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1. Arnold and Phillip are the drone specialists at House4Hack and build almost everything from scratch. 2. Charlton Davids owns Segulla Electric, the sole manufacturers of the RoboBeast 3D printer. Factory capacity tops out at around 20 units per week. 3. House4Hack is a place for collaboration and skills transfer, a kind of open source classroom.



4



5



6

4. Omar-Pierre Soubra pitches the Cape Maker Faire to some of the members of House4Hack. 5. Quentin Harley is finally ready to take orders for his RepRap Morgan 3D printer. 6. Schalk Heunis owns the title deed to the house and is the godfather of this network of enterprising backyard inventors.

WE FEEL THE BEATING HEART OF THE LOCAL MAKER MOVEMENT AND MEET THE PEOPLE AT THE BLEEDING EDGE OF GARAGE ENGINEERING.



SOUTH AFRICA: MAKER NATION

BY LINDSEY SCHUTTERS

I USUALLY SHY AWAY FROM INDIA PALE ALE because, you know, the *smell*. But the room-temperature one I'm holding right now isn't that bad; it smacks more of hops than the acidic-metallic urine notes I usually associate with an IPA. Maybe it's a combination of the crisp late autumn suburban Centurion air and the whiff of solder drifting outside from the 80s-style family home. It's a Tuesday night in Pretoria and I'm at House4Hack, the centre of South Africa's maker universe.

You may think it bold, calling this prosaic space in Lyttleton Manor the centre of any kind of universe. But a quick roll-call of the projects that have been spawned by these Tuesday-evening meetings of minds lists Robobeast, Reprap Morgan and Hans Fouche's Cheetah in attendance. All three locally made 3D printers started here. That's a stat no other maker space in the country can boast. And they also make palatable IPA.

YOU DON'T BRING PROBLEMS TO THE HOUSE, YOU BRING PROTOTYPES. Something to show that you at least tried to solve your problem. Now you can draw from a 300-strong hive mind and learn new skills. That's the real beauty of these maker spaces. There isn't really any formal training to become a maker, so you learn by making (and sometimes breaking). All you need is an inquisitive mind, really.

Schalk Heunis is the godfather of the house, which he sees as an incubator for technology

companies. "It all started with a 3D printer," he recalls. "Now, when they first came out we were very intrigued and got one. It took us about a month to assemble it, because there weren't clear instructions. One of the parts would break if you tightened it too much and the kit actually came with spares. Tightening it to breaking point was part of the instructions."

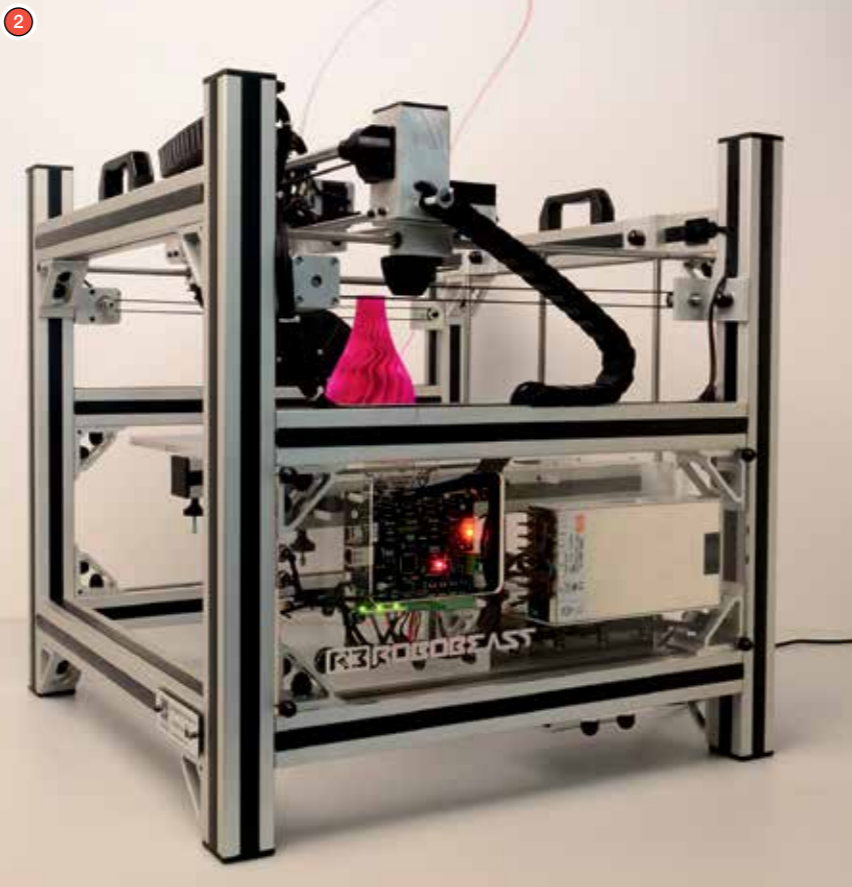
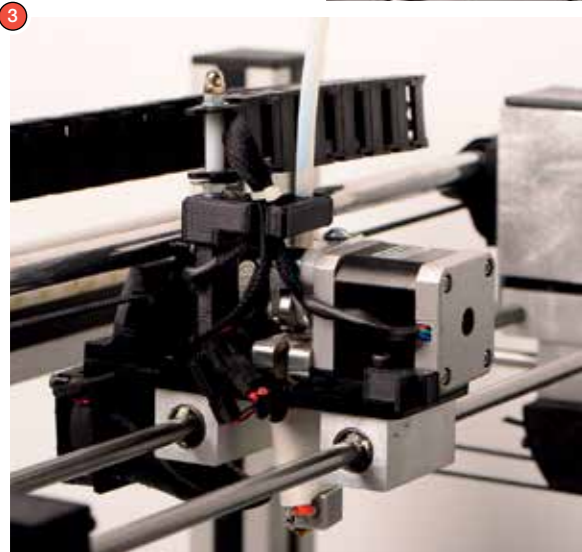
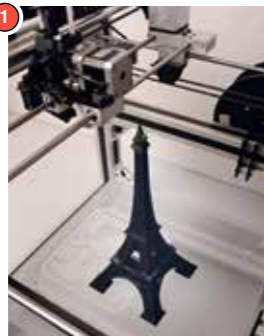
Before the dawning of the 3D printer, the house was a place to tinker with existing electronics. Then came the explosion. "Pieter van der

