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This year hasn't got off to a good start so far. Lemmy, Bowie and now everyone's favourite Sheriff of Nottingham, Alan Rickman, have all passed over to the other side. It's been a sad couple of weeks for the creative industry and the world of music and entertainment. I was pondering this trio of deaths as the magazine went to press, as ever, fuelled by a few too many sleepless nights, far too much coffee and heavy metal playing a little too loud (at least, according to the folks in the office beneath mine). Creativity is something that's often looked at as the sum of its constituent parts – the complete works, so to speak.

But there is something in Russell Beard's column this month that struck a chord with me and made me think about creative endeavour a little more microscopically than usual. I realised that it's the small details, the things that go unnoticed that really take something from the successful to the sublime. Whether it was Lemmy's thundering basslines, punctuated with a run up the fretboard of that Rickenbacker; whether it was Bowie's occasionally odd pronouncation of a word; or Alan Rickman's master stroke, humming to himself in a lift as Hans Gruber in 'Die Hard'.

In the world of design and engineering, we often get caught up in focusing on the bigger picture, but the reality is that real delight often lies in the smaller details – the tiny touches that make the whole thing sing. This is something that our cover story details, too. Philip Norman, who with a bit of luck will be speaking at this year's DEVELOP3D Live, took a long, hard look at the details of the world around him and then took his learnings to develop a modular platform for robotics. His business, in short, is based on attention to detail, which has led him to do things that simply can't be done in any other way.

Whether you're taking the micro or the macro view of your current project, we hope you enjoy this issue.

Al Dean
Editor-in-Chief, DEVELOP3D Magazine, @alistardean

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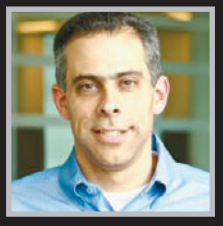
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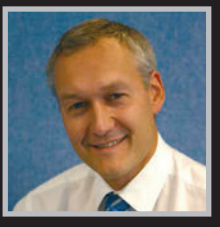
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FEBRUARY 2016 ISSUE NO. 75

8 **NEWS**
FARO launches next-generation 3D scanner Cobalt, PTC acquires Kepware and a glimpse into Faraday Future's design process for its FFZERO1 concept car

COMMENT
14 Finding a manufacturer to make your product is a lot like dating, says Sarah Krasley of Unreasonable Women
16 God is in the details, so don't neglect the unseen detailing of your product, advises Russell Beard of Square Banana

18 **INTERVIEW**
DEVELOP3D speaks to Ben Crundwell of Cambridge Design Partnership about Amazon.com, his software tools of choice and his hopes for wearable technologies

FEATURES
20 Visual design guide: Technics SL-1200G
22 Coming soon: DEVELOP3D LIVE 2016
24 **COVER STORY Ross Robotics' modularity mission**
30 Robot Revolution: Robotics and 3D printing in construction
36 Node Red: Prototyping an autonomous underwater vehicle
39 Simulation helps Whirlpool build a better burner
42 Mayku aims to bring rotomoulding to the masses
47 Formaplex saves with injection simulation software

REVIEWS
50 Onshape
54 Fusion 360
58 SimScale
60 Workstation Specialists WS-M151
63 Fujitsu Celsius J550

64 **DEVELOP3D SERVICES**

66 **THE LAST WORD**
What can we reasonably expect from third-party partner applications, accessed via the cloud, asks Al Dean?

FARO LAUNCHES NEXT-GEN 3D SCANNER COBALT

FARO Cobalt 3D Imager mounted on a robot and scanning a car door

In its quest to take automated industrial manufacturing metrology to the next level, FARO Technologies has announced the release of a new, highly adaptable 3D imager array.

The new FARO Cobalt 3D Imager is equipped with dedicated on-board processors, an industry first. The smart sensor allows unique multi-imager array configurations, with an unlimited number of 3D imagers scanning simultaneously and controlled by a single computer.

Combining blue light projection, stereo 5-megapixel cameras with adjustable narrow or wide field of view for capturing more or less data, powerful on-board processing allows for millions of data points to be processed faster.

With high resolution, automatic exposure and high dynamic range, FARO claims that Cobalt expertly handles complex parts with fine details, varying colours, textures and reflectivity.

With integration into the production environment expected, Cobalt can also be installed in more conventional ways. For example, it might be used in conjunction with a rotary table, robot or industrial inspection cell.

"With no restrictions on the number of sensors in an array, the sky's the limit for improving inspection cycle time, making it an exciting new product that enhances the FARO portfolio for in-process or near-process inspection," said FARO president and CEO, Dr Simon Raab.

tinyurl.com/Faro-Cobalt

ITI receives UK government R&D grant

International TechneGroup Incorporated (ITI) has received a three-year R&D grant award from the UK government, supported by the Aerospace Technology Institute (ATI), in order to fund its participation in the AuGMENT project.

In collaboration with Cambridge Flow Solutions (CFS), the lead partner on this initiative, computer-aided engineering specialists ITI will support the development of leading-edge advanced geometry processing and automated meshing solutions for the aerospace industry.

Through the AuGMENT project grant, ITI and CFS will engage to develop advanced tools for Computational Fluid Dynamics (CFD) geometry preparation and meshing. These, it is envisaged, will allow engineering simulation to participate fully and effectively in the earliest stages of industrial design.

tinyurl.com/ITI-AuGMENT

Dell workstation prize winner

The winner of the AMD FirePro and Dell Precision mobile workstation competition was drawn out of our virtual hat this month.

Congratulations goes to Stephen Hatcher of P+HS Architects, who scoops the Dell Precision 7510 mobile workstation powered by AMD FirePro graphics.

DEVELOP3D would like to thank everyone that entered the competition as well as our very generous sponsors, AMD FirePro and Dell Precision. We are already planning our next competition.

Factory floor IoT is focus of PTC acquisition of Kepware

In a deal potentially worth $118 million, Kepware's KEPServerEX will become the next strategic component of PTC's fast-growing ThingWorx technology platform for the Internet of Things (IoT).

A software development company that provides communications connectivity in industrial automation environments, Kepware offers integration products to give organisations insight into operational performance, quality and time to market.

Once the two companies' products are integrated, machine data will be aggregated in the PTC ThingWorx platform and then automatically analysed using ThingWorx's machine learning capabilities.

In its June 2015 research report, entitled *The Internet of Things: Mapping the Value Beyond the Hype*, the McKinsey Global Institute identified the factory floor as one of the locations set to benefit most from the adoption of IoT.

PTC has established a dedicated business segment and has formed a strategic alliance with industrial giant GE to pursue this factory opportunity. The acquisition of Kepware is intended to complement the alliance with GE.

Kepware and PTC, meanwhile, have suggested that they share many common customers who will quickly be able to realise value from the acquisition.

"PTC is committed to helping manufacturers, infrastructure operators and others realise the enormous value inherent in the Internet of Things," said Jim Heppelmann, PTC president and CEO.

"With this acquisition, we will gain entry into heterogeneous factory and operating environments with robust technology, an impressive list of customers, and a high-quality, profitable company with incredibly talented employees."

tinyurl.com/PTC-Kepware

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A glimpse into Faraday Future's design process

Since its inception 18 months ago, Faraday Future's team of multidisciplinary experts from the technology, automotive, aerospace and digital content fields has, according to the company, "dedicated itself not only to building the next generation of safe, reliable, high-quality electric vehicles, but also to creating an entirely new vision for mobility."

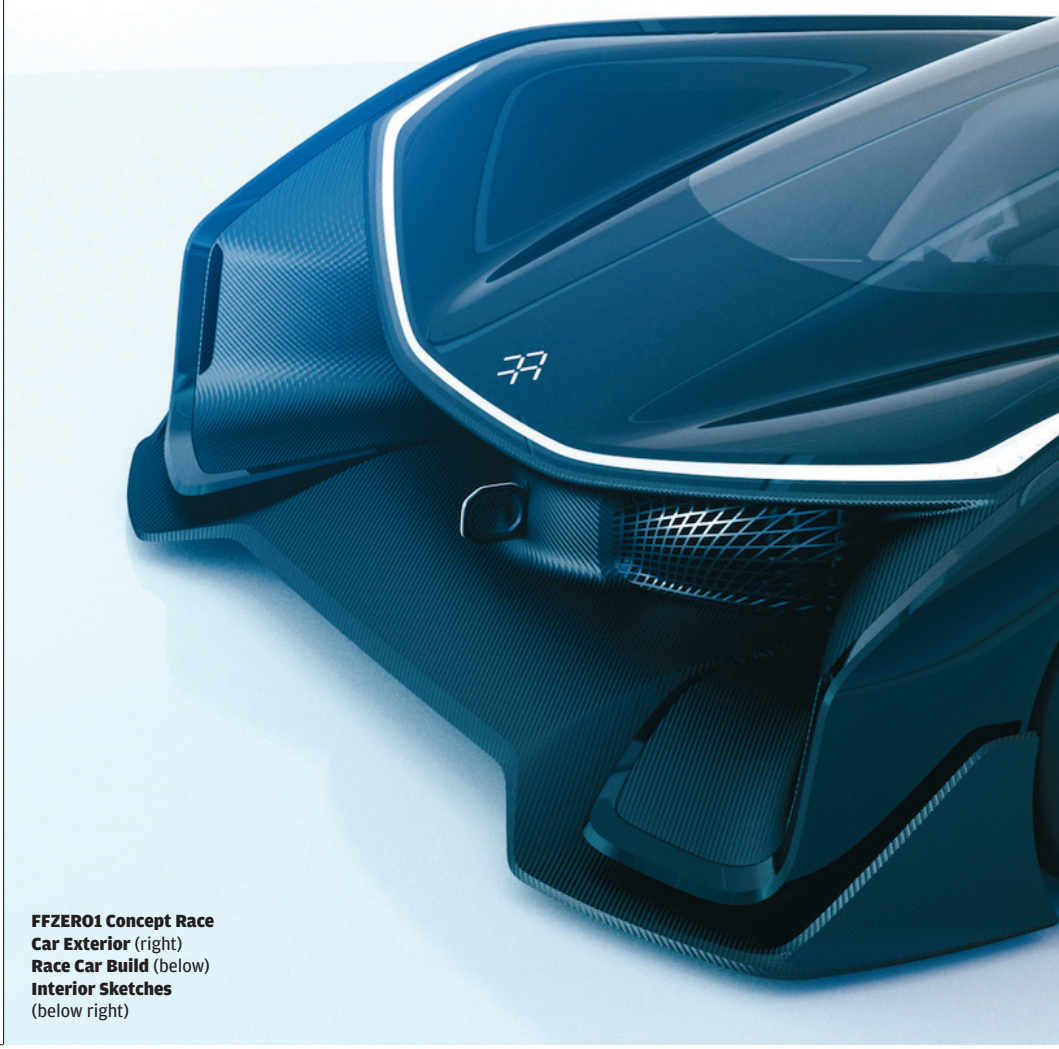
The company's FFZERO1 concept car certainly got plenty of attention at CES 2016 in Las Vegas and DEVELOP3D has learned that two software modules from Dassault Systèmes were used in its development.

These were: Target Zero Defect, an integrated, open development platform designed (as the name suggests) to minimise defects; and Smart Safe & Connected, for electrical systems definition and performance validation.

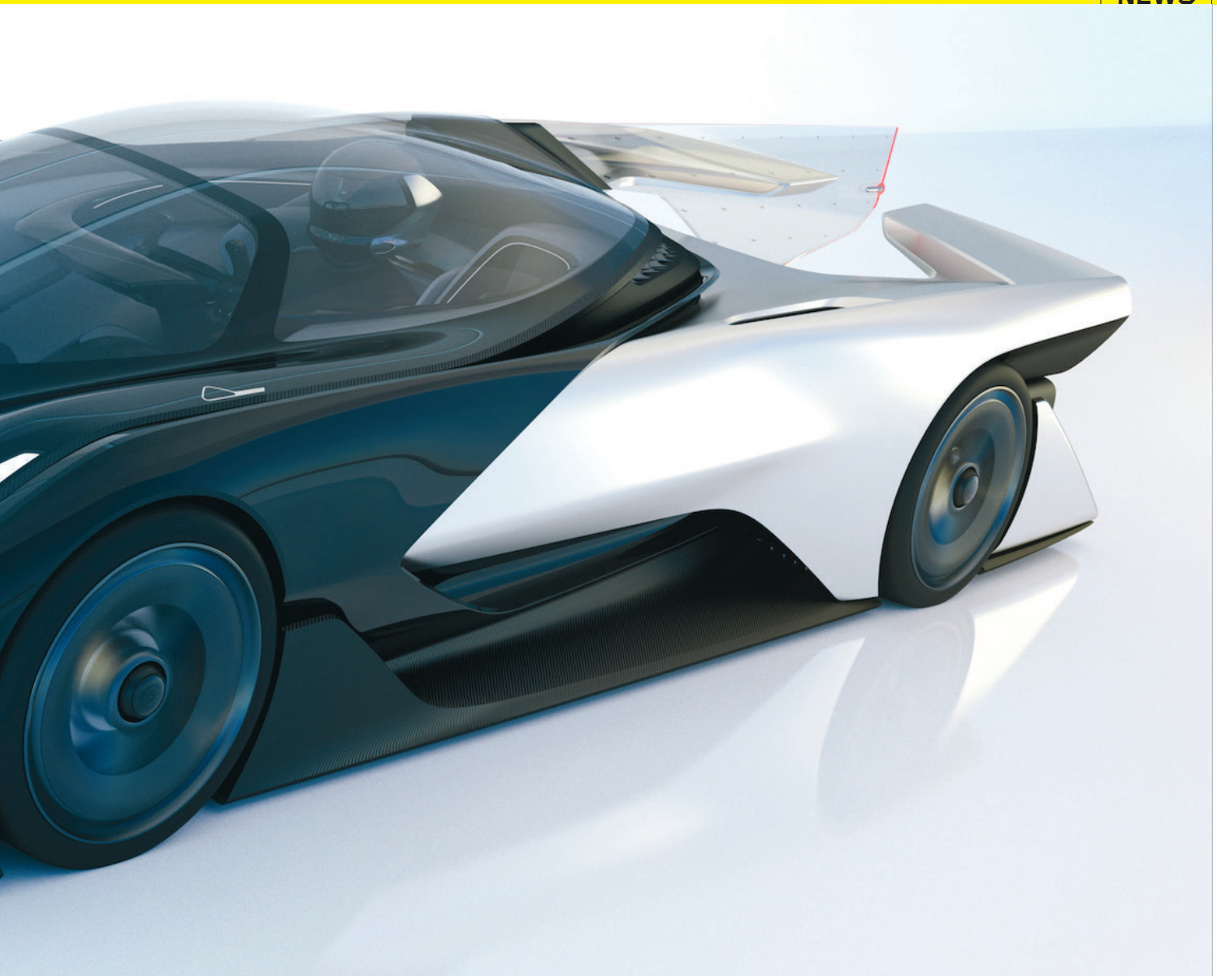
The design process also incorporated augmented and virtual reality tools, parametric design and 3D printing.

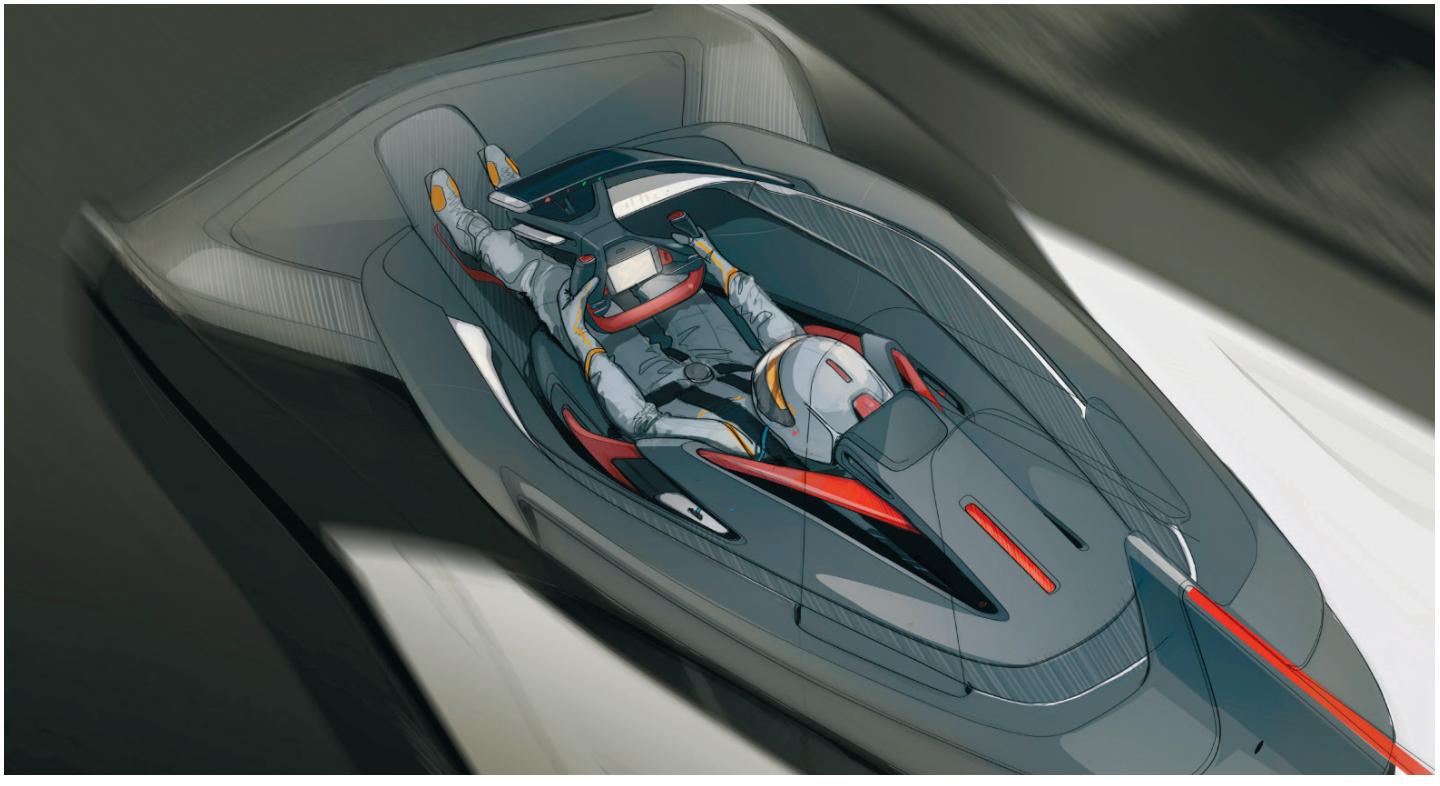
FFZERO1 is based on Faraday Future's Variable Platform Architecture (VPA), a modular engineering system on which all the company's future production vehicles will be based. This will enable it to reduce R&D and manufacturing times, to bring new vehicles to market faster, while controlling costs.

faradayfuture.com



FFZERO1 Concept Race Car Exterior (right)
Race Car Build (below)
Interior Sketches (below right)





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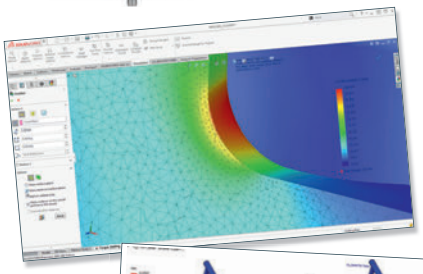

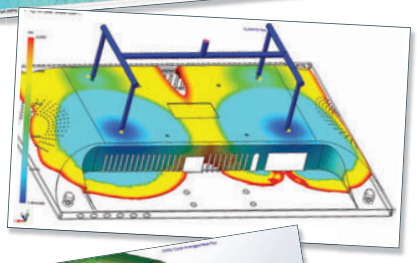

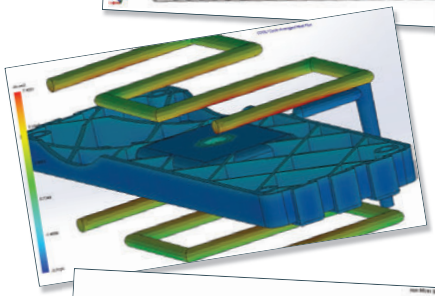

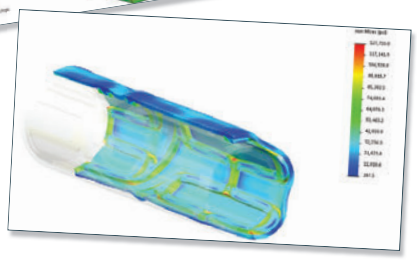

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GPU CLOUD RENDERER IRAY INTEGRATES WITH ONSHAPE

RealityServer for Onshape is a new cloud-based rendering technology for the browser-based 3D CAD system. The ray trace renderer uses the Nvidia Iray physically based rendering technology and harnesses multiple high-end Nvidia GPUs to do the rendering calculations in the cloud.

The RealityServer Onshape application currently utilises the Iray Photoreal rendering mode, but developer Migenius says it will expose more modes over time, including an even faster Iray Interactive mode, which allows for greater speed at the expense of some accuracy.

Materials are based on the Nvidia Material Definition Language (MDL) and, in the future, users will be able to use their own MDL materials directly with RealityServer for Onshape.

MDL materials are transferable to other Nvidia Iray-based rendering applications, including SolidWorks Visualize.

To use the service, users simply add the RealityServer application to their Onshape document and it will appear as a new tab. Users will then be taken to a page where they can manage GPU server resources and select the model they want to convert along with the tessellation settings.

RealityServer for Onshape is available in the Onshape App Store, currently in private beta. RealityServer for Onshape is also currently in beta and Migenius has said it will be adding features progressively over time.

During the Onshape App Store private beta, RealityServer can be accessed free of charge. Final pricing will be announced at the conclusion of the beta program.

migenius.com/products/onshape

RealityServer for Onshape uses Nvidia GPUs in the cloud for ray trace rendering

Comsol simulation in the cloud

Engineers using the physics-based modelling and simulation software, Comsol Multiphysics, can now run their computationally demanding analyses in the cloud.

Comsol customers can hook into Rescale's dynamic pay-per-use High Performance Computing (HPC) platforms, making use of built-in administration and collaboration tools designed to improve and speed up the simulation process.

"For customers seeking HPC resources for bigger analyses, this important initiative with Rescale allows our users to take full advantage of both the Comsol Multiphysics software and Rescale's secure and flexible simulation environments," says Comsol's Phil Kinnane.

rescale.com | comsol.com

ESI delivers SaaS platform for CAE

ESI Cloud is a new SaaS platform from virtual prototyping specialist ESI, designed to deliver advanced engineering simulation in the cloud, across multiple physics and engineering disciplines.

The service offers customers 'instant access' to selected ESI CAE solutions, from anywhere, and is designed to provide elastic resources to fit varying simulation needs, from occasional use to peak loads.

According to ESI, it is the only CAE cloud platform that includes parallel workflows, templates and sample projects, which enable even novice users to become productive quickly. The first software available on ESI Cloud is ESI's virtual performance solution (VPS).

esi-group.com

DEVELOP3D.COM THE BEST FROM THE WEBSITE

Got a sticky problem? The team at 4D Modelshop has produced a handy in-store guide to help customers pick the right adhesives
tinyurl.com/4D-Adhesives

Chinese design firm NANOIN Design reveals new approach to eco-friendly protective casing for shipping breakables
tinyurl.com/Nanoin

Materialise is teaming up with Cooksongold to take precious metal printing of near net-shape parts to the next level
tinyurl.com/MaterialiseGold

LPW Technology has launched a new powder management product line called Powderflow for metals 3D printing
tinyurl.com/LPW-Powderflow

Robot Wars is set to return to UK TV screens, after an absence of ten years, with a new six-part series on BBC Two
tinyurl.com/BBC-RobotWars

Finding a manufacturer to help you create your product is a lot like dating, says Sarah Krasley. She talks to Dorian Ferlauto, founder and CEO of Britehub, which aims to help designers make the right match

I taught a brand new Design for Manufacturing course at New York University's storied ITP Program this Fall. In seven weeks, we blazed through milling, injection moulding, blow moulding, cutting, stamping, PCB ordering and 3D printing, alongside factory relations, requests for quotes and the mysteries of shipping something on those big barges laden with colourful boxes.

We somehow managed to not get whiplash. I delighted when I saw my students recognise parting lines in plastic parts and was somewhat pleased that the most common takeaway was: "I had no idea it was such a pain in the ass to make something."

Almost all of my students were trying to bring new connected products to the burgeoning Internet of Things (IoT). None of them had made a product before and all needed to navigate the waters of finding and developing an agreement with a factory.

While my students were on a steep learning curve compared to more barnacled product designers, I think we can agree that when it comes to developing a new product, there are a dizzying number of options out there. The reason for this is that "new" no longer means a riff on the old. It means experimenting with a new material, a new complex shape, a new benchmark for efficiency and/or putting electronics inside something that used not to have them.

It strikes me that finding a manufacturer to help you make something new is a lot like dating. Do you want them to be located near you or are you OK with a long-distance relationship? Do they feel you have your act together sufficiently that any relationship would prove stable, over the longer term? Is there potential for mutually beneficial growth?

Success in dating and relationships boils down, primarily, to good communication. Developing supply chain relationships is no different. Dorian Ferlauto made this creative leap back in 2013 and founded a company called BriteHub that aims to bridge the communication 'valley of death' between product designers with ideas and contract manufacturers who might produce said ideas. It's a yenta – a matchmaker – for production, if you will. BriteHub now works with over 2,000 organisations every day making magic, one casing at a time.

Ferlauto placed her bets early and carefully, because she knew BriteHub couldn't be everything to everyone. She sought to find out how people communicated, so that her company could build a platform that was helpful to them. In doing this research, she says, "we learned that it's one thing to have a data scrape, but in order for people to transact business and work together, there needs to be a uniform way of doing things."

