression.

Positive expectations matter. So many kids with a specific learning disability (for example, dyslexia, autism, ADHD) – who have areas of strengths and weaknesses – are labelled "learning-disabled". They are fed a steady stream of negative expectations on a daily basis, and this has a major impact on their performance.

Elisha Babad found that the expectations that teachers bring to the classroom have systematic effects on their grading and also affect their students' performances on standardised tests. Kathleen Cotton found that teachers with lower expectations of their students offered fewer opportunities for their students to learn new material, gave insincere praise (which the students were quick to pick up on), provided less stimulating and lower-level cognitive questions, and gave less effective but time-consuming instructional methods.

Children are very sensitive to the overt and covert signals they are receiving from their friends and teachers. While teachers may try hard to suppress their low expectations, they still display a fair amount of communication "leakage". Jan Pieter van Oudenhoven and Frans Siero found that even though teachers gave students thought to be learning-disabled twice as much overt verbal praise, they simultaneously gave more negative non-verbal feedback, such as exhibiting discouraging head movements.

This expectation leakage has serious effects on brain development. Kenneth Kishida and his colleagues had people take an IQ test alone as a measure of their baseline level of ability. Then they gave the participants another IQ test in a small group setting. Importantly, after each test item, they were given feedback on their performance ranking within the group. While everyone performed worse in the group setting, those who suffered the most were those who were told they were "low performers".

Not only did these people perform significantly worse than their baseline level of performance, but they also showed brain changes in areas associated with fear and working memory (the amygdala, the dorsolateral prefrontal cortex and the nucleus accumbens). These results suggest that the lowered expectations brought about anxiety, which prevented them from showing their true colours. Low expectations literally shut down their brains.

What about the other end of the spectrum: those with high ability? Well, they too can be heavily impacted by expectations. Like Peter Parker, there are so many children with an incredible knack for something – whether it's science, maths, writing, photography, art, music, dance or theatre – who fall between the cracks. So many of these children don't flourish because it is expected that they will automatically do everything brilliantly just because they have a knack for something. Unfortunately, there is often little effort to help students with high ability figure out how their rapidly developing abilities fit in with their simultaneously developing self.

Consider a study by Jennifer Fredricks and colleagues, in which they conducted in-depth interviews with gifted and talented adolescents. Their gifted sample consisted of students aged 17 to 21 who were identified as gifted by their elementary school and were also in the top 25 per cent of students. These university students were asked to recall their high school experiences in gifted education.

In contrast, the talented sample included students in grades 9, 10 and 12 who were perceived (by themselves and by parents and teachers) as being highly competent in at least one non-academic activity, who valued engagement in that activity, and who spent considerable time in the activity after school. Non-academic domains included sport, instrumental music, vocal music, drama and dance.

The researchers found striking differences in the responses between the two groups. The students in the talented sample reported a great love for their domain, a strong sense of identity, more frequent flow experiences, and the desire to engage in their domain all the time. In contrast, the gifted sample didn't appear to be nearly as wrapped up in academics as the talented adolescents were in sport and the arts. Many of the students in the gifted sample were depressed and had a bleak vision of their future. The researchers speculate that there was more passion for non-academic domains because individuals' need for challenges, autonomy, competence and relatedness were more likely to be met in athletics and the arts than in academic domains. Youth in the talent sample talked more about having opportunities to make choices, receiving public recognition for their ability, and being supported and encouraged by teachers and peers. Tellingly, the researchers found that when students in the gifted sample were given greater freedom of course selection, they reported greater enthusiasm.

This study highlights the fact that passion isn't an automatic consequence of performing well on an IQ test or getting good grades in school. Passion is activated by a clear set of conditions, and these rules apply to *everyone*; no one is immune. We're all human, with fundamental needs, even if we may differ in our level of development in any one slice in time.

Those who are often the most vulnerable to having an identity crisis are those with advanced ability in some area who *also* have a specific learning disability. On the one hand, these students are constantly being told that their identity is "learning-disabled". On the other hand, they know they are capable of amazing things. This creates conflict and confusion at a crucial time in their adolescent development, when they are in the throes of figuring out who they are and just how they would like to contribute to this world.

'Many of the students in the gifted sample were depressed and had a bleak vision of their future.'

I personally witnessed the power of the radioactive spider. Prior to ninth grade, I had no identity other than "learning-disabled". I was placed in special education very young due to an auditory processing disability that constantly left me one step behind the rest of the kids in the classroom. Despite coming home and writing elaborate fantasy stories, or acting out soap opera plots in my head, it never dawned on me that any of that *counted* as smart or creative. Until I was bitten.

One day in ninth grade, a special education teacher I had never seen before came into the special education classroom. She looked past my label and saw my boredom and frustration. But most importantly, she saw *possibility*.

'I personally witnessed the power of the radioactive spider.'



Taking me outside the classroom, she asked why I was still in special education and why I wasn't taking more challenging courses. This seemingly simple question snapped me out of my ordinary state of awareness. Everything suddenly clicked as I realised I had no good answer to her question. I realised that I was holding myself back.

From there, I signed up for everything I possibly could sign up for. I tried out various identities, from Latin scholar to actor to opera singer to cellist. Some things didn't click. But some did. Slowly but surely, with a newfound belief in my abilities, I discovered my identity. As a result, I went from a C or D student to a straight-A student. The grades naturally followed from my newfound identity.

I wonder how many children we judge too soon. I wonder how many we write off as "stupid" or "slow" when all it would take is a radioactive spider bite to show us all what they are really capable of achieving. I also wonder how many high-ability children fall between the cracks because of bullying by classmates, or because of the messages they receive from teachers that indicate that high ability is all they need and that identity, purpose and perseverance don't matter.

Unfortunately, in this standardised testing culture, the teachers who inspire and enable others to see what's uniquely inside them are about as rare as radioactive spiders. But some day, hopefully, I can change my analogy, because there will be so many teachers transforming students that they will become an entirely common species.

I'm convinced that there is so much more possibility in all students than we realise. Imagine what would happen if educators helped all students see in themselves what is possible, and then helped them integrate that into the core of their identity?

I bet we'd have a lot more superheroes.

First published in *Huffington Post*.

● Scott Barry Kaufman, an adjunct assistant professor of psychology at New York University, is author of *Ungifted: Intelligence Redefined* (Basic Books).

PM

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Inventors, Inc

QUIRKY BRINGS NEW IDEAS TO MARKET—WITH HELP FROM ITS ONLINE FRIENDS.

LIKE MANY A GREAT INVENTION, Jake Zien's power strip was born of frustration. After completing his penultimate year of high school, the Milwaukee native was taking a summer course in industrial design at the Rhode Island School of Design when the surge protector beneath his desk, overwhelmed by outsize adaptors, invoked his ire one too many times. "I threw my hands in the air and said, damn, I wish I could just stretch this thing out and make 'em all fit," he says. "And then I thought, well, how hard could that really be?"

For his final project, Zien presented his classmates with a novel solution, a power strip that telescoped to make room for larger plugs. Each outlet rotated for added flexibility. The concept later earned him an honorable mention and a T-shirt in a Nasa-sponsored Create the Future contest.

The story might have ended there. Zien didn't have the money, the expertise nor the resources to

Each week Ben Kaufman and his staff review close to 2 000 product pitches from Quirky's online community and choose the top two or three for R&D.

bring the product to life – not even with the help of a family friend who practised patent law – so his idea remained dormant for four long years as he went off to university.

Then, in 2010, during the third year of his four-year degree course, Zien got a call from his lawyer friend, who told him about a startup named Quirky that was searching online for product ideas. While sitting in class, Zien called up the company's Web site on his laptop, wrote a one-paragraph pitch, attached a few pictures, and submitted an entry fee used at that time to weed out crackpots. "Best hundred bucks I ever spent," he says.

A week later Zien learned that Quirky had decided to produce his invention. And one year and R10 million in development costs later, Pivot Power was for sale for the US equivalent of R300. It has gone on to become Quirky's best-selling product, a model for what can be achieved when you harness the brainpower of the online universe.

By using the collective might of social networking, rapid prototyping and advanced manufacturing, Quirky has created what has been described as the world's most innovative consumer products company. "Anyone can be an inventor," says founder and CEO Ben Kaufman. "We truly believe that. We open up invention to the world."

In the course of a week Quirky fields some 2 000 ideas – the kind people cobble together in the cafeteria over lunch or sketch on a Starbucks napkin – from an online community of 600 000 would-be inventors. Working in small groups, the staff reviews each pitch and whittles the list down to roughly 15. On Thursday nights in the company's New York City headquarters, a former brick warehouse outfitted with weathered wood floors, sleek glass walls and lofty white ceilings, Kaufman assembles the staff and a handful of honoured guests to help him choose two or three winners. (PopMech's Jerry Beilinson is an occasional participant.) The online community observes

the entire process on a live Internet feed, offering input along the way. After a few minutes of discussion Kaufman asks for a show of hands from the attendees seated in the eight rows of folding chairs in front of him.

If the community responds strongly to an idea – no matter how crazy – Quirky finds a way to make the product, putting its mechanical engineers and industrial designers to work exploring the possibilities. In essence, the concept has already been focus-grouped. "When you understand the problem, that's when the beauty of the design happens," says Doreen Lorenzo, who left the international firm Frog Design to join Quirky as president last October. "A lot of people are giving us ideas based on a problem. And they're living those problems every day."

The 27-year-old Kaufman knows first-hand what a challenge it is for people to bring their visions to life. At age 17, he convinced his parents to remortgage their home to help finance his first invention – a lanyard that concealed the headphone wires on his iPod shuffle so he could secretly listen to music during high school classes.



Jake Zien was a student at the Rhode Island School of Design when he pitched the idea for Pivot Power to Quirky. Within a year, he held a US patent.

He spent nearly R2 million in Shenzhen, China, shuttling from factory to factory, tweaking the design to align with the manufacturing process. The experience paved the way for him to launch the Apple accessory manufacturer Mophie at age 19. He eventually lost control of the company in a battle with investors.

Undeterred, Kaufman holed up with a few friends in an apartment in Manhattan's East Village in 2009 to hatch the plan for Quirky. From the start he made it his mission to tear down the barriers to innovation.

Quirky's in-house design team has more than R20 million worth of prototyping equipment: 3D printers, CNC milling machines, vacuum-forming machines – the works. Staff experts handle patent questions, regulatory issues and sales. The company has also received R300 million from GE as part of a five-year deal to release 30 co-branded products using Quirky's open-source WINK software, which lets consumers operate household items from a mobile phone app (think lawn sprinkler and garage door opener). Quirky has even built an online platform to share 30 000 GE patents with the public. "By opening up lab-proved technology and

patents to everyday inventors," GE senior vice president Beth Comstock says, "we can help inspire new ideas."

They don't have to be big ideas. All told, 853 online contributors, or "influencers", played a role in perfecting Pivot Power's design, packaging and marketing materials – and each received a small stake in the royalties. That interaction is critical: Quirky genuinely listens to what its community has to say. Kaufman cites as an example the app-enabled WINK egg tray. It originally had a dozen cups for eggs, because, well, grocery stores sell eggs by the dozen. But the influencers pointed out that people buy fresh eggs when they get down to the last two. And so, the egg tray went to market with 14 cups. "That's the power of doing things the way we do them," Kaufman says. "The fact we're in people's living rooms, understanding the real-world implications of the things we're inventing, has enormous value."

Few companies in the world are set up to innovate at the pace Quirky has established. Kaufman now has 150 employees to help him develop three new products a week. "Our speed here is unbelievable," says Josh Wright, who was one of the community's first influencers, conceived two inventions, and then moved his family from Florida to New Jersey to work as a jack-of-all-trades at Quirky. "We've had nights where we crank out five working prototypes – from idea to something you hold in your hands – in 14 hours. That includes design, 3D printing, electrical engineering, assembly, painting and having the thing ready to go on an airplane for a retailer demo."

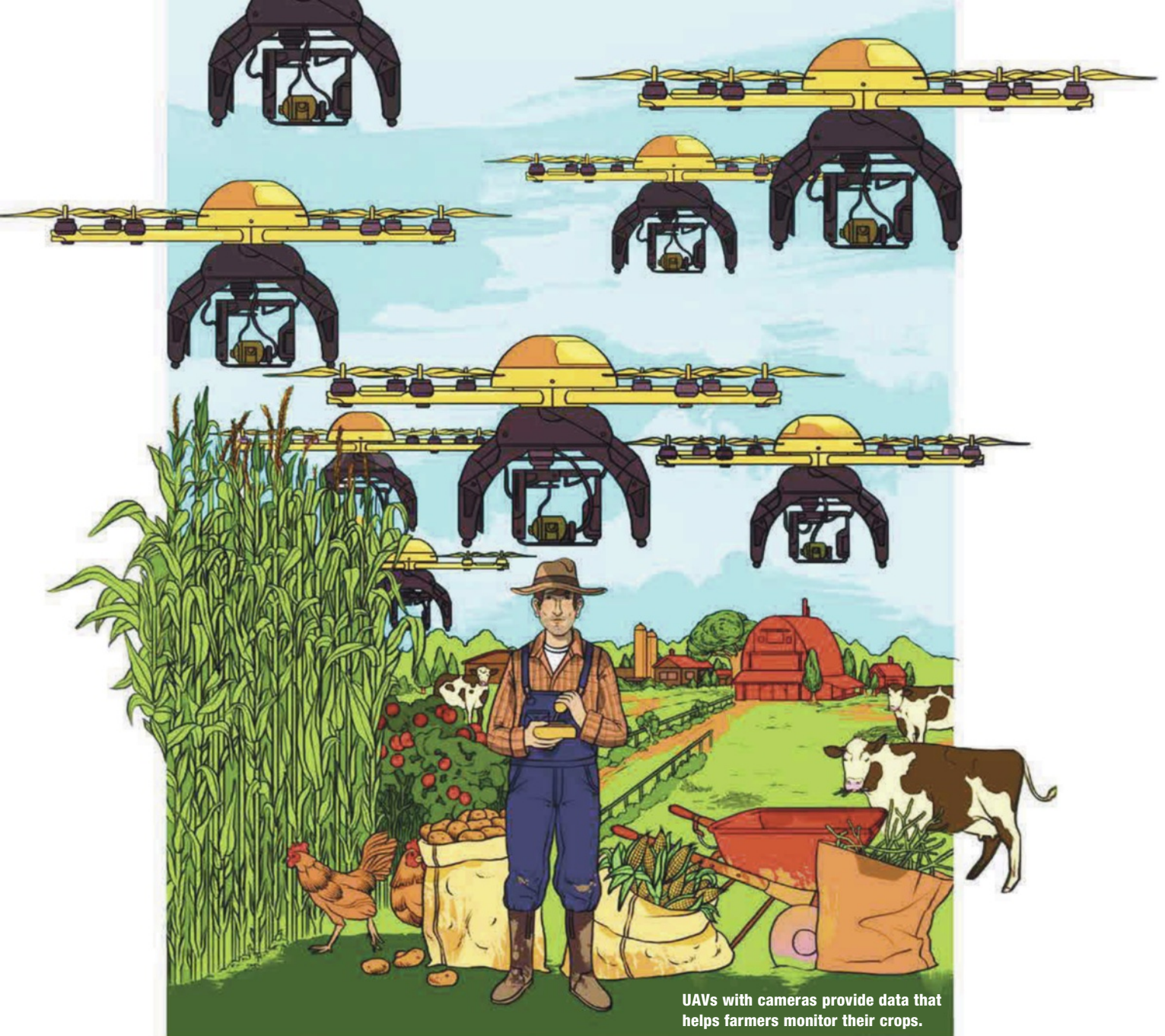
"We are only slowed by things that are not within our control," Kaufman says.