Walt came past here and said he'd heard of a thing called a Printrbot and he wanted to print a Printrbot," explains Heunis. "Everyone was looking at me to tell him he was mad." Heunis's response: "Whatever, dude, go for it."

He went for it. A few weeks later, he had printed his own Printrbot and evangelised House4Hack to the dark art of RepRap (replicating rapid prototyping). (I have a problem with the term "RepRap". It should actually be "SeRepRap" because the core of the project/movement is printing components to make more printers; so it's mostly a self-replicating machine. At least that's the way three house members have used it.)

Whereas fellow house members Hans Fouche and Richard van As have gone with conventional cubic designs for their respective Cheetah and RoboBeast 3D

1. The maker movement revolves around the rapid prototyping talents of the 3D printer. 2. Richard van As' RoboBeast is possibly the biggest success story to come out of House4Hack. 3. RoboBeast stays true to the RepRap philosophy with all the plastic parts printed on another RoboBeast.



4. The RepRap Morgan has morphed from spare parts to precision machining. 5. Quentin Harley, maker of the RepRap Morgan, helped develop the RoboBeast. 6. While RoboBeast sells mainly to engineering firms, Morgan is meant for the home and small business.



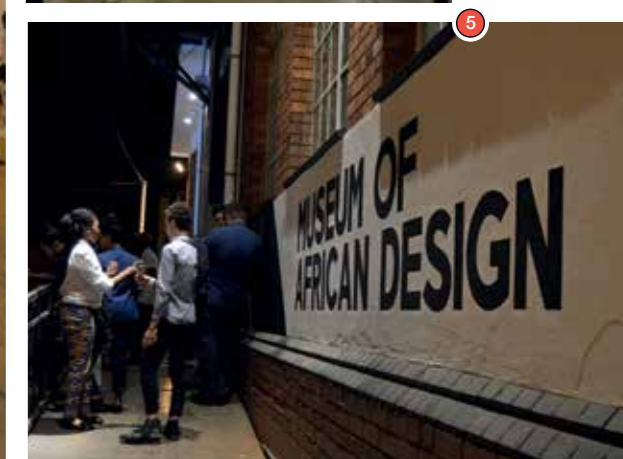
printers, Quentin Harley has a RepRap Morgan that looks like a piece of modern art. All RepRap machines are named after science superheroes, by the way; the Morgan is named after Nobel laureate biologist Thomas Hunt Morgan. Professor Morgan's greatest work was observing the unusual-looking offspring of two regular fruit flies. The namesake machine is intended to make more unusual printers.

Fittingly, the newly launched Maker Library at the Museum Of African Design (MOAD) has ordered a Morgan. I'm told it was more of a cost-based decision than an aesthetic one. MOAD's maker library librarian (yes, it's an actual title) and education director Batya Raff has been hard at work bringing the de facto tool of the makers to her carefully curated space. "We're not a white-wall, red-tape, stuck-up museum," says Raff about MOAD – which is ironically nothing but bare, white

walls as the museum prepares for a new exhibition and the launch of its maker library.