Ferlauto and her team attacked standardisation with laser focus for multiple reasons. From the point of view of manufacturers, "many work on the factory floor and want to be able to vet potential business leads coming through quickly and easily. In many cases, facilities don't want new leads; in reality, they just want the right ones. In every case, the process of vetting jobs and providing quotes needs to blend into their daily workflows and it has to happen in a standardised way, so it's not new every time," she explains.

> **"Success in dating and relationships boils down, primarily, to good communication. Developing supply chain relationships is no different"**

The second objective BriteHub focuses on is extending the relationship beyond the request for quote (RFQ) and bid acceptance stages, through to workflow management. Ferlauto explains that ducking out after architecting the initial interactions between product designers and contract manufacturers isn't enough and wouldn't serve either party well. In order to keep things moving along, BriteHub's platform extends through engineering change orders (ECOs), supplier scorecards and connection points to enterprise software solutions. It also gets both parties off email and other disparate, difficult-to-track forms of communication wherever possible.

Dorian Ferlauto, founder and CEO of BriteHub

In an effort to extend the dating metaphor to the very end of my piece, one might beg the question, why focus on standardising human interaction at all, when eventually, institutional knowledge from contract manufacturers will be turned into solvers that can predict cost, feasibility and the optimised way to do something in two shakes of a lamb's tail?

Ferlauto believes that the human element won't go away, or at least not in our lifetimes. "It's about human behaviour in the end," she says. "Sure, there is a growing chorus of 'Humans will be removed for total machine and design learning', and I believe that there are some processes where this will be true. However, I believe there will always be human components. There is too big of a knowledge base to lose them, and instead of total machine learning, people working in factories will be highly technical and [these people] will get smarter alongside the machines."

Smarter relationships? Well, that sounds almost as romantic as lights-out manufacturing.

Sarah Krasley is the founder and principal of product, service and workplace policy design firm, Unreasonable Women (unreasonablewomen.com)**. She is also an Adjunct Professor at New York University's ITP Program. Learn more about her at** sarahkrasley.com

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An Altair Company

The phrase 'God is in the detail' applies just as much to the internal details of your product as it does to its outer shell, says Russell Beard. Just because unseen details are unseen doesn't make them less worthy of consideration

With every New Year, we are bombarded with column inches telling us how to simplify our diet, clean ourselves up, detox and get back to basics. Well, to draw a very poor parallel, I'd like to talk about how this advice might apply to product design and, in particular, the 'innards' of a product.

Much of what we see as a result of fervent product design activity is the outer shell of a product – its colour, finish, form, interface, branding, texture, messaging and style. The visual, tactile and emotional side. The face, smile and handshake of the product.

These facets of product development and refinement are hugely important, but I would like to see more focus on the inner workings of that very same product – the tiny screw bosses, location ribs, snap fits, alignment widgets, sub-assembly gizmos and cable tidies that some poor sod has had to cram into a space that probably isn't ideally sized to accommodate them and has needed to be rearranged countless times in response to project feedback.

I have to admit to finding this stage of design work incredibly fulfilling. I know I could so easily place this rib or that boss in whatever position I'd like and, as long as it does the job, no-one will ever notice. But, at the same time, there's an obsessive little corner of my brain that wants this rib or that boss to be positioned and located in an inherently logical way.

It's what makes part of me die a little death when I open up a 'quick and dirty', copycat product from China to find a bodged piece of design work that displays no awareness of the finer nuances of why that boss has been positioned in a particular place or why the ribbing is so vital to improved mould flow or – better still – to create a subtle, yet distinctive, sink pattern on the upper surface of the moulding.

Great design should showcase an in-depth knowledge of product functionality and manufacturing processes to create geometry that has purpose and meaning, inside and out – deliberately, purposefully, carefully. When it comes to internal detail, to use the excuse that 'no-one will ever see it' is to admit that you haven't given your product the time and consideration it deserves.

It ignores the beauty that can exist in a well-balanced fillet in a complex internal surface or in internal angles designed to ensure that a tool will last that little bit longer. There have been countless products that I've designed into which I've built all manner of little, deliberate features and logic, that will go unnoticed, not just by the end user but also by the immediate client. But just because unseen details are unseen doesn't make them less worthy.

It's a bit like having visitors to stay and 'tidying up' by cramming all the rubbish into cupboards and under-bed drawers, along with other nooks and crannies, in order to get it out of sight. The outward impression of harmony and togetherness you'll achieve is a sham.

On a more pragmatic note, those finer, unnoticed details could give your product the edge over its more hastily considered competitors. Get these right and, because of the consideration you've given to the inner workings of your design, the tooling goes exactly to schedule, the parts measure accurately after T1 sampling, part moulding is consistent, component parts fit perfectly, assembly is seamless and the product 'feels' solid.

Now, it may be that nobody notices that it was the way that the product designer had considered all the tiny details upfront that meant the product passed through typically problematic stage-gates without fuss or bother. They may just assume it was down to the efficiency of the toolmaker, the complexity of the moulding machines, the skill of the assembly team or the care of the user. But as designers, I see it as our job to anticipate and preempt a bumpy product journey by designing in those features, details and subtlety, wherever possible.

In other words: measure twice, cut once. Don't neglect the hidden details – and don't hand them off to someone else to sort out. See the project through to the end. The best designs are those that have had continuity, a steady hand on the tiller throughout.

In client expectation terms, this can be difficult to manage. Thanks to rendering software, products can be visualised at a very early stage, leading clients to believe that the design is pretty much ready to be sent to China for tooling.

> **"When it comes to internal detail, to use the excuse that 'no-one will ever see it' is to admit that you haven't given your product the time and consideration it deserves"**

Designers have to be careful to push back against these expectations, explaining that time is still needed for the invisible detailing and development that will ensure the product is as great as the renderings so prematurely promise. What clients don't see are the hundreds and hundreds of tiny component reshuffles, the dimension tweaks, assembly modifications, parting line alterations, wall-thickness adjustments and other edits that ensure that everything works in harmony.

These edits can arise from seemingly throwaway project-review comments – such as 'Can we make it 2mm shorter?' or 'Can we add in this extra battery, please, it's only small?' – but can involve countless hours of extra work if product integrity and design intent are to be maintained.

I, for one, love these seemingly 'dull' phases of work. It's incredibly satisfying, despite wanting to tear your hair out at times. By when you've finished, you know that every square millimetre of your product, inside and out, has a harmony and balance about it – regardless of styling – because you have considered every aspect, however tiny and (apparently) worthless.

Designers often use the phrase 'God is in the detail' to refer to the smaller features and refined aspects of an external product form that delight the user and set the product apart from the market competition. The phrase, to my mind, is equally relevant to the inner skeletal structure and unseen detailing that silently and efficiently ensure that your product goes that little bit further, works that little bit harder and lasts that little bit longer.

Russell Beard is the founder of product design consultancy Square Banana. On Twitter, he's @rbsquarebanana. Read more of Russell's thoughts on design challenges at: blog.squarebanana.co.uk

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60 second interview

» Ben Crundwell of Cambridge Design Partnership tells us about his admiration for Amazon, his software weapons of choice and his hopes for wearable technology

Ben Crundwell, Cambridge Design Partnership

Why did you become a designer?
I've always had an entrepreneurial streak and enjoyed puzzles and problem solving when I was younger. Product design allows me to get paid doing what I love, which is fantastic!

Which designer or company do you most admire and why?
It's perhaps a bit of an odd choice, but I really admire Amazon. I remember when the company first started up, when the Internet was in its infancy, and it really paved the way. Amazon's grown and evolved over the years, with the right attitude of putting user needs first and developing a business around that, and nowadays, they even design and build first-rate products like the Fire and Echo alongside their cloud-based services.

What product couldn't you live without?
My Media Centre PC. It automatically records and categorises TV shows, along with our music and film libraries. I've been running it for years and I'd be devastated if I had to go back to watching TV live again.

What design would you have loved to have designed and why?
The Raspberry Pi project is close to my heart, and I would have loved to have been part of it. As a STEM ambassador, it's important to me to encourage and develop a love of design and engineering in the next generation and the Raspberry Pi range has achieved this magnificently.

Play-Doh, Meccano or Lego?
Lego of course! In fact I was bought the Classic Mini and the Batman Tumbler kits for Christmas and they are sat on my desk right now.

What are your weapons of choice?
Altium Designer, SolidWorks, Illustrator and Android Studio are the main tools on my laptop, but every new electronic device needs a new software suite, so you never stop learning new tools.

What is missing from your toolset?
You can never have too many monitors, or too powerful a PC.

Is there anything that would make your design process run smoother?
Presenting concepts to colleagues and clients is always a bit clunky with a projector and a single laptop. Better ways of immersing people in a new design would really help. There have been fantastic developments in holographic displays and VR goggles (for example, Oculus Rift) that are starting to crack this open, but we still have a way to go.

What would you say is the biggest challenge facing designers?
User expectation. Most people have a £600 smartphone in their pocket and expect any user interface they interact with to be as smooth and snappy as their iPhone. The days of physical buttons and simple LED displays are numbered, but products can't afford to cost any more money to build. Many designers have solved this by offloading the UI onto the user's smartphone to give a better experience at zero BOM cost. But many applications don't have the luxury of doing this and it's becoming a struggle to keep up with expectations.

Can you predict any future trends?
Wearables and VR are going to hit their peak this year and it will be really interesting to see how they all converge to create novel solutions and niche products.

If you were hosting a dinner party who would you invite and why?
Mel and Sue from the Great British Bake Off – they'd be a great laugh and hopefully bring along some awesome cakes! And why not bring Richard Ayoade and Stephen Fry along too, to make it an evening to remember? I try not to take anything too seriously.

Ben Crundwell is a consultant electronic engineer. In his work at Cambridge Design Partnership, he recently led the development of the First Response Monitor, a wearable device designed to help medics save the lives of casualties in natural disaster and battlefield situations.

If you want to take part please contact greg@x3dmedia.com

VISUAL DESIGN GUIDE
TECHNICS SL-1200G

With vinyl records having a renaissance, and in celebration of its 50th anniversary, Technics has reworked its legendary SL-1200 turntable for the true audiophile

IMPROVED SOUND QUALITY

In conventional analogue turntables, sound quality was degraded by tiny vibrations of the motor and by rotational speed fluctuations known as 'cogging'. However, by combining expertise acquired as the originator of direct-drive turntable systems with a newly developed coreless direct-drive motor without iron core, Technics has found a way to eliminate 'cogging'

THREE-LAYERED TURNTABLE

The turntable has a three-layered construction, consisting of a rigidly combined heavyweight brass and aluminum die-cast platter, and deadening rubber covering its entire rear surface. This helps eliminate unnecessary resonance, achieving high rigidity and vibration damping

OPTIONS, PRICE & AVAILABILITY

To celebrate the launch of this new Technics SL-1200 development, the Technics 50th anniversary limited edition Grand Class SL-1200GAE will be available from this summer with a limited serial number plate and restricted global availability of 1,200 pieces. The Grand Class SL-1200G will be available in the winter.

technics.com

TRADITIONAL GIMBAL

High initial-motion sensitivity is achieved by employing the traditional Technics gimbal suspension construction with the horizontal rotation axis and the vertical rotation axis intersecting at a single central point, as well as high-precision bearings using a cut-processed housing

HIGH DAMPENING TONEARM

The tonearm employs a lightweight material (aluminum for the SL-1200G and magnesium for the SL-1200GAE), which has been cold-drawn in order to improve the characteristics of the material and increase the dampening effect

FOUR-LAYERED CABINET CONSTRUCTION

A hairline-processed, 10mm-thick top panel of immaculate aluminum has been added to the previous three-layered construction of aluminum die cast, Bulk Moulding Compound (BMC) and heavyweight-class rubber of the SL-1200MK5. This four-layered construction combines high rigidity with a premium finish and feel

BACK TO BASICS: VIRTUAL REALITY HEADSETS... AGAIN

Q We're back on this are we? Did Santa by any chance pop *The Lawnmower Man* in your Christmas stocking?

A Sort of. We've finally found out how much the Oculus Rift is going to cost customers when it launches in a month or so. And the answer is around the $600 mark.

Q $600 for a raft?

A No, you plum. For the Rift. It's a head-tracking immersive virtual reality (VR) headset. Oculus got bought for a gazillion dollars by Zuckerberg and the Facebookers shortly after shipping its first set of development kit devices to its Kickstarter backers.

Q And they've finally launched the consumer product?

A Yup. It looks like it's built around a 2,160 x 1,200 OLED screen (remember, that's split across both eyes), has integrated audio, comes with a head-tracking camera and an Xbox controller.

Q An Xbox controller?

A Yup. Oculus is developing a special-purpose remote control that allows you to interact with content (presumably giving you some form of 'virtual' hands as well), but it's not quite ready to ship.

Q OK. I'm with you. $600 seems a bit steep, no?

A It does, but to be honest, five years ago, you'd have shelled out an order of magnitude more for that, minimum. The point is VR is becoming affordable.

Q So will my design tools work with this?

A At the moment, there are very few systems that allow you to use VR content. Our prediction is that this is will change in the next 12 months. In fact, once someone comes up with a 3D CAD viewer that allows you to load geometry and pop on your headset, we reckon they'll make a killing.

DEVELOP3D LIVE 2016 PREVIEW

» With more exhibitors than ever before and a stellar conference programme, DEVELOP3D LIVE on 31 March 2016 looks set to be our most exciting event yet

These are exciting times for designers. There has never been so much innovation in both software and hardware to help bring high-quality designs rapidly to life. Every year, DEVELOP3D's editorial team travels the world, in order to bring you news of what's cutting edge in product design technology, together with stories of how designers and manufacturers are reaping the benefits of improving their processes. Based on this research, we organise our free, one-day conference and exhibition, DEVELOP3D LIVE, which brings together key industry speakers and new technology demonstrations, together with the best designers we have seen throughout the year. This year, we invite you to join us at DEVELOP3D LIVE on Thursday 31 March at Warwick Arts Centre, based on the Warwick University campus.

CONFERENCE: Now in its fifth year, DEVELOP3D LIVE has become a globally recognised event where VPs and CEOs from the major CAD developers share a single stage to present current and future developments. We'll have thought leaders from Dassault Systèmes / SolidWorks, Autodesk, PTC, Siemens, Onshape and others updating us on what's possible today, as well as sharing insights as to what's coming tomorrow. In one day, attendees get a clear picture of the current state of the art in product development software, as well as the chance to assess each product's progress.

After a combined session in the morning, the conference splits into three streams, covering the following areas: Product Design; Future Fabrication (including 3D printing); and Design & engineering in the Cloud. There will also our main stage keynotes and videos of additional talks available on the exhibition show floor and online.

For those who attended last year and hit the roadworks, the good news is that the Warwick University campus is no longer a building site and, based on exceptional attendance in 2015, we've instigated more regimented onsite parking along with a regular shuttle bus.

SPEAKERS: We've begun to announce this year's speakers online at **develop3dlive.com/speakers** and will add more names over the coming weeks.

From the design tools industry we already have a top-drawer line-up: Gian Paolo Bassi, CEO of Solidworks; Jon Hirschtick, founder of Onshape; Scott Reece, VP of cloud platform at Autodesk; Kevin Schneider, director of product management for Fusion 360 at Autodesk; Dan Staples, VP of mainstream engineering and R&D at Siemens; Brian Thompson, head of PTC's CAD business; Mike Payne, CEO of Kenesto; and Simon Floyd, director of business development and strategy for PLM at Microsoft.

To give an industry perspective, we have industrial designer Duncan Fitzsimons of 7th Design & Invention. Duncan, the inventor of the Morph Wheel – the world's first foldable wheelchair and bicycle wheel – studied at the RCA, was James Dyson Innovation Fellow in 2010, is a fellow of the RSA and was a finalist in the Saatchi & Saatchi World Changing Ideas Awards.

Melding man and machine, we have Sebastian Andraos, VP of human/machine interactions at HAL Robotics in London. The company specialises in robot control, focusing on novel applications of robotics in the creative and construction industries.

With HP developing a long-awaited industrial-scale 3D printer, we're very pleased to welcome Louis Baldez, software strategy programme manager at HP, who will be flying in from Barcelona to give us an overview the 3D print industry and hopefully more details of what the company's got up its sleeve in this area.

Laurence Marks of SSA will be looking at how analysis and simulation can help direct manufacturing strategies.

With cloud an ever-popular topic at our event, David Heiny of SimScale, a web-based simulation platform, will be talking about how the cloud offers new possibilities, while Adam Jull of IMSCAD Global will be discussing how to set up and manage virtualised design environments.

Visit **DEVELOP3DLIVE.com** to get more information and check for updates, or simply register and we'll keep you automatically updated when new speakers are announced.

CLAIM YOUR FREE TICKET
develop3dlive.com/registration

We look forward to welcoming you to DEVELOP3D LIVE at Warwick Arts Centre, CV4 7AL on Thursday 31 March

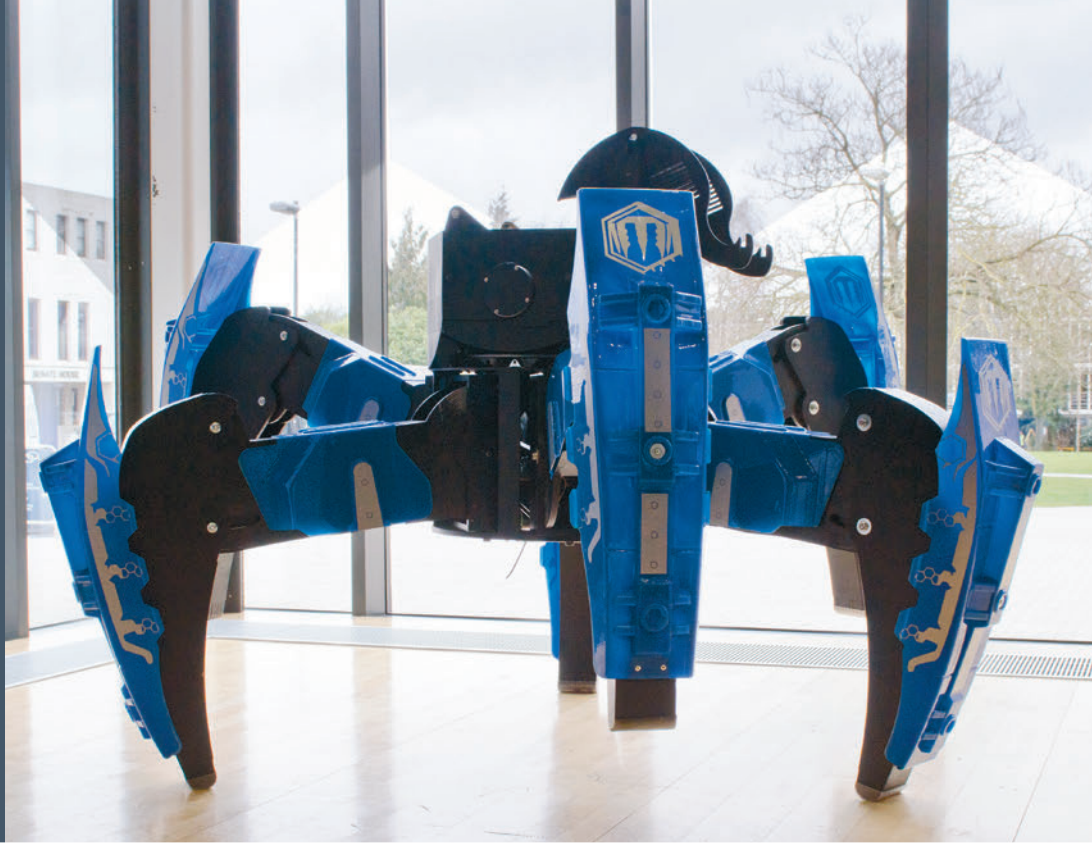
EXHIBITION

Each year, DEVELOP3D LIVE grows and this year is no exception. We have expanded the exhibition floor and have allowed dedicated spaces for more 'hands-on' technology demonstrations in the public spaces. There is also a dedicated demonstration area for start-up firms with bold new product design technologies and services that are making a debut.

We have streamlined our conference breakout tracks to allow attendees a little more breathing space and brought the main stage presentations to dedicated areas around the Arts Centre building.

There will also be a number of major new exhibitors on the show floor and we welcome back our long-term supporters, sponsors and partners.

develop3dlive.com/exhibitors

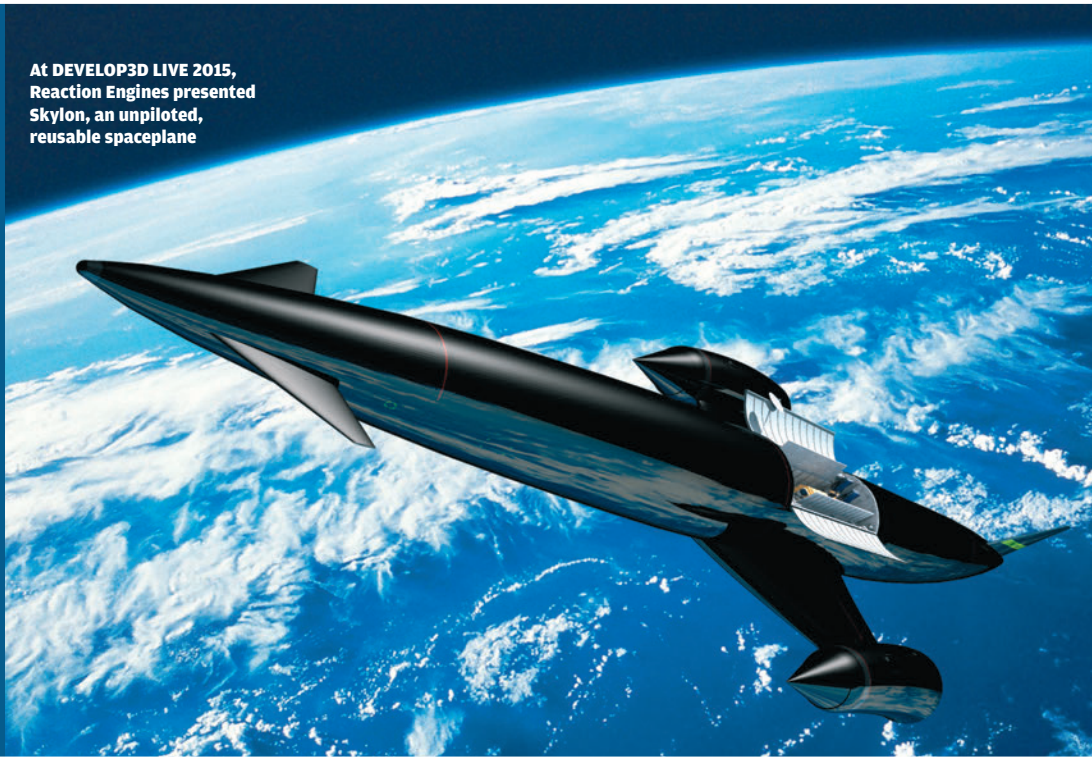


A TASTE OF D3D LIVE

For those of you who have not attended DEVELOP3D LIVE before, you can get a taste of the event by watching many of the previous years' presentations at *develop3dlive.com/videos*.

Here, you will learn everything from how to design an America's Cup yacht to why the UK needs to re-shore manufacturing. We've had designers give their views on the patent system, 3D printing for jewellery, persuading VCs to part with funding, concept sketching, rapid manufacturing and even how 'Game of Thrones' uses special effects. With frequent breaks and plenty of time for meetings and fascinating corridor conversations with your peers, we can confidently promise you a varied and rewarding day out.

develop3dlive.com/videos



At DEVELOP3D LIVE 2015, Reaction Engines presented Skylon, an unpiloted, reusable spaceplane

INDUSTRY TRENDS

Looking over the innovations we have seen in the past year, together with some knowledge of what's coming, DEVELOP3D LIVE 2016 will feature a range of talks and exhibitors covering the following areas:

3D PRINTERS & DESKTOP MACHINING

Now that the hype has died down and few still believe that 3D printing will revolutionise the home-repair of everything, the real revolution is becoming more clear to designers, both small and large, working in both plastic and metal. In fact, there's been an explosion of high-quality desktop-size machining equipment enabling a whole workshop of tools to occupy a couple of benches.

CLOUD

With Onshape, Autodesk Fusion and a whole host of virtualisation technologies, software has been liberated from workstations and now thrives on smart phones, mobile tablets and dumb terminals. Prices and barriers to entry have dropped, although the maturity of traditional desktop applications means that many still offer wider breadth and deeper capabilities.

INDUSTRY 4.0

If you believe the papers, the robots are coming to take all our jobs! The reality is that robots are getting cheaper, smarter and will be vital tools to re-shore engineering, increase productivity and level global competitiveness.

VR AND AR

In 2016, Virtual Reality finally moves out of the science fiction world and into broader adoption. The Oculus Rift is now shipping and many other headsets are about to hit the market. Augmented Reality will also see increased deployment in 2016: Microsoft's Holoviz glasses are on their way and start-up Magic Leap is promising to combine the computer-generated world with our own.

COMPUTER AIDED DESIGN (CAD) 4.0

Old CAD was mere digital notepaper. Future CAD, by contrast, will allow us harness server-level power in order to simulate and test thousands of possible solutions to the most complex engineering problems.

In many cases, final designs will probably be prescribed by analysis iterations. Autodesk, for example, has already demonstrated its Dreamcatcher technology at work on a live Airbus project.