"That's the ethos of the team here: We move as quickly as possible."

Indeed, Zien – now the lead graphic designer at a startup named Floored, which creates 3D-modelling software for the property industry – is still awed by the turn of events in his life. Less than three years out of university, he has his name on a US patent. He appeared in Quirky's six-episode TV show on the Sundance Channel. His picture can be found on Pivot Power packages worldwide. His product has inspired a series of spinoffs. And then, of course, there's the matter of his mushrooming bank account. As the 2013 holiday shopping season approached, Quirky had sold close to 700 000 units of his pivoting power strip, earning him more than R4 million in royalties. The company predicts he will reach R20 million before 2014 is out.

"People are like, oh, so why do you have a day job?" Zien says. "And I'm like, because I'm 24 years old and I have a career ahead of me."

The truth is, all this good fortune makes him a little self-conscious. "I would prefer to be private about it," he says. "I have friends paying off student loans and stuff." **PM**



UAVs with cameras provide data that helps farmers monitor their crops.

TECHNOLOGY • BY ALEX HUTCHINSON

10 Tech Terms For 2014

WHAT PEOPLE IN THE KNOW WILL BE TALKING ABOUT THIS YEAR.

1.

Farm drones

That sound you hear is a swarm of drones, revving their tiny engines as they wait for the Federal Aviation Administration to update its rules on commercial UAV flight. The biggest beneficiaries may be farmers who hope to use cheap UAVs armed with cameras to monitor the health of their crops, employing aerial photography – digital and infrared – to fine-tune delivery of water, fertiliser and other chemicals. To tap that hungry market, companies such as PrecisionHawk have developed simple plug-and-play sensors and data-processing software for use with their 1,5-kg GPS-guided Lancaster UAV. For now, the FAA rules governing farm use are vague (no one has got into trouble yet), but the agency is expected to clarify things this year and issue final rules in 2015.



2 .

In-memory computing

In traditional computer architecture, there's memory (the 6 GB of RAM in your laptop that provides lightning-quick access to the data required to run your applications), and then there's storage (a 1 TB hard drive, slow and inefficient to access but spacious enough to archive your many files). The same dichotomy holds true for massive-data centres, which makes it hard to analyse big-data sets without the delays inherent in retrieving each piece of data from the clunky spinning disc where it's stored. But now that flash memory is relatively inexpensive and getting cheaper by the year, companies such as SAP and Oracle are experimenting with a radical alternative: stowing all your data right in memory. This in-memory computing offers dramatic increases in speed

and, by some estimates, energy savings of up to 80 per cent for big-data centres. With the release of Violin Memory's inexpensive in-memory storage cards, individual servers can now take advantage of those benefits, too.

3 .

IPv6

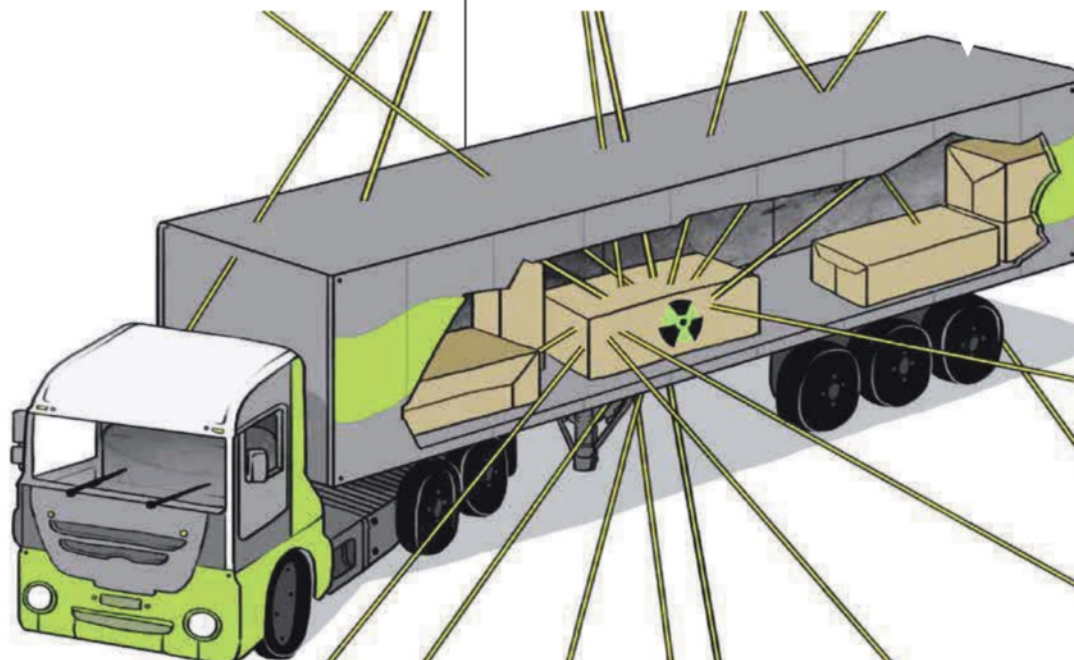
In February 2011, the Internet officially ran out of IP addresses. You probably didn't notice, because new devices continue to connect to the Web via address-sharing work-arounds. But those are stopgap measures. It's time for a wholesale shift from the 32-bit, 4,3 billion-address IPv4 system developed in the 1970s to the 128-bit IPv6 and its mind-boggling 340 trillion trillion addresses. To complete the change, every Web site and Internet provider has to buy in, updating equipment when necessary. At the moment only about 2 per cent of Google's traffic arrives via IPv6. Will the world get its act together in time to avoid missed connections? Many holdouts are looking to Washington for the answer: the White House has mandated that all US Government servers switch to IPv6 by October.

4 .

Decision Sciences' scanning system uncovers nuclear threats by tracking the movements of muons, which penetrate much more deeply than X-rays.

Muon tomography

Though very similar to computed tomography (better known as CT scanning), muon tomography offers one key advantage: instead of assembling images with radioactive X-rays, it uses particles created naturally in the upper atmosphere by the cosmic rays that constantly bombard Earth. These particles, known as muons, penetrate much more deeply than X-rays, which





means they can pass through shielding materials such as lead – and that makes them perfect for detecting nuclear material hidden in shipping containers. Decision Sciences, working with Los Alamos National Lab, has developed the Multi-Mode Passive Detection System, which can scan a 12-metre shipping container in 30 seconds, looking for the telltale ways in which muons are deflected by uranium and plutonium. And before year's end, the company plans to introduce a software upgrade that will enable the device to detect conventional electronics and other contraband. It comes as no surprise that the US departments of Defence and Homeland Security have already signed up to use the technology.

Going once, going twice... Startups such as Personal are developing online marketplaces where consumers can collect and sell their personal data in return for cash and deals.

6.

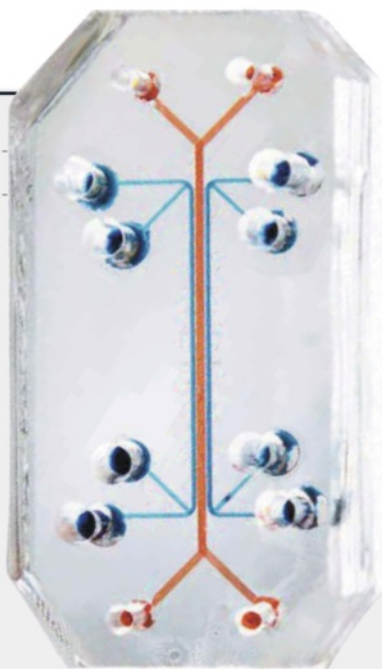
PERSONAL-DATA AUCTIONS

In 2000, a public outcry forced Yahoo and eBay to cancel their plans to auction personal data collected from 200 000 people by a marketing company. Today that data is more accessible and more valuable than ever, but people still strive to protect it. Public sentiment may be changing, though. Last year a New York University student served up two months' worth of private data mined from his digital devices in a Kickstarter campaign. The stunt raised \$2 733 (about R28 000) from 213 amused backers. Now startups such as Washington DC-based Personal are betting that others will follow suit, lumping their online accounts together in one place for convenience and for profit. Once their data is collected, they can choose whether to part with chunks of it – in exchange for special deals and other enticements, that is.

5.

Organ-on-a-chip

Drugs that work well in a petri dish – or even in a mouse – often turn out to be ineffective or dangerous in humans. That's why researchers at Harvard's Wyss Institute for Biologically Inspired Engineering set out to create computer chips capable of simulating the functions of real organs. The lung-on-a-chip has a membrane lined with human lung cells on one side and blood-vessel cells on the other. Air flows across the lung-cell side and a blood-like liquid flows across the other. The device even expands and contracts as it "breathes". Scientists are currently working with the US Food and Drug Administration to test counter-radiation drugs on bone marrow, gut and lung chips. The next step is bolder yet: a R380 million DARPA-funded plan to link various chips in what amounts to a whole-human-body-on-a-chip.



The lung-on-a-chip mimics the mechanical and biochemical functions of a living, breathing organ.



7.

3D counterfeiting

In February, a series of 3D printer patents will expire, clearing the way for a flood of cheap professional machines. That's good news for small manufacturing shops, but bad news for companies that make highly desirable – and easily copied – objects such as jewellery and sunglasses. Rogue websites like *thepiratebay.sx* have already added sections to distribute the printing specs, pulled from pirated blueprints or 3D scans of the originals, for such objects. While designers wrestle with how to insert digital rights management codes in 3D-printer files, some experts predict that, by 2018, companies will be losing a trillion rand a year in intellectual property. The more immediate issue for everyone, though, is figuring out exactly what is protected by copyright (for creative work) and patent (for useful devices). A screw? No big deal. A replacement part for your car? That's trickier.

8.

SEMI-AUTONOMOUS DRIVING

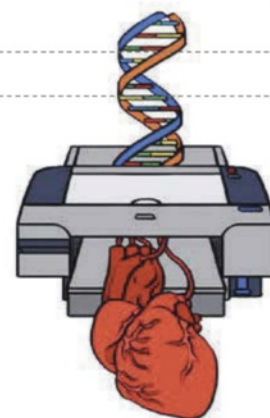
We still have a way to go before cars pilot themselves to the office but, little by little, technology is now assisting us with the driving. Manufacturers including Mercedes-Benz, Ford, Audi and Volvo have designed vehicles that can park themselves. GM's hands-free Super Cruise control will adjust the steering and the brakes to keep your car at a safe remove from the SUV ahead. The Direct Adaptive Steering system in Nissan's Infiniti Q50 uses circuits to sidestep the rack-and-pinion system, speeding up the response time between steering wheel and tyres, maybe even paving the way for vehicles operated by joysticks. Cool? You bet, but advances like these also have the potential to make for safer roads, fewer bottlenecks and, yes, hands idle enough for you to enjoy a doughnut with your coffee.

PHOTOGRAPH BY KIMMO EROVOLA

9.

Bioprinting

Imagine taking an inkjet printer, filling it with bio-ink made from stem cells, and printing a new kidney for anyone who needs a transplant. The process is a little more complicated than that, of course, particularly when working with multiple cell types or tubular structures, but after years of research that incredible scenario is almost within our reach. Organovo, which unveiled the first commercial 3D bioprinter in 2009, expects to release functional human liver tissue in 2014 that drug companies can use for medical research. Scientists are also working on printable bone and wound-healing materials. It's still a big leap from there to a fully transplantable organ, but take heart: now you don't have to be a science-fiction fan to believe it's possible.



10.

Active cyber defence

Even classified military networks are vulnerable to hackers. So, in 2012, DARPA launched an Active Cyber Defence programme. Think pre-emptive strikes. Proponents aim to identify and disarm would-be attackers with, say, fake data. The start-up CrowdStrike is bringing the same aggressive approach to the private sector, promising to use big-data analytics to monitor real-time activity in client networks. Some advocates are even pushing for changes in privacy laws for permission to hack into an adversary's network to retrieve or destroy stolen data.

PM

THE IMPROBABLE FLYING MACHINES OF SYWELL

BY JEFF WISE
PHOTOGRAPHS BY REED YOUNG
TYPOGRAPHY BY JACKSON ALVES





**PILOTS OF
PEDAL-POWERED
AIRPLANES DEFY
PHYSICS TO
COMPETE IN
AVIATION'S MOST
OBSCURE CONTEST.
WELCOME TO THE
ICARUS CUP; NO
ENGINES ALLOWED.**

“Dad! Hold the tail down!” David Barford shouts to his 73-year-old father, Paul, who shuffles along the grass while supporting a slender spar that connects the rear stabilisers to the cockpit and wings of Betterfly, a fragile aircraft that balances on two inline wheels. David’s 20-year-old daughter, Charlotte, supports the starboard-wing spar with his best friend, Paul Wales. David’s 17-year-old son, Chris, marches alongside the port wing, while David, 44, co-ordinates the action from the nose of the plane.

Team Betterfly’s sense of urgency grows as the summer daylight fades and the sky west

**Team Betterfly guides
its delicate aircraft
across the grass of
England’s Sywell
Aerodrome during the
2013 Icarus Cup.**



David Barford (centre), best friend Paul Wales (left) and Paul's dad, Ray, repair the cowl- ing of the Betterfly after a crash during take-off. Barford built the craft in his garage and living room, to his family's occasional chagrin.

attempt at the speed-course event. Two dozen spectators also anxiously monitor the weather, hoping the threatening rain doesn't ground the pilots.

The team gently sets Betterfly on the centre line at the end of Sywell's lone paved runway. To shed weight, Barford strips down to his underwear and bike shoes, then eases into a red fabric pilot's seat made from two aluminium folding chairs. The

of Sywell Aerodrome, a rural air-strip 120 km north of London, darkens prematurely with thunderclouds. It's the second day of the week-long Icarus Cup, the world's most challenging human-powered-aircraft competition, and Barford wants to make a first

only controls in the transparent cockpit are bike pedals and a handle for the rudder.

Barford calls out "Three, two, one – rolling!" and begins to pedal furiously. The front-mounted propeller claws the air and Betterfly starts gathering speed as it rolls down the runway. The crew supporting the aircraft walk, then jog, then sprint as the wings rise from their hands. Betterfly floats off the runway, oh-so-slowly. Barford's legs churn. "Go, go!" Wales shouts. The nose dips precariously, sinking to within centimetres of the asphalt before slowly rising to an altitude of under two metres. Barford flutters down the runway at an airspeed of 29 km/h. "The experience is quite odd," he says later. "You feel like you're just pedalling a bike, and then everything goes quiet because you're no longer in contact with the ground."