THE ROAD TO MOAD if you're travelling from OR Tambo airport takes you past bustling market (Bruma Lake) and cultural importance (Coca-Cola Park via the Albertina Sisulu freeway). I counted five schools en route to Joburg's Jeppestown. The museum is in the heart of the cosmopolitan Maboneng Precinct, so the space is at an intersection of hipster craft and education-

1. The Basotho Heritage Blanket-inspired clothing and accessories by Aranda is decadent in its Africanness. 2. Museum of African design's vernissage was well attended and received. 3. Batya Raff, herself a ceramic maker, is the librarian at MOAD's Maker Library. 4. Clothing and textiles are possibly the oldest of maker mediums. 5. MOAD is situated in Joburg's Maboneng precinct and attracts patrons from all cultures and walks of life.



al tools, fertile ground for cross-cultural collaboration and skills transfer. "It's a place of connection," explains Raff. "A place that draws in people who wouldn't ordinarily come into the Joburg CBD and a place where you can experience design and art in a different way. We're trying to show high African design and high African art as well as explore what it means to be in that making space and experiencing the process of making."

On opening night, the white walls are dotted with high-quality photography depicting uniquely African street scenes. There are two projector screens playing videos of girls getting their hair and make-up done in a nondescript African township. I'm tempted to buy a jacket made from a Basotho heritage blanket from their exhibition and to get drunk on the bespoke Bos Ice Tea cocktails. I bump into Raff in the Black Bottle whisky bar; it's conveniently located in the basement about five metres from the Maker Library, which has morphed into an interactive space where guests can build geometric shapes out of laser-cut pieces from a Trispace maker kit. It's all a bit high art and even higher fashion, but then I realise that artists and fashion designers are also makers.

"We're not following the tech shop model with big machines and electronics," she explains. "Whether it's woodworking tools or a 3D printer, we're equipping the space with tools that will help us bring these exhibitions to life."

It seems a world away from the beer and pizza-fuelled buzz at House4Hack, but the tight-sporting men and high-waisted ladies at the MOAD event are here for the exact same reasons: to be inspired and collaborate. If you think about it, Arduino control boards and Raspberry Pis are the same as sewing machines and cameras when used by skilled creatives in the way that the products perform a function and were made by people.

BACK AT THE HOUSE, Arnold and Philip give me a tour of their custom-built drones and show off a glider that took a snap of the Earth's curvature from 32 km up. They rapid prototype on a hot wire CNC machine that they built themselves. Arnold is the only guy in the house who uses Windows and this is proving

GREATEST HITS

South Africa has a proud maker heritage. Here are some of our finest moments

Statscan

The technologically advanced X-ray system is so amazing it was even included as a character on *Grey's Anatomy*. The ability to do a full body scan in around 13 seconds has revolutionised trauma units around the world and saved countless lives.

Bumbo

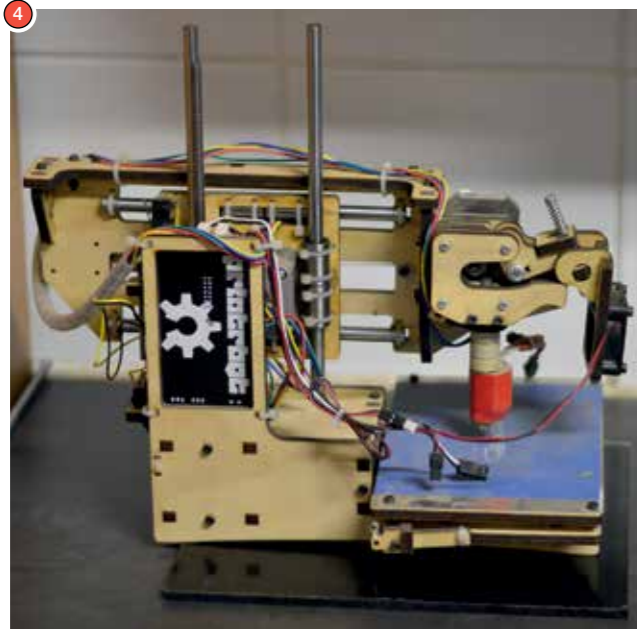
Oprah put this product on the map – and rightly so. It's a brilliantly simple way to prop your baby up so he or she can have a better view of the world. Aside from some *special* parents who leave their kids unattended on top of tables and want to use the Bumbo as a car seat, this product has received high international praise.

Dolos breakwater block

An elegant and effective way to protect against water turbulence – and often left off lists such as this because of the ubiquity of application. You find them everywhere in the world, but they were designed right here in SA in the 1960s.