ROBOT MAN

» The path from a child's toy to industrial robots that can operate in some of the world's most dangerous environments is an unusual one. **Al Dean** visits Ross Robotics to hear the story first-hand from founder Philip Norman

Philip Norman tests a naked EXTRM SC 2.0 robot platform outside the company's headquarters at Lowgrounds Farm Yard in Buckinghamshire

“With our approach, we recognise that the customer has the closest knowledge of what’s required and our system is designed to adapt to that requirement”

Philip Norman, Ross Robotics

1 Norman is joined by Ross Robotics team members on the front lawn of company HQ

Philip Norman is a classic British polymath. He's an architect, an artist, a published author and illustrator of children's books (we recommend *The Carrot War,* if you can get hold of a copy). He's also an inventor of robots.

Robots, he says, can be relied on to perform many tasks more reliably and cost-effectively than humans. They don't need food. They don't get bored. They're happy to work 24-hour days and they don't complain about workplace conditions.

They also represent a vast and growing market opportunity: the industrial robotics market alone, worth $26.8 billion in 2012, is forecast to reach $40 billion by 2020, according to recent estimates from Allied Market Research.

Robots, in other words, are big business — and it's a business to which Norman is keen to bring new thinking, new flexibility and what he terms 'modularity', via his Marlow-based company, Ross Robotics.

Curiosity about the design systems found in nature is what originally led Norman to start exploring the notion of 3D modularity almost two decades ago. In the late 1990s, with small children at home, he developed a modular child's toy – but with a background outside of the world of engineering, he'd always tended to use a rather traditional process to capture his ideas.

"I was drawing this with ink and all sorts of instruments, protractors and set squares and the like," he explains. "I showed these drawings to an engineer friend who worked at Aérospatiale building big jets, and he looked like he'd seen a ghost and said 'Haven't you heard of CAD?'"

Norman had previously downloaded 30-day trials but hadn't got on well with the software. But after a party in 2013, Norman's friend gave him an impromptu demo of Solid Edge at midnight and, within 24 hours, he was completely won over. "Suddenly all my ideas came alive in 3D," he recalls.

With a more powerful toolset now in place, Norman explored his idea of a modular toy, refined it and patented it. He very nearly sold it to Hasbro. "It didn't happen in the end," he says. "I didn't get showered in gold and I was left holding my patent, my designs and a big problem burning in the middle of my life, wondering what to do with this thing."

NEW DIRECTIONS

The answer, when it came, was to take the same core idea of modularity and switch the focus, from the high-volume, low-margin world of toys, to the low-volume, high-margin world of robots. Norman spent a year doing research into

BIOMIMICRY IN PRACTICE

One of Ross Robotics' early customers put in a request for a robot that could ascend steel staircases found in industrial facilities. Traditional wheeled robots struggle with this type of task. For inspiration, Norman looked to the natural world.

As he explains: "We took inspiration from the cockroach, which can work in very unstructured environments. Obviously we didn't want to build robotic cockroaches, but we could look at how they solved problems and adapt that to our needs."

The trick, Norman explains "was to develop a set of legs on a revolute axis that could self-correct without any additional, higher-level intelligence, much like the cockroach. The legs we designed are passive/adaptive systems, so that no matter what the terrain is, they tend to do the right thing."

The end result was a wheel with bi-directional flexible flippers, which can climb difficult terrain without the need for additional assistance.

"Once we'd come up with the idea, it developed very quickly. We did a lot of very quick field testing, tried it on different obstacles and tuned it so that the materials and the geometries eventually gave us the desired result."

“We design and build generic robotic building blocks, which can be combined to make robots to perform a wide range of tasks”

markets that he thought might benefit the most and began developing a modular robotics system that could operate in environments that humans might find inaccessible or unacceptably hazardous.

“My goal was to build a system of components that could be assembled and connected, in the dark, on an oil rig, by someone who doesn’t really understand [robots] and have it just work,” he says. At the same time, he adds, the resulting robot needed to be very robust and affordable, “so that anyone that needs it, can buy one and use it.”

Norman looked at the typical connector companies that might take on this type of work and pondered over what he could bring to a design that they couldn’t already access. Quickly, he realised that the same universal connector design that he had developed for his toys could be reconfigured and made suitable for the robotics world. Taking things further, through research into metallisation of plastics, he also realised that these same mechanical connections could become the means by which power and data signals might be passed around the robot.

It’s this combination of both modularity and simple connectivity that has enabled Ross Robotics to develop a range of robots to serve all manner of industries and solve complex tasks. The company has also coined (and trademarked) the term ‘robosynthesis’.

As Norman explains: “Robosynthesis is literally the synthesis of robots. To date, robots have been designed from a blank sheet to perform a specific task, an approach based on a philosophy of product development-and-delivery inherited from the industrial era.”

“Robosynthesis technology is based on a completely different philosophy: instead of designing and building robots to perform a specific task, we design and build generic robotic building blocks, which can be combined to make robots to perform a wide range of tasks.”

These tasks are, in general, specified by the customer, he says. “This approach turns the conventional product-provision model on its head. Conventionally, the manufacturer provides a product that the customer has to adapt to. With our approach, we recognise that the customer has the closest knowledge of what is required and our system is designed to adapt to that requirement.”

“We’ve taken this route because, in our analysis, one of the major impediments to the development of the emerging mobile robotics market worldwide is the challenge of integrating different systems to create the many different and highly specific unmanned systems that are required,” he continues. There’s a need, he says, for unmanned mobile systems to replace human beings in harsh environments such as are found in industries such as offshore oil and gas, mining, disaster relief, nuclear decommissioning and agriculture.

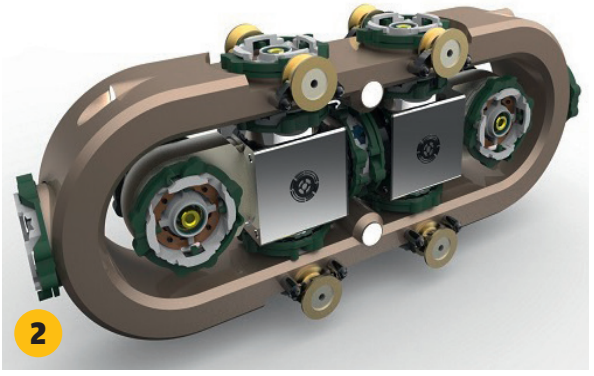
“These needs can only be met if the cost of integration, the long lead times involved and the resultant complexity for the end user are dramatically curtailed.”

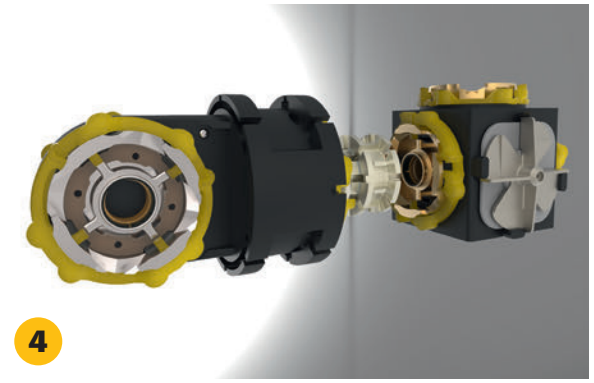
At present, Norman and his team are developing a range of modules for the company’s robotics platform, from a single power source – the Power Cube – that connects directly into every other module. This can process data signals to a range of movement assistance devices, from all-terrain wheels to special purpose paddles for navigating pipes. The modular nature of the design means that the same design can be reused at a variety of different scales.

Norman is particularly proud of the work that Ross Robotics has done on the Power Cube. “We’re working towards making this completely loom-free. Inside the pod are contacts that get demetalised and that creates the circuitry. We’re making our own batteries, because we can give the customer what they want and take a lot of the cost out. We’re just buying in these Panasonic cells and dropping them into the structure,” he says.

“The point is that we can make a battery, monitor every pair of cells for power management and then bring the data up on a demetalised part, so we won’t have any wiring. That makes it cheaper (because there’s less assembly) and more robust as there’s less to rattle free.”

One of Ross Robotics’ earliest customers was the European Organization for Nuclear Research (more commonly known as CERN), which is using one of Norman’s first robots to conduct routine maintenance in an environment that’s highly hazardous to humans.





2 Modular assembly of the Armourdillo robot platform

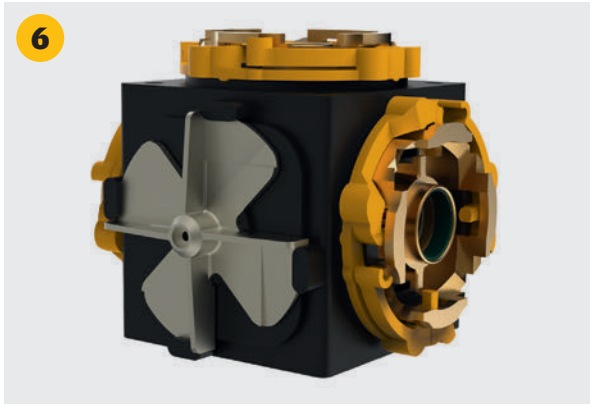
3 The EXTRM SC2.6 robot platform in short wheelbase configuration

4 Assembly of a Motor Module with the PowerCube

The nature of the Ross Robotics' platform and its construction using plastics means that this device can operate in the highly charged electromagnetic atmosphere of the Large Hadron Collider, where more metallic robotic solutions would fail to perform. In fact, says Norman, a protective frame built to protect a Ross Robotics machine is now used as a doorstop in his customer's office, while his invention roams the facility with no problem.

The relationship between Ross Robotics and CERN is ongoing, with the two organisations working to co-develop a range of robotic systems that can continue to operate reliably inside the Large Hadron Collider, even as background radiation levels increase and the magnetic fields required for experiments grow stronger.

"The advantage for CERN in working with us is that our system can be available 100% of the time," says Norman. "Breakdowns (if they occur), upgrades and modifications can all be resolved in minutes by swapping modules. CERN does not have the resources to operate a large and sophisticated robotic fleet unless that fleet can be kept operational with minimum effort and cost. It can also develop very specific robot applications in a fraction of the time and at a fraction of the cost [that would be incurred] were it to go down the conventional engineering route."



FUTURE CHALLENGES

Ross Robotics is also developing a range of ready-to-ship products that customers can build upon, adding their own sensors and other equipment to solve particular tasks. The EXTRM is a fully modular robotic platform that allows for an extremely wide range of robots to be built from the same parts. As needs evolve, the robot can be reconfigured to suit new environments, operations and payloads.

It features four wheels (or other traction methods), a central track that enables it to roll over obstacles that might otherwise ground it and can be fitted with all manner of additional devices, from robot arms, cameras, sensors and other equipment. Interestingly, the whole base platform weighs just over 30kg, can run for 2 hours (expandable up to 4 hours) and has a top speed of 6 kilometres per hour. The iBOID, on the other hand, is an amphibious device that can swim as well as tackle tough terrain and is intended for surveillance and monitoring.

As the business grows, Norman sees challenges ahead. "Modular robotics requires a constant watchfulness to ensure that the modularity remains robust. Modules must be recombinable in anticipated and unanticipated configurations without loss of functionality. Ideally, a modular system should perform at least as well as a designed-for-purpose system," he explains.

"If it can outperform task-specific systems, then that is a plus. To achieve this, the modular architecture has to be consistent at all levels – physical, electronic and software. This means thinking through configuration scenarios and working very closely with electronics and software engineers, clarifying the steps when specifying the product and recognising inconsistencies at as early a stage as possible."

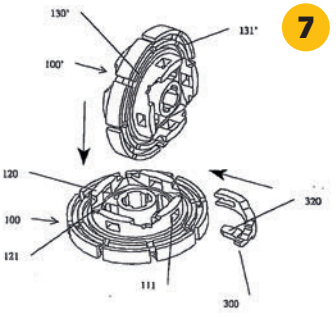
It also means maintaining an awareness of technologies that are available and bringing them into the process, he says. "For a system to be robustly modular, the physical elements must be able to assemble with one another at variant angles in three dimensions and the electronics architecture needs to be distributed, as there is no 'central' element. The software needs to understand the architecture and adapt accordingly."

Despite these hurdles, Norman is enthusiastic about tackling new opportunities as his company spreads both its wings and its customer base. "We're starting to work in adjacent sectors, notably oil and gas and agriculture, where the requirement is to reduce cost by streamlining existing working methods."

In many sectors, he says, using human labour becomes nonsensical once robots are adopted. We're often told that the robots are coming – but Norman jokes that the phrase needs updating. "The modular robots are coming," he says.

robosynthesis.com

"Modular robotics requires a constant watchfulness, to ensure that the modularity remains robust"



5 An amphibious eye: the iBOID can swim as well as tackle tough terrain and might prove useful in surveillance work

6 The Power Cube that lies at the heart of all of Ross Robotics' designs

7 Illustration from Norman's original patent, US 20130102221

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Prion Cutting Edge Customer Ross Robotics have developed the world’s first modular robotics platform using Solid Edge.

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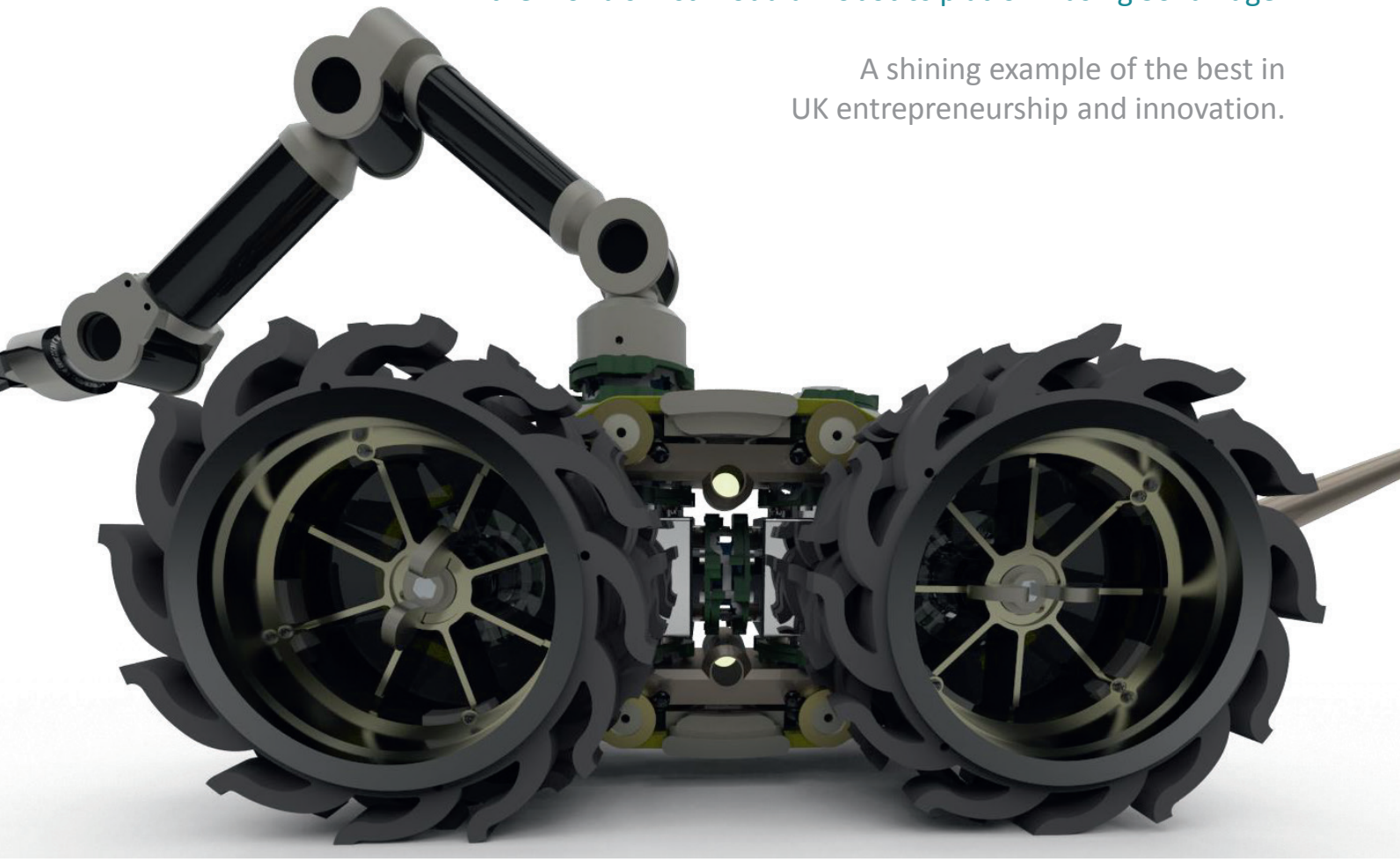

“With Solid Edge, I can visualise my ideas quickly without hindering creativity; progressively adding more detail to my 3D model to explore alternatives.” Philip Norman, Ross Robotics.

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ROBOT REVOLUTION

Martyn Day evaluates the latest projects and technologies that focus on getting robots and 3D printing working in the construction industry

While the general media seems happy to stir up fears of mass unemployment and social instability brought about by the infiltration of robotics into traditional middle-class jobs, the construction industry remains relatively untouched by automation, despite decades-old flagellation over market inefficiencies.

Building Information Modelling (BIM) has been touted as a way to address some of this inefficiency but, looked at a different way, it is also the entry point to robotic fabrication.

In the manufacturing world, we're seeing a move to 3D modelling-enabled Computer Numerical Controlled (CNC) machining and 3D printing, the aim of which is the creation of a 3D model to drive the software and, from there, to drive the machines.

As a model-centric approach becomes more mainstream in the Architectural, Engineering and Construction (AEC) sector, it will inevitably drive the digital fabrication of components or complete buildings. However, today's attitude towards creating BIM models is more about documentation and will need another step-change if it is to address model-driven fabrication.

While much of the current work in this area resides in the research labs of universities, there are companies like Laings, which are actively seeking to deploy rapid fabrication technologies that hitherto have been the preserve of the automotive industry. Laings is doing so with its Design for Manufacture and Assembly (DfMA) approach to modular construction.

A number of other highly publicised projects are also seeking to demonstrate that robots and 3D printing can be utilised effectively on large-scale projects.

MODULAR AND PREFAB

Modular design and prefabrication has long been a popular subset of AEC. It has been proven to work for 'protocabins', McDonald's restaurants, emergency shelters and caravans, which need to be 'manufactured' rapidly and deployed in weeks.

However, despite many attempts, prefabrication has generally failed to get much traction in construction until relatively

recently. There are now a number of firms, such as China's Broad Sustainable Building (BSB) company, which are working out how prefabrication can have benefits without the old drawbacks.

Autodesk's VP of strategic industry relations Phil Bernstein recently examined how technology changes are pushing the AEC industry towards embracing prefabrication. (*lineshapespace.com/future-of-construction*).

Mr Bernstein envisions that buildings will be 'assembled' and then mass customised, enabling sophisticated design changes, even though components are configured within a production line environment.

He provides a number of examples that he says prove that it is in fact possible to utilise digital fabrication and get a unique end result.

For example, BSB built a 57-storey tower, with 800 apartments, in just 19 days (producing an amazing three storeys per day) using prefabricated components.

The B2 Pacific Park building in Brooklyn Navy Yard had a very complex design that used prefabricated components to build 32-storeys, 363 apartments and 930 modules.

Facit Homes (*facit-homes.com*) has developed a unique way to employ digital fabrication within its BIM process for domestic dwellings. Using Autodesk Revit, customers work with the firm to design their individual home.

The Revit model is then used to generate GCode to run a CNC milling machine, which is delivered to the construction site in a shipping container. The building is assembled from insulated wooden box sections, which are cut fresh each day at the individual building site and controlled back at base in London.

Facit Homes managing director Bruce Bell explains why he thinks the traditional view of prefab buildings from factories will not work in the residential sector. "There is a direct correlation between factory fabrication and repetition, because you can't have factories sitting idle due to the overheads. So, as soon as you have a factory, you need turnover, and in order to have turnover, you need standardisation – and you end up producing the same thing over and over again," he says.

"If you build on-site, which [is the case for] the vast majority of buildings, the constraints are completely different and fabricating on demand has benefits such as having no heating, storage costs etc, as running a factory would.

"The economics (of prefab) just don't stand up. It leads to standardisation and people don't want the same, and every site has its own requirements. There is no one size fits all."

NEW HORIZONS

Robotics use in construction remains embryonic, with today's plinth-located manufacturing robots making Doctor Who's Daleks look positively advanced.

However, there are a number of projects that aim to teach robots to weld and lay brick. To do this, it is important to overcome platform immovability, limited arm reach, onsite spatial awareness and real-time clash detection.

Safety is also a major concern as these robots will be more than likely working alongside humans. (see box on page 32 for some of the latest developments).

When it comes to 3D printing technology, there remains considerable hype around potential applications, even though the technology has been around for a while now. This is probably, in many ways, due to its fall in price to address the emerging 'maker' and consumer markets.

Now, the reality is beginning to dawn on AEC professionals that those with engineering knowledge and CAD skills can manufacture with a growing range of desktop machines. While the print technology progresses slowly, there has been a great leap forward in materials that can be used.

I have seen 3D printers that use chocolate, mud with seeds, plastic, cake mix, candy, ceramic, rubber, colours, UV curing liquid and various metals. It was only a matter of time before concrete and clay became available on the 3D print menu.

1 MX3D is planning to build a 15-metre long bridge using robots

2 Foster + Partners is part of a consortium set up by the European Space Agency to explore the possibilities of 3D printing lunar habitations

FIVE TECHNOLOGIES TO KEEP YOUR EYE ON

HAL ROBOTICS

Originating from an academic Master's project, HAL Robotics offers a popular Rhino Grasshopper plug-in to enable control of ABB, KUKA and Universal Robots machines. The software enables fabrication directly from a digital model, supporting hotwire cutting, milling and pick and place, without having to go through additional programming steps.

Founded by a multi-disciplinary team of architects and engineers, HAL Robotics is involved in over 200 research and commercial projects, with both on- and off-site fabrication needs, and which may require collaborative robotic interaction or real-time sensors.

The company is currently working on its next-generation tool, which will be platform- and format-agnostic, so it could be pumped into Revit, ArchiCAD or a Raspberry Pi. As most of the major six-axis robot manufacturers run proprietary operating instructions, HAL is looking to produce a single tool that will be able to talk to them all. Called the Grammar Engine, it can translate into any required robot language for offline programming.

HAL Robotics' VP of human/machine interactions Sebastian Andraos explains: "Construction is the Holy Grail of robotics. It's very much in line with industry 4.0 – it requires autonomyof machines, awareness of their environment, collaboration between man and machine and error-correcting in real time.

"As things stand, construction is an incredibly complex task for the current generation of robots. For the time being, it'll be complex, more expensive projects that will see the benefits [of] using digital fabrication.

"There is huge inertia yet to be overcome for the adoption of digital fabrication. There is a huge amount of education that is required before we start to see these kind of technologies used. If you use the example of BIM in the construction industry when considering inertia, ArchiCAD came out in 1982 as the first BIM tool. Here we are 35 years later and there are people that have still not got on board. And instead of digitally fabricating directly from the model, we are generating 2D drawings to hand downstream where errors can be introduced."

"One of the most interesting aspects about robots is their ability to change tools. So you could have one robot in a room [and] one minute it could be running cables through wall, then plastering, then painting.

"We are already seeing many more experiments with 3D printing in construction. But nobody is really using it to its full extent, as most experiments are limited to extruding with the 3D printer, which is like using a nail gun to hang a picture.

"Meanwhile, firms like Xtree are trying to experiment with forms and shapes. But I don't really see 3D printing as a way to create a whole building. On-site construction will remain modular, with bricks, breeze blocks, and large panels, with prefabrication of certain elements.

"The real advantages will [come] from the logistics of timing the on-site preparation with the production of prefabricated components. We could have half the building ready by the time we have planning permission and turn up on site."

■ **hal-robotics.com**

MX3D

Based in the Netherlands, MX3D is a start-up with ambitions to build a 15-metre long steel bridge using multi-axis robots. The plan is to combine robots, printing in metal, and build above water (something that most robots don't like too much).

The robot arms will be fitted with welding heads and fed with metal rods of material to produce layers of welds. The robots will either sit on the bridge as they weld, or on barges.

The project is estimated to take three months to complete. It has the support of Autodesk, Dutch construction firm Heijman, and ABB, a Swiss industrial robot manufacturer.

■ **mx3d.com/projects/bridge**

HADRIAN

Hadrian is an Australian brick and mortar laying robot, devised by Mark Pivac of Fastbrick Robotics. It can lay 1,000 bricks an hour at an accuracy of 0.5 mm by using site-wide laser scanning.

Hadrian seems to mainly comprise of a special attachment and feed system to a crane with a 28-metre boom, giving it incredible reach. It is estimated that Hadrian could produce a standard size house in two days, although apparently, it's not too hot at doing corners.

■ **fbr.com.au**

SAM

Created by Construction Robotics of New York, SAM (Semi Automated Mason) is a robot that works alongside a human mason, taking the strain and enabling the laying of two to four times more bricks than the mason could typically lay on their own. Again, it does not like corners but excels at long, straight runs.

SAM sits in a self-contained metal box that has a small robot arm and brick/mortar feeder, which all together weighs 3,000lbs and runs on a propane generator. It moves along a scaffold wall and uses laser measurement to dynamically apply mortar and to place bricks.