When Betterfly settles back on to the asphalt, the crew race



Picture: Nasa Dryden/Jim Moran

Top and left: This delicate flying machine (Gossamer Albatross II) was the backup craft for the record-breaking cross-Channel flight by the original Gossamer Albatross on 12 June 1979. It is shown here undergoing slow-speed flight tests at the Dryden Flight Research Centre in California.

Dr Paul MacCready was later awarded the most prestigious prize in American aviation, the Collier Trophy, for his work on the project. The Albatross II was fitted with a small battery-powered electric motor and flight instruments for the Nasa research project. The minimal power required to fly the aircraft suggested it could be solar-powered, and led to numerous record-breaking projects involving solar energy.

up to support the wings, trailed by spectators on foot and bicycles. Barford has completed the 200 m course in 42 seconds. He also earns duration points for remaining aloft a total of 62 seconds. With 1 438 points, he's risen to second place, a mere 30 points behind the leader, who's flying Betterfly's nemesis, Airglow.

Human-powered flight, dreamed of since the days of the ancient Greeks, was long considered to be impossible. Aeronautical engineers assumed that no aircraft could be light enough to fly on such a limited power source – a pair of legs – and still be sturdy enough to carry a pilot.

Then, in 1977, American aeronautical engineer Paul MacCready, capitalising on breakthroughs in strong, lightweight materials, built a human-powered plane called the Gossamer Condor. After take-off, MacCready's pilot cleared an altitude of 3 m, then flew

a figure-eight pattern around pylons 800 m apart in Shafter, California. The feat earned MacCready the £50 000 (about R890 000) Kremer Prize, established in 1959 by British industrialist Henry Kremer. In 1979, MacCready's Gossamer Albatross, which used carbon fibre instead of aluminium, flew 35 km across the English Channel in 2 hours 49 minutes.

After those accomplishments, the public lost interest in this esoteric corner of aviation. But David Barford did not. As a boy growing up in the town of Northampton, just 32 km southwest of Sywell Aerodrome, he built model Gossamer Albatrosses out of cellophane and drinking straws. He left school at 15 to become an apprentice machinist at a race engine-manufacturing company but never lost his fascination with human-powered aircraft. "They are a pure challenge," he says. "They demonstrate what can be done with so little power and the human mind."



Human-powered aircraft gather at the 2013 Icarus Cup. Of the four planes that competed, only two flew for longer than a minute. Organisers hope to turn this obscure hobby into a sport.

With encouragement from other enthusiasts and support from his family, Barford decided to build his own pedal-powered aircraft. He milled aluminium parts in the garage of his suburban home and made rib assemblies out of balsa and Depron foam in his living room, sheathing them with Dacron and Mylar.

He cannibalised the chain and bearings from a mountain bike and the wheels from his daughter's childhood bicycle. It took nearly eight years and R136 000 to complete the 40-kg Betterfly, which can fly on just 300 watts of power, compared with the 400 watts required by most human-powered aircraft – a power-to-weight ratio well suited to the middle-aged, 1,73 m-tall Barford, who holds no pilot's licence. "I wanted to build it," he says, "purely so I could fly."

As Barford was completing his plane, another enthusiast, Bill Brooks, chairman of Britain's Human Powered Aircraft Group of the Royal Aeronautical Society, was organising a competition to

showcase the country's pedal-powered fleet. He named it the Icarus Cup, after the Greek mythological figure who plunged into the sea after flying too close to the Sun and melting his man-made wings.

Brooks devised arcanelly scored events to demonstrate the strengths of different designs: speed on straights, endurance on long hauls and manoeuvrability on a tricky triangular course.

His real goal was to demonstrate that flying human-powered aircraft competitively could become an international sport. "I don't see that we'll all be flying to work in the mornings by pedal power," he says. "But what's wrong with a fascinating and interesting new sport? We hope to be in the Olympics one day."



Flight instructor and glider pilot Mike Truelove prepares for take-off in Airglow, the aircraft that won the 2012 Icarus Cup. In this competition, pilots double as engines.

The first Icarus Cup was held in 2012 at the home of the Lasham Gliding Society, 88 km southwest of London, with five aircraft in competition: Betterfly, two craft built by universities, a plane built by professional aircraft designer John Edgley, and Airglow. Multiple pilots flew each plane; the pilot with the most cumulative points earned R36 000 and a small silver cup. Clearly, glory, not fortune, was the motivation.

Although Airglow flew four times as far as Betterfly and topped the field, Barford had proved he could compete. His 460 m flights were 10 times further than he had expected.

This second edition of the Icarus Cup has been sanctioned by the International Air Sports Federation, and federation officials are mulling over the creation of a world championship in 2015. If that occurs, Brooks will have achieved his ambitious goal in a remarkably short time.

Meanwhile, back among Sywell's patchwork of wheat fields,

hedgerows and sheep meadows, Barford may be the hometown favourite, but the odds are against him. The same professional glider pilots who triumphed in Airglow at Lasham are keen to repeat last year's victory – Robin Kraike, who has logged 1 000 hours in microlight aircraft; and Mike Truelove, who is a flight instructor. Both are in their 40s, lean, athletic and a head taller than Barford.

"I felt on top of the world," Kraike says. "That's what we came here to do... to win." The previous day, while Kraike and Truelove were racking up points for precise take-offs, Barford was replacing adhesive tape and foam that mice had gnawed off his aircraft while it was stored in its travel trailer.

Physics does not favour

human-powered flight. To lift a 68 kg pilot, an aircraft with Betterfly's 33 m² airfoil and 22,8 m wing-







VIDEO > Visit www.popularmechanics.co.za to catch Airglow and Betterfly in action at the Sywell Aerodrome during the 2013 Icarus Cup.

span requires around 0,41 kW to take off and about 0,335 kW to fly. Even well-trained athletes can manage only up to 0,37 kW in bursts, and 0,22 kW for extended efforts.

The aircraft competing for the Icarus Cup have comically long wings, but they need the length to fly. All wingtips generate swirls of air, or vortices, that disrupt airflow and produce drag. The longer the flight surface, the smaller the effect of the vortices, and the less a pilot has to pedal to overcome drag and stay aloft.

Yet long wings also make an aircraft heavier, which demands more power from the pilot. Every ounce saved from the design counts for more air time and longer distances. That's why Barford flies in just his underwear in an aircraft made of balsa, foam and thin plastic. Another weight-saving omission: safety belts and harnesses.

Betterfly's wings, however, have tapered tips, "like a Spitfire airplane from World War II", Barford says. This wing shape minimises induced drag and decreases the chance that air will separate at the wingtip during a turn, causing a stall.

All Icarus Cup entrants, even Betterfly, have trouble steering. Control surfaces on wings generate very little force at these sluggish speeds. Everyone crashes, and even low-velocity impacts produce major damage for these fragile aircraft. Airglow veers off

Barford secures victory on the last day of the 2013 Icarus Cup by flying Betterfly into the challenging triangular course.

course and breaks both wings piling into a multimillion-rand King Air; Betterfly bumbles a take-off and cracks a cowling. Barford's son, Chris, steps on a wing and forces a night-time repair to fix cracked spars, which is performed at Sywell under car headlights.

The real Icarus competition becomes the repair marathon. Tool kits here contain spanners and files for working with aluminium tubing, blue extruded Styrofoam, balsa and resin. Around the tents and recreational vehicles of the team encampments stand large spools of replacement Dacron and Mylar that look like oversize rolls of clingfilm.

Betterfly is not exactly the same aircraft that flew in the first Icarus Cup. The team has added fixtures to the wings that enable them to move forward on the fuselage, changing the plane's centre of gravity. "That should allow us to fly slower, with less drag," Barford says. But the first days of the competition are windy and the team doesn't risk using the new design.

On the fifth day, when conditions are calm, Barford changes the wings' location and notches an impressive 102-second flight. But that achievement is quickly overshadowed by a successful 200 m run by Airglow's Truelove, which raises his score to within 26 points of Barford's first-place total.

Barford is visibly exhausted. His good-sportsman, we're-all-just-here-to-have-fun spirit has been overtaken by a gritty determination to win. The day ends with a lacklustre 7-second flight. After Team Betterfly rolls the plane into the hangar, Barford slumps to the ground. "It's just not worth it," he says.

At dawn, Brooks announces that high winds and more rain will probably make this sixth morning's flights the last of the Icarus Cup. At 7:30 am, Truelove takes off, rises quickly and glides above the runway for more than a minute and a half, a personal best. The flight puts him in first place with a comfortable margin of nearly 200 points.

Now it's all up to Barford. His friends and family push Betterfly to the starting point and wait for the officials' all-clear signal. When it comes, Barford shouts to his crew, "Three, two, one!". Betterfly rises smartly but then drifts worryingly to the right. Barford straightens and stabilises about 1,8 m off the deck. He's never flown so smoothly.

Then, halfway down the airstrip, the plane once again veers sharply. No pilot in the competition has made this kind of turn on purpose. The crowd stills, then cheers. Barford is heading into the intimidating triangle course. The crowd is shouting, "Go, David! Go, David!" Even Team Airglow is rooting loudly.

Barford completes the first leg of the triangle, then makes the 60-degree turn. The course's tight corners are the ultimate test for Betterfly's elliptical wings. The plane dips, rises a fraction, then settles on the grass 102 seconds after lift-off.

The nose is practically resting on the white chalk line that marks the end of the second leg. "He's done it!" a marshal announces over the PA system. Grinning, Barford climbs out of the cockpit and collapses on the grass as his team and spectators surround the aircraft. "I gave it everything I had," he pants.

After he pushes himself to his feet, Barford's father lets go of the wing spar long enough to give his son a hug. "I've only cried twice," Paul Barford says. "Once when you were born, and just now when you made that turn."

It will be hours before the rules committee awards 500 points to Barford, securing his position in first place. But with family, friends and human-powered flight fans celebrating at his side, he's already won.

PM

diy

Tech



5 E-MAIL MYTHS DEBUNKED

WEEKEND

THINK YOU KNOW EVERY E-MAIL TRICK?
THINK AGAIN.

We're all e-mail power users, based purely on the hundreds, if not thousands, of messages we get each week. So it's easy to assume that we all know the best tips and tricks for managing that deluge: keep your inbox lean, set up multiple accounts to stay organised, devise a strong password. It turns out that some of the conventional wisdom is outdated, and most of it is incomplete. Here's a rundown on those misconceptions and the best tools for making your e-mail efficient – and secure.

NEON SIGN BY LITE BRITE NEON



MYTH: *The right way to deal with e-mail overload is to clear out all your inbox notifications.*

REALITY: *Folders, tags and filters can be better organisational tools.* There's a push lately to reach "inbox zero", which is exactly what it sounds like. That empty-inbox feeling may sound satisfying, but for someone who receives hundreds of e-mails a day, it may be more trouble than it's worth.

So here's a compromise: an inbox that holds the messages you need to see, but keeps them all easily searchable and structured, with distinct folders and tags. In other words, your messages are not entirely filed away; they are organised. "Rather than having all the e-mails in your inbox at once, crowding your focus, keep it lean," suggests Aye Moah, chief of product and cofounder of Baydin, the company behind the e-mail add-on Boomerang. She's also a proponent of filtering your messages according to rules (parameters such as who the sender is or key words in the subject line) that require manual set-up, but then work on their own.

Gmail, Outlook and Yahoo all let you create rules and filters, either in settings or directly in the inbox. For instance, you might create a filter that finds all messages that contain "First National Bank" or "ABSA" and have a rule that automatically applies the label Finance. You can also create filters to tag every e-mail from a certain sender or to automatically archive messages with attachments.



MYTH: *Setting up e-mail aliases isn't worth the trouble.*

REALITY: *Sure, it's a pain, but it could make your life easier.* Aliases are different addresses that connect to your main account; they can help organise your inbound messages. They come in two forms: completely different usernames, and disposable e-mail addresses with various separators between

the base name and the tag. (Not every e-mail service allows for both approaches.) Why create aliases? They can turn an address into something more professional-sounding, or group certain e-mails according to their purpose. For instance, my main e-mail could be rachel@gmail.com, and rachel+shopping@gmail.com, an alias, could be the address I use with online retailers. I would still get all e-mails from retailers in my rachel@gmail.com inbox, but rachel+shopping@gmail.com would become a searchable term, which is useful. Additionally, if I had created a completely new username, such as rzashopping@outlook.com, to give out to online retailers, I could decide to delete it later to stop getting their e-mails.



MYTH: *Using a strong password will secure your e-mail account.*

REALITY: *A strong password is just the start. Use extra measures*

EXPERT TIP

TRICKS FOR THE BIG 3 OF E-MAIL

GMAIL

- For about 5 seconds after you send a message, Gmail lets you unsend it. To enable the feature, go to Labs in Settings and enable Undo Send.
- Worried that you're signed in to your e-mail on another computer but can't remember where? Scroll to the bottom of any gmail.com page and look for the Details link under Last Account Activity. There you can see any open sessions and sign out everywhere at once.

OUTLOOK

- Right-click on a message in the inbox to reveal an Outlook-specific context menu, not just your browser's default menu. Below the standard items you'd expect to find – Reply, Forward, Archive, etc – you'll see ones that are for a specific sender. Among these is Schedule Cleanup, which lets you automatically move or delete e-mail from that sender after a set number of days. That way you'll see only more recent messages, reducing your overall inbox clutter.

YAHOO

- Perhaps the best secret feature in Yahoo is Not My E-mail, which the company launched after it began letting users claim dormant addresses. (The unintended side effect of that was people receiving messages not meant for them.) The button, which you can apply to messages without opening them, returns unwanted e-mail to the sender. Eventually, Not My E-mail also trains your system: if the subject line contains any hint that the e-mail doesn't belong to you, you'll never see it surface.

that probably already exist in your e-mail system.

Enable two-step verification. This adds a second factor to your password, usually a code sent to your phone. With that added layer of security enabled, every time you sign in, you'll have to check your phone for the second key, which can be texted to you or retrieved in an app. It's slightly annoying, but worth it. You can streamline the process by choosing to "trust" a specific computer; the system will require only a password and not the extra code if you are logging in from that machine. Additionally, application-specific passwords (strings of letters and numbers randomly generated by the e-mail service itself) let you secure third-party applications that work outside a browser, usually on a different device, and which aren't compatible with two-step verification – such as Apple Mail, Android Mail and Outlook. Then within your Settings page, you can manage the apps you've connected to your account. So if you lose your

mobile device or stop using an app, you can simply remove access to the app to eliminate the security risk.



MYTH: You can only manage your e-mail in real time, when you're in front of your computer or using your mobile device.

REALITY: Add-ons can time-shift your e-mail.

Besides making it simpler to keep track of received messages, a supercharged e-mail account can also make it easier to manage incoming mail. The key to that is getting e-mails only when you can deal with them. Of course, you can't expect everyone writing to you to wait until a designated time, but you can hide e-mails and have them automatically appear when you want them to.