1. Many of the maker projects revolve around the Arduino control board, but the South African-produced Speedy board is a hot favourite at House4Hack. **2.** The glider that flew up 32 km in the air and photographed the curvature of the Earth. **3.** Linux is the OS of choice for SA's open source-loving makers. **4.** The infamous PrintrBot was the first 3D printer printed by another 3D printer at the house. **5.** The Replicator printed the first pieces for the RoboBeast and the RepRap Morgan and was the primary 3D printer at House4Hack for many years.



problematic. The laptop isn't communicating with the 3D printer very well and everyone he asks for help uses Linux.

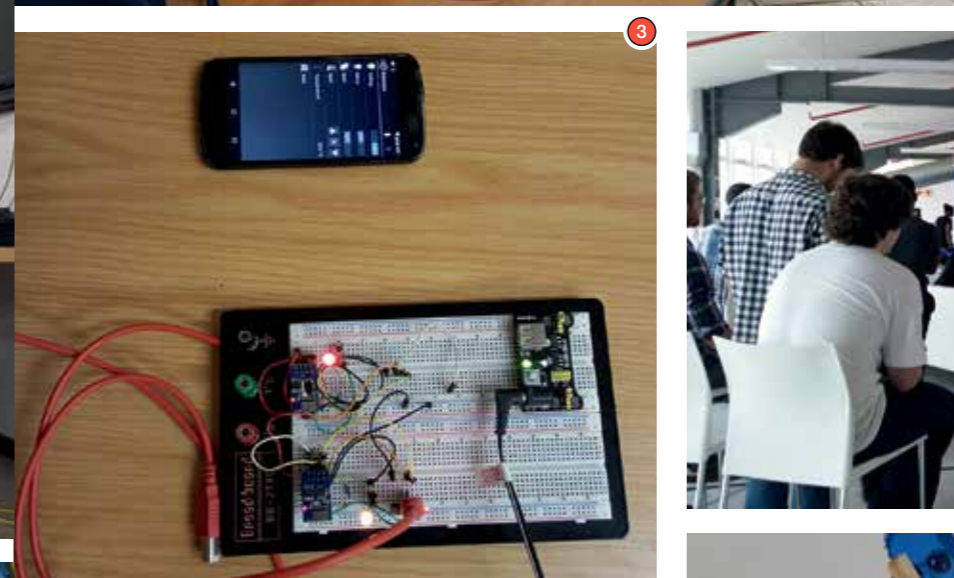
I move over to find Org tinkering with a couple of lights on a PC board. He tells me that the lights are modules that connect to the smart home system he is busy developing. The red light is supposed to be the geyser; you can switch it on and off, and monitor the temperature using a smartphone app. I ask him if he has used the ZigBee smart plug/switch with the Altech Node. He says No and explains the philosophy behind tinkering. I think I've offended him.

There's an almost naïve charm to the excitement around each project I encounter. You can buy similar products off the shelf, but these guys are pouring their hearts into making it their way. And each one has a business plan. Some have even abandoned successful careers to turn their tinkering into commerce. I want to back each and every one of them, but I can't seem to shake the feeling of dotcom déjà vu whenever I hear about one of the start-ups.

The variety and levels of skills among the guys attending tonight's House4Hack



meeting is truly astonishing. There are only about 12 here now, but Schalk says the membership stretches to 300. They're mostly doing these projects in their spare time; most have day jobs and families. The group tell me about a 12-year-old member who built a robot that is intelligent enough to identify the colour blue and how they collaborated with another maker community to build fire-spewing projects for AfrikaBurn. My mind is blown and I want to go home and tell the world about South Africa's maker movement.



1. Org is the common model of a modern maker who tinkers in his spare time. **2.** A Raspberry Pi does duty as a Wi-Fi router. **3.** A small-scale smart home that you can control from your phone. **4.** Intel is trying hard to lure makers on to its Galileo platform through its developer zone network. **5.** This contraption will point out any star you ask it to and was developed by UCT students in 10 days using Intel's Galileo board.

IT'S AN IMPORTANT NIGHT because Omar-Pierre Soubra from Trimble is pitching his Maker Faire idea to House4Hack. Maker Faire is happening in Cape Town in August and will showcase South Africa's making chops on the Grand Parade. The house is skeptical because they were burnt at 2014's Maker Faire Africa in Joburg, which turned into an arts and craft show rather than a celebration of backyard engineering. Schalk wants a trade show where house members can exhibit their start-ups to a wider audience. The concerns are valid, but the South African public still needs to be made aware of what making is before they will invest in the products. The house is excited and speaks of an extensive mailing list that blankets our country's entire network of makers.

We have about 56 active maker spaces in our borders. The projects that come out of these hubs are as diverse as there are stars in the sky.