■ **construction-robotics.com**

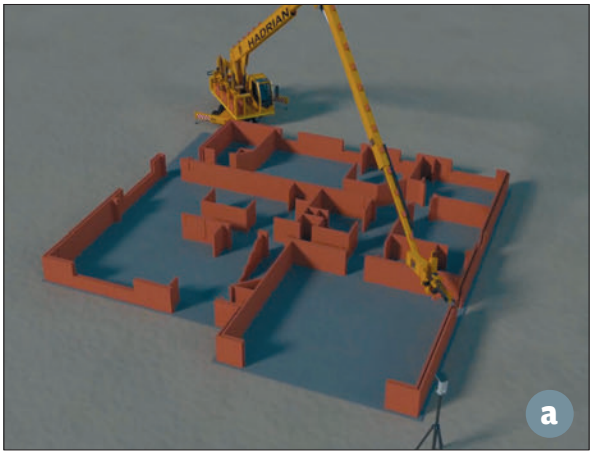
ASMBLD

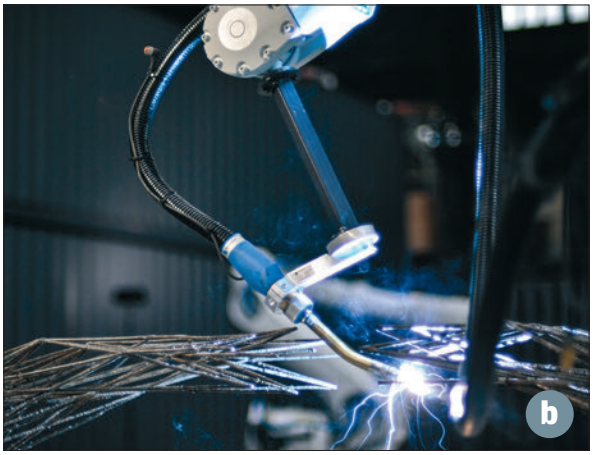
One of the more bizarre projects we've uncovered is Project Dom Indoors from New York-based construction robotics company Asmbld.

The concept here is that rooms are broken down via a raised-access floor into pixel-like grids. A number of small robots move about within the raised floor in order to assemble structures that get lifted, raising the floor level to meet the design.

This essentially means the room can be 'built' and sculpted on the fly, much like the terrain in Minecraft.

■ **asmbld.com/dom-indoors**





a Hadrian is a brick and mortar laying robot that can lay 1,000 bricks an hour

b MX3D uses robot arms fitted with welding heads to produce layers of welds, one on top of the other

c Multi-robot steam bending of timber elements with 6-IR camera-based real-time trajectory compensation

Credit: All Bent Out, Robots in Architecture 2014, Carnegie Mellon University 2014, Joshua Bard, Thibault Schwartz and Richard Tursky

Many 3D-printed buildings currently come out of China, although many do not appear to entirely live up to the 3D-printed label. For example, Zhuoda Group claims to have produced a 1,100 square metre 'neoclassical mansion' featuring multi-storey (five floors) and decoration in just 10 days. However, further investigation reveals that 3D print was used to generate components in a factory, which were delivered on site, not 'cast' in situ from a roving 3D print head.

WinSun has developed its own system – a 3D printer array that stands 6.6 metres high, 10 metres wide and 40 metres long.

The 'print engine' sits in WinSun's factory and fabricates building parts in large pieces. These are shipped and assembled on-site.

WinSun claims the process saves between 30% and 60% of construction waste, can decrease production times by between 50% and 70%, and labour costs by between 50% and 80% percent.

Yingchuang New Materials claims to have 'printed' up to ten buildings in 24 hours. Each 'house' was made for less than £3,000.

So far the Chinese company has spent 20 million yuan (£2 million) and taken 12 years to develop its additive manufacturing device. The only sections not produced by the printer were the roofs.

Chinese companies are also keen to find new materials, such as using recycled concrete from unwanted buildings to produce new 3D printable concrete. However, mixing concrete with fibreglass and different resins could lead to health issues should anyone actually live in these buildings. The materials science of 3D-printed buildings is still some way off.

Amsterdam's Dus Architects (*dusarchitects.com*) has been experimenting with plant oil-based materials to create a 3D-printed house on its open source KamerMaker (room maker) 3D printer. Again, due to build size issues, 3D printing is used to create 2m x 2m x 3.5m high sections of the design, which are stacked up like Lego bricks to create a 3D printed equivalent of a Dutch gabled canal house. The project started in 2014 and is set to last three years.

3D PRINTING CONCERNS

There are many challenges for 3D printing buildings. Physically, there is a need to have a huge frame around which the 3D print head can move, otherwise it will remain as print sections and assemble.

The materials need to be durable and fit for purpose and consistent – you do not want air bubbles or material weakness in supporting loads, for example.

There are also many problems with printing 3D buildings in concrete. The first is that the model has to be constructed in such a way as to get the best fabrication success rate, which will certainly not be the same as producing a BIM model to produce drawings. In addition to the BIM model for architecture and a BIM model for construction, at the moment it would require a model for digital fabrication too.

Concrete curing times have to be taken into consideration. The print head needs to travel as fast as possible and the material deposited needs to solidify and harden within minutes.

Suddenly, architects will find themselves faced with questions that engineers and industrial product designers tackle every day when designing cars, planes and consumer products. When buildings are made of prefabricated components or are 3D printed, they become more like machines, more an assembly that needs to be durable and repairable.

AEC professionals need to consider how to build in structural elements, reinforcement and lighten non-supporting walls.

Should the walls be fabricated in one long continual 'print' or be broken down? Should ducting or spaces for ducting be included in the 3D model and what would that mean for later refurbishment or alterations/repairs?

How will the material consistency change over the time of the 3D print? Will the weather negatively impact cure times? How long is the material guaranteed for?

What's the toxicity of the material? Can one material fulfill all criteria for each part of the design? What are the legal issues?

There are also fundamental problems with devising shapes for manufacture in today's AEC tools, which frankly were never designed with 3D print or direct manufacture in mind. This area should improve over time as cement companies like LafargeHolcim experiment with extrudable and quick-curing materials.

3 6-axis hot wire cutting of a 3.4m Abeille vault (reciprocal structure)
Credit: Nexorade & Reciprocal Structures, workshop at The Bartlett GAD RC5, UCL, 2012, Tutors: Philippe Morel, Thibault Schwartz with Lucia Mondardini, Martina Presepi and Tristan Gobin

FABRICATING BUILDINGS WITH 3D PRINTING

XTREE
Xtree is an impressive consultancy for advanced digital processes in architecture, which also offers fabrication services and technology development in the space. It has been involved in a number of European research projects for 3D printing complex walls, optimising lattice structures for 3D print.
■ **xtreee.eu**

D-SHAPE
Using sand and a binding agent, the D-shape 3D printer creates layered 'sandstone' models. The company claims this is superior to Portland cement and does not require reinforcement. With a build volume of 2,500 metres square, each sandstone layer is between 5mm and 10mm thick. The printer can produce models from foundation level to the roof, including stairs, partition walls, concave and convex surfaces, bas-reliefs, columns, statues, wiring, cabling and piping cavities.
■ **d-shape.com**

WASP
World Advanced Saving Project is an Italian initiative aimed at producing low-cost sustainable housing that doesn't use concrete. The team has developed a number of products including PowerWASP – a 3D printer that mills wood and aluminium and can print ceramic mixtures.

The six-metre tall Big Delta WASP printer can be assembled by three people in an hour and print modular reinforced concrete beams, eliminating the need for moulds. It can also print ceramic mixtures.

The system consists of a large aluminium space frame and print head and the design will be able to use local materials, such as mud and clay, running off solar panels. The company has also really scaled things up with a 39-foot high, 20-foot wide WASP print structure, capable of producing large buildings. All revenue from sales of WASP machines is re-invested in materials research.
■ **wasproject.it/w/en/wasp**

BRANCH TECHNOLOGY
Branch Technology, a start-up based in Chattanooga, Tennessee, has developed a process called C-Fab or Cellular Fabrication. The system uses a Kuka Robotics 12.5-foot robotic arm attached to a 33-foot rail.

At the end of the robot arm, there is a print head that uses a unique mixture of ABS plastic and carbon fibre, which produces 3D-printed matrix support structures, over which traditional materials can be layered. Branch Technology says its printer can cover an area 25-foot wide by 58-foot wide.

For now, the company is focusing on interior spaces, art installations and exhibition structures, but will eventually expand to produce load-bearing and exterior walls.
■ **branch.technology**

SKANSKA
Loughborough University has signed an 18-month development programme with Skanska, Foster + Partners, Buchan Concrete, ABB and Lafarge Tarmac to develop a commercial concrete-printing robot. Now in its second generation of development, the system is fitted to a gantry and features a robotic arm and print head and can already print complex structural components, curved cladding panels and architectural features. Using this technology, Skanska hopes to reduce the time needed to create complex elements of buildings from weeks to hours and is seeking to develop a 3D printing supply chain.
■ **skanska.com**

CONTOUR CRAFTING
University of Southern California's Dr Behrokh Khoshnevis has spent over 15 years developing what he calls 'the contour crafting system', which uses a fast-drying concrete mix.

The system has created walls up to 6 feet high, with layers that are six inches high and four inches thick. It could be mounted onto a gantry frame and potentially do the plumbing, wiring and painting.
■ **contourcrafting.org**

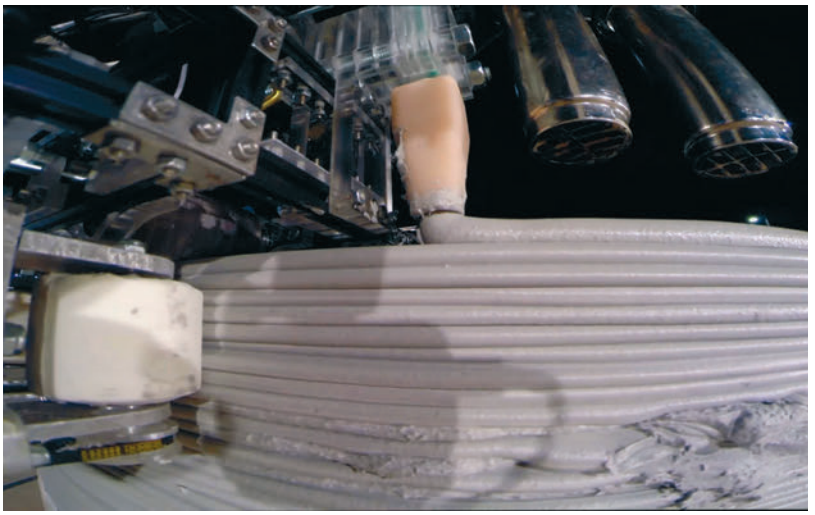
APIS COR
One of the more intriguing 3D print technologies is the Apis Cor printer, a Russian design that consists of a single arm. Weighing in at 2.5 tons, and folding into a compact shape for transport, the printer can be assembled within half an hour.

The arm has a print zone of 192 metres square from a single point of print. The design features a rotating extraction head that allows for the creation of walls that slope both horizontally and vertically and uses as much power as five kettles. If there was a machine designed to convince me that you could print all the walls of a residential building in one go, this would be it.
■ **apis-cor.com**

MINIBUILDERS
The Institute of Advanced Architecture of Catalonia has been developing a community of small robots, which each have their own tasks and which collaborate to create big structures.

The foundation robot is an extruder that creates the first 15cm (20 layers) of a structure through 3D printing, using infrared follow lines on the floor. The second robot clamps onto the foundation layer and is called the Grip Robot. This 3D prints on the foundation and builds up the walls and can tilt to build walls that slope in or out.

A third robot uses suction cups to climb up faces and is called the Vacuum Robot. This robot can print on the surface of the 3D printed walls.
■ **robots.iaac.net**



The Institute of Advanced Architecture of Catalonia uses a community of small robots, which each have their own tasks and which collaborate to create big structures

MUPPETTE
Gensler's research project, the MUPPette (Mobile Unmanned Printing Platform) equips a drone with a 3D print head. The logic behind this is that drone-based printers can print as big as you want, in X, Y and Z axis.

Started in 2014, the project consists of a hexocopter platform and a gimbal with a 3D printer attached. The gimbal is an essential element here to stabilise the print head from the copter base, which may be moving with the wind. The PLA plastic-enabled print head can print in flight.

A swarm of these could turn up and print a structure at a remote location. The reality of getting a precise build from this type of technology would seem next to impossible and the video of the MUPPette in action suggests it is lucky to get more than a couple of blobs of plastic on an A4 sheet of paper. However, I have to admire the ambitious concept.
■ **gensler.com/projects**

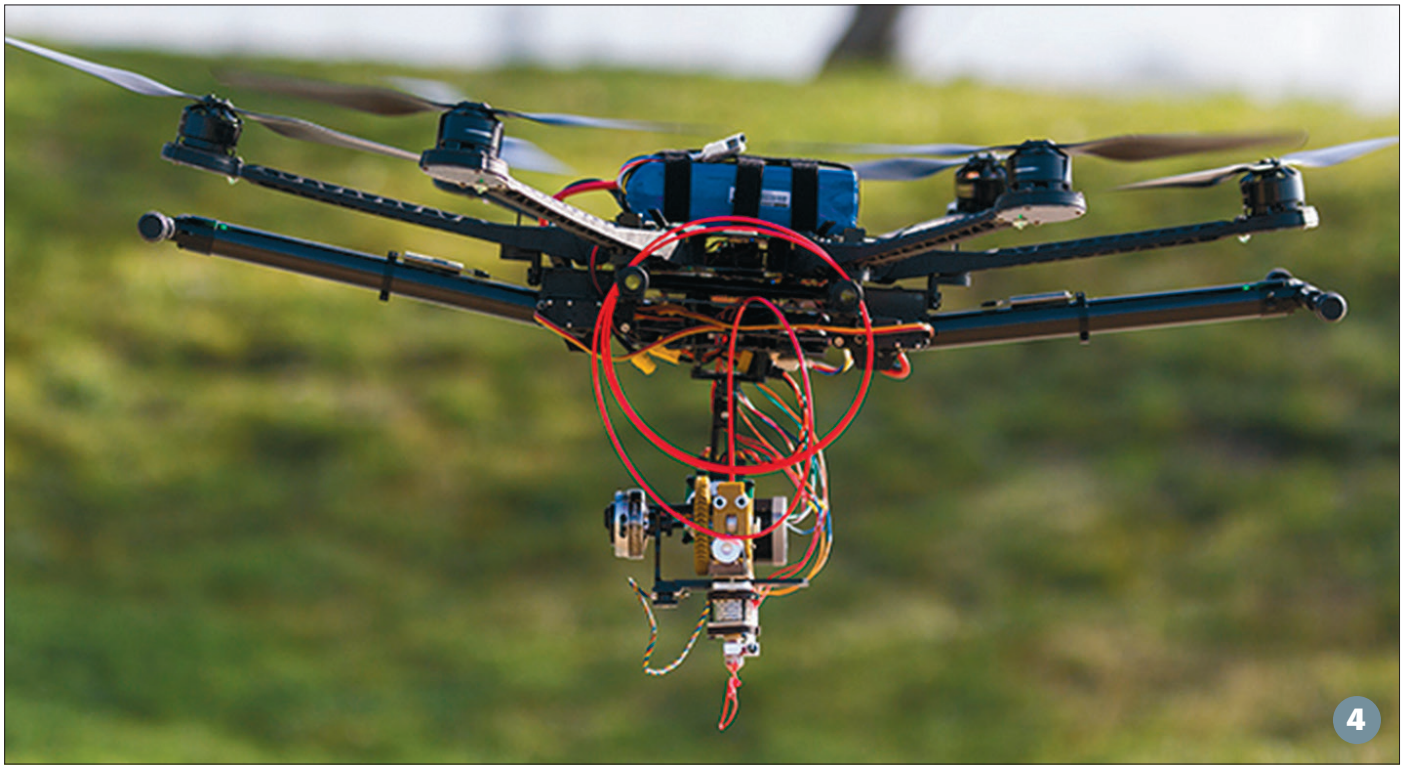
AADRL SWARM PRINTING
Architectural Association School of Architecture's Design Research Laboratory and Robert Stuart-Smith from the Kokkugia experimental architecture research collaborative are working on a project that is certainly 'out there': they envisage using swarms of UAVs to thread fibres to create 'bridges' and spanned woven structures.
■ **kokkugia.com**

SWARMSCRAPERS
Talking of swarms, a research team at the California College of Arts has been developing a series of autonomous robots that harvest on-site materials to fabricate buildings.

For now, the machines just turn sawdust into termite-like structures using glue, but this concept could be of use to NASA when it requires the fabrication of shelters on moons and planets, with no access to a handy builders' yard.
■ **instructables.com**

UC BERKELEY
UC Berkeley researchers, led by Associate Professor of Architecture Ronald Rael, who is world renowned in this field, have devised a new 3D print process for buildings that lays down dry cement powder, an iron-oxide-free Portland cement polymer, which is then sprayed with water to harden.

The system does not need to extrude wet cement or clay-based materials. The advantage of the powder approach seems to be the quality of the finish, the precision of placement and the ability to make lightweight structures.
■ **iced.berkeley.edu/resources/digital-fabrication-lab/**



4 Gensler's research project, the MUPPette (Mobile Unmanned Printing Platform) features a drone with a 3D print head

COMPLEX FORMS

Despite the challenges, signature architects like Zaha Hadid and Foster + Partners find themselves drawn to the possibilities of the technology.

We are seeing an increasing use of non-standard fabrication materials and methodologies to achieve stunning forms that previously could never have been built for an acceptable budget.

As many of these shapes are derived from generative and computational methods, connecting them to automated fabrication machines sounds like a good idea.

Many of Frank Gehry's designs could not be built, because the cost estimates from fabricators had huge 'risk' fees included, since it was not totally clear from the 2D drawings how components could be manufactured.

When Gehry's practice started using the CAD tool Catia to produce detailed 3D models, his contractors and fabricators better understood the design and could reduce costs by using the model to cut the steel and aluminium. Gehry is still proud that he can have a sculpted wall for the same price as a straight one.

Foster + Partners is part of a consortium set up by the European Space Agency to explore the possibilities of 3D printing lunar habitations. As it is prohibitively expensive to ship heavy materials to the moon, Foster + Partners is looking to process and print a lunar soil-based material into an inflated dome. Simulated lunar soil has been used to create a 1.5 ton mock-up using a D-Shape printer.

SOM, together with the Oak Ridge National Laboratory, has been working on research for a 3D-printed structure made of C-sections called AMIE, which generates solar energy and has a symbiotic power-sharing relationship with a 3D-printed electric car.

CONCLUSION

Digital fabrication is undoubtedly coming to the construction industry. With so many active research projects and investments being made in materials and robotic technology, some developments seem sure to stick, eventually.

However, it is going to take a while for the various dots to get connected, as significant changes are required to software, hardware, contracts and mindsets.

The idea of a machine or robots creating a building in a single 3D print still seems like science fiction to me.

At best, it may work in space, for quick military fortifications, or in emergency shelters or homes. But single continuous pour does not seem to make much sense.

I also seriously doubt that 3D printing a flat wall is actually any faster or better than building a traditional block wall, unless you have severe labour shortage. This, to my mind, is a misapplication of the technology.

Much of the 3D printing hype from China seems, on closer inspection, to be about prefabrication and on-site assembly – and most just look like concrete sheds.

There also need to be considerable technological advances in all fields to make this work. As 3D print industry guru Terry Wohlers has said: "When considering the time and cost of constructing an entire building, the skeletal walls are a small part of the project. You also need floors, ceilings, roofs, stairs, and kitchen and bathroom fixtures.

"Consequently, I cannot see how the use of 3D printing technology could save any time or money.

"When you factor in the added cost of a very large, expensive, and not very portable 3D printer, the cost of these walls are likely far more expensive and time-consuming than conventional walls. The use of 3D printing may be good for marketing and attention, but that's all."

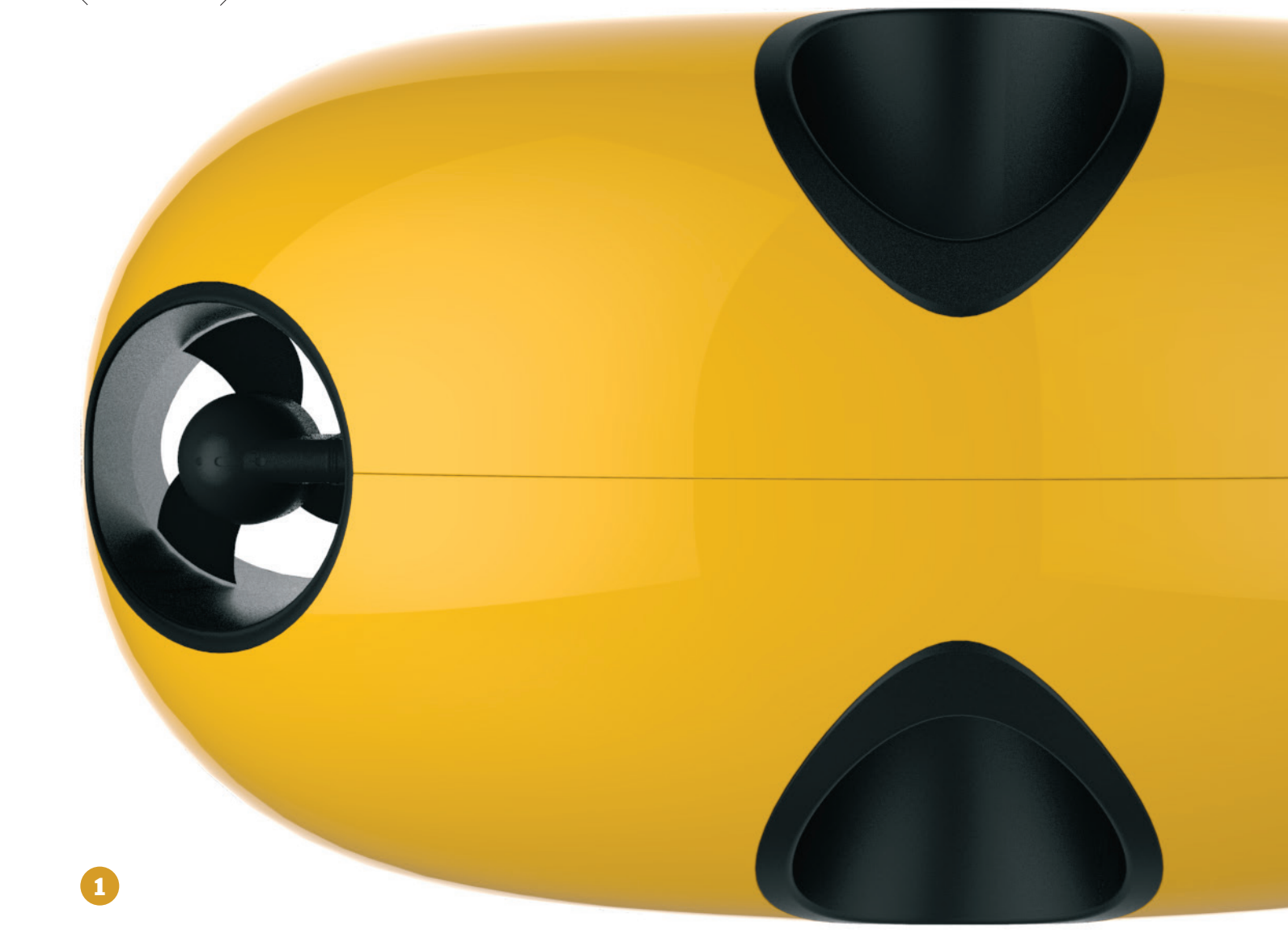
For now, prefabrication and assembly on-site can lead to incredible productivity benefits, if perhaps not to stunning architecture.

Robots work best in environments that are controlled and predictable. They are therefore much more likely to be of use in a factory fabricating components.

To effectively employ these methods, designers will need to understand the limits of the actual construction, materials and fabrication technologies far better than they do today.

Even in engineering, which is typically much more connected to fabrication, engineers still create designs that cannot easily be produced digitally or otherwise.

This article originally appeared in DEVELOP3D's sister publication for the AEC industry. Free subscriptions are available from aecmag.com



1

NODE RED

Looking to showcase its pioneering seismic technology to exhibition attendees, ARL turned to Amalgam to create an eye-catching mock-up for its stand

Wiltshire's Autonomous Robotics Limited (ARL) is developing next-generation seismic technology to gather data from the ocean floor using its Flying Node — a new type of automated underwater vehicle.

The oil and gas industry requires very high quality data, gathered from ocean bottom seismic (OBS) surveys, often operating at extreme depths and traversing often complicated geology.

ARL's planned system for a 'swarm' of Flying Nodes will significantly reduce the cost of collecting seismic data, with the ability to record on the seabed for up to 60 days, covering a wide range of surveys.

Having prepared a paper on the Flying Node to share at the Society for Exploration Geophysicists 2015 conference in New Orleans, ARL wanted to demonstrate a full-size version on its exhibition stand.

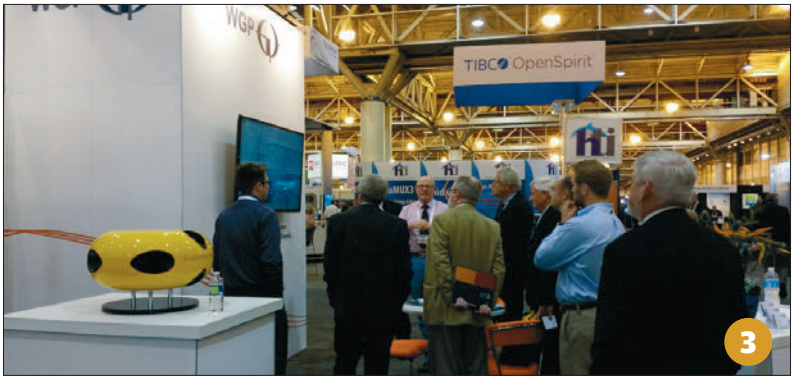
Since the Flying Node is a pioneering development in the off-shore seismic market, ARL needed to find a way of representing it physically on the stand to engage the audience and excite their interest in its potential.

Engineering manager Arran Holloway's search for a model-maker led him to Bristol's Amalgam, a company that has been making exhibition and architectural models for over 30 years. ARL provided an early CAD model and tasked Amalgam with developing it further into a model for display.