"E-mail is a pretty old technology, relatively speaking," Baydin's

Moah says, "and we haven't really come up with new tools to handle the load of e-mail we're getting today." Her company's Gmail-only Boomerang plug-in does several things, but the primary use is to schedule outgoing e-mails to be sent later.

Boomerang also has a snooze feature, like the one popularised by the Mailbox iOS app: the feature temporarily hides an e-mail and pops it up in your inbox again at a set time, preventing e-mails from clogging your inbox until you know you'll be able to respond. You can also have Boomerang remind you to follow up on messages to which recipients have not yet responded. The snooze feature hides e-mails that you select; if you prefer to have all your e-mails come to you at a specific time, Inbox Pause (for Gmail only) will do the trick. It adds a Pause button to Gmail, which will hide your e-mail until you choose to see inbound messages again.



MYTH: If Google wants to read your Gmail messages, there's nothing you can do to stop it.

REALITY: Encryption can block outsiders, including your e-mail provider, from snooping. (For more on digital security, see "Privacy".) Basic encryption through the HTTPS protocol comes standard in Gmail and Outlook and can be turned on in Yahoo mail. But that only makes it harder for hackers to steal data as it moves between the e-mail server and your browser. Micah Lee, a staff technologist for the Electronic Frontier Foundation, says, "The only way to truly keep your e-mail private from e-mail services themselves is to use OpenPGP e-mail encryption." (PGP stands for Pretty Good Privacy.) With free services such as Mailvelope (for Gmail, Yahoo and Outlook), any recipient you send an encrypted message will have to enter a password to read it.

PM



ON
SALE
24 FEB

DON'T BUY A CAR

UNTIL YOU'VE READ OUR TOP 12 BEST BUYS FOR 2014

What's the best new vehicle in the market? There isn't one, but 12 of them. CAR's editorial team has selected the best vehicles in 12 categories of the South African market, ranging from the best budget car right through to best performance car, SUV and double cab. The winners list is the product of rigorous testing, discussion and deliberation because you deserve to have the most comprehensive buying guide at your disposal. Let CAR's March 2014 issue help you choose the best vehicle.

car

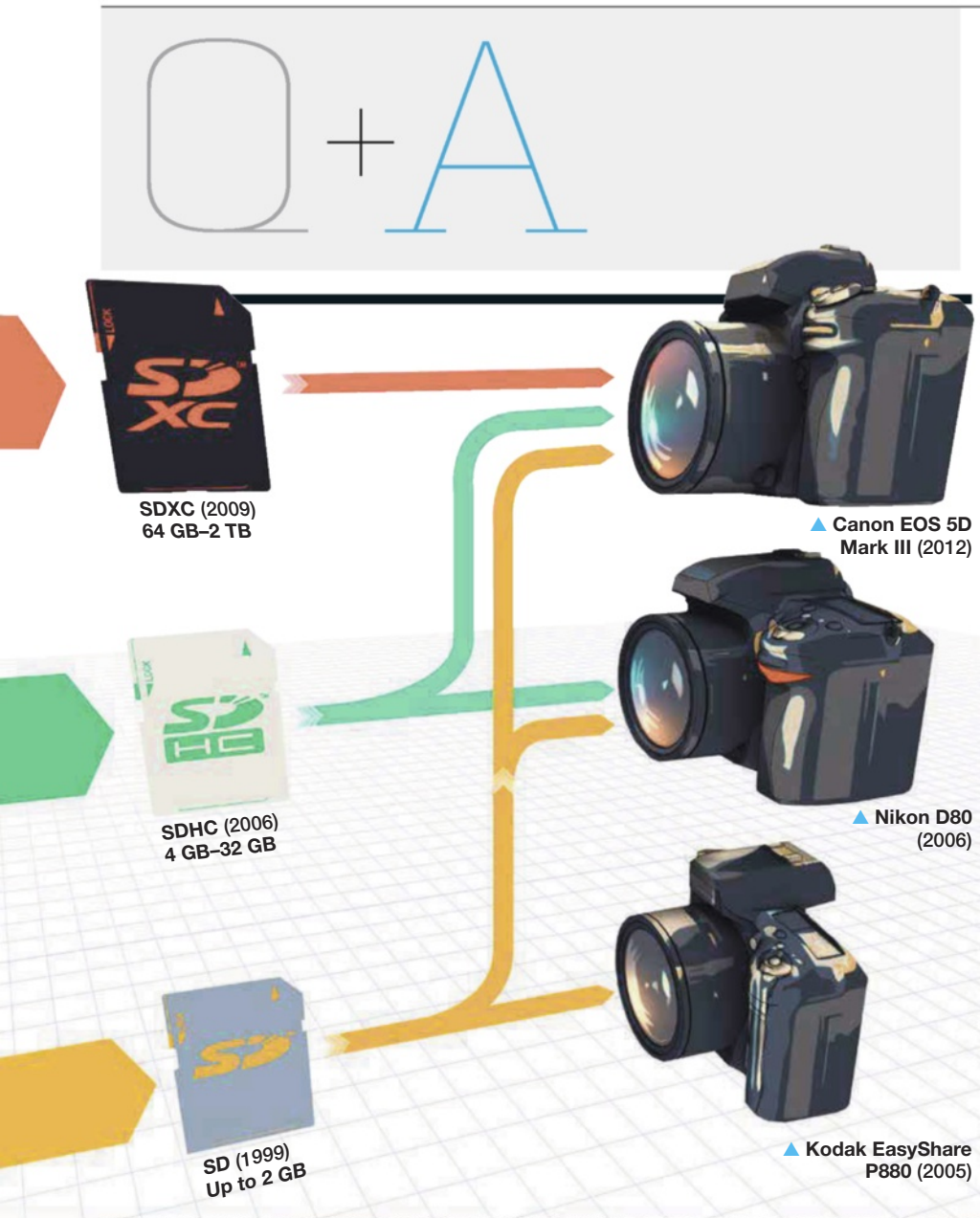
TOP
12

BEST
BUYS
2014



in association with

TRACKER



only a few megabytes. Today memory cells are one-fifth the size and store thousands of times as much data.

There is another difference between the two standards beyond their total capacity. SDXC cards are formatted in the exFAT file system, which allows for files of virtually unlimited size. (SDHC, which uses FAT32, can record files up to only 4 GB.) But that matters only if you generate huge files because you have a very high-resolution camera (and a sensor to make that resolution worth it), or you shoot hours of video. Most files are much smaller than 4 GB.

SECURITY COLLISION

I lost my computer. I have a password on it, and I also have tracking software. Will the password lock keep the tracking from working?

Your two computer-safety technologies – a login password and tracking software – may work against each other. Tracking software, such as Find My Mac for Apple computers and Prey for PCs, Macs and Linux machines, requires you to be connected to the Internet to work. (Prey is the best option for PCs because it is nearly invisible on your computer, making it hard for thieves to disable.) Unfortunately, your computer won't get online unless you've logged in. So, if you have a password, you're out of luck. But in the future you can plan for the worst with a work-around: create a limited-access guest account.

First make sure location services are enabled. On a Mac you'll find this in your Privacy setting. Also turn on Find My Mac in the iCloud section of Settings. Then create a guest account without admin access, so that whoever logs in using that account won't have access to your files. As soon as the computer connects to the Internet, you'll be able to see it on a map on icloud.com and erase or lock it.

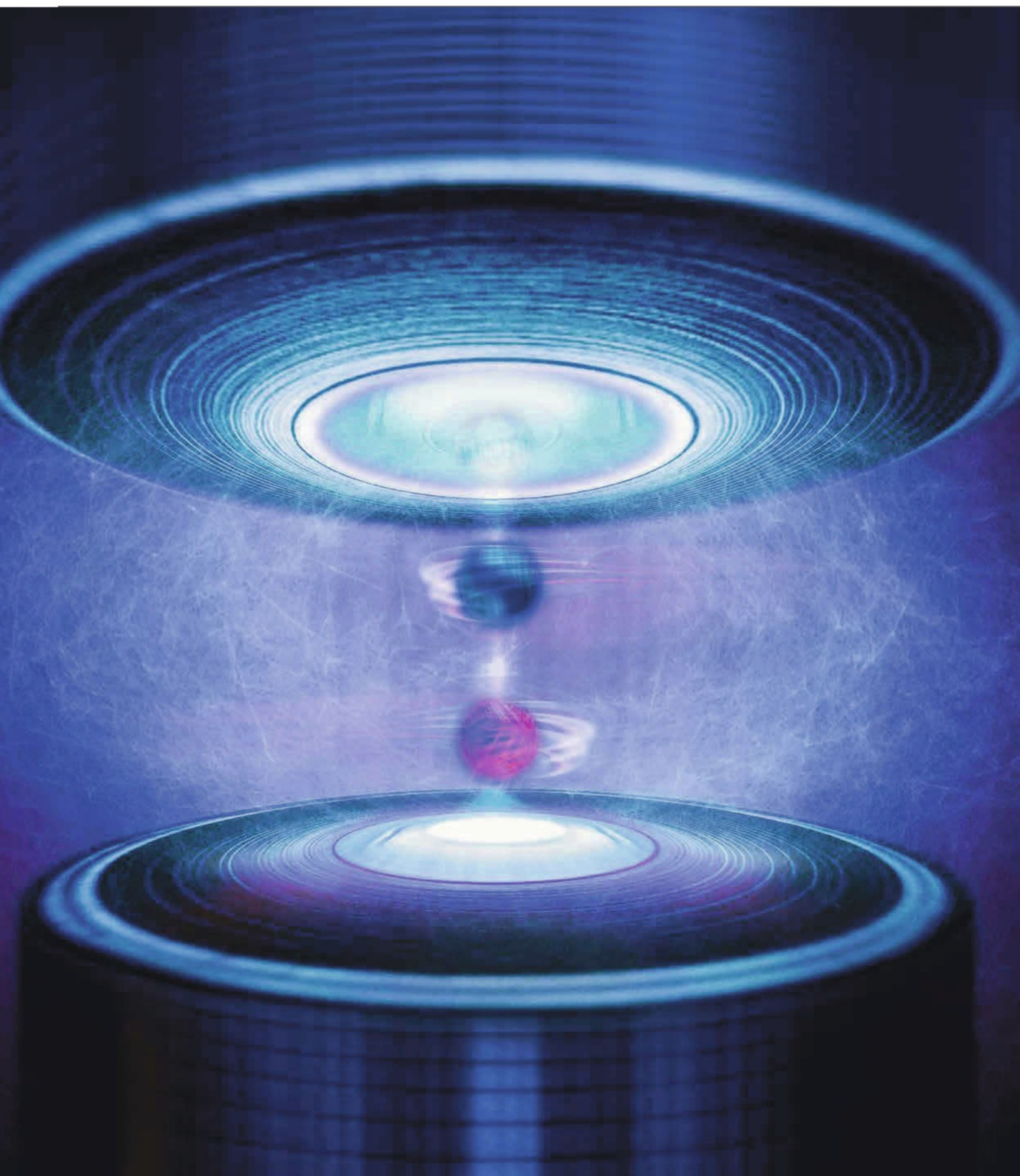
In Windows, enable location services in PC Settings. If you're using Prey, go to the site to mark your computer as missing. You might have to wait a few hours for the service to send you a digest, which includes the machine's location, along with a photo taken with the built-in camera, and a shot of what's on the screen. Prey will also display an alert on the missing computer that tells the user that the computer has been stolen and provides your e-mail address; you can offer a monetary reward for the machine's return.

PM

Memory mismatch

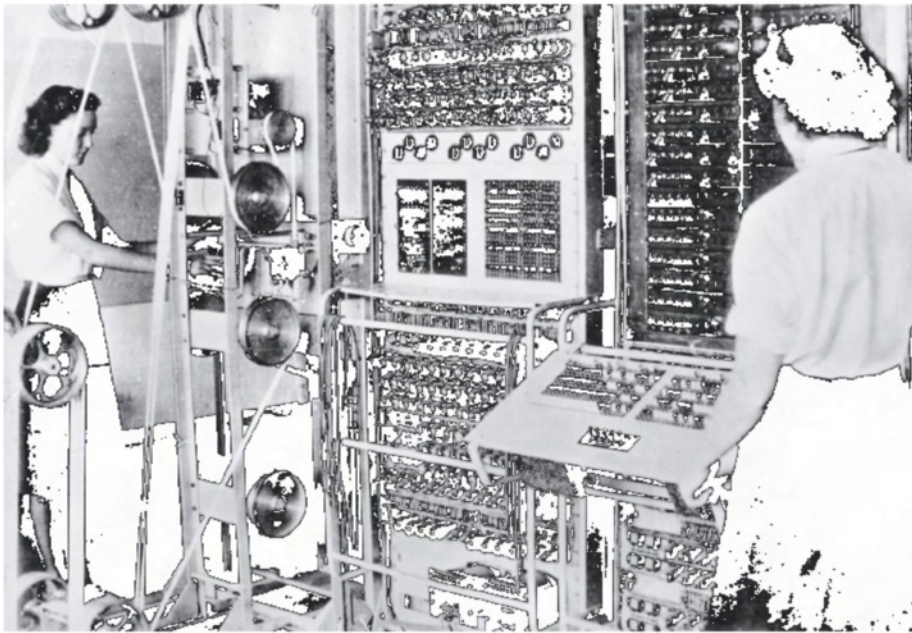
I put a 64 GB memory card in my camera; when my camera tried to format it, I got an error message. When I went back to my old 32 GB card, it was fine. Is my 64 GB card bad, or is there a problem with my camera?

Neither, I'd guess. Your camera probably isn't equipped to read cards larger than 32 gigabytes. The larger cards fall under the SDXC standard; cards between 4 and 32 GB follow the older SDHC standard. You can use SDHC cards in a device that reads the new SDXC cards, but the newer cards aren't backwards-compatible. That's unfortunate, given their high capacities: theoretically, the new cards could reach 2 terabytes, though now they max out at 256 GB. Even that's impressive. In the early 2000s, SD cards – which contained memory cells larger than 100 nanometres – could hold



SPIN REVOLUTION

Spin – the quantum revolution coming to a computer near you. This mysterious property is already harnessed in your hard drive; now it's set to take over the rest of your gadgets, too.



ONE foggy day in early December 1943, a giant awoke. Born in an engineering lab in north-west London, Colossus was the world's first digital, programmable electronic computer – a tower of racks and wires that ate its way through several kilometres of punch-card instructions every hour. Its processing power would enable the Allies to quickly decipher messages from Nazi high command – and help them win the Second World War.

Computers have come a long way in the 70 years since, but deep down, they work in essentially the same way: by manipulating electrical charge. Guided by its punched cards, Colossus moved charge through thousands of glowing valves. In modern computers, charge passes through millions upon millions of transistors to make the texts, images and sounds that form our digital worlds. It has proved an eminently upscalable approach: the average smartphone today is a million times faster than Colossus, not to mention a hundred thousand times smaller.