At an Intel event, I met three UCT students who developed the software and hardware for a device that will point out in the sky, using a laser pointer, any star or constellation that you ask it to. They built it in 10 days, the same time it took for a group from Tuks to build a radio-controlled car with a camera that will point any way you want to look.

On a larger scale you have RoboBeast, the robust 3D printer you can use upside down or in the back of a car. The inventor/designer Richard van As founded House4Hack with Schalk Heunis, and Quentin Harley was on the RoboBeast development team. RoboBeast manufactures in Roodepoort; all the components except the stepper motors and battery pack are locally made. Charlton Davids owns the company that builds the RoboBeast. You can call him a maker, too.

If you make something you're a maker. Since we're all making a better country together, South Africa really is a nation of makers.



CALL IT MADNESS OR GENIUS, BUT HANS FOUCHE IS COMPELLED BY A DEEP DESIRE TO CHANGE THE WORLD AND LEAVE HIS MARK IN WHATEVER WAY POSSIBLE.

THE KING OF THE MAKERS

BY LINDSEY SCHUTTERS

IT DOESN'T TAKE LONG TO SEE WHY there isn't a line forming round the outside of Hans Fouche's Kempton Park property or why his inbox hasn't exploded with buyers clamouring for his home-baked Cheetah 3D printer. The machine, like its inventor, isn't what you can call refined. And if you were spending R100 000 on an industrial 3D printer, you'd be within your rights to expect better finishing and at least a housing for the control boards.

Still, though it may not look like it, the Cheetah has come a long way. It launched Fouche 3D Printing on the road to international notoriety. Actually, that's a bit of a fib: Fouche has many admirers around the globe. And most of them will know that Fouche 3D Printing started with chocolate.

"Do you know the term 'Chocnology?'" an animated Fouche explains. "If you Google it, you'll find an event that was hosted at MOAD (Museum of African Design). I 3D-printed chocolates for the Chocnology thing." That "thing" was a Nestlé event that invited artists to design chocolate sculptures to celebrate the launch of Android 4.4, also known as Kitkat. But how Fouche came to be a specialist in chocolate 3D printing starts with a tale involving the Rooivalk attack helicopter and Formula 1 race cars.

"Many years ago I was a mechanical engineer working at Kentron (now Denel) doing launchers for the Rooivalk attack helicopter's anti-tank missiles," explains Fouche. "I got to the age of 30 and something happened in my mind. I wanted to see my career ahead of me and couldn't see that at Kentron. I took my December thirteenth cheque and jumped on a plane to the UK with a pack of 15 CVs to hand in at all the F1 racing car teams. The story was, at least I had aircraft manufacturing experience, which is very similar to racing cars."

Eric Broadley of Lola Cars eventually gave Fouche his break with a three-month contract. Admittedly, that was at a much reduced salary than he was earning in South Africa, mostly because Broadley couldn't verify the contents

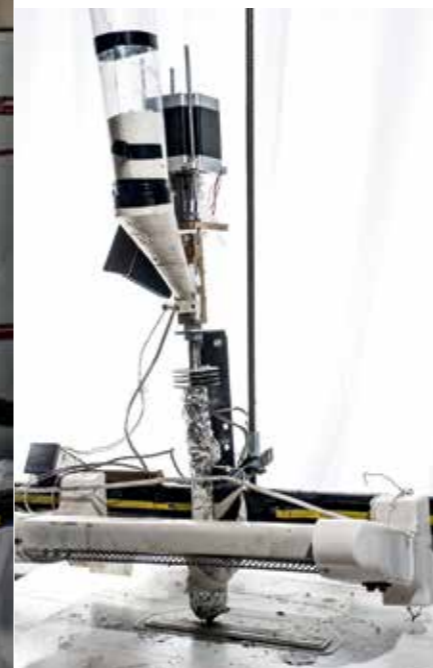
of his CV – a problem I found with this story, too. Fouche grabbed the opportunity, returned home to sell everything he owned and reported for duty at Lola. "When I arrived there was an opening at the Formula 1 team at Lola," he says. "I said, thank you very much, because F1 is my great passion. When I was growing up in Kempton Park I used to cycle to Kyalami to watch the races. There wasn't a meeting at Kyalami that I missed."

Throughout his tenure at Kentron, Fouche was a dedicated reader of international car magazines and it was in the pages of those magazines that he found his dreams come to life. He never says he was unhappy at Kentron; he rather recalls the frustration of the pace of development. There's nothing slow about race car development because, even over the course of a race season, engineers are refining and evolving the car design.