The first step was to take the previous 3D CAD model and progress the internal components, which would be fitted

1 The Flying Node is a next-generation seismic technology, designed to gather data from the ocean floor

> **“The exhibition model was a real eye-catcher and drew lots of attention to our stand. Amalgam demonstrated its 3D CAD expertise, whilst providing an exceptional finish and level of detail to the model”**
> **Arran Holloway, engineering manager**



2 The design was cut, in two halves, using Amalgam’s CNC machine

3 Finished exhibition model on ARL’s stand in New Orleans

into the metal casing that holds the electronics. This metal casing forms the pressure vessel, designed to cope with the extreme depths involved in OBS explorations.

Once the final size for the pressure vessel was determined, Amalgam defined the size of the external casing using calculations of mass, centre of buoyancy and volume of the node.

After making changes and adjustments to the CAD, an exhibition model was produced from tooling board. The design was cut, in two halves, using a CNC machine, and then finished and sprayed to achieve the glossy yellow appearance planned for the final body shell.

Realistic mock-ups of the manoeuvring thrusters were also added to the model, once they’d been 3D-printed using Amalgam’s Objet printer. The exhibition model contained no pressure vessel or electronic components, as it was built solely to demonstrate the size and form of the Flying Node at the exhibition.

The end result was a relatively lightweight model, guaranteeing ease of transportation overseas. ARL also produced an animation of the system in operation, using Amalgam’s 3D CAD, to accompany the model and to promote the Flying Node system on its website.

Returning from the exhibition, Arran reflects, “The exhibition model was a real eye-catcher and drew lots of attention to our stand. Amalgam demonstrated its 3D CAD expertise, whilst providing an exceptional finish and level of detail to the model.”

autonomousroboticsltd.com
amalgam-models.co.uk

HAL
robotics ltd
www.hal-robotics.com

All Bent Out, Robots in Architecture 2014, Carnegie Mellon University, 2014, Joshua Bard, Thibault Schwartz and Richard Trusky

INNOVATIVE
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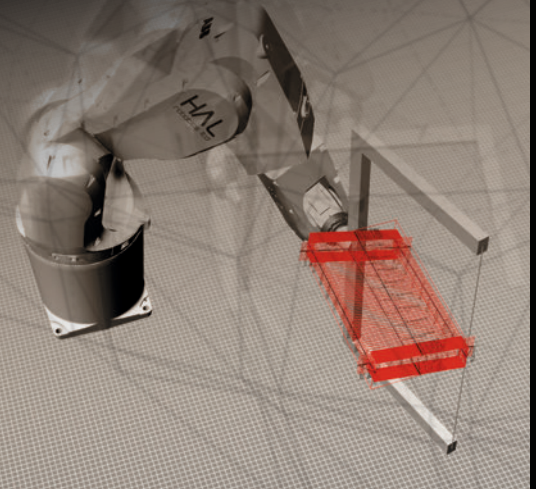
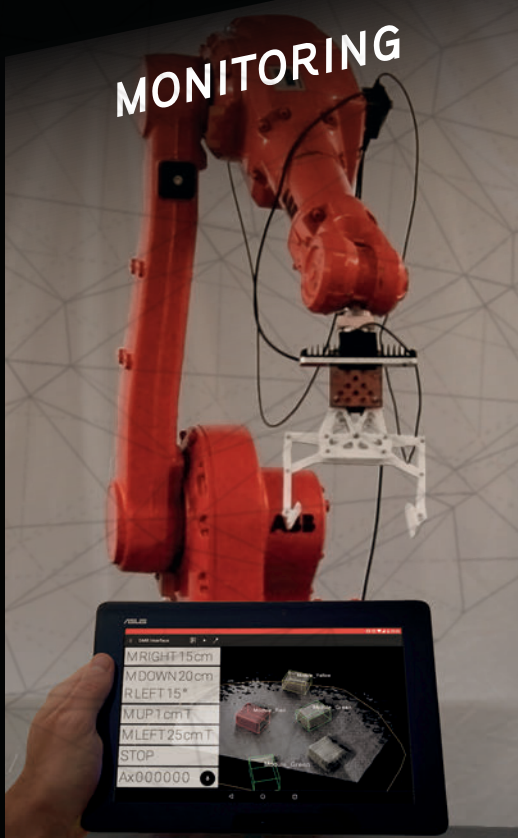
SIMULATION



CONTROL

Clay Robotics, The Bartlett GAD RC5, UCL, 2014, J. Sun, K. Lo, S. Wang, Tutors: Philippe Morel, Thibault Schwartz and Guan Lee

MONITORING



BURNING RING OF FIRE

Whirlpool has reduced the time required to develop a new cooktop by 35% with Ansys' direct modelling and fluid simulation tools, as **Pablo Filgueira Rodeiro**, senior manager in simulation-based design at Whirlpool, explains

The design of gas burners for cooktops is challenging because of the many design parameters involved. How well a burner will perform depends on the geometry of the port where the flame is produced, the injectors that provide gas and air to the ports and the grates that support the ports, as well as the relationship between the ports and the metal surface of the appliance.

Whirlpool Brazil relies heavily on simulation to design gas burners for freestanding ranges, built-in ovens and cooktops. Simulation helps engineers not only to reduce fuel consumption and cooking times, but also their own development times, by predicting the performance of proposed burner designs ahead of the prototype phase.

Whirlpool's engineers use Ansys computational fluid dynamics (CFD) software to evaluate proposed burner designs for flame stability, energy efficiency, surface temperature and carbon monoxide generation. However, they also required a tool that would enable them to prepare models for simulation, so that they could quickly

explore a range of designs and come up with the best burner to meet all criteria.

Whirlpool overcame this challenge by using Ansys SpaceClaim Direct Modeler, which allows easy geometry clean up and generation of closed volumes required for CFD simulation. With the SpaceClaim approach, Whirlpool engineers can directly edit any geometry feature without worrying about parametric constraints, reducing the time required to prepare a concept design for analysis by up to 90%. The ability to much more quickly define and evaluate new design iterations has reduced the overall time required to develop a new cooktop model by 30% to 40%.

STREAMLINING THE DESIGN PROCESS

Whirlpool engineers had been creating burner designs using a parametric CAD system. CAD systems generate the highly detailed models that are vital to meeting rigorous manufacturing requirements – one of the final steps in the design cycle.

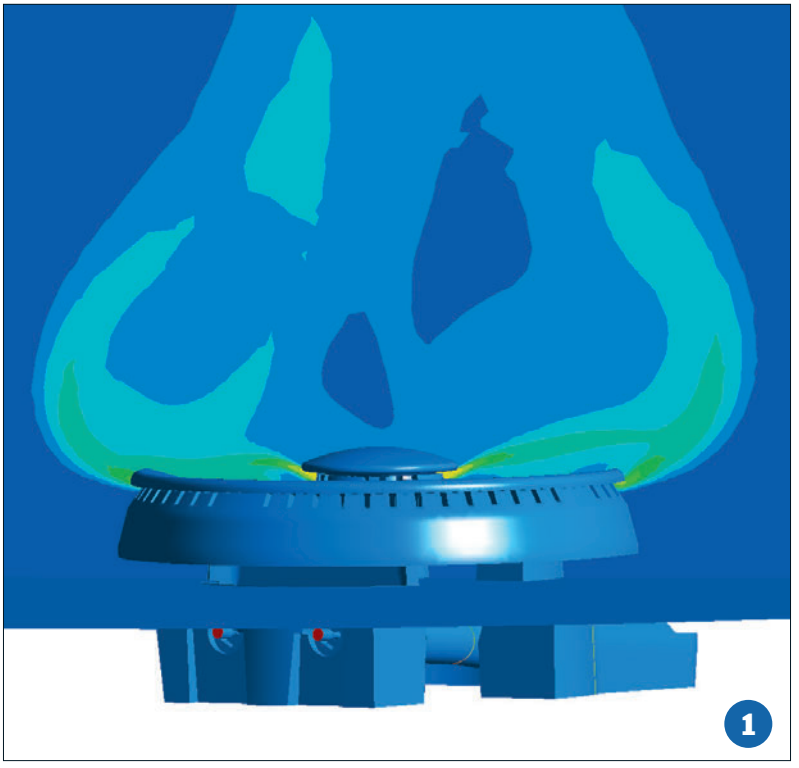
However, early in the design phase, engineers needed a tool that allowed them to make multiple design interactions easily. They could then virtually test these designs using simulation. A single CAD model took a week to prepare, and at least 100 days were required to complete a new burner design.

Integration of Ansys SpaceClaim Direct Modeler within Ansys Workbench enables engineers to make and investigate design modifications in a fraction of the time required in the past. Whirlpool Brazil engineers used these tools recently to design a new cooktop for the consumer market. Engineers first created a baseline design using the company's parametric CAD system. Then they stripped out the parametric constraints by exporting a STEP file into the Ansys Workbench design environment.

SpaceClaim Direct Modeler's advantage is that it uses pattern recognition on an imported model to determine the user's intention when making an edit, so the model can be manipulated as if it were fully parametric. For example, even though a pocket has not been defined as a feature, the user can select it and the software will recognise, in real time, that it is a feature and then allow the user to change its size or move it without breaking it down into its individual entities, such as lines and arcs.

PUT INTO PRACTICE

In the case of the cooktop burners, Whirlpool Brazil engineers began by using a SpaceClaim tool that automatically finds and fixes gaps and overlaps between the surfaces of the model. This tool addressed the majority of the problems with the original model. Engineers then corrected additional areas using other SpaceClaim tools, such as one that cleans up small features and fills holes. Further edits were made simply by selecting faces and edges and pulling or moving them into the right position. The model was ready for meshing and simulation in just four hours.



1 Simulation of new burner design. Simulation was conducted to study air/fuel ratio at different locations inside and outside the gas burner. The image shows natural gas concentration on a cross section of the burner.

2 Iso-volume of percentage of fuel with temperature plot

The mesh had 2.5 million nodes and 10.2 million tetrahedral, hexahedral, wedge and pyramid elements.

Whirlpool engineers ran an Ansys Fluent CFD combustion simulation using the EDC combustion model and SST turbulence model. The simulation took 36 hours to run on a high performance computing (HPC) platform with 20 cores.

Results showed the mass flow of fuel and primary air, carbon monoxide concentration and surface temperatures on the cooktop.

Whirlpool Brazil engineers also wrote a script to calculate burner efficiency. The simulation revealed significant areas for improvement in the initial design.

In total, Whirlpool's engineers generated a total of 16 iterations with SpaceClaim to investigate changes in port and injector geometry. They focused on increasing the primary air entrainment, a measure of how effectively air is taken up by the burner during operation, expressed as a percentage of stoichiometric supply.

Over the course of these design iterations, engineers increased primary air entrainment from 36% to 52%. This delivers a stable flame with nearly complete combustion, high levels of efficiency and low levels of carbon monoxide.

The complete design process took about 65 days, 35% less time than would have been required using previous methods.

This application demonstrates the time- and cost-savings that can be achieved by enabling simulation engineers to quickly and easily prepare design geometry for simulation, as well as how an efficient design can be determined using simulation.

whirlpool.com | ansys.com

1

BREAKING THE MOULD

In a stately setting, **Stephen Holmes** meets up with Ben Redford of Mayku, a start-up that's promising to benefit makers and prototypers at all levels

A plush café, located in a former royal residence, is not the usual setting for a DEVELOP3D interview, but then again, Mayku is not your typical hardware start-up.

The company is based in Somerset House, an iconic central London landmark. The lavish reception floors of this vast Neoclassical building overlooking the Thames give little hint to what lies beneath: an expansive basement level that plays host to a pioneering community of over 60 maker businesses within its hive of corridors, vaults and old storage rooms. These are coordinated by the organisation, Makerversity.

Opened in 2014 with the goal of providing such businesses with affordable space, tools and workshop facilities, it's an oasis for product designers in the heart of one of the world's most expensive cities.

The scheme has continued to expand, and now offers opportunities for collaborations, projects and even seed funding — more of which later.

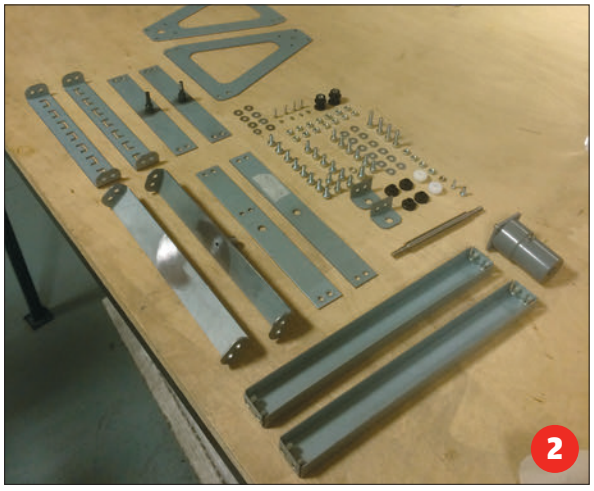
Back above stairs, Mayku co-founder Ben Redford explains how his company found a home in the building. In his former role as a digital designer for a creative agency, he says, he was responsible for building a number of physical products, a process that got him hooked on making.

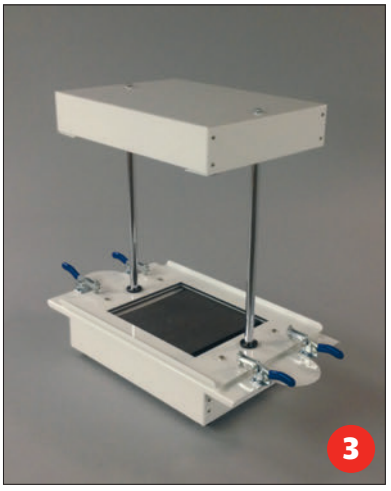
His idea for a miniature projector, which shines Instagram snaps copied to physical film onto surfaces, raised $90,000 on Kickstarter. Its development journey took him on a factory tour of China to find PCB and injection moulding suppliers, but also introduced him to a wide range of industrial manufacturing technologies.

"Finding myself in China, I realised that a lot of the machines that are used out there could potentially be miniaturised – not necessarily as powerfully or as effectively as the ones you get in factories, but to a point where the average consumer could understand the process," he explains.

His idea was that scaled-down versions of rotomoulders (for making single-part canoes and oil barrels) and vacuum

> **"We think it's good to start with a non-digital process, because it's more of an 'entry level drug' for consumers"**





1 With its non-digital fabrication tools, like its FormBox vacuum moulder, Mayku is hoping making will become a more mainstream activity

2 The designs have taken industrial machines and stripped them down into as few components as possible

3 The FormBox vacuum moulder will be released as a completed product, with the final design having a smaller footprint than even this iteration

4 A miniaturised rotomoulding machine, the RotoBox can help churn out parts faster than simply 3D printing them

formers (for creating packaging) could be good entry-level machines for consumers and still adaptable for more experienced makers.

"If you're making ten things, but you want to put them in a blister pack, so they look professional [and] so you can sell them at a craft stall, but not just on a cardboard backing... that's a really hard thing to do. So we thought it'd be a really interesting thing to explore."

LEVELLING UP

On his return from China, Redford quit his day job, ensured the stability of his miniature projector business, and started to build models of the machines he'd seen in Chinese factories.

"I come from a digital background, so my process is similar to making websites: I'll build something shoddy out of glue and sticks to see if it works, and if it works, I'll level it up a bit," he says.

"[With] lot of the early prototypes, I wouldn't even go into 3D CAD until I'd knocked something up on Illustrator, laser cut it, formed it out of those parts, and then [I'd] move into 3D CAD as soon as I knew it would function."

Initial wooden models of a miniature rotomoulder were enough to encourage him to pursue the idea of developing a full family of miniaturised maker machines, and through a colleague at his previous job, Redford met with Makerversity for the first time.

He was provided with a free hot-desking space for the first three months, giving him time to develop his idea. Through Makerversity, the next step was to apply to the Design Council Spark Fund for financial backing.

A successful pitch saw the idea receive seed capital, and Mayku co-founder Alex Smilansky join the team. The start-up then moved into a Makerversity vault space, where the development of their first machines has progressed.

When we meet, the Mayku team is awaiting the arrival from suppliers of iteration five of the FormBox, a desktop vacuum moulder.

The FormBox will be shipped as a completed product, beginning with a Kickstarter campaign. A desktop rotomoulder, christened RotoBox, will be shipped as a beta, with Mayku looking for feedback from designers and modelmakers to aid its development.

"We want to get making stuff more mainstream," explains Redford. "We think it's good to start with a non-digital process, because it's more of an 'entry-level drug' for consumers.

"But these are our first two machines and we have a whole lot of other machines in the works, and there'll be a slow development into digital."

NEW AUDIENCES

The target market is clear: the launch products will be available and easy for anyone to use and can be used in conjunction with digital products like 3D printers and laser cutters.

Instead of 3D printing ten simple-shape parts, which might take 100 hours, a user could print one part in ten hours, vac-form it in minutes and produce casts much cheaper and faster in a wide range of materials.

Machine cost and size will play an important part. As Redford explains, most schools now have vac forming on their curricula, but the cheapest machine costs around £1,600 - a barrier for classrooms tight on budget, not to mention space.

"Leatherwork, pottery, all those crafts have one thing in common: they're really accessible, easy to go and learn how to do. 3D printing has a high barrier to entry: you have to know CAD," he says.

With Mayku's range of machines, the goal is to lower the cost of entry to a such a level that industrial-type making can sit comfortably and naturally alongside pottery or leather-working classes.

"Why not do it with plastics?" offers Redford. "I feel it's looked down upon in a way, but it shouldn't necessarily have to be."

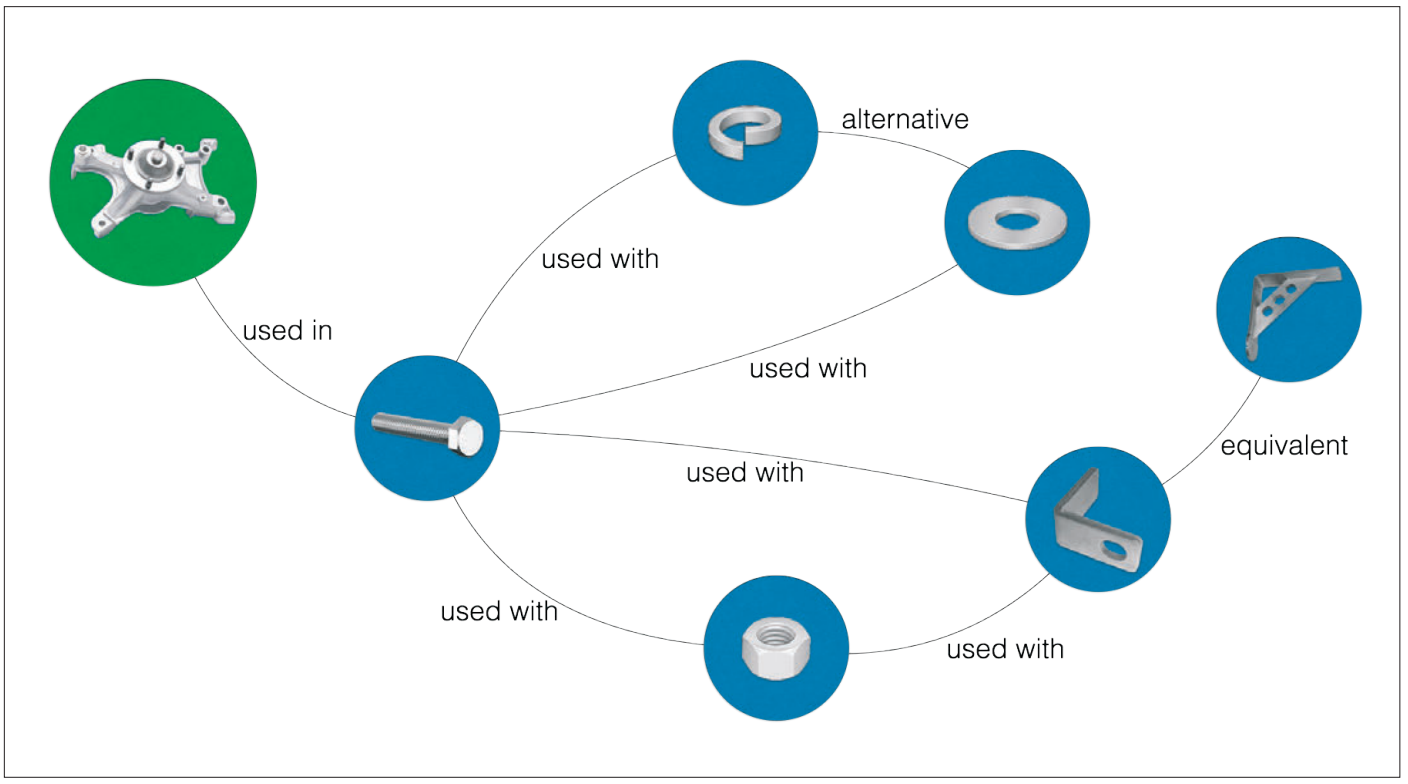
With its own machines, in fact, Mayku stands as testament to what can be developed using modern approaches.

"The barrier to making hardware is now massively reduced," says Redford. "The fact that we've made two products on a very small amount of cash with two people? I don't want to blow myself up here, but that would've been really hard to do 10 or 15 years ago."

He adds: "It's a similar sort of thing to what you get with app design – it's a kid in his bedroom. You can do that a bit more now with products."

As Mayku's desktop machines get sold and begin to produce parts in customers' bedrooms, workshops and classrooms, there's a chance here, finally, that the reputation of manufacturing skills will rise from the basement with them.

mayku.me | makerversity.com



DESIGN & MACHINE LEARNING

Geometry search and part organisation go hand in hand, but haven't become a part of our standard workflow to date. Autodesk is working on a solution to that problem in the form of Design Graph

Any designer who's ever worked at a large firm most likely knows the frustration of looking for a design file for a standard component and coming up empty handed. A gear for a bicycle, for instance, has certainly been designed and used before. The question is: where's the file? You've searched, using all the obvious terms, but it's not there. So what do you do? You design it again.

You're not alone. It turns out this is a common problem. "One customer we talked to had 899 versions of the same part," says Mike Haley, Senior Director of Emerging Products and Technologies at Autodesk. "Not 899 digital copies of the same design – it had actually been designed 899 different times over many years."

Not only is all that duplicated work expensive, it can also create problems in production. What if the new gear design turns out to be off by a millimetre? An error like that can mean weeks of unplanned retooling in the factory if it isn't caught in time.

The root problem? Organising design data is a significant challenge, according to Haley. "After all, design data is inherently graphical. It's not text. And it's hard to search for something that's not text."

So how should you organise it? Haley and his team at Autodesk are working on a solution. Over the past four years, they've used machine learning to create a system that can categorise design data without human assistance and build design taxonomies, so when you need a certain design, you can find it.

The product, called Design Graph, will become available to the public for the first time later this year as part of Autodesk's A360 cloud-based design and collaboration platform.

Haley shared his thoughts on the system with product designers as part of Autodesk University 2015 in Las Vegas, explaining how it has the potential to save time in the design process, decrease redundant work, and reduce costly errors. Eventually, it may even enable computers to do some elementary design tasks for us.

MACHINES THAT LEARN ON THEIR OWN

Machine learning is a branch of computer science that uses algorithms to enable computers to learn independently, identify patterns, and make predictions based on what it learns.

It's used in tasks like spam filtering, optical character recognition (OCR), and automatically recognising faces in your photo album – anywhere you want computers to identify the common traits of objects as well as to discern the subtle variations in them and the contexts in which they appear.

In the case of design data, the goal has been to teach computers to be able to identify and understand designs based on their inherent characteristics – their shape and

Design Graph will be part of Autodesk's A360 cloud-based design and collaboration platform later this year

When you look at Lego bricks, your brain knows almost instantly what they are - the same is true of chairs, but for different reasons

geometry – rather than by any labelling or metadata.

After all, whoever designed the part originally could label it any of dozens of ways, using full words or abbreviations. Metadata created by people, unless carefully managed, is simply unreliable. Instead, the computer uses its own observations about the 3D mesh, which every 3D model has by definition.

SHAPE VS. FEATURES?

Programmers have been trying to create a system like this for more than a decade. But it turns out that it's harder than it looks, according to Haley. Why? Because there are two primary ways that we organise visual data: by feature, and by morphology or shape.

Haley gives the contrasting examples of Lego building blocks and chairs. "When you look at Lego bricks, your brain knows almost instantly what they are, despite the fact that they may be all kinds of shapes and colors," he says.

"You don't care about the variation. Your eyes hone in on the little studs. Those studs are the features that are more important than the shape of the bricks."

A group of different chairs, on the other hand, is the opposite. In that case, they have different features – some have armrests, some don't, some have padding, some don't – "but your brain knows that they're chairs," says Haley. "Your brain picks up on their morphology."

"So you have two completely opposite approaches to shape," he goes on. "This is a very human thing. It's how we relate to those objects and how we use them."

With Design Graph, developers had to figure out the balance of these two approaches – feature-led and morphology-led – using different algorithms that work in tandem, depending on context.

DESIGN GRAPH IN ACTION

The result is a mind-blowingly complex graph, in which each node represents a design or a component within a design, and the lines connecting them represent the relationships between them.

Using the Design Graph, however, is relatively simple. Say that you're designing that bicycle, for example, and you need a certain gear. If you're working in A360, you'll be able to switch to Design Graph and search based on name, shape, category, properties – or a combination of these – to find the right pre-existing gear design from your own firm.

While the system uses the millions of designs stored in the cloud to learn, it only serves up designs that you have privileges to access. Identical designs will appear as a single object, while slight variations will appear as separate designs, and you'll be able to see how frequently each was used.

Once you find what you're looking for, you just drop it into your design – no hunting through the catalogue.

Eventually, Design Graph will go one step further, and begin to suggest parts based on what you're designing. "For example, if it sees that you're designing something with a bolt and a plate, it might suggest a nut and a washer, since those are frequently used together," says Haley.