But charge is beginning to feel the squeeze. As components have shrunk, they have been handling fewer and fewer moving charges. There is only so far this

The groundbreaking computer known as Colossus was developed for British codebreakers during World War II to help in the cryptanalysis of the Lorenz cipher. Ten of these machines were in use by the end of the war. Most of the Colossus hardware and blueprints were subsequently destroyed in the interests of secrecy, but a functioning replica was completed seven years ago. (Wikipedia)

can go before random charge fluctuations make the operation of the transistors unreliable.

"We're simply running out of electrons," says Dan Hutcheson of VLSI Research, a company that analyses technology markets. Add to that the effect of the large amounts of heat generated by very many transistors in a small space, and it is clear we are reaching some fundamental barriers.

But a potential solution is at hand: spin. This peculiar quantum property is already central to the way computer hard drives work. Now it is poised to march into other parts of our digital gadgetry, bringing smaller, faster and more flexible calculating machines – and perhaps even one that can mimic that most powerful of all number crunchers, the human brain. Spin could be the biggest revolution in computing since Colossus.

Spin is a slippery concept to grasp. A quantum property of many sorts of particles, including electrons, it was first proposed in the early 1920s by Wolfgang Pauli, an Austrian theorist so strong-willed it was said he could make experiments fail simply by entering their vicinity. With spin, he didn't have to. Its signature is seen when you send a stream of electrons through an uneven magnetic field. The particles are deflected in opposite directions seemingly at random, as though each one has an intrinsic rotation that is somehow "caught" by the magnetic field, causing it to veer off course.

Picturing electrons rotating on their own axes like a spinning ball is useful, but also misleading. A ball can spin by any amount in any direction, whereas an electron is restricted to just the two ways revealed in the magnetic field, dubbed "up" and "down". What's more, if an electron really were a spinning ball of charge, its surface would have to be moving several times faster than the speed of light, defying Einstein's theory of relativity.

What we do know about spin is that it is intimately connected with magnetism. Inside a permanent magnet such as a lump of iron, many of the electrons have the same spin and are locked in place, creating a magnetic field. Apply a large enough opposing magnetic field, and these spins can be made to flip direction, swapping the magnet's north and south poles.

'If an electron really were a spinning ball, its surface would be moving at several times the speed of light.'

This is a property that has long been harnessed in our computers. A computer hard drive is nothing more than a rotating platter of tiny magnetic "bits". The two different field directions that can be set by flipping the spins in each bit represent the binary values zero or one. Information stored in this way is read back by passing the bits underneath a "read head". The electrical resistance of the read head dips or spikes depending on the orientation of the field, creating pulses of current that are sent on to the computer's processor.

In the early days of digital computers, the route to bigger memory banks was simple: cram more bits into a smaller space. A decade or so ago, that was already running into difficulties. The magnetic fields of the miniaturised bits were getting so small that the change in resistance they caused in the read head was becoming almost undetectable.

In 1988, Albert Fert at the University of Paris South in France and Peter Grünberg at the Jülich Research Centre in Germany independently came up with an inkling of a solution. Electrical currents generally consist of electrons with a random mixture of up and down spins. But send a current into a magnet, and the magnet acts like a strict choreographer: its vast array of fixed spins forces incoming electrons to adhere to the same routine and all spin the same way, too.

Fert and Grünberg envisaged sending a current through a stack of two or more magnetic layers. If the spins in these layers were all oriented the same way, it wouldn't take the electrons long to get their spins in step, and there would be only a slight drop in current as electrons carrying spins of the opposite orientation were slowed.

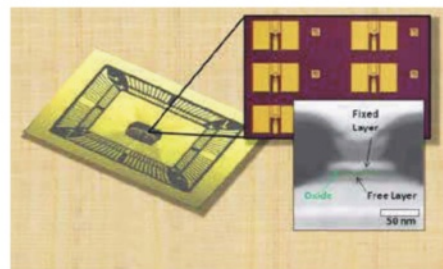
But twist one of the magnetic layers around and the moving electrons, having all been compelled to spin in one direction, would stumble almost to a halt when forced to spin in the other. The stack's overall resistance would skyrocket (see "Round and around").

Within years, spin "valves" had been developed that used this effect, known as giant magnetoresistance, to switch from a low to a high resistance state using just the tiny fields generated by magnetic bits. Read heads formed of spin valves allowed hard-drive capacities to balloon from megabytes to gigabytes. In 2007, Fert and Grünberg won the Nobel prize in physics for their discovery.

For all that, this first spin computing revolution was limited. Magnetic bits are good for hard-drive storage because once written, they stay written even when the



Above: Nobel Prize-winning French physicist Albert Fert at work. Fert is best known as one of the discoverers of giant magnetoresistance, which enabled the production of gigabyte-sized hard discs. Right: A UCLA research team has developed an improved memory which they call MeRAM (for magnetoelectric random access memory) with potential use in future memory chips for almost all electronic applications, including smartphones, tablets, computers and microprocessors, as well as for data storage.



power is off; only when a further magnetic field is applied can they be rewritten. But searching through the magnetic bits on a hard drive for the bits you want to write or retrieve is a slow process. This is why there is a marked delay as your computer retrieves information when you start a program or access a file.

INSTANT ON

It is also why there has been a lot of time and money invested in finding alternative storage technologies, such as the electrically driven "flash" memories used in smartphones, tablets and, increasingly, in laptops. But no alternative has yet been found that is fast enough to cut the mustard for your computer's other type of memory.

Random access memory, or RAM, is where information hauled from a hard drive is stored temporarily while it is used. This is done by charging and discharging capacitors with pulses of current – a process up to 200 times faster than accessing data on a hard drive. But as anyone who has lost work during a blackout will testify, all that information evaporates when the power is switched off.

The dream is to combine the permanence of hard drives or flash memory with the easy access of RAM, allowing for truly instant, loss-free computing. "The calculation would still be there, wherever you left it," says physicist Del Atkinson at Durham University in the UK.

Spin could do it. Magnetoresistive RAM (MRAM) is an idea that dates back to the mid-1990s. It involves the use of tiny spin valves, not as a hard disc's read head, but to form magnetic bits themselves. In MRAM's first incarnations, ones or zeros were written using external magnetic fields to flip the spin orientation in a valve's bottom-most magnetic layer. This information was then read out simply by detecting the electric resistance of the whole valve.

This approach introduced an awkward size limit: the bits had to be big enough so that the fields used to write them did not overlap. The first element of the solution came in 1996 with the idea that you could do the writing with electrical currents. You first pass a current through a thick magnet so that all the moving electrons end up with the same spin. If this spin-polarised current is strong enough, it can overpower the fixed spins in the

thin first layer of a spin valve, forcing them to reorient.

There was still a problem in making spin-polarised currents that were strong enough to be effective but which didn't melt the materials they passed through. Now, finally, this is possible. Everspin, a company based in Chandler, Arizona, has just started manufacturing spin-torque MRAM with a capacity of 64 megabytes for developers to toy with, while Crocus in Grenoble, France, and Samsung-owned Grandis in California, have versions in the pipeline.

Scaling that up to gigabyte capacity is now just a matter of time. In principle, there is no reason why spin-torque MRAM couldn't fill the roles of traditional RAM and permanent data storage, saving time and energy on electrons whizzing between different parts of your circuit board. "There has been a move away generally from

with electron spins, rather than electrical currents, an attractive idea. Unlike currents, spins do not need sustaining: once flipped they stay flipped, meaning less power is used and less heat wasted.

In 2007, Ian Appelbaum, then at the University of Delaware in Newark, and his colleagues demonstrated the principle of spin processing with the first spin transistor, which used a combination of electric and magnetic fields to switch a current according to the value of its spin. But this was little more than a conventional transistor translated into the language of spin. The same year, Hanan Dery of the University of Rochester in New York state and his colleagues suggested a different, potentially much more powerful, scheme (*Nature*, vol 447, p 573). Their spin-logic device uses two spin-polarised input currents and two magnetic contacts whose spin direction can be flipped to produce



'Spin technology could even be tailored to mimic that most flexible computer of all: the human brain.'

any sort of hard disc drives in personal computing, and I suspect this would be the next stage," says Atkinson.

But why stop there? If spin is so good for memory, perhaps it could also help out the very core of your computer: the processor.

Today's processors are made up of a billion or so transistor switches that are flipped on and off by applying an electrical field. These switches are combined into logic gates, each of which performs a single operation. A NAND gate, for example, takes two binary inputs and lets a current pass only if at least one is zero. As you write an e-mail or a text document, or play a video or a piece of music, millions of logical operations are performed by flipping these gates in series according to the instructions contained in the program you are using.

This way of working requires a lot of logic gates to do relatively little. As more and more logic gates have been crammed into processor chips, they have been generating more and more heat, raising a significant barrier to reducing processor size further.

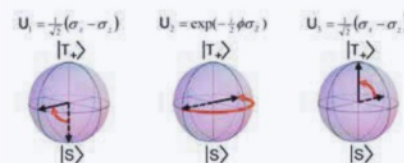
All this makes operating transistors

a gate whose logic operation can be changed on the fly (see "Flexi-logic").

This is radical stuff. In a normal processor, the type of each logic gate is set during manufacture, and engineers have to build in numerous different gates to accommodate the needs of different programs. Gates that can rewire themselves would radically reduce the amount of hardware needed to produce the same performance and versatility. "It's like a factory doing something on a jacket's lining so the customer can wear it inside out, too," says engineer Behtash Behin-Aein of the computer chipmaker Global Foundries in Milpitas, California, who has worked on a similar proposal for spin logic.

Implementing spin logic is no cakewalk: one problem is keeping output currents strong enough so that they don't fade away before they reach the next gate. Given the amount of investment in existing computing architectures and fabrication processes, spin logic will probably only be able to take off when conventional transistors finally reach their limit, which they are predicted to do in a decade or so.

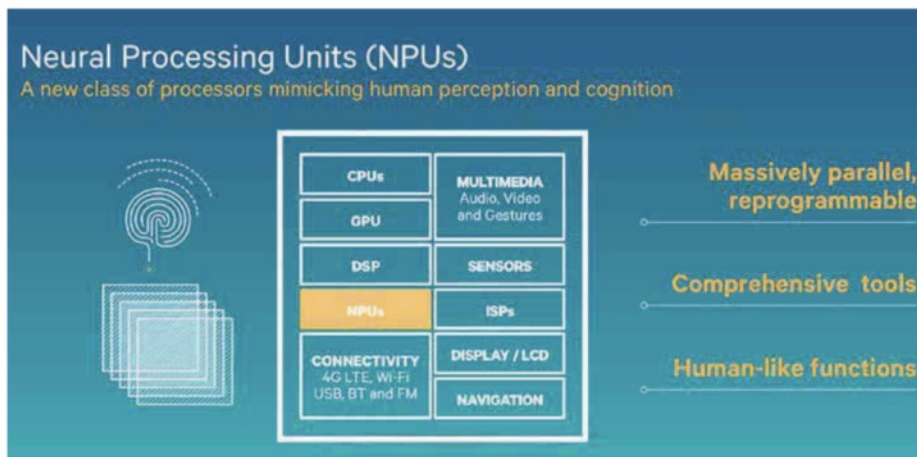
Once this spin revolution begins, some physicists believe the technology could



ROUND AND AROUND

In 2010, researchers from two Materials Research Science and Engineering centres at Princeton University and the University of California, Santa Barbara, made a significant breakthrough in the worldwide pursuit of quantum computing when they engineered a method to control the spin of a single electron within a magnetic field without disturbing nearby electrons.

The method – developed by a team of researchers led by Jason Petta (above), assistant professor of physics at Princeton University – traps one or two electrons in microscopic corrals created by applying voltages to minuscule electrodes, giving them an ability to control spin orientation.



even be tailored to mimic that most flexible computer of all: the human brain. Logic gates in today's computer chips process information in sequence, each one taking its input from the previous gate's output. The brain, by contrast, does things in parallel. An input – the reading of a word, say – causes a bunch of neurons to fire, sending electrical pulses through junctions called synapses, which cause further neurons to fire. Rather than being “on” or “off”, neurons fire only if the signals within them overstep a certain threshold. That allows them collectively to perform subtle and complex tasks such as text recognition.

BRAIN-LIKE CHIPS

Last October, the chipmaker Qualcomm, which has its headquarters in San Diego, California, announced that it was using the standard method for manufacturing electrical transistors in an attempt to create brain-like “neuromorphic” chips. Grouped in complex circuits, these transistors can be made to switch only when a certain level of input current is reached.

But this approach is inherently problematic, says physicist Julie Grollier of Unité Mixte de Physique CNRS/Thales near Paris. You need dozens of transistors to represent a single neuron, and dozens again to represent a single synapse. Even if you could somehow squeeze all these components together, you still face that most exhausting of computing problems: overheating.

In 2011, Grollier, Fert and others exposed the bare bones of an alternative approach. The spin memristor is a device whose resistance can be set with a spin current to any value you like. It is rather like a more elaborate spin valve that instead of just being off or on can be off, on, or anything in between (*Nature Physics*, vol 7, p 626).

Grollier believes that a single spin memristor could function as a synapse,

Chip manufacturer Qualcomm is working on a new computer architecture called Zeroth, which mimics the human brain and nervous system so devices can have “embedded cognition”. In future, says the company, it might be possible to train devices for human-like interaction and behaviour.

with its programmable resistance offering a way to set the strengths of connections between neurons. Meanwhile, the neurons themselves would be other types of spin valve with thicker magnetic layers that would need a certain threshold spin current to flip their states.

“These spin devices have very nearly a one-to-one connection with biological neurons and synapses,” says Kaushik Roy, an engineer at Purdue University in West Lafayette, Indiana. In September last year, he and his colleagues performed simulations to show that spin neurons would generate just one per cent of the heat of more conventional potential neuromorphic technologies, removing a big barrier to getting a brain-like computer working in practice (arxiv.org/abs/1309.3303).

It is still very early days, and Roy is cautious about how far spin can take us in building a brain. “It’s not exactly what the brain does,” he says. “First of all, we don’t know exactly what the brain does.”

What’s certain, though, is that from small beginnings, spin is starting to worm its way into all aspects of our electronic devices. The spin revolution is only just dawning – and no one is quite sure where it will end. “It’s one of those things that has been waiting at the gates,” says Hutcheson. “And all of a sudden, we’re starting to move really quickly.”

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PM

SPIN COMMS

It’s not just computer chips that could benefit from a spin revolution; your phone could, too. Mobile network operators in different countries rely on different microwave frequencies to carry signals. To go “roaming”, your phone needs separate microwave generators – silicon devices that oscillate electronic current to create fields of the right frequencies. These oscillators could be replaced by a single spin device thousands of times smaller.

A current of electrons all with a particular spin creates magnetic forces that cause the spins in nearby magnetic materials to try to align. Get the strength of current right, and the magnet spins will begin to rotate, but not quite flip. Send in pulses of current, and the spins will begin to oscillate, sending out pulses of energy at microwave frequency.