His first day at Lola was quite chaotic. "In SA, I was a senior engineer and had two guys under me. I was a boss," he recalls. "Draughtsmen do the drawing work here, but there engineers do it. I had to run off to the stationery shop to get rulers and pens. In SA, I was already working on CAD and had little experience working on a drawing board, but luckily the design process is the same for both."

From Lola Fouche moved to Leyton House, eventually ending up at Brabham as the chief aerodynamicist. Wikipedia lists him on the design team for the BT59 Formula One car and he was also involved in the abysmal BT60, Brabham's last race car, best remembered for a last place at the 1992 South African Grand Prix – our first post-isolation race. But it was at Brabham that Fouche started playing in the world of rapid prototyping.

"When you make a race car nose you actually build about 20 and you test it in the wind tunnel," he explains. "You then take the two or three best-performing models and take them a step further. And you do that with the wings, side pods, everything. In those years it was either NC



Hans Fouche has done a lot of making in his life, but his two most renowned inventions are the Cheetah 3D Printer that prints with ABS pellets – and the missile deployment systems for the Rooivalk.

PHOTOGRAPHS BY WALDO SWIEGERS

JUNE 2015 _ www.popularmechanics.co.za



Proof of concept for ABS as a printing medium and the Cheetah as an industrial machine was the first project, printing a lawnmower which Fouche uses to cut his grass to this day.

(numerical control) cutting or you carve it out of wood. The more models you could make, the better your work was gonna be."

It was then that an idea sparked to build a machine that could form the models quickly from CAD designs. "I took a plotter, replaced the pen with a modified superglue tube with compressed air behind. You do the first layer with superglue, then spray it with an activator so that it immediately sets and then lift it one millimetre to do the next layer." He did all this in his spare time, so there's no official record of his ground-breaking innovation. Brabham also closed its doors nine races into the 1992 season, so his invention couldn't be proven through performances either.

When Hans returned home he got a gig designing rubbish trucks, but was trying to convince his friends at the CSIR to start designing F1 cars. His argument gained traction and a team pooled from SA's world-leading engineering companies (Atlas, Aerotek and Kentron) got to work. The project started brightly with the CSIR wind tunnels at Aerotek providing the perfect home base for development. Fouche installed a rolling road in the wind tunnel so the models could be tested with wheels running relative to the wind speed and the team signed a contract with Forti. What formed out of this partnership was Forti's FG01, which was little more than a reworking of the Brabham BT60-succeeding Fondmetal GR02 concept which was designed by Fouche's former Brabham colleague – and then Forti design chief – Sergio Rinland.

To call the FG01 a disaster would be a bit harsh, but a legacy of being the last F1 car with a manual gearbox – and only one on the grid in 1995 – speaks volumes for the car's outdated technology. To their credit, the South Africans were testing the radical new Formula One changes implemented after the Senna tragedy in 1994. The poor performance of the Ford Cosworth ED V8 engine did the team no favours, either. The wind tunnel models, however, were built via stereolithography, which is also known as resin printing; that cool new 3D printing process where the object forms out of a liquid like the T-1000 Terminator.

"The South African mindset wasn't suited to the timescales of F1 and worked better for military contracts, so the project collapsed," explains Fouche. "But I realised while working on that project that I must take this technology further. So I bought a little plotter and a PC and started, but then the need for wind tunnel models evaporated. So I put icing sugar into the machine to decorate cakes by computer. But pumping icing sugar was a bit of a problem, especially with compressed air behind it."

He soon grew tired of the sweet explosions and started using chocolate. "The nice thing about chocolate is that you can heat it, but pumping it is difficult," he tells us. Fouche's innovative mind led him to a solution to his chocolate pumping woes: the peristaltic pump.

"Ever since, I've printed chocolates with my machine," he says. "I then took the Z-axis out because it's very slow when you do it that way. The other very important lesson I learnt in speeding up the process was adding more nozzles. I multiplied to a machine with eight nozzles, which prints eight times faster."

Fouche Chocolates thrived with the two machines, but the technology, stagnated. This was a good thing, because the technology



Below: Fouche's racing car passion is echoed by an abandoned skeleton for a Lotus 7-inspired track car which uses the engine and suspension sub-frame from a Fiat Uno.



Left: The 3D Printer that printed the Cheetah stands abandoned in the garage, stripped of all its worth. Far left: Also in his garage is the "infinitely variable transmission" a concept intended for a motorcycle that will automatically switch between any of 32 gears under full power.

remained expensive and the number of skilled technicians stayed low. Fouche started a new company with two other friends that was to produce chocolates, stained glass and do NC routing for frames. A fatal car accident involving one of the business partners halted development and Fouche then spent the next 18 years without access to this machine control technology to further his interests.