Haley's hope is that Design Graph will enable designers to focus more on the design problem itself, rather than the mechanics of representing the design.

COMING SOON

Haley expects Design Graph to debut in A360 sometime this year, although the date hasn't yet been set. A360 is Autodesk's cloud-based design and collaboration platform which enables teams to work together on 3D designs from anywhere.

au.autodesk.com

To learn more about Design Graph and see it in action, you can watch Haley's class from Autodesk University 2015 in Las Vegas by visiting tinyurl.com/DesignGraph-AU. To learn more about the A360 platform, you can watch a class by software architect Alex Chien by visiting tinyurl.com/A360-AU

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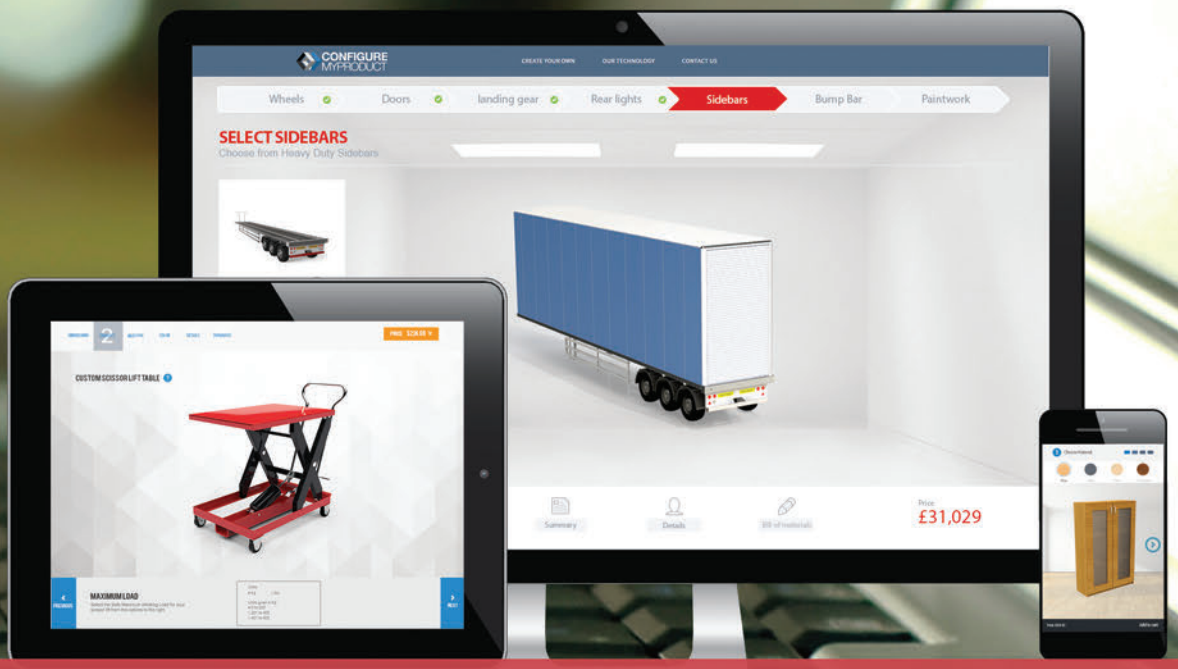

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SIMULATION SUCCESS

Formaplex can promise long-lasting integrity from its mould tools, thanks to the company's use of VISI Flow from Vero Software

With operations spread across 150,000 square feet in three state-of-the-art sites in Hampshire, UK, and a new 120,000 purpose-built site set to come online in 2016, Formaplex can boast an impressively wide range of business activities.

The company designs and manufactures aluminium and steel injection mould tools for the automotive, motorsports and aerospace industries. It produces low-volume finished moulded components, from brackets and fixings to bumper assemblies and instrument panels. And it also supplies composite tooling and components and carries out specialist machining and finishing projects, component painting, flocking and assembly.

All that calls for a wide armoury of tools. The company has over 40 CNC machines, both 3- and 5-axis, offering a range of machining envelopes up to 8m x 6.2m x 2m, to suit a wide variety of design projects. Its capabilities are further supported by 11 injection mould presses, from 55 tonnes to 3,500 tonnes.

Formaplex technical director Adrian Chapman says the company's strengths lie in being able to provi full design support and advice for tools, covering areas as diverse as plastic flow analysis, logistics project management, production, measurement, tool testing, design and manufacture.

In order to ensure the long-lasting integrity of the company's mould tools, Formplex relies on VISI Flow from Vero Software. The injection simulation capabilities provided by the package, says Chapman, help the company to achieve cost-effective and reliable designs and optimum moulding conditions, such as well-balanced runners with symmetrical filling patterns, for example.

"Aluminium moulds, in particular, can be damaged if filled from the wrong position, in the wrong sequence or by excessive pressure with inadequate clamp tonnage," he explains. "It's all too easy to blow the mould and damage the parting faces. But VISI Flow shows us all potential manufacturing issues such as welding lines, air traps and the best gate location, before the mould is trialled."

1 Specialist engineering manager Grant Keates (left) discusses a finer point of an automotive fixture with technical director Adrian Chapman

"We can quickly analyse where the pressure will be too high, whether the material will freeze too quickly, if we need to have more than one gate and whether they're in the right place," he continues. "Once we've analysed and understood exactly what we need to do, we can advise the customer on necessary changes such as part-thickness modification, changing the material or re-engineering."

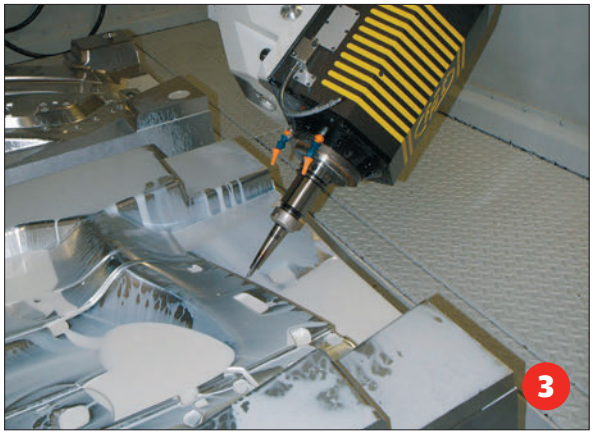
Initial studies of moulded features and draft check analysis tell Chapman all he needs to know to complete his initial Design for Manufacturability (DFM) work. He then carries out initial fill studies, where VISI provides the same level of control over injecting molten polymer into the mould cavity as is available on the moulding machine itself.

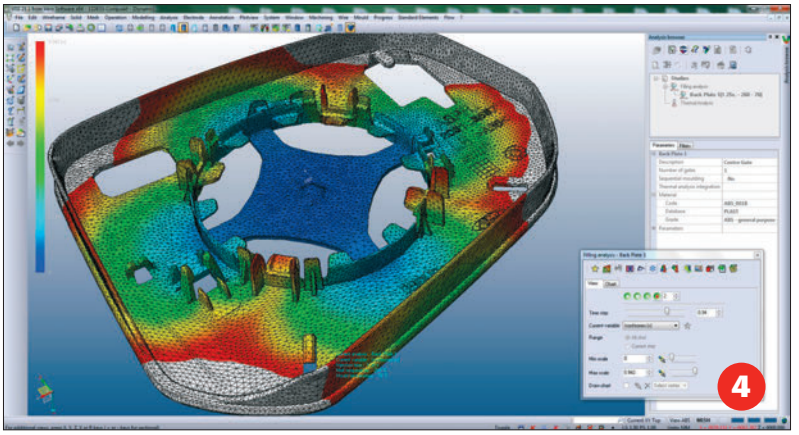
> **"With VISI, we can simulate the mould kinematics and correct any issues before we start cutting expensive metal. It gives a very clear indication of all areas where problems could arise."**

The simulation then provides the ability to forecast and visualise how a component will be filled by the plastic melt front, making it possible to identify any potential aesthetic issues. VISI Flow provides a number of analytical tools that allow the investigation of moulding variables such as pressure, temperature, shear stress, frozen skin, fibre orientation, clamping force and others.

"With VISI, I can quickly analyse the customer CAD data to verify moulding feasibility by checking for draft conditions and undercut features; then VISI Flow shows the capability of successfully moulding the required plastic part," he says.

"We use the part splitting tools to create parting faces,





2 VISI helps Formaplex create bespoke fixtures for their inspection process, ensuring absolute accuracy and repeatable tolerances

3 Working on a mould tool with a Dinox drill

4 VISI Flow analyses filling patterns and maximises process parameters

enabling us to quickly design the main core and cavity block. Once we have those finalised, we model the sliders, lifters and any other small components – whether they're automatic or manual – and incorporate them into the mould tool.

With VISI, Chapman and his team can simulate the mould kinematics and correct any issues before they start cutting expensive metal.

"It gives a very clear indication of all areas where problems could arise. We can give our customers full and accurate information regarding the development of their mould tools. Without it, our dynamic approach and customer service would definitely be hindered."

Once the mould tool is complete, it undergoes a maturation procedure – a series of process trials that monitor and review the continuous improvement of the product until the component is ultimately accepted.

A crucial part of the Formaplex business is its Specialist Engineering division, which supports the Metrology Department. Here, moulded components are accurately inspected and measured with the latest CMM technology. Formaplex designs and manufactures bespoke fixtures for the inspection process, under the guidance of specialist engineering manager Grant Keates.

VISI plays a key role in this process, too, according to Keates, by ensuring absolute accuracy and repeatable tolerances. He says his team designs the fixture by importing the native CAD model into VISI and creating the fixture around the critical points of the component.

"The CAD data can come from our customers in a range of formats, but VISI handles it all seamlessly, which is a great advantage for our speed and efficiency of design."

The next step is to send the finished CAD data of the fixture to the shop floor, where VISI Machining's dedicated high-speed milling techniques and built-in smoothing algorithms create intelligent 3- and 5-axis toolpaths for the company's Doosan and Kondia CNC machines.

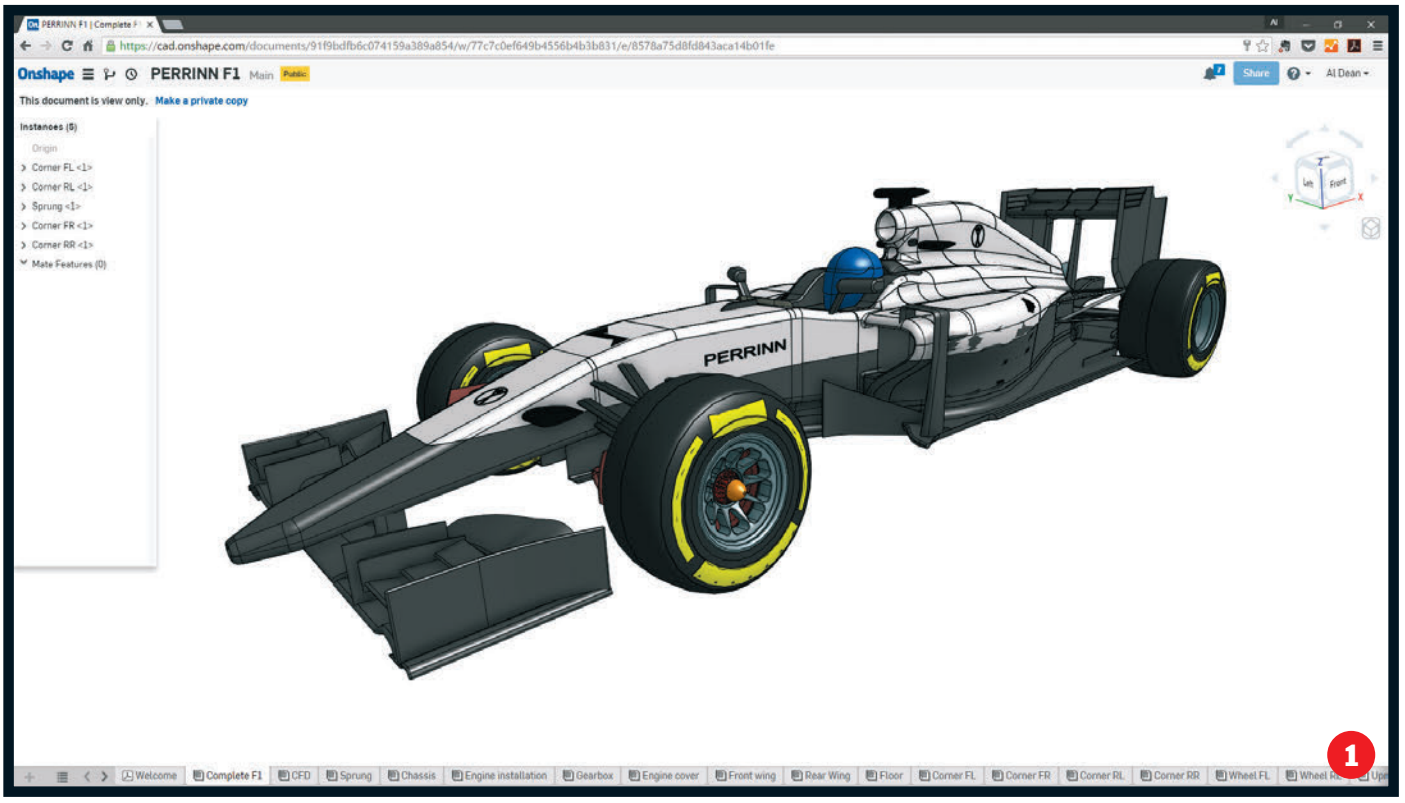
"We don't have any real challenges or issues with designing and manufacturing our jigs and fixtures, because VISI helps us achieve everything we need to."

The Specialist Engineering division at Formaplex is keen to embrace new technology and is investing heavily year on year. It is now able to offer sheet metal fabrication, too, encompassing a wide range of steels, as well as more exotic metals such as titanium.

Summing up the company's overall experience of using VISI, Adrian Chapman says: "It provides us with key information at the design stage and it supports the complete mould process, which ultimately ensures total end product satisfaction."

"A conservative estimate is that, within the first month of using VISI Flow to analyse the correct filling pattern and maximise our process parameters, we saved the cost of the software by avoiding downtime, repairs, wasted toolmaking and setting time and reduced material costs."

formaplex.com | visi-software.com



Onshape Q1 2016

In the first of our planned quarterly catch-ups with Onshape, **Al Dean** takes a good look at what's been happening with the cloud-based design system, now that it's out of beta and available for commercial use

The announcement and subsequent launch of Onshape has possibly been one of the most exciting things to happen in the 3D design and engineering software market in recent years. It's not often, after all, that we see an entirely new company enter this sector.

As we've discussed before, the team behind Onshape honed its skills for many years at SolidWorks (and at other companies), and the company's progress to date has been a rollercoaster to watch. Along the way, it's bagged huge funding ($100 million to date), plus a substantial community of users. During its beta programme, the company reckons that over 10,000 users signed up to Onshape and, between them, spent almost half a million hours logged on to the system.

The company has also launched the pricing for its system (a pretty straightforward $100 per month) and tied down the details of its free plan – ten private models, 100MB of storage for those models, and unlimited numbers of public models, as long as you stay under the 5GB limit.

More recently, it launched the beta of its App Store, which sees partners bring on stream a wide variety of applications and services designed to work alongside Onshape, from simulation and rendering, to fabrication and machining.

» **Product: Onshape**
» **Supplier: Onshape**
Price: Free to $100 per month
onshape.com

1 Perrinn Limited is using Onshape's collaboration tools to build a global team of racing engineers
See case study on page 52 for more details

We'll be taking a look at the growing range of Onshape partner apps next issue, but this month we'll focus on what's new and improved in the core service offering.

CORE MODELLING UPDATES

If you've been tracking its development, you'll be aware that Onshape is centred on a set of tools that allows you to create geometry using a familiar palette of both solid and surface modelling tools. By that, I mean that the tools are pretty consistent with almost every other solid modelling system out there, from revolves and extrudes to sweeps and lofts, fillets and chamfer.

Onshape uses a history list to track your feature-creation and editing operations and, due to its cloud-based nature, keeps a complete list of all changes. Not many systems can boast entirely unlimited undo/redo like this.

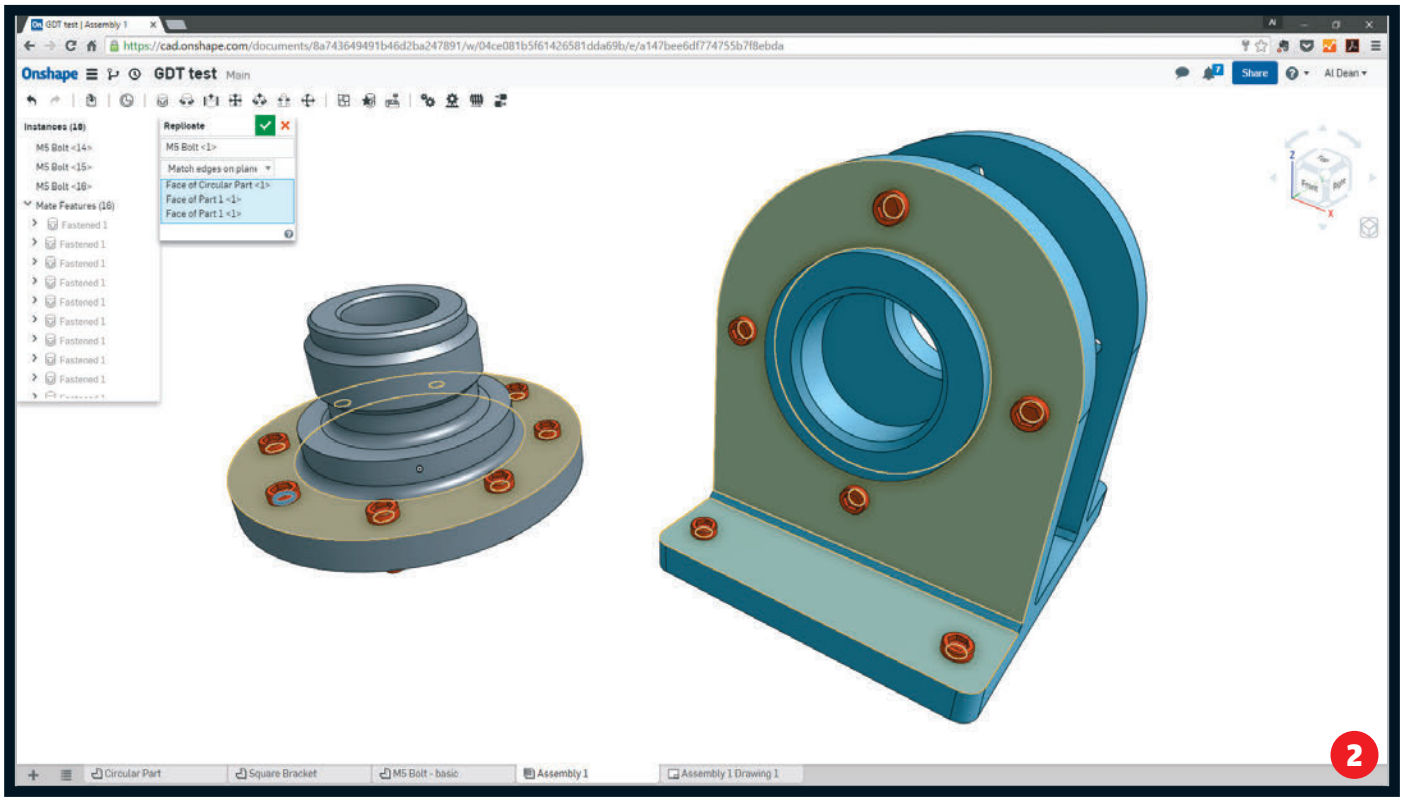
In the last few releases, this core set of tools has been enhanced to include, for example, more powerful termination results in an extrude and greater control over how lofts are constructed. With every update cycle (a cycle typically runs for three weeks), users are finding that most operations have grown in their capability.

The assembly modelling tools are growing at a similar clip, being fleshed out quickly and pretty consistently.

The end result is a system that allows you to build complex parts and assemblies in the manner in which you'd expect – but we're also starting to see signs of fresh thinking, too. An excellent example is the recently introduced Replicate operation. This, in short, enables you to grab a part and its mating conditions in an assembly studio and then copy it into another set of geometry. Assuming that the mating conditions match (for example, holes are the same diameter), then the part will replicate.

DRAWINGS

When we last looked at Onshape in the September 2015 issue of DEVELOP3D, the Onshape team had just announced drawing



2 Alongside fleshing out pretty standard modelling tools, Onshape is gaining some new innovative functions, such as Replicate

support, by partnering with a company called Graebert.

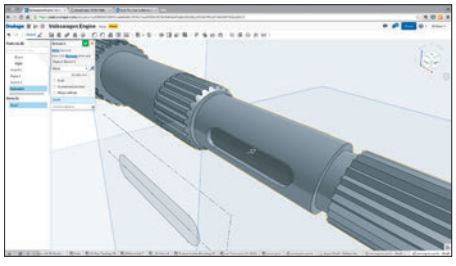
If you've not come across Graebert before, it's a company best known for developing AutoCAD clones – of which there are admittedly many. Still not ringing a bell? If you're a SolidWorks user, or have downloaded and used Dassault's DraftSight application, then you're already using Graebert's products.

Alongside its desktop-based applications, the company has migrated other products to the cloud, which is what allows Onshape to take advantage of its drawing capabilities. The toolset, four months after launch, is pretty solid and the workflow follows a familiar pattern: you take your part and create a drawing that links to that geometry. Onshape is supplied with a range of templates (conforming mostly to ANSi and ISO standards), but you can also develop (or import) your own. You then lay out the drawing views, which are extracted from the model.

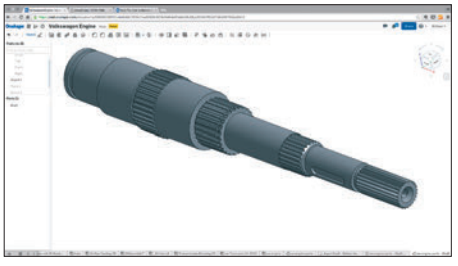
The first one you define sets up the whole system in terms of scale, but you can then add in additional projected views, sections and details (that said, it's worth noting that you can't currently add details of sections, as you'll see in our workflow below).

You then add those all imported dimensions, tolerances and other annotations to your model. There's a good set of GD&T tools already in place, with datums and feature-control frames added just before the New Year. That said, both parts lists and balloons currently need to be created manually. A quick check of the Onshape forums shows that this is in

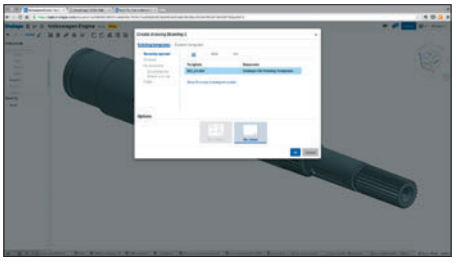
WORKFLOW: CREATING DRAWINGS IN ONSHAPE



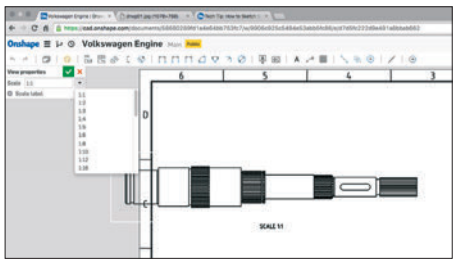
1 Work through the normal process of modelling up your part, perhaps using the new slot sketch operation



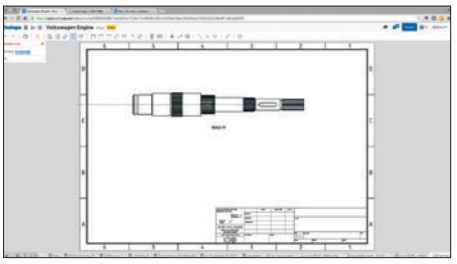
2 Once the part is ready, look for the part (or assembly) tab, right click and hit the 'Create Drawing From' command



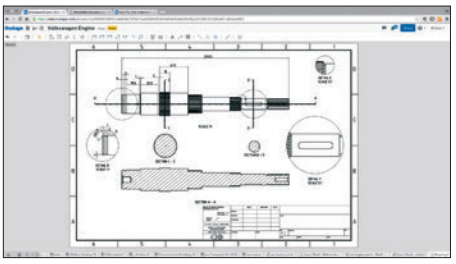
3 Onshape is supplied with a small but tidy range of pre-defined templates or you can use your own



4 Start to lay out the drawing views and –set the scale options to fit the views most appropriately on the sheet



5 You can then add in additional projected views, sections and details, before introducing GD&T tools into the mix



6 Onshape includes a range of annotation and dimensioning tools, but no BOM-related functions as yet

development at the moment.

While the goal of Onshape is to keep things digital (remember, drawings, like 3D models, can be shared and collaborated on very easily using the cloud), you're probably going to want to print them off at some point. Onshape doesn't support print directly; instead, it gives you the option to export drawings as a PDF, or via DWG or DXF, depending on your preferred method.

COLLABORATION & MANAGEMENT

Alongside the core modelling and draughting tools, data management and collaboration tools are also worth a look. Due to its browser and cloud-based nature, Onshape has some interesting and inherent capabilities for data management.

As we've discussed before, it features version management, combined with branching and merging tools that allow you to track the development of a part and assembly pretty closely. During the early stages of design, when parts can take different paths, the branching and merging tools are ideal for keeping versions centralised and manageable.

But it is in the latter stages when the versioning really comes into its own. While Onshape allows you to define the current state of parts (for example, 'in progress') it doesn't, as yet, have any revision control in place – but I wouldn't mind betting that's coming soon. Work is also underway to enable greater workflow control between different users working on the same documents. Starting with the ability to pass on control of a set of data to another user, this is an indicator that change management is going to get attention.