This frequency is easily tuned by introducing a second electrical current that makes the magnetic material flick back quicker or slower, an effect rather like changing the mass on a bouncing spring.

In 2012, engineer Kang Wang at the University of California in Los Angeles and his colleagues demonstrated a spin valve that could pump out microwaves at 0.28 microwatts, close to the power needed for mobile telecoms. A spin-valve oscillator could be inside smartphones within the next five to 10 years (*ACS Nano*, vol 6, p 6115).

Fibre-optic telecoms could also use a spintronic makeover. Currently, the pulses of laser light used to encode signals are generated by shifting electrons back and forth. That is one of the factors that limit the rate at which information can be sent to about 50 gigahertz. In 2011, Nils Gerhardt at the Ruhr University Bochum in Germany and his colleagues showed that this speed limit could be overcome by generating laser light by flipping electron spins (*Applied Physics Letters*, vol 99, p 151107). This process can produce pulses at nearly three times the frequency of a conventional laser – a turbo boost that might dramatically improve your internet bandwidth within the next decade.



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WHAT'S HOT ON PM ZONE

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Engineered to be the ultimate battle tank, it's not surprising that the OGRE – the newest titan in the game **Titanfall**, launching in SA on 14 March – has top notch armour and offensive capabilities. Check out the OGRE in the video on PM Zone's Web site.



With the emergence of Electro (Jamie Foxx) in **The Amazing Spider-Man 2**, superhero Spider-Man (Andrew Garfield) must face his biggest battle yet. The film releases in SA on 25 April. For a sneak peek, watch the official teaser trailer at www.pmzone.co.za



Hearthstone: Heroes of Warcraft has officially entered its open beta test. Want to try Blizzard's new free-to-play digital collectible strategy card game? Then go to www.pmzone.co.za for the details.



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@larsliedberg Really enjoyed The Hobbit: The Desolation of Smaug. Here's my friend Sarah's movie review shar.es/UGQ0A via @popmechsa

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A BRIEF HISTORY OF THE ... TUNNEL

Tunnel building may be boring, but it's never dull! From spoons to high-tech TBMs, we dig into the long, winding story of the tunnel. BY AMANDA GREEN



2180–2160 BC.: Babylonians dig a 1 000-metre tunnel under the Euphrates River.

1681: France's 157-metre Royal Canal in Languedoc is inaugurated; its tunnels were blasted using gunpowder.

1867: Tunnel construction, er, booms when Swedish engineer **Alfred Nobel** (yes, that Nobel) patents dynamite.

1927: The Holland Tunnel uses a ventilation system to remove exhaust. On either side of the Hudson River, 84 fans in four buildings change the tunnel's air every 90 seconds.

1952: James S Robbins comes up with a dam good idea and designs the modern tunnel-boring machine (TBM) for South Dakota's Oahe Dam project.

I'M THE ORIGINAL KID DYNAMITE.



1962: Inspired by a *PopMech* issue, three Alcatraz inmates escape through a tunnel they dig with stolen spoons. They paddle out into San Francisco Bay on a makeshift raft and are never seen again.



1963: In *The Great Escape*, which is based on a true story, prisoners escape from a German POW camp by digging three tunnels they name Tom, Dick and Harry.

1988: Boring through the Du Toit's Kloof Mountains between Paarl and Worcester in the Western Cape, the drilling heads in the 3,9-km Huguenot tunnel – South Africa's longest – meet just 3 mm out of line.

1988: Japan's 53 km-long Seikan Tunnel, the world's longest and deepest railway tunnel (240 metres below sea level), connects the islands of Honshu and Hokkaido. Alas, many time- and cost-conscious travellers stick to flying.

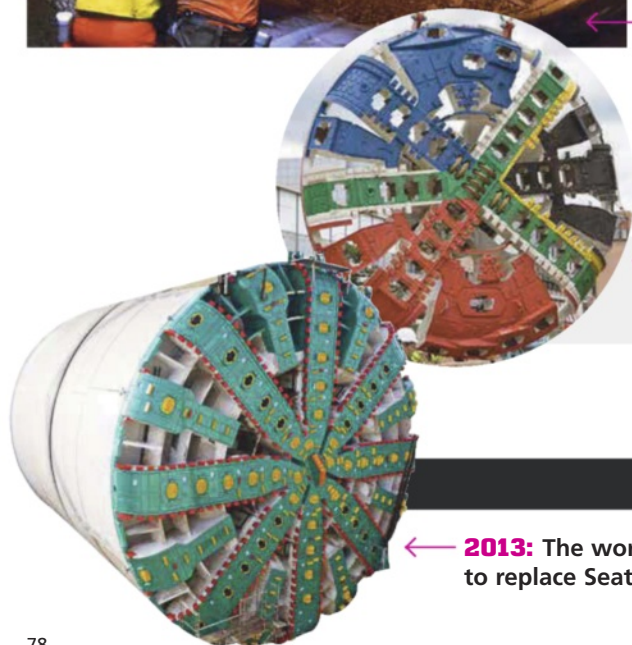
1994: After 192 years of planning and six years of building, the Channel Tunnel runs under the English Channel, connecting England and France. With a price tag of R210 billion, it's the costliest construction project to date.

2005: Smugglers dig a 110-metre tunnel from a Quonset hut in Canada to the living room of a house in Lynden, Washington. Police admire its lights, ventilation and concrete floor.

2008: The German-built tunnel borer *Imbokodo* ("grinding stone") starts carving out the trickiest 3 km of Gautrain's 15 km of tunnels. Four years and many billions of rand later, local high-speed rail travel finally starts.

2010: New York City turns on the first TBM for the Second Avenue Subway line, a project 81 years in the not-making. Builders later use cut-and-cover and drill-and-blast methods.

2013: The world's largest TBM, at 7 000 tons and 17,5 metres wide, begins a tunnel to replace Seattle's Alaskan Way Viaduct. It will be the widest in North America. **PM**



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Innovation UNLIMITED

CONTINUING A LONG AND PROUD TRADITION, 2014's International CES saw 20 000 new product launches, introduced a host of major tech breakthroughs and, as always, showcased an astonishingly diverse assortment of desirable gadgets. Over 3 200 exhibitors assembled at the Las Vegas Convention Centre and other venues to engage with merchants, entrepreneurs, the media and other players in the global consumer tech industry.

In the field of 3D printing, visitors were impressed by the 3D Systems ChefJet, the CEL Robox and the new MakerBot Replicator printer series. Audiophiles were treated to Samsung's HW-H600 and MX-HS8500 GIGA, ClearView's invisible speaker (dubbed Clio) and LG's SoundPlate. In the digital health and fitness arena, they encountered the Intel Edison Chip for wearable tech, the Jaybird Reign Fitness wristband, the Kolibree Smart Toothbrush, the LG Lifeband Touch fitness activity monitor, the Razer Nabu, the Scanadu Scout and the Sleep Number X12 Smart Bed.

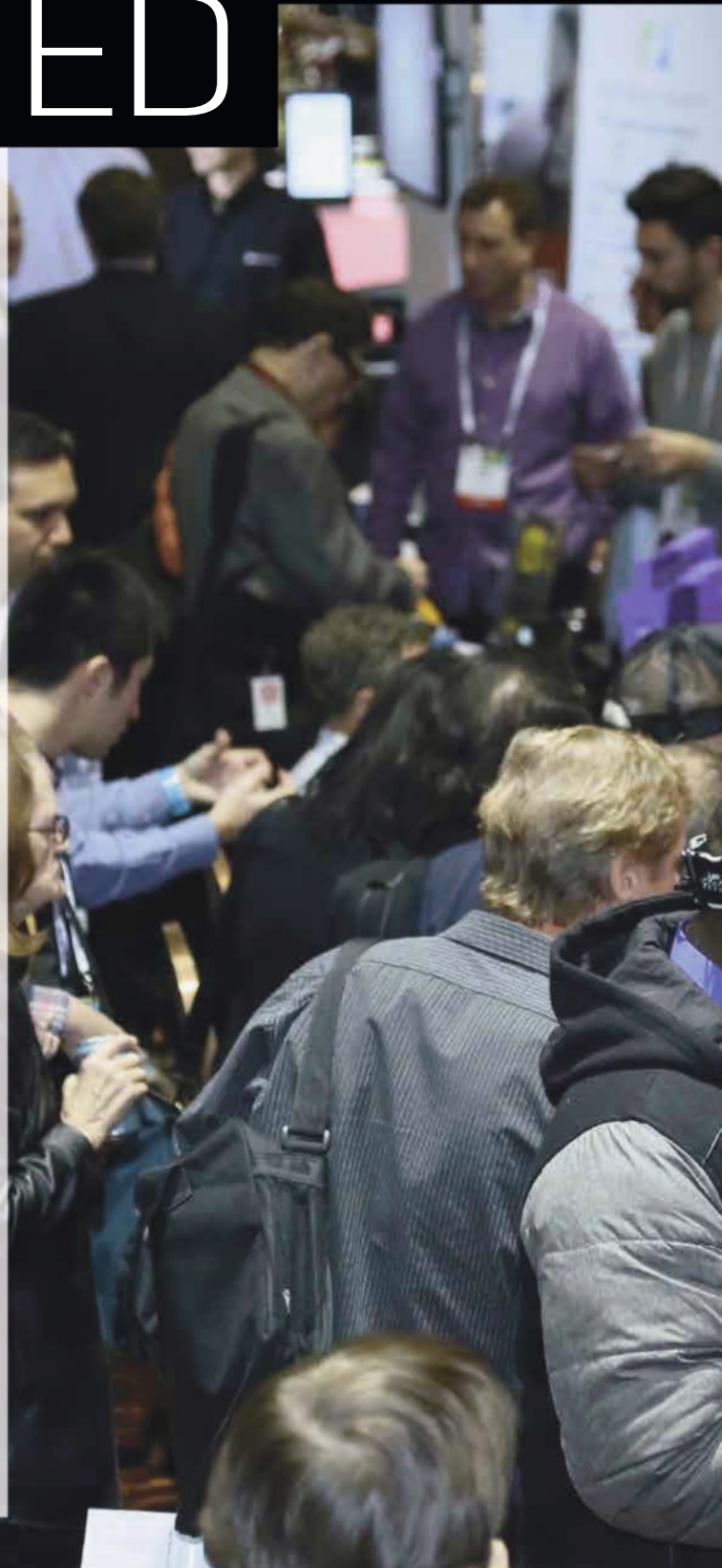
Attention-grabbing wireless devices included the Huawei Ascend Mate2 4G smartphone, LG's G Flex, the Martian Notifier, the Mophie Space Pack, Sony's Xperia Z1 Compact phone and the Typo iPhone keyboard case. In electronic gaming, stand out products included the Avegant Glyph, BenQ XL2720G, Gigabyte Brix Pro Steam Machine, iBuypower SBX Steam Machine, Oculus Rift Crystal Cove and Razer Project Christine.

More breakthrough products lit up the video category, where Samsung showed off its 105-inch curved UHD TV and 78-inch U9000 curved UHD set, Sony showcased its 4k ultra short throw projector and LG dished up its 77EC9800 UHD OLED TV and LG webOS Smart TV.

Then there's the utterly compelling Eyelock myris, which connects to any USB port and uses video of your irises to verify your identity, identifying more than 240 points on each iris and generating a unique 2 048-bit digital signature. Since no two irises are alike, the chances of a false match are less than one in two trillion – which, as its developers point out, is more than the population of 315 Earths. Just plug it in, find the app on the desktop and launch. You'll be guided through a few simple steps to set up your profile and generate your unique iris-based ID.

And let's not forget the Parrot Jumping Sumo. Piloted via Wi-Fi with a smartphone or tablet, it's a new genre of connected robot. Described by its creators as half robot, half insect, it's equipped with a gyroscope and an accelerometer to deliver "foolproof" agility and intuitive piloting. It can roll, turn 90 degrees with speed and astonishing precision and perform spectacular jumps (up to 80 cm), always landing on its "wheels".

It comes with an integrated camera that streams its stunts to the screen of the controlling smartphone or tablet. Our take on this: every home needs one.



Year after year, certain people (granted, not many) make bold statements to the effect that the International CES in Las Vegas is doomed to a slow decline and eventual extinction, citing its overwhelming size and escalating costs. And year after year, they are proved wrong. This year's showcase of cutting-edge consumer technology was another humdinger...



Intel CEO Brian Krzanich wowed CES delegates with the chipmaker's vision of the near future, showcasing exciting 3D technology and using the magic of augmented reality to make a virtual whale float above their heads.



Marissa Mayer, president and CEO of Yahoo!, presents her keynote address at the 2014 International CES. Her plans for the search engine's future include new apps and Web sites, more acquisitions and two new products, Yahoo News Digest and Yahoo Magazines.





Polaroid Socialmatic

Isn't it weird that Polaroid has returned with an instant camera that prints images you can actually hold in your hand? Their fetching Socialmatic captures images with its 14-megapixel front or 2-megapixel rear camera, then prints 2x3-inch (about 5 cm by 7,6 cm) photos instantly on ink-free paper using something called Zero Ink printing technology. The results are said to be smudge-proof, water-resistant and tear-resistant.

When you're ready to share, you can do so via the built-in Wi-Fi, showering your Facebook and other friends with all manner of badly composed pictures, with captions saying cute stuff like "wish you were here". The Android-based camera comes with a 4,5-inch LCD touchscreen for easy navigation.

Kolibree smart toothbrush

This useful bathroom accessory (hey, you can never have too many apps or gadgets) features a unique technology that analyses your brushing habits and displays them on a mobile dashboard that you can access from your phone. You simply download the free mobile app, connect via Bluetooth, and every brushing is recorded. Information is automatically synchronised to your smartphone, telling you whether you brushed for long enough and whether you tackled those hard-to-reach but important parts of your teeth and gums.

The app works with several toothbrushes, enabling the entire family to participate, and you can easily share your stats with your dentist and family (yeah... like *that's* going to happen). Whereas Kolibree doesn't claim to solve periodontal disease or suggest it can keep cavities or gingivitis at bay, we are reminded that the better care we take of our teeth, the more likely we are to avoid serious problems. But wait – there's more! The brushing data will be available via an API to let third party game designers develop new apps and enhance brushing time. Okay, now that's pushing it a little too far.

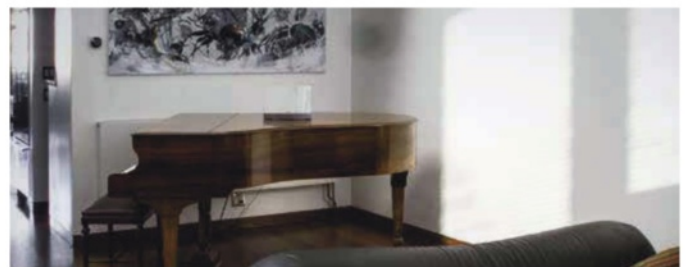


Smart monitor's SmartWatch

This innovative product was among the winners in the "Everyday Health" awards, which recognise innovative digital health technologies that are revolutionising the practice of patient care.