Fast-forward to the age of Arduino, where open source control boards and software became widely available (around 2011) and Hans Fouche emerged from his tragic slumber. "Around the same time I discovered House4Hack and realised that I could do it myself," he explains. "Then 3D printers were becoming available so I bought a RapMan machine and started playing around for a year and put it to work printing small things like rapala lures and plastic washing pegs."

When Fouche 3D Printing was conceived with the products of the RapMan machine, he was still stuck on his multiplication model to speed up production. Then he went bigger. "First I converted the machine to work with a 3 mm nozzle. Then I moved out to the garage and converted one of my idle chocolate machines to a 600 x 600 x 1000 mm printer. I built all the connecting pieces for the Cheetah."

The Cheetah prints fast and cheap, but the resolution is crude. We say it prints cheaply because, instead of printing with plastic filament at R250 per kilo, the 3 x 2 x 3-metre monster uses ABS

(the stuff you make hard hats out of) pellets which cost a mere R35 per kilo. Combine that with a 500 g per hour flow rate and you have the perfect machine for industrial rapid prototyping. It's also built with the RepRap philosophy, so the business plan is to build more Cheetahs and sell them to industry. And that's the key. The Cheetah isn't intended for backyard hobbyists to make dainty trinkets, but rather an alternative to expensive injection moulding.

Hans Fouche gets ridiculed and derided not for his inventions, but for the presentation. There aren't many makers in South Africa who can boast a CV to match his, but that legacy is also littered with ultimately failed projects and missed opportunities. All he wants is support for his claim for the throne of the maker community. You have to admire his resolve and his vision.

"Being a maker means doing everything yourself. I'm a mechanical engineer, so engineers tend to make a lot of things themselves. Normally you've got the garage, you've got the drill, you've got the press, the hacksaw, the welder. And with these machines (3D printers) you can design projects in CAD, just press a button and there it is. Of course it's not as simple as that, but that's the idea. The other thing is the universal manufacturing machine – the machine that can do it all. This is definitely one step closer to the universal machine. Because you can do ashtrays, the next day you do shoes, the next day you do whatever. In that respect, it's the closest we've come to the universal manufacturing machine."



3D PRINTING 101

HERE'S WHAT YOU NEED TO KNOW BEFORE GETTING STARTED AT HOME

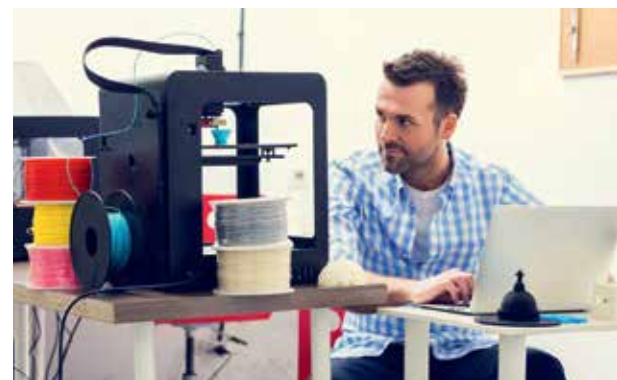
BY SEAN WOODS

To say additive manufacturing – or 3D printing as it's commonly known – has a promising future would be the understatement of the century. Granted, although we're nowhere near walking into some futuristic printing shop with the design of our next vehicle (wiring and all) on a flash drive just yet, no one can deny that this burgeoning, disruptive technology has already gone mainstream. We take a peep behind the tech of a typical 3D printing machine.

PRINTER TYPES

FUSED DEPOSITION MODELLING (FDM) printers are what most hobbyists use when conjuring up their own designs. Affordable, they are also available in various sizes, designs and levels of sophistication (think RoboBeast and MakerBot). They print objects by extruding a stream of heated or melted thermoplastic material, which is placed layer upon layer, working from the bottom up.

STEREOLITHOGRAPHY (SLA) machines employ a vat of liquid ultraviolet curable photopolymer resin and an ultraviolet laser to build layers one at a time. The laser traces a cross-section of the pattern on the surface of the resin, causing it to cure and solidify under the ultraviolet light and join to the layer below. Once



Main image: Checking out the future now... visitors at a recent PM display stand around mesmerised as they watch a 3D printer perform its magic in real time. **Above:** Thanks to the 3D printing revolution, manufacturing your own bespoke items at home has never been easier.

complete, the grown item is washed in a chemical bath to remove excess resin, then cured in an ultraviolet oven.

SELECTIVE LASER SINTERING (SLS) is a technique that uses a high-power laser to sinter layers of powdered materials – typically metals – into solid structures. Needless to say, this technique is more suited to the likes of tech heavyweights the CSIR rather than your average home workshop.