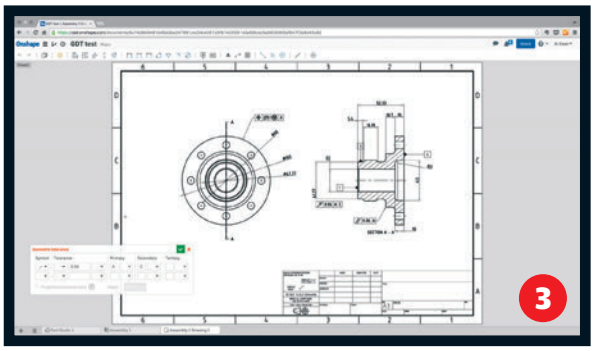
IN CONCLUSION

Now that it's out of beta, it's a fair bet that the team behind Onshape considers its system ready for real production work. Whether they're right or wrong really depends on the work that you, the user, needs to get done. The modelling tools are advancing nicely, with all of the options and variables you typically need to get started.

It's the small, incremental additions, however, that will give you a better set of tools and make Onshape comparable to the tools you've been using for decades. A great example is the Replicate function: this addition shows that the Onshape team is genuinely looking for new ways to improve workflows and tasks, rather than just flesh out a set of CAD capabilities that already exists elsewhere.

The drawing tools, too, are shaping up nicely, but unless you're working on single-piece parts and looking to define manufacturing data for them, the lack of automatic Bills of Materials (BOMs) generation and intelligent ballooning could well be a drawback – for now.

BOMs, after all, are the lifeblood of many engineering projects and Onshape has the potential to do some very interesting things here. A BOM doesn't just have to be a tabular form inside a drawing sheet. Instead, by taking BOMs to the cloud, you've got the opportunity to interlink them, making them shareable and referenceable in a way that transcends a technical drawing. That might mean sharing purely tabular data with colleagues in procurement, or linking BOM data to ERP or MRP systems. There's a lot of potential here.



3 Drawings within Onshape are starting to mature nicely, but there are still some key capabilities missing (such as intelligent BOMs and ballooning)

To sum up, Onshape is getting there. For users of the more traditional 3D modelling packages that have been around for years, its toolset is still emerging and maturing. But to dwell on that fact is to miss an important point: Onshape really isn't about providing yet another set of 3D modelling and drawing tools. It's about finding new ways to work that better match the needs of today's designers and engineers. As such, the real innovation is going on in the background, as the Onshape team works to build a platform that can handle multiple users, working on the same data in a free-form, yet controlled, way.

The opening up of the App Store, meanwhile, also demonstrates that the company is serious about helping users achieve their goals in areas such as rendering, simulation and fabrication.

ONSHAPE IN USE: PERRINN TAKES ON THE RACING GIANTS

Racing drivers certainly get an adrenaline rush from their activities – but for their many millions of fans worldwide, watching a race remains a relatively passive experience. They may catch a blur of their favourite car or a gust of exhaust fumes, but they have little influence over which car crosses the finishing line first.

That could change if engineer Nicolas Perrin gets his way. Perrin, the founder of Perrinn Limited (the extra 'n' was added to make the brand stand out, apparently), is attempting to turn the racecar design world upside down, even in an industry where every gear change is a closely guarded secret.

What he plans to do is make his designs available to his opponents and the wider public alike, in a move that might, on the face of things, look like a regrettable sacrifice of competitive edge, but which he believes could help him source new design talent.

"Sports [are] very powerful for bringing people together, so we can go a step further and effectively make this team, our design team, something a bit more special," he explains.

"Building a car is a team experience. The Internet provides services to connect with friends, or search, or do things like that, but we want to use it to create a better team of designers, working from any location in the world, while allowing the public to access our design to learn or simply to follow our progress."

"If you're a football fan, you can follow the game easier if you've ever played it yourself," he continues. "You can just take the ball and go do it. The difference with motorsports is that technology is a big barrier for people to truly feel like they can get involved and actually play themselves."

Perrinn Limited currently has a core design team of five professionals split between England and France. To facilitate internal collaboration and with outside partners and the public, the company chose Onshape, which enables multiple authorised people to simultaneously work on the same design from any location, over the Internet.

"The advantage of open access is that many people can check what you're doing in real time, learn from it and potentially even work on the project as an expert," notes Perrin, whose goal is to develop cars for the international Formula 1 and Le Mans 24 Hours races.

Using Onshape allows Perrinn Limited to instantly share its car designs with fans around the world without the need for them to purchase expensive CAD licenses, to download or install any software.

Non-CAD users can follow the progress of the design without any knowledge of engineering, while designers can access the model anytime in the cloud, using any computer or mobile device.

Perrinn's slogan is "We Are a Team" and its founder hopes to recruit that team from a far wider pool of candidates in future. "We're trying to start a movement to bring everyone a bit closer together," he says.

The company's LMP1 design, for Le Mans, is now ready for production. The Formula 1 car, meanwhile, is still in the early design stages and could take between two and three years to fully develop, but its design is already fully accessible as an Onshape Public Document.

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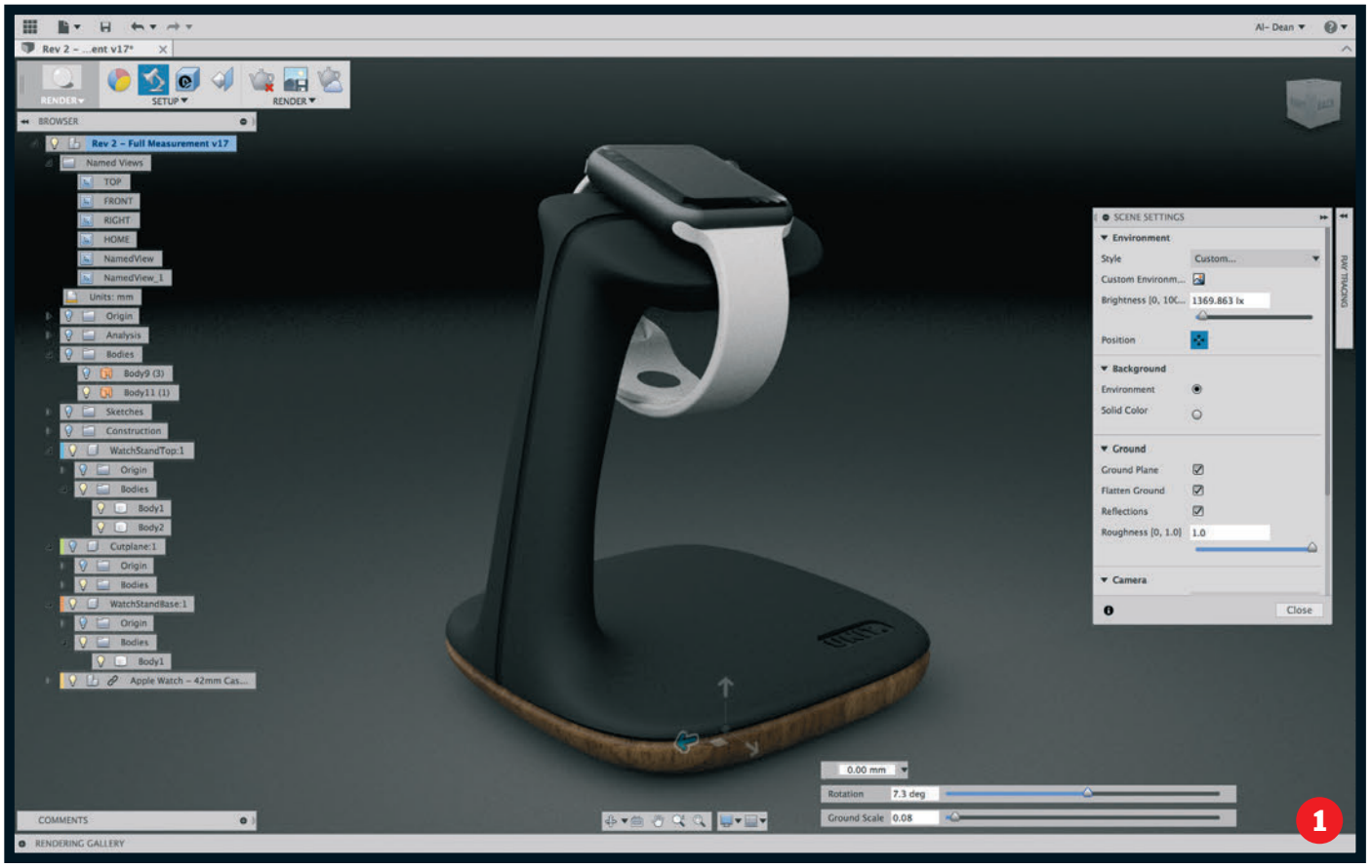


Fusion 360 Q1 2016

As the cloud-based design software industry hots up, **Al Dean** takes a look at Autodesk's Fusion 360 – a service growing in maturity and gaining tools that simply aren't available at the same price point elsewhere

Let's start by taking stock of where things are at with Autodesk's cloud-based design and fabrication system, Fusion 360. It's only been on the market for a couple of years as a commercial product, rather than a technical preview. But in recent months and updates, the focus has expanded beyond solid, surface and subdivision modelling (based on T-splines), into simulation and manufacturing tools as well.

The result is a system more capable than ever of addressing the full scope of work that design and engineering-focused organisations of all sizes do on a daily basis: creating 3D models; simulating their behaviour; moving parts and assemblies into the manufacturing phase, with full technical documentation (in the form of drawings); and starting to prepare for manufacturing using CNC machine tools.

USER EXPERIENCE

For those who are already using Fusion, recent months have seen perhaps the most-requested feature added – namely, keyboard shortcuts, to speed up access to frequently used commands and operations.

Alongside this, the team at Autodesk has also introduced a more customisable shortcut mechanism. Hitting the S key, for example, brings up a context-sensitive menu for each environment (sketching, solid modelling, sculpting and so on). Each has a couple of shortcut options already in place, but adding new ones is simply a case of typing in the name of the command and adding it to the toolbar.

SIMULATION

To date, we've not really discussed Fusion 360's simulation capabilities, which were introduced in the last quarter of 2015. Essentially, Autodesk's approach has been to take the core concepts of CAD-integrated simulation for both static linear analysis and modal analysis, and then start to build out a framework for simulation in the Fusion environment. As with all things Fusion, simulation gets its own tab/mode in the system and switching to it automatically loads up the tools.

If you've used CAD-integrated simulation tools before (of whatever flavour), you'll be familiar with the workflow. Grab your model, switch to the Simulation tab, then choose the type of simulation you require.

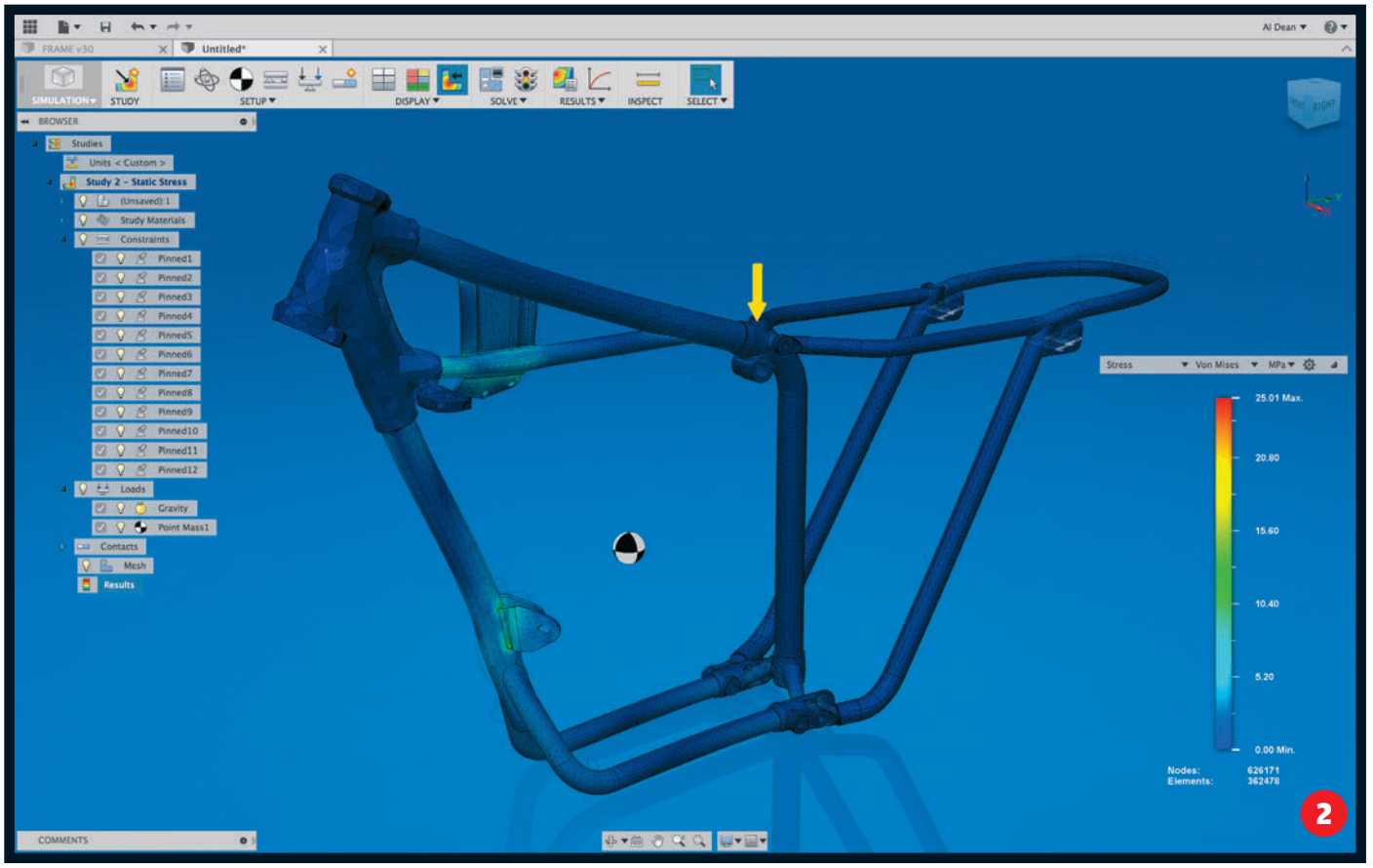
Take, for example, the linear static set-up process: if you've already defined materials during design, these are picked up. (That said, you can override them at any time, using a compact dialogue that enables you to handle multiple changes in one go.) You then start to define any contacts. Again, this is automated, but can also be overridden pretty easily if needed. Then, as you'd expect, you need to define the loads and constraints on the model. The last major release saw the introduction of point mass loads as well as gravity definition (the two are closely related).

Once your boundary conditions are set, your materials in place and your mesh has been generated, you set it to solve. For now, this is done locally. There's no cloud-compute option, which is a shame, but I suspect it's coming soon. You then have a set of results inspection tools, enabling you to see where stress concentrations are.

Interestingly, the system is set up to make

» Product: Fusion 360
» Supplier: Autodesk
Price: $25 per month
autodesk.com

1 Fusion's rendering tools have gained greater HDR image control, better depth of field and a wider selection of materials, which can to be downloaded on demand



experimentation pretty simple. Studies can be cloned and, of course, your geometry is linked to the simulation, so any design modifications can be propagated through your various simulations very quickly.

DRAWINGS & DOCUMENTATION

The ability to create technical documents is a relatively new capability in Fusion and it's still a work in progress. That said, the current toolset is pretty rich and should let you get most of the way there, in terms of creating full manufacturing drawings.

You'll find the familiar set of tools to lay out drawing views, details and sections and to create Bills of Materials (BOM) tables and balloons. More recent additions include the ability to add in more complex GD&T tools, with tolerances, datums, feature frames and all that good stuff. These take you from a simple 2D drawing to a true technical drawing that includes real production and manufacturing information. Also related to this is the ability to include exploded views in your drawings, using Fusion's animation environment.

RENDERING

The last time we caught up with Fusion, rendering tools had just started to be introduced, enabling users to assign materials, choose lighting from a selection of HDR images (or using a custom-image map) and render, either locally or using Fusion's cloud-based rendering tools.

Here, there have been a couple of changes worth noting and exploring. The first is that you're now given more control over the environment. In previous releases, you could adjust the floor of the environment to your needs, but had little other control beyond brightness or contrast of that map. Now, you've got the ability to rotate the map and adjust the 'ground scale'. This adjusts the size of the environment map, so you can really nail the reflections and shadows.

The second change is a range of new materials, based on procedural texture maps. These are suitable for more complex surfaces, such as wood, so they maintain the correct mapping as your geometry updates. These new materials don't come pre-installed – they need to be accessed as downloads, but this is a very simple action to perform.

COLLABORATION

The collaborative aspects of Fusion have shifted in the last six months. Originally, Autodesk tried to bring everything into the Fusion interface, particularly project management tools. The end result was an interface that was a little overly complex.

The company now splits things out: pretty much all of your design and engineering work is done inside Fusion, but the project management aspects are conducted through Autodesk's A360 platform.

If you've not looked into A360 before, it's worth the effort. It provides a nice set of project management tools that will be particularly useful if your team is dispersed geographically. Naturally, these are accessible through a variety of devices and platforms. Recent updates to Fusion have also added the ability to view and interact with simulation results as part of the default A360 toolset, which will also make collaboration easier in a web-based environment.

On that subject, it's also worth noting that Autodesk offers iOS apps for A360 and for interacting with Fusion projects and data.

There's no editing here, but there is a good set of collaboration tools as well as some pretty nifty model-viewing tools for when you're out on the road or don't have access to a workstation.

Of course, with Autodesk's recent launch of Project Leopard, this might become less of an issue in the coming months, as you'll soon be able to access and, more importantly, edit that data directly in the browser, using pretty much the same set of tools as you have here today.

Another area that's worth investigation is a preview of the forthcoming Live Design Review capability. This isn't switched on by default (you need to enable Previews in your Fusion preferences), but once done, you can fire up a Live Design Review session, send the link to those that need it, jump on the phone or Skype and inspect the model at hand.

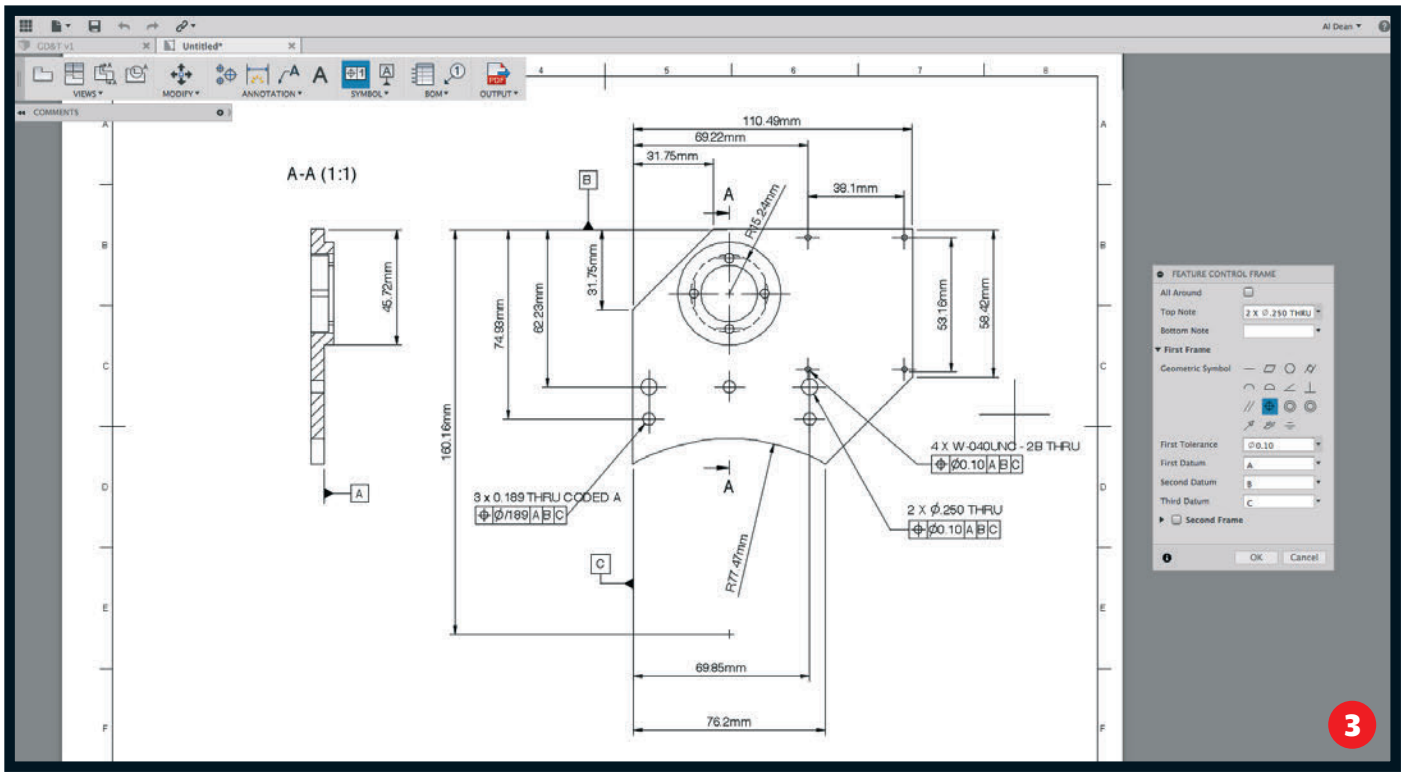
Views can be synchronised, there's live chat and the web-browser viewing mode features some rich inspection tools.

It's early days and some work needs to be done on markup and such, but this is a good indication of where things are heading.

IN CONCLUSION

Fusion 360 is maturing in all areas and has done so since its reincarnation as a cloud-based tool. The addition of simulation in the last couple of months makes it

2 Simulation is maturing iniside Fusion nicely - the tools to make effective use of such tools are being built in, such as automatic contact detection and point mass loads



3 The technical drawing tools inside Fusion are gaining the maturity that proper technical drawing tools require, such as feature control frames, datum references and a fuller set of GD&T

attractive to those who are keen to analyse the performance of their products, but have yet to dig into other simulation tools on the market, whether due to cost or lack of experience with such tools.

The manufacturing side of things is also coming along, supporting 3-axis up to 5-axis positional, though lacking some of the more advanced simulation tools that might be needed to ensure problem-free tool paths. It's also gaining support for machine tools beyond pure milling and lathe work.

There's an initiative underway, for example, to have the system drive laser cutters, water-jets and more.

But alongside these headline items, other tools in the system are also getting smaller, but just as important, updates – finer control in the sculpt environment, more tools for solid/prismatic modelling and the ability to create final technical drawings with the addition of GD&T.

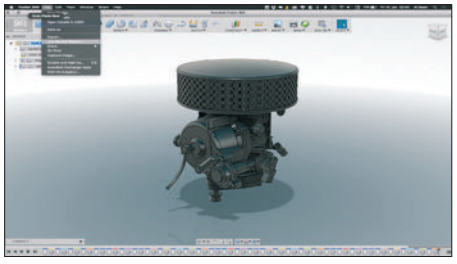
Looking at Fusion 360 as it stands today, there's huge capability available now, with more to come, ranging from ECAD integration, more simulation tools (CFD is on the roadmap already) and further expansion of the manufacturing tools.

The Project Leopard initiative will give users yet another, browser-based method of accessing the toolset.