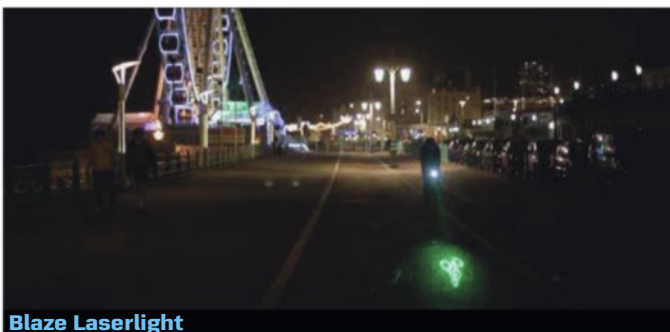
The SmartWatch is a non-invasive wristwatch that continuously monitors the user and instantly alerts family members and caregivers at the onset of abnormal movement patterns, providing real-time data analytics that healthcare providers need to deal with these incidents while also providing peace of mind for family and loved ones. Should the watch detect a repetitive shaking motion, it will signal the user's Bluetooth-connected Android phone to send text and phone call alerts to designated contacts. (We've just had an inappropriate thought: repetitive shaking motion? Can this function be deactivated?)

That aside, the device's comprehensive analytics make it useful for clinical studies, especially those tracking the efficacy of drugs or devices for reducing convulsive motions caused by epilepsy or other disorders.



ClearView Clio

Punted as the world's first "invisible" speaker (actually, it employs a transparent, gracefully curved acrylic membrane), the Clio is stylish and certainly unobtrusive. Unlike traditional cone speakers that push sound waves in one direction, this 2.1 stereo system is said to surround you with a rich and clear sound driven from both sides of the acrylic membrane. It features Bluetooth connectivity, so you can move it from one location to another without getting tangled in unsightly speaker wires. Hmmm...



Blaze Laserlight

We like the confidence of the Laserlight's inventors, who make this bold statement about their product: "We have reimagined the bicycle light." They may have a point: its green laser projects the image of a bike 5-6 metres ahead on to the road, alerting the drivers of other vehicles to the presence of the unseen cyclist and (hopefully) preventing them from turning across its path.

The classic blind-spot scenario is one of the greatest hazards faced by cyclists. We're told that 79 per cent of cycle accidents occur when the bicycle is travelling straight ahead and a vehicle manoeuvres in front of the rider. The "kickass" Laserlight – rechargeable, USB-compatible and fully waterproof – counteracts this by delivering a bigger visual footprint on the road. The battery should be good for up to 13 hours in the recommended mode.

Razer Project Christine

It's a very cool idea, and we're amazed that no one has thought of it before. Razer's Project Christine is still at the concept stage, but if they can pull it off and actually build a marketable product, we reckon they'll have a winner on their hands. In essence, Razer wants to pack the various components of a desktop PC into individual modules, enabling the user to upgrade with minimal fuss. Each module will be equipped with connectors for the components, plus dual-stage valves that allow the set-up's mineral oil to flow freely when it's all put together.

Mineral oil? Er, yes... we forgot to mention that the desktop will be cooled by circulating mineral oil rather than fans. What's the point? For starters, think reduced complexity and quiet operation – and judging from these images, amazingly good looks, too.



Sleep Number x12

Okay, so it's an odd inclusion, but the company called Sleep Number deserves attention because it has just announced a product called the x12, a bed equipped with a whole bunch of sensors that not only monitor your sleeping habits and movements, but also your heart and breathing rates. The bed has two independently adjustable sections, so once it has learnt about the sleeping habits of you and your partner (is this starting to sound creepy, or is it just us?), it can suggest ways of making your rest more comfortable – perhaps by changing one or more angles. Otherwise, control is vested in you, via voice commands.

Here's the clincher: a Partner Snore function allows you to raise your Significant Other's headrest to eliminate this potentially harmful (here we're talking relationships rather than health) habit. While your mind boggles, consider the price: you probably won't get much change from R80 000.

Jaybird Reign

You may not yet be a convert to the notion of wearable fitness bands (no, we're not talking about those dodgy products for which they make the most bizarre claims), but you have to agree that this one is pretty cool. The Jaybird Reign comes with an integrated "personal fitness assistant" that oversees your activities – including sleep patterns – throughout the day and recommends the best time for you to exercise (for the record, this is the "Go-Zone"), transmitting the data via Bluetooth to a dedicated iOS or Android app. The product is expected to sell in the US for about R2 000.



URB-E/BLACK SOCK STUDIOS

Urb-e

It's claimed to be the world's most compact personal e-vehicle, folding small enough to fit between your legs on a train or bus (or in your car's boot) and capable of travelling for over 30 km on a single charge. Aimed at schools, large corporate campuses and anyone who wants to take their transport wherever they go, the Urb-e will (hopefully) be financed by a Kickstarter campaign launched in February.

The company behind the Urb-e is EgoLogical Mobility Solutions, founded last year by Grant Delgatty, Mateo Neri and Todd Belle – all with a product development and interactive design background in the automotive, footwear and entertainment industries. Their brainchild features a 36-volt lithium-ion battery, a 250-watt brushless hub motor and a patented folding mechanism with a comfortable, "shock-absorbing" seat.

It also comes with a universal smartphone mount with app to monitor battery status, range, speed and navigation, a USB charging port for smartphone and other devices, and an integrated luggage rack. Top speed is about 25 km/h. Two models are planned – the two-wheeled Urb-e GP and a trike version, described as "better for congested areas". Prices are expected to range from R15 000 to R20 000.

PM



diy

Home



BY DAVID AGRELL AND ERIC WELL // PHOTOGRAPHS BY REED YOUNG

Build a STONE COLD BEAUTIFUL BENCH

CONCRETE
FURNITURE
LASTS FOREVER,
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WHEN YOU BUILD
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TOOLS AND SUPPLIES

Concrete mix / sheet of 16 mm white melamine chipboard / table and mitre saws / hot-glue gun / 2 mm packing foam / shipping tape / black silicone caulk / paste wax / 10 mm rebar / calibrated mixing container / three 25 -litre buckets / 100 litre refuse bin / electric drill / universal mixing paddle / 60 cm screed or float / trowel / hammer / 120-, 220- and 320-grit sanding blocks / masking tape



Eric Weil (photo, opposite) once studied wood carving in Ghana, but nowadays it's the urban textures of New York City that inspire his work. Weil runs Oso Industries in the Big Apple, crafting furniture primarily out of concrete. It's a material he values for its appearance, adaptability and strength.

We commissioned Weil to produce a bench project for PM readers that is less complicated than it looks: three slabs combine with elegant through-tenon joinery, so you won't need any connecting hardware. The key is to fabricate accurate moulds; then just mix up a batch of concrete and pour.

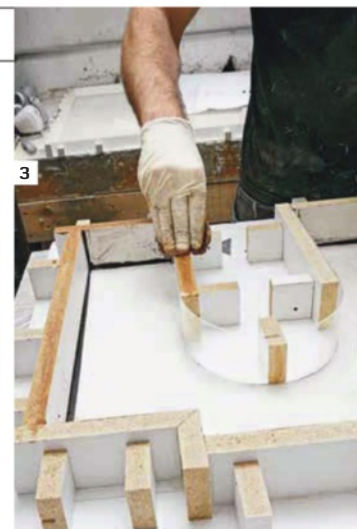
BUILD THE MOULDS

This bench relies on well-formed mortise and tenons for strength, so assemble the moulds with care. Create them as you would a piece of furniture.

Make the sides and support blocks by ripping the melamine chipboard into strips with a table saw and cutting them to length with a mitre saw according to the materials list on page 90.

Lay the remaining chipboard on a flat, level surface and use a pencil to trace the outline of the bench parts. Arrange the parts with enough surrounding space to allow for the support blocks.

Attach the side pieces along the layout lines with hot glue. Mitre the inside corners of the leg moulds where the shoulders meet the tenons, then glue support blocks 100 to 150 apart around the perimeter of each mould [1]. To create the curved sections of the leg moulds, install a block on the inside of each curve and bend acrylic (perspex) around it; make



RECIPE: ERIC WEIL'S CONCRETE MIX

This time-tested mix sets smooth and hard and can be honed to a granite-like finish. Make two separate batches of this recipe: one for both legs, another for the bench top. Not ready for concrete alchemy? Pick up bags of premix (check with the counter hand for the correct mix) at your building or home supply store.



10 kg Type I white portland cement



15 kg multi-purpose sand



15 kg pea gravel



2,3 litres cold water



1,6 litres acrylic additive



200 g black alkali-resistant pigment

sure the straight sections of the perspex extend past the bottom of each leg.

The bench top's mortises are created from two rectangular knockouts. Assemble with hot glue and wrap them in foam packaging material and a layer of shipping tape. This makes them easier to remove after the concrete has set; it also provides just enough wiggle room to make final assembly a snap. Trim the foam and the tape around the knockout [2].

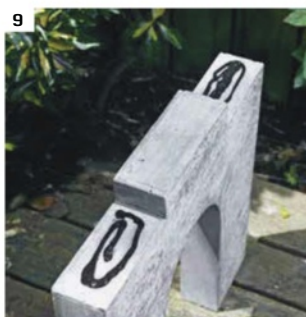
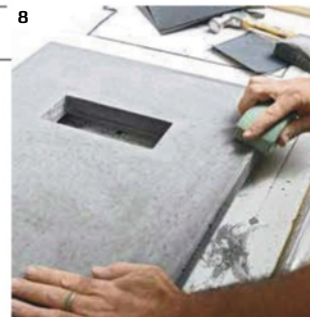
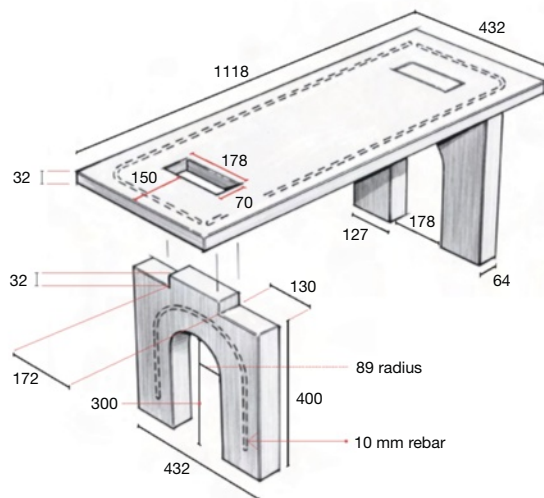
Next, apply caulk neatly along the seams. Black silicone caulk is easy to see against the white melamine and can be cleaned up with soapy water. Apply clear paste wax to all inside and top-edge surfaces [3]. Buff the wax with a soft cloth, but take care not to damage the moulds.

PREPARE THE CONCRETE

Concrete has excellent compression qualities, which means it's difficult to crush. However, it lacks tensile strength when used across a span, so you'll need to reinforce your bench with rebar. Cut 10 mm rebar with bolt cutters, and bend the pieces into shape by hand or with a rebar bender.

Mix enough concrete to form both legs (see "Recipe: Eric Weil's Concrete Mix"). Many of the ingredients are toxic and irritate the skin, so wear a cartridge respirator, eye protection and gloves. Use a calibrated mixing container to measure the cold water, acrylic additive and pigment, and combine them in a 100-litre refuse bin. Next, measure the cement and aggregates (the sand and gravel) into separate 25-litre buckets. Add half the

CONCRETE BENCH



Parts list



Qty	Description	Material	Size (all measurements mm)
2	Sides for bench-top mould	16 mm melamine	32 x 1 168
2	Sides for bench-top mould	16 mm melamine	32 x 483
4	Knockouts for bench-top mould	16 mm melamine	32 x 140
4	Knockouts for bench-top mould	16 mm melamine	32 x 70
4	Sides for leg moulds	16 mm melamine	64 x 400
6	Sides for leg moulds	16 mm melamine	64 x 172
4	Sides for leg moulds	16 mm melamine	64 x 241
4	Sides for leg moulds	16 mm melamine	64 x 64
4	Sides for leg moulds	16 mm melamine	64 x 165
24	Support blocks for bench-top mould	16 mm melamine	25 x 25
46	Support blocks for leg moulds	16 mm melamine	50 x 50
1	Backing sheet for all moulds	16 mm melamine	914 x 2 440
2	Sides for curved sections of leg moulds	2 mm perspex	64 x 762
2	Rebar for bench top	10 mm rebar	1346
2	Rebar for legs	10 mm rebar	837

cement to the liquid mixture, and combine using an electric drill and a universal mixing paddle. Then add half the aggregates; mix well. Add the remaining cement; mix again. Add the remaining aggregates, and mix once more [4]. The concrete should have the consistency of yoghurt.

Immediately pour enough to fill each leg mould to within 25 mm of the top, working it into the corners. Once the concrete starts stiffening, set the rebar into each mould [5]. Top up with the remaining mixture, screed the surface and flatten with a trowel [6].

Repeat for the bench top using the identical amount of concrete mix. Cover the parts with plastic sheeting and leave to cure for a couple of days.

ASSEMBLE THE BENCH

Free the parts by knocking away the moulds with a hammer [7]. Smooth everything with a sanding block, starting with 120-grit paper and moving towards 320-grit [8].

Set the legs upright and squeeze silicone caulk onto the shoulders [9]. Get help positioning the bench top onto the legs.

Tape around the mortise and tenons, and fill the voids with a sanded grout

mixture, adding pigment to match the bench colour if desired [10]. After the grout has cured, remove the tape and clean with a damp sponge.

PM



ILLUSTRATION BY GEORGE RETSECK



BEFORE YOU REMODEL, LOOK UP – WAY UP

I have just bought a house with a roof that has seen better days. There's lots of rough-looking flashing. Anything I should worry about before I start interior repairs?

"The roof comes first" is an old expression, but it remains as meaningful as ever. The roof is your home's first defence against the elements, so don't tackle any interior remodelling projects until you evaluate what's above the eaves. "If the roof is bad, everything below it gets wet: walls, ceiling, insulation, electrical wiring, floors, carpets, furnishings, and heating and cooling equipment," says roofing expert Jason Joplin. "If any of this stuff stays wet, mould can form – and there's a real danger of structural deterioration."

If a roof inspection reveals problems serious enough to warrant repairs, the next step is to decide whether to fix it yourself or call a professional. In most cases it's better and safer to hire a pro. Still, it's important to educate yourself before making the call so you know what to expect.

If your roof is shallow and low to the ground, and you're confident you can walk on it safely, climb up there and start inspecting. Watch your step and avoid low-hanging electrical cables. If it's too steep or high, inspect it from the ground using binoculars.

Start by checking the roofing material. Look for loose or missing tiles or, less commonly here, shingles that may have begun to curl up, cup down, are chipped or torn, or have lost their granule coating. If a significant area of roofing is past its best, you may have to consider replacement rather than repair.

Next, inspect the roof deck for sagging areas that could indicate a compromised structure beneath. Then note any loose, damaged or previously repaired flashing, and check the valleys for cracked roofing material. Look for severe weather deterior-

ation or previous repairs around skylights, vents and chimneys. While you're up there, check that the gutters are well secured.