TYPICAL COMPONENTS OF A HOBBYIST'S FDM MACHINE

Seeing that FDM printers are what most of us are likely to encounter as hobbyists, here's a breakdown of their basic components:

MOVING MECHANISM

In order to move along 3 axes/dimensions (X, Y and Z) most printers make use of fixed rods, timing belts and pulleys to manoeuvre the print head and/or platform to the exact position required – and small stepper motors permit extremely precise movements of a fraction of a millimetre. These motors are important components as they're in part responsible for the quality of the end product.

EXTRUDER

The extruder's job is to feed the filament into the so-called "hot-end". Extruders are where some of the biggest differences between 3D printers exist, and where the biggest developments are most likely to take place in the future. Some models integrate the "filament driver" as well as the hot-end in one piece; other printers feature a "material feeder" separated from the "extrusion head". Both types have their pros and cons.

RETRACTION

Retraction is a technique that sucks molten plastic back into the heated hot-end. Retracting the filament back into the nozzle just before jumping across gaps prevents cobweb-like thin strands of plastic (called "stringing") from forming – a messy, time-consuming job to clean up should it occur.

DUAL EXTRUDER

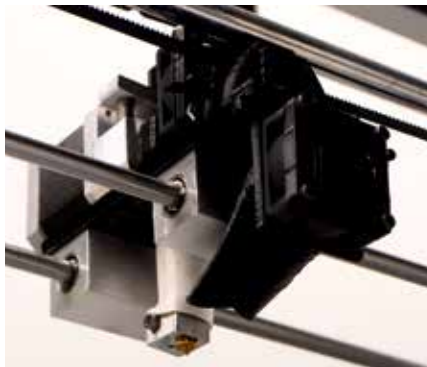
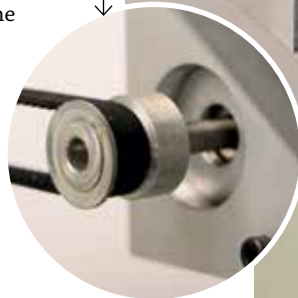
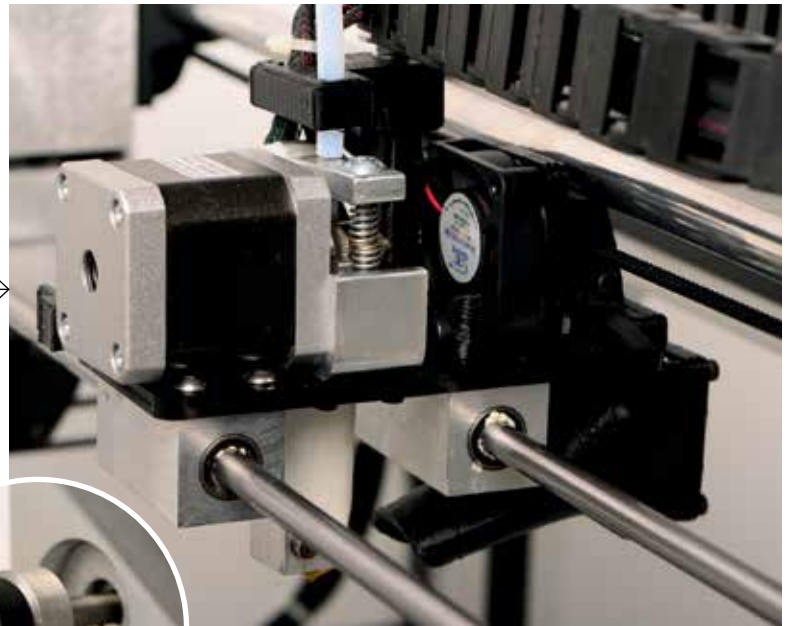
Some printers feature dual extruders, allowing them to print with two filament drivers and as well as two hot-ends – giving you the ability to print in dual colours or even two different materials. This is a great feature for those wanting to print items with large overhangs that require a scaffold supporting structure.

HOT END

Usually made up from a block of aluminium, the Hot End gets heated up to around 250 degrees to melt the plastic filament, and includes a nozzle and heat sensor. Typical nozzle diameters range from 0,2 mm to 0,5 mm in size. The smaller the nozzle, the finer the print, but the longer it takes to complete.

PRINTBED

The most common printbeds are made out of acrylic, aluminium or glass. When buying a printer, always check the exact printbed size, as it plays a determining factor in the maximum size of your future printed objects. Some printbeds are heated to prevent the warping or cracking of prints, especially when using ABS plastics.



FILAMENTS

The two most common filament types are PLA and ABS. Each plastic has its own physical and chemical properties, so each type needs its own specific set-up within your printing software. Before purchasing any filament, make sure you know what diameter fits your printer.

PM

SOUTH AFRICA: **MAKER NATION**