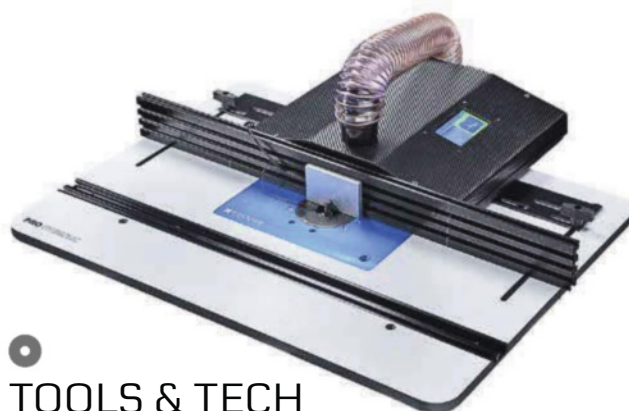
Finally, head into the attic and inspect the underside of the roof deck. Mould or water stains on plywood sheathing and insulation could mean that moisture is coming in through the roof or that condensation is forming inside the attic.

Generator life skills

Our standby generator has been working overtime this winter. Is there anything I should be doing to keep it from wearing out?

During long outages, check the generator's oil daily and avoid running it at full capacity. When possible, have the unit professionally serviced at the beginning of any outage that is expected to last more than a couple of days. "Most professionals inspect and change the appropriate filters, add fresh oil and check the outputs," says HVAC manager Pat Porzio. "A quality professional will also check the valve lash and spark plugs, which are often overlooked." Ideally, call for a service any time your unit logs 48 hours of continuous use.

PM



TOOLS & TECH

ROCKLER READY2ROUT ROUTER TABLE FENCE

Though woodworkers have been bench-top manufacturing for centuries, Rockler's new router table borrows from the latest desktop manufacturing technology. It features a computer-controlled aluminium fence that automatically adjusts according to a program selected via a touchscreen interface. The system comes preloaded with apps for fabricating box joints, dadoes, half-blind dovetails, fluted columns, and beadboard.

WHY WE LIKE IT

The Ready2Rout takes precision automation to a wood-working-specific and super-easy-to-use place. Most interestingly, it features a USB port for installing third-party apps, making it entirely hackable. The maker community will be all over this: think custom mouldings, multilayered inlays and Escher-inspired joinery.

GLOSSARY

valley

The V-shaped intersection of two sloping roof parts. The roofing extends into a closed valley, but stops short of an open valley.

flashing

Any impervious material installed around roof projections, such as chimneys, to direct water away from the joint.



diy

Auto

STRANGE
VIBRATIONS
SMARTPHONE
SCAN TOOL
IGNITION
TROUBLE



HOME EV CHARGER BASICS

CONSIDERING AN ELECTRIC
VEHICLE? THE APPROPRIATE
CHARGER WILL MAKE LIVING
WITH IT EASIER.

Degree of Difficulty: 9/10

Unless you have ample experience with home electrical work, this is probably a task best left to a professional.

Imagine never going to the filling station again. Such convenience is one of the key advantages of an electric vehicle, although it comes with two drawbacks: short range (sometimes less than 100 kilometres) and long charging times. Unless you can afford a Tesla Model S (R700 000 in the USA), which goes nearly 500 km on a charge, there's not much you can do about an electric vehicle's limited range.

Charging time is a problem, too. Where many of the world's EVs are found, in the US, home charging can take up to 18 hours on that country's 110 AC mains, which provides an input power of 1,92 kW. With a Level 2 (240-volt) charger that time shortens markedly to as little as 3 hours, with considerably greater power available. For plug-in hybrids, this means that instead of tapping into the fuel tank, you can restore the car's electric range after you get home from work and before you head out for a night on the town.

Of course, this is probably a job for a professional electrician. The good news for US consumers is that many electric utilities offer incentives that cover the cost of a charger and its installation. In South Africa, it's early days yet, with just the Nissan Leaf on the market; Nissan has for now bundled a home charger set-up with the car.

With the likelihood that electric cars will gradually grow in popularity, here are the key things you need to know to get your house EV-ready.

PICK YOUR CHARGER

EVs and plug-ins tend to use the SAE-standard J1772 plug. Although they work more or less the same way, not all chargers are created equal.

COST: The two biggest factors are current and cord length: if you want more, expect to pay more.

INSTALLATION TYPE: This unit is meant to be a permanent installation, mounted to the wall on a bracket. But some are classified (confusingly) as "permanently installed, removable" and use a standard plug so you can take the charger with you if you move.

CURRENT: Level 2 chargers come in 16- or 30-amp flavours. A 16-amp charger works fine for plug-ins such as the Chevrolet Volt, which doesn't draw more current than that, and can often be installed

with your existing wiring. But 30 amps should be the default, as it provides maximum charging speed and future-proofs your purchase if you buy a second electric vehicle.

CORD LENGTH: The location of the charger in your garage will depend on how far you'll need to reach to access the car's charge port. A Nissan Leaf, for instance, is about 4,4 metres long and charges from the nose. We recommend a spot close to the garage door, so you can charge your car even if you're parked in the driveway. A 5- or 6-metre cord should be fine, but go longer if you can afford it. These units can't be retrofitted if you've left yourself short.

GET YOUR HOUSE READY

The biggest potential headache with an EV charger is whether you have proper electrical service. If your house can't handle the extra load of a charger, you're dealing with an even bigger project of getting a new service drop, which means cutting off power to the house and

installing a new meter and breaker panel. You'll also need to consider the age of your garage and its distance from the house. Old wiring going to the garage might need to be replaced, and longer distances can come with a nominal increase in the size and cost of the cable that runs to the charger. In most instances, though, an electrician will be able to properly wire your garage. If you're experienced with home wiring, make sure you follow all the guidelines. Ignoring them carries a very real risk of an electrical fire. The US National Electrical Code Article 625 covers the rules for EV-charger installation, such as where a charger can be mounted and what kind of wiring is required.

If you don't have a garage, you can install a charger in your driveway. For outdoor mounting, you'll want a unit with a NEMA (National Electrical Manufacturers Association) rating of 4X – the Bosch Power Xpress is one example – which is made to stand up to rain, cold and dust.



WHAT'S SO SPECIAL ABOUT THAT PLUG?

The SAE J1772 charging plug is as inelegant as its name. And the five ports that connect to your car might seem complicated, but they're actually pretty straightforward.

1 AC power, just like the power plug for your TV.

2 Proximity detection. This is simply a mechanical switch that makes sure you're plugged in all the way.

3 Earth wire.

4 Communications, used to relay data between the car and the charger about how much current is needed.

PM



PUNISHING POTHOLE

I was driving my Mazda5 to work when a pothole came out of nowhere. I avoided it with the front tyre, but nailed it with the rear. Ever since, there's been a faint vibration that I can hear and feel coming from that area of the car. Is there something wrong with my suspension?

Potholes can viciously assault innocent vehicles – you're lucky it didn't swallow the car whole. Unless you were going extremely fast, though, there probably isn't any structural damage. It takes a pretty big hit to bend a piece of the suspension. Still, a pothole can do a number of bad things to the wheel and tyre. It's most likely that vibration comes from a bent wheel rim. You should be able to see any damage on a close inspection; don't forget to check the inside lip of the wheel as well. Most steel and aluminum wheels can be repaired relatively inexpensively.

It's also possible that the impact knocked off one of the wheel balancing weights. And though it's unlikely, crashing your tyre into a pothole can sometimes damage the steel belts inside, causing them to be out of round. After a quick look, take the car to a tyre-and-wheel specialist for inspection and repair.

FILL UP AND NO GO

My 2008 Hyundai Accent starts fine – except after refuelling, when it needs several tries to fire up. It's a weird problem, and I hope you know the solution.

It's probably the purge control solenoid valve, which controls the pressure or vacuum in the tank. The evaporative emissions control system in modern cars contains and controls the fumes from evaporating fuel and prevents them from venting into the atmosphere. The fumes get trapped in a charcoal canister that later sends them to the engine under the right conditions. Too much pressure in the evap system and excess fuel vapour is pushed towards the engine, which won't start until the pressure equalises. A replacement valve is affordable and is easily installed on some cars.



TOOLS AND TECH

ACTRON U-SCAN (ABOUT R800)

The U-Scan is a new take on the traditional scan tool. It still hooks to the OBD-II connector under the dash, but instead of a crude display connected by a cord, the U-Scan connects wirelessly to your smartphone via Bluetooth. A simple interface makes it easy to check error codes, and in-app purchases expand what you can do. For \$8 (about R80) per car or double that for unlimited use, you get manufacturer-specific codes and live data monitoring. ABS code reading is available for R60 (R300 unlimited), and a database of common fixes costs R140 (or R400).

WHY
WE LIKE
IT

Even loaded with all the add-ons, the U-Scan is a bargain compared with high-end scan tools, which cost around R2 000. And the U-Scan is easier to use. With no wires, you could even leave it plugged in all the time and use it as an extra gauge. **PM**

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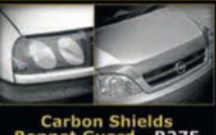
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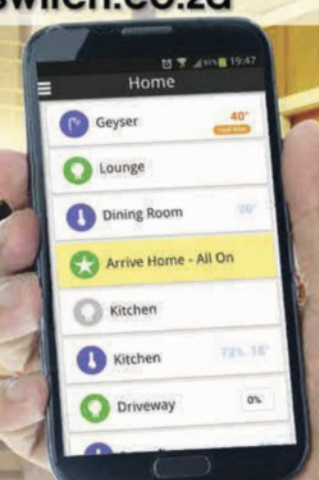
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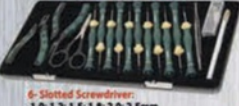


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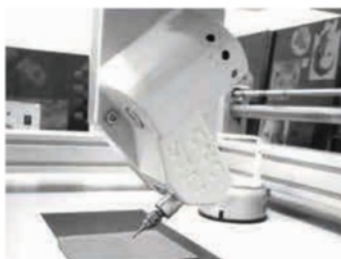
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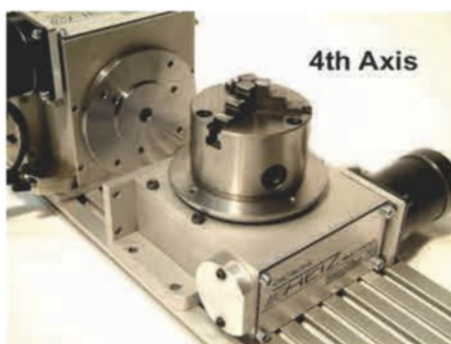
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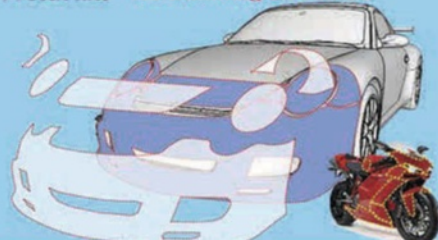
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SMS / email: Two models are available that send live images to your cellphone or email. With a totally invisible black-IR flash these units are ideal for asset protection, prevention of livestock-theft and other security applications.

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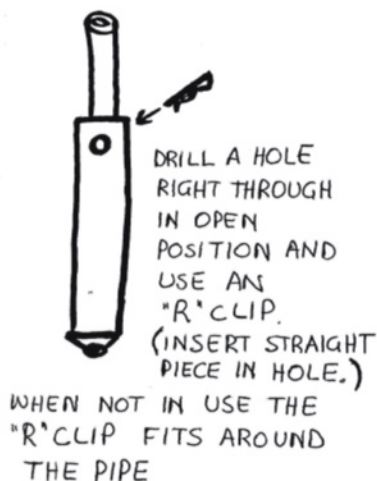
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WINNING TIP

DENIS DOES IT HIS WAY

My neighbour, Denis Bezuidenhout, 81, has experienced a very common problem with the canopy door on his bakkie – the cylinders that are supposed to hold it open are worn out. A common remedy is to prop open the door with a broom handle (how many old hatchbacks have you seen with this “accessory”?), but he came up with something better, using a drill and an R clip; see the drawing at right.

JOHN BOOTH
ANERLEY



Stop water ingress on flat roofs

Flat roofs or roofs with a very shallow slope are notoriously vulnerable to water leaks. A specially problematic area is the part where the water runs off into the gutter. When the roof angle is not sufficiently acute, water tends to run back on the underside of the roof sheeting until it reaches the wall, where it separates from the roof sheeting and results in wet walls and peeling paint.

A simple solution is to install self-adhesive sealing strips on the underside of the sheeting profile (see above). The water still runs back at the bottom section of the roof but when it hits the new strip, the water separates from the roof and end up in the gutter. Make sure the underside of the roof is clean before installing the strip.

FRANCO WEYERS
BRACKENFELL

Getting a grip

My wife, Moira, was looking for a pair of wooden tongs for removing toast from a toaster (*we'll assume everyone knows metal tongs are less than sensible* – Editor) but had no success, so I decided to seek the help of Google, which came up with the

following link: <http://bit.ly/1iqmOny>

Going there, I discovered I was reading an article from the March 1976 issue of POPULAR MECHANICS – and that brought a smile. But then I found the perfect solution, making a pair of tongs from some scrap wood I found in the garage (see picture). It was easy, and my wife is happy.



ALF STOCKTON
VIA E-MAIL

Cutting edge hint

The sequence below illustrates a safe way to dispose of broken glass without damaging the refuse bag or accidentally cutting yourself while handling it. All you need is a 2-litre soda bottle.

DERIK PIETERSE
VEREENIGING PM



SEND US YOUR HINT – AND SCORE!

Send us your best home, garage, workshop and general DIY hints – and win! This month's best tip wins a Bosch hamper consisting of a PSB combi drill, a Glue Pen and a PTK cordless tacker, all worth R2 667. The light-weight combi drill has two gear settings and 20 torque settings, as well as a drill and impact drill setting. The Glue Pen offers the convenience of a short curing time and reduced dripping, thanks to a glue recovery mechanism in the heating chamber. It heats up in 15 seconds. The cordless tacker comes with a push-and-release system that provides full control of the stroke release and a viewing window on the side that shows the remaining load. For more information, contact Bosch on 011-651 9600 or visit www.bosch-pt.com/za/en

Send your tips to: PM Do It Your Way, Box 180, Howard Place 7450, or e-mail popularmechanics@ramsaymedia.co.za Please include your name, address and contact number. Regrettably, only South African residents are eligible for the prize. Prizes not claimed within 60 days will be forfeited.



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Entrepreneurship is working for me

Refilwe's uncle, Katleho Madikeng, is one of Investec's 3,455 CSI beneficiaries. As part of Investec's partnership with Junior Achievement South Africa (JASA) and Enke, Katleho received entrepreneurial training, his leadership skills were developed and he founded a community youth project called Sisonke. Sisonke now teaches other youths from the community, including Katleho's niece Refilwe, the value of entrepreneurship in their own lives. So for the community of Phuthaditjhaba, Free State, Katleho's success is theirs too.

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