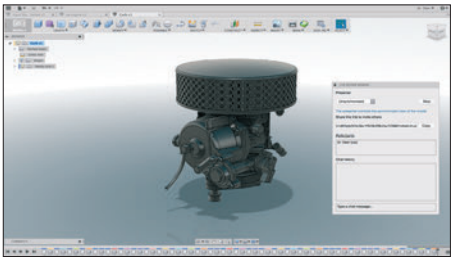
It's also worth noting that, at the moment, Fusion and all the tools we've discussed here are available for $25 a month (based on a 12-month contract). Frankly, that's ridiculously cheap, given the scope of what's on offer.

autodesk.com

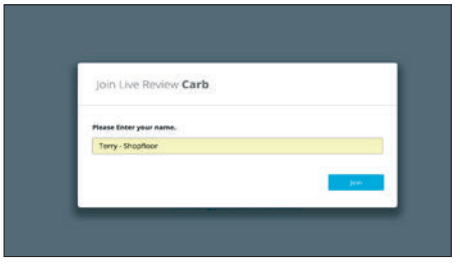
WORKFLOW: COLLABORATION WITH FUSION'S LIVE DESIGN REVIEW



1 Select "Live Design Review' from the pull-down menu, which needs to be turned on in Preferences

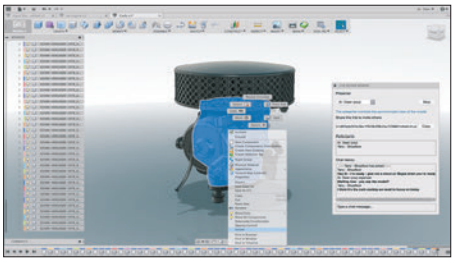


2 This brings up the control panel and gives you a link to send to other people on your team

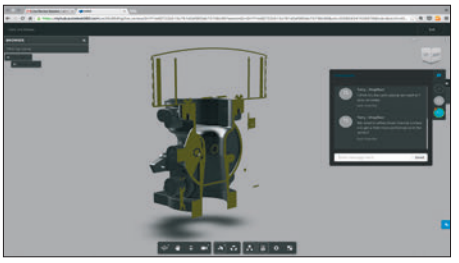


3 The other parties open the link in a browser and add in their name. There's no download, just the model stream

4 The viewing parties have a range of model exploration tools as well as a threaded live chat



5 From Fusion, you can synchronise views (so everyone sees the same), as well as disconnect the session



6 While sections don't synchronise between views and there's no mark-up as such, these features are coming soon

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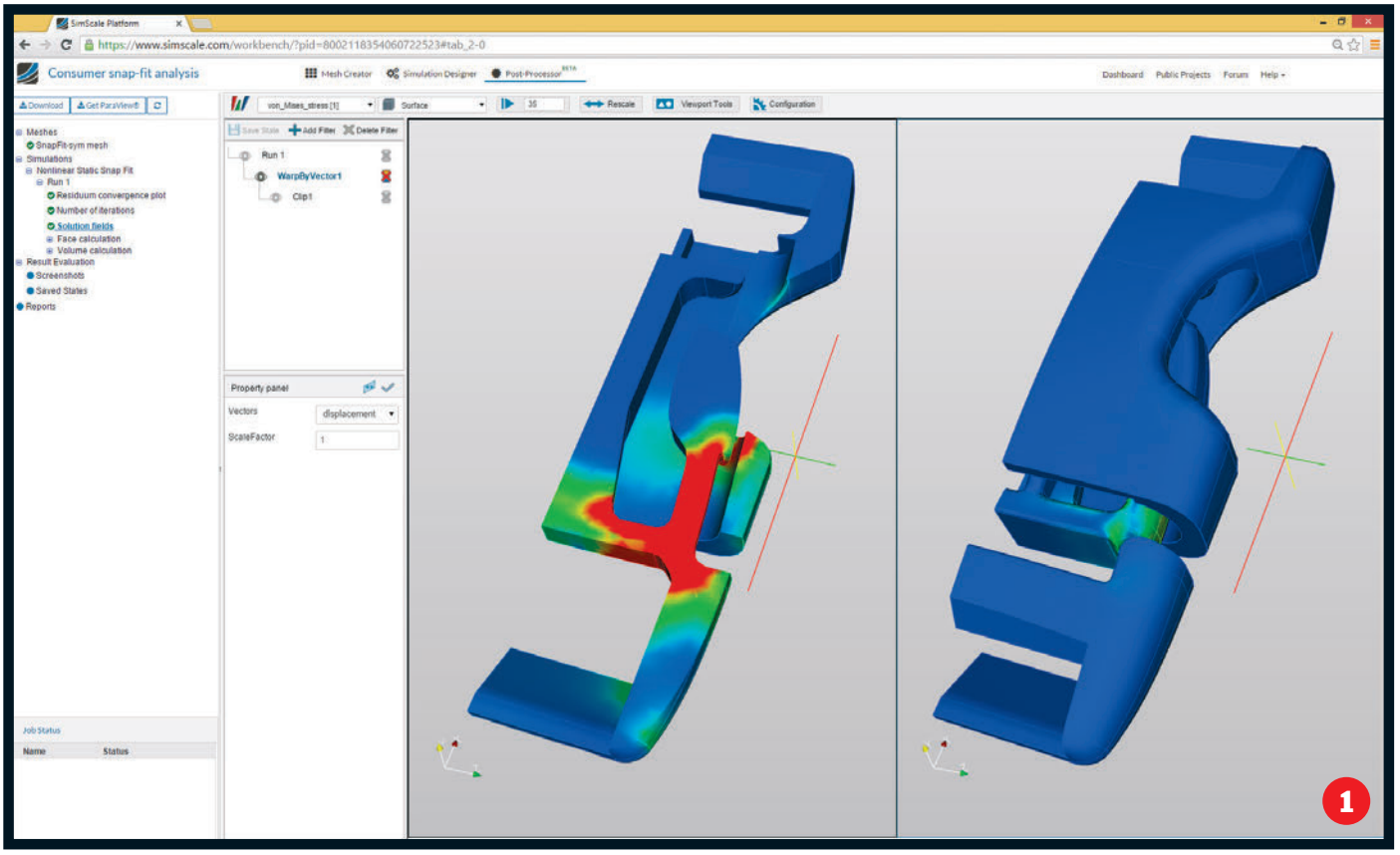


SimScale

Simulation is an area ripe for cloud-based delivery and SimScale is looking to take advantage. **Al Dean** investigates the company's platform, which offers users access to a wide array of physics and solvers

The ability to simulate a product's likely performance before building a physical prototype has been around for decades. Whether using Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD) or other methods, we should all be aware of the benefits.

That said, significant barriers to greater adoption persist, preventing such technologies from becoming more widely used. One of these barriers is down to skills – designers and engineers not having an adequate level of expertise to take their product into the simulation environment – but there are others; namely, cost and access to computational resources.

When it comes to cost, traditional simulation tools are expensive. The CAD-integrated tools offered by traditional 3D design systems don't come cheap either – particularly if you're looking to mix and match your physics models.

While FEA is suitable for mechanical performance analysis, for example, if you then want to add in CFD to simulate fluid flow and thermal considerations, you're looking at a decent wedge of additional cash, whichever way you want to cut it.

Computation is also an issue. While basic FEA can be conducted on the desktop, the limitations of the average workstation mean that if you want to ramp up the complexity of your simulation work or to carry out other tasks while a simulation is calculating, you're looking at a completely different set-up, whether that's based on dedicated workstations, formal or informal clusters or another approach.

It's these two factors that Munich-based start-up SimScale aims to address. Launched in 2013, its platform promises to widen access to advanced simulation technologies and, at the same time, offer some serious computational resources to make them work – all through the cloud.

USER INTERFACE

SimScale is an entirely cloud-based service. All work is conducted through your web browser of choice (as long as that's not Internet Explorer). Once you've signed up, you'll have a log-in and password. At this point, it's worth discussing how SimScale structures its offering.

» **Product: SimScale**
» **Supplier: SimScale**
Price: See text
simscale.com

1 Dynamic simulation of a consumer snap-fit stress analysis using SimScale

As with many such cloud-based services, the company is operating a 'freemium' model.

Freemium models typically come with some restrictions, whether that's the amount of storage on offer, the jobs you can perform, or the number of compute hours available. In SimScale's case, it's built around the privacy of your data and the number of compute hours.

Essentially, you can carry out any number of simulations, as long as they're public and you don't use up your 3,000 compute hours or go over your 500GB of storage.

The first step to using the tools on offer is, as always with simulation, to bring your geometry into the SimScale environment. As with all things cloud, that means uploading it over the Internet to the company's servers.

SimScale supports a variety of geometry formats, but the most reliable will be

STEP (skipping IGES, for reasons we all know). Interestingly, there's also an option to cross-load from Onshape if you have an account to that service. Doing this is simple: you simply authorise a connection between the two services, then select the data you want. (It's worth noting that, at present, you can only select the current version and last-opened branch from your Onshape model, so you'll need to bear that in mind when prepping your data.)

The data you bring to the SimScale platform will vary, of course, based on the job at hand. I think it's fair to say that you'll need to do any preparatory work upfront, since SimScale doesn't include any pre-processing tools for de-featuring or abstraction. So if you're working on internal fluid flow studies, for example, you'll need your fluid volume data ready to go.

MESHING

Once your geometry is loaded, the next stage is meshing. Here, there are a couple of different options for meshes for structural studies, then the CFD related meshing options, too. With each option, you'll get some guidance on the most appropriate option for your task – something that's essential for those new to FEA and CFD.

The meshing process takes place in the cloud and you have the ability to define the number of cores used to do it. This is an interesting capability, particularly when you realise that, while you might want to ramp up that number (to 32 cores) and get your mesh back quickly, you'll burn through your compute hours more quickly.

This process, of course, doesn't tie up your workstation and can be done, pretty much, on any computer with an Internet connection. Once underway, you can monitor progress on the web or wait for the notification email that will be sent to you once it's complete. You'll also be informed, again by email, if it has failed for any reason.

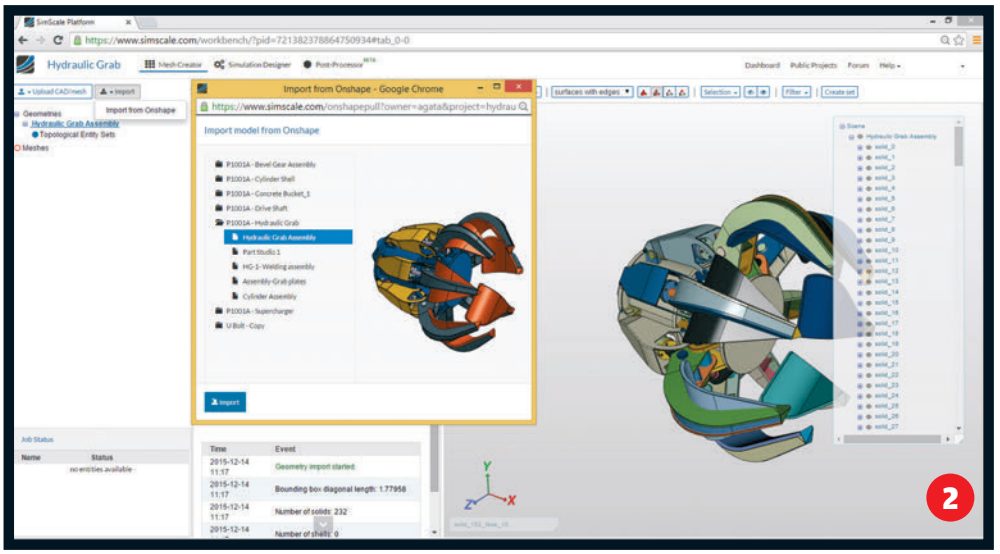
PRE PROCESSING & SET-UP

Once meshing is complete, your next step is to switch to the Simulation Designer tab. This allows you to start to flesh out your study, assigning boundary conditions, materials and other study variables.

The workflow for each step will vary on the type of study you're conducting, but it's all pretty clear and straightforward, assuming you know your product's characteristics and are familiar with the ins and outs of the simulation process you're working with.

Once set-up is complete, you then send the job off to compute. Again, the system gives you control over the number of processors used to calculate your results, as well as all those details you'll need when working at the more complex end of the simulation spectrum (for example, convergence).

As with the meshing computation, you can monitor progress live, or simply close down your browser and carry on with other tasks until the email notification arrives to tell you that the job is complete.



2 Hydraulic grab assembly model imported from Onshape to SimScale, via the integrated SimScale Connector App

POST-PROCESSING

When it comes to post-processing, SimScale has integrated tools from Paraview (paraview.org). These let you set-up the various views, charts and other results inspection and data extraction tools that you'll need. Interestingly, it's also possible to download the Paraview desktop app, along with your results dataset, and do the work locally.

Whether you're looking for stress/strain concentration in structural work, or inspecting flow in fluid volumes, the tools are there to help you document those results (it's also got one of the common report-generation tools).

Because of the cloud-based nature of the tool, these are also readily shareable with others on your project and both screenshots and view states can be saved easily for later review.

IN CONCLUSION

While we've primarily focused here on how the system works, many readers might be concerned with the freemium model and, in particular, the idea that any projects you carry out will be made public, at least within the SimScale community.

This does have some benefit, though. First, there's the learning aspect: the more folks that share their projects, even with test data, the more knowledge transfer occurs within the SimScale community. Everybody benefits. You can see how other users have carried out their work, even adapting their use cases and applying them to your own problems.

The second benefit is ease of access: the freemium model means you can try out the system without too many hassles. While you may not want to share highly confidential data on the platform, you do at least have the opportunity to do some meaningful testing of its capabilities, before making any financial commitment.

Once you start to think about making that step, there are currently two paid plans available. SimScale Professional gives you private documents, 3,000 compute hours a month and 500GB of storage space for €170 per month. SimScale Enterprise ramps this up with 30,000 hours of compute time and 5TB of storage data. That comes in at €850, but can be shared among five named users. Both plans include telephone and email support.

SimScale isn't the kind of pre-baked, wizard-driven tool that many are familiar with if they've used the types of simulation tools built into their workhorse CAD systems.

Rather, it's a fully featured system that gives you a lot of capability and a lot more control over the process. As such, if you're experienced in working with FEA and CFD systems, then you'll feel right at home.

If you're not, it may not be the best place to start. It's also worth noting that it includes particle and acoustics. The range is likely to expand in coming months.

The good news is that it's available now and you can find out whether you're ready or not to use it – for free.

A good way to think about SimScale's offering is that it gives you access to a number of different simulation capabilities and some pretty serious processing horsepower, on a pay-as-you-go basis. There are no massive licensing fees and no massive requirements for in-house computational resources. All you need is your geometry and a web browser.

You also get a lot of learning resources to guide you through the system and assist you if you come up against any tricky problems.

Simulation at this level has traditionally been a costly business, but it's clear that, as many adopt CAD-integrated simulation tools, they quickly run up against the limits of the capabilities on offer, both in terms of functionality and computation requirements.

SimScale offers a different approach, one that takes advantage of the cloud and looks to solve both issues with some advanced simulation tools combined with highly scaled computational resources in a very flexible and accessible environment. It's definitely one to keep watching.

Workstation Specialists WS-M151

» The WS-M151 may be bulkier than your typical mobile workstation, but this incredible 15-inch laptop has performance to rival most desktops, writes **Greg Corke**

- **» Intel Core i7 6700K (4.0GHz, Turbo to 4.2GHz) (Quad Core) processor**
- **» 64GB (4 x 16GB) DDR4 SODIMM 2133MHz memory**
- **» 256GB Samsung SM951 NVMe SSD + 1TB 2.5-inch HDD)**
- **» Nvidia Quadro M3000M GPU (4GB GDDR5) (354.56 driver)**
- **» Microsoft Windows 7 Professional 64-bit**
- **» Clevo P751DM chassis 386(W) x 262(D) 35.7(H) mm**
- **» 3.4kg**
- **» 3 Years Full Parts and Labour warranty (Return to Base)**

The Workstation Specialists WS-M151 might not have the sleek, modern aesthetic of a Dell Precision 7510 or HP ZBook 15, but with a top-end desktop CPU inside, it certainly trounces the competition when it comes to performance. In fact, this 15-inch mobile workstation has the processing power to rival most desktops.

Impressed as we were with the HP Z240 (tinyurl.com/HP-Z240-D3D) and Fujitsu J550 (page 63) desktop workstations, the WS-M151 edged out both in our number-crunching benchmarks. The 'desktop replacement' label, so often applied to powerful laptops, has never been more appropriate.

So how is all this possible? Most mobile workstations feature CPUs specifically designed for laptops which, due to heat dissipation and battery life requirements, draw a maximum of 45W.

With the WS-M151, Workstation Specialists rewrites the rulebook by doubling the power envelope to 91W. It can host anything up to an Intel Core i7-6700K (4.0GHz up to 4.2GHz), a top-end quad core CPU usually only found in desktops made by specialist workstation manufacturers.

In contrast, most mobile workstations are limited to the Intel Xeon E3-1505M v5 (2.8GHz up to 3.7GHz) or Intel Core i7-6820HQ (2.7GHz up to 3.6GHz) mobile CPUs. While we don't have benchmark figures to compare these chips, the difference in GHz indicates there is likely to be a significant performance gap here.

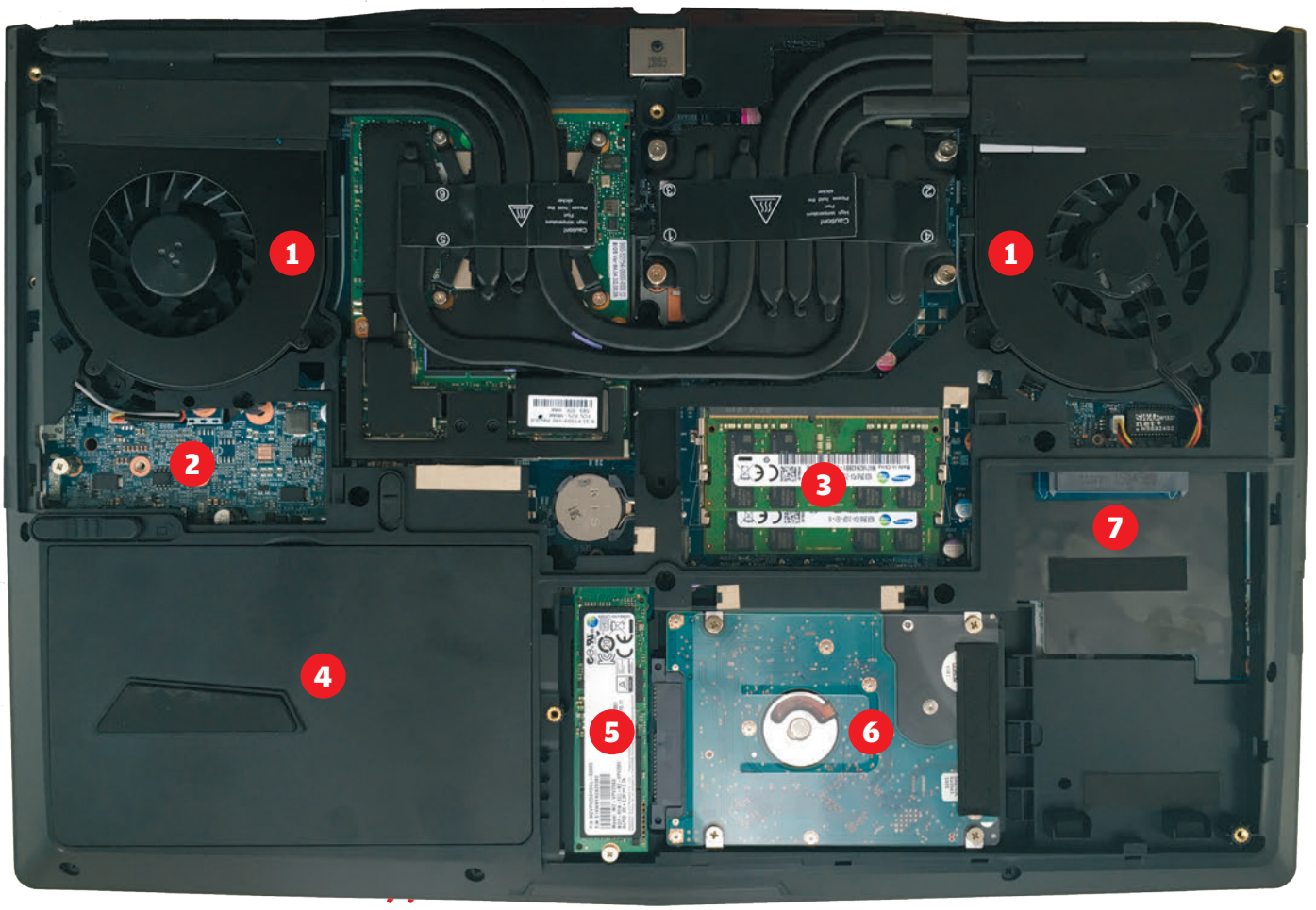
Compared to a standard 15-inch mobile workstation, the WS-M151 also takes graphics up a level. Our test machine's Nvidia Quadro M3000M (4GB) GPU is a step up from the Quadro M2000M found in the Dell Precision 7510 and HP ZBook 15, but it can also take a high-end Nvidia Quadro M5000M (8GB). Traditionally, such powerful GPUs are only available in 17-inch mobile workstations.

With the CPU rated at 91W and the GPU rated at 71W (or 100W with the M5000M), the WS-M151 needs a serious thermal management system to get rid of all the heat it produces. A complex array of heatpipes cooled by two large fans expels air at the rear of the machine and does a pretty good job. In tests, while fan noise was significant, we didn't find it too annoying, even under very heavy load.

The WS-M151 doesn't waste time when it comes to cooling its processors. From idle, fans kick in as soon as you start to stress the machine and it only took a few seconds for them to reach full speed when rendering a scene in 3ds Max.

However, even when hammering all four cores for more than an hour on a series of render jobs, the CPU was not throttled in any way. This means you should get the full 4.0GHz at all times (the CPU rarely went into Turbo mode and reached 4.2GHz).

To really push the machine to its limits, we decided to stress the GPU at the same time. Impressively, even when running the PTC Creo SPECapc graphics benchmark alongside our 3ds max render test, neither processor slowed down.



Of course, as with any mobile workstation, in order to keep the machine running at its optimum speed, care is needed to ensure fans remain free of dust. The good news is, it's relatively easy to remove the fans for cleaning. All you need is a Philips head screwdriver, a keen eye and a can of compressed air – but check with the manufacturer first to see if tinkering affects the 3-year warranty.

Storage is also high end, courtesy of a 256GB Samsung SM951 PCIe NVMe M.2 Solid State Drive (SSD). With sequential read speeds close to 2GB/sec and write speeds of 1.1GB/sec, the small form factor SSD is one of the fastest we've seen. There should be noticeable benefits over a standard SATA SSD if you work with very large datasets in areas such as point cloud processing or simulation.

A second Samsung SM951 SSD is an optional extra and both drives can be configured in RAID 0 (to boost performance) or RAID 1 (to keep data safe, should one drive fail).

» CPU benchmarks
(secs - smaller is better)

CAM (Delcam PowerMill 2016) i) 100 ii) 156 iii) 216

Rendering (3ds Max Design 2015) - 187

» Graphics benchmarks
(bigger is better)

CAD (SolidWorks 2015 - SPECapc graphics composite noFSAA) - 5.47

CAD (SolidWorks 2015 - SPECapc graphics composite FSAA) - 5.33

CAD (Creo 3.0 - SPECapc graphics composite) - 8.21

> **"I'm still having trouble getting my head round quite how powerful the WS-M151 is. Performance is head and shoulders above most mobile workstations"**

For the bulk of your CAD data, the machine is fitted with a 1TB 2.5-inch Hard Disk Drive (HDD). There's also space for a second 2.5-inch drive, so those with heavy storage needs are unlikely to go short.

For our test machine, Workstation Specialists has maxxed out the RAM to 64GB. This may be overkill for most CAD workflows. A downgrade to 32GB would do just as well and bring the price of the machine down to £2,034.

The 15.6-inch FHD (1,920 x 1,080) matt IPS display is impressive, with CAD models sharp and colours vivid. Considering this is a true desktop replacement, most designers will also want to hook it up to a larger external display or displays in the office. There are plenty of options here, with one HDMI 2.0 and two DisplayPort 1.2 ports located at the rear of the machine.

While there are only three dedicated USB 3.0 ports, there's also an eSATA that doubles as a powered USB 3.0, and a new generation USB-C port that offers both USB 3.1 and Thunderbolt 3.0. In short, the I/O options are pretty extensive.

The backlit keyboard and touchpad are nice to use and there's a numeric keypad which is great for engineering calculations. For security, there's a fingerprint reader which doubles as a middle mouse button.

With such a high-end specification, battery life is not its forte, lasting around 25% to 35% shorter than a typical 15-inch mobile workstation. As the battery clips out easily, without having to remove the back panel, carrying a spare is one way around this. However, with the machine weighing 3.4kg, the power supply 0.95kg and a spare battery 0.43kg, the overall carry weight would rise to just under 5kg.

Finally, audio quality isn't something we'd normally comment on, but the Onkyo sound system is so impressive, both in terms of volume and clarity, that we're making an exception here. Aside from the obvious benefits for music, films and games, this could be an important consideration if you deliver audio-rich client presentations.

CONCLUSION

Having spent the past week with the WS-M151, I'm still having trouble getting my head round quite how powerful this laptop is. Performance is head and shoulders above most mobile workstations and, indeed, many entry-level desktops.

Of course, the downside of having such incredible power in a laptop is portability. At 3.4kg and 35mm thick, it is significantly bulkier than most 15-inch mobile workstations, the differential even bigger when compared to a workstation Ultrabook. But if you're willing to sacrifice a little bit of portability in return for incredible performance wherever you go, then the WS-M151 could be a powerful asset for demanding CAD users.

Interior of the WS-M151 (back panels removed)

1. **Dual cooling fans with heavy duty heatpipes**
2. **Location of secondary M.2 Solid State Drive**
3. **Two memory modules (the other two are factory installed underneath the keyboard)**
4. **Removable 8 cell Smart Lithium-Ion battery pack (82WH)**
5. **256GB Samsung SM951 PCIe NVMe M.2 Solid State Drive (SSD)**
6. **1TB 2.5-inch Hard Disk Drive (HDD)**
7. **Location of secondary 2.5-inch drive**

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Fujitsu Celsius J550

» Designed and manufactured in Augsburg, Fujitsu has used its German engineering know-how to create an SFF workstation with no-compromise graphics. By **Greg Corke**

While most workstation manufacturers already have several generations of Small Form Factor (SFF) workstations under their belts, Fujitsu has only just rolled out its first. But for designers seeking a compact desktop with almost no compromises, the Fujitsu Celsius J550 has been worth the wait.

The Celsius J550 stands out for its 3D graphics capabilities. Unlike other machines in its class, it can host a full height graphics card, up to the mid-range Nvidia Quadro K2200 (4GB) or AMD FirePro W5100 (4GB).

This is big news for 3D CAD users as they can now get levels of 3D performance previously only available in a tower.

In comparison, SFF workstations from Dell, HP and Lenovo rely on low profile graphics cards, such as the AMD FirePro W2100 or Nvidia Quadro K1200, inside their slimline chassis. For more demanding 3D CAD users, these GPUs can be a bit underpowered.

The Celsius J550 manages to squeeze in its full height graphics card by making it sit parallel, rather than perpendicular, to the motherboard. The riser card that makes this possible is a simple but impressive piece of German engineering. It can be quickly removed from the motherboard making upgrades or repairs easy.

Similar attention has been paid to storage, with a drive cage that hinges through 90 degrees to give easy access to up to four 2.5-inch Solid State Drives (SSDs) or two 3.5-inch Hard Disk Drives (HDDs).

For workflows with high I/O requirements, such as point cloud processing, video editing or simulation, high-performance PCIe storage is also on the menu. There's support for up to three M.2 NVMe SSDs (one on the motherboard and two on a PCIe add-in card) and it's even possible to configure two of these tiny drives in a RAID 0 array. Such high-speed storage used to be a hallmark of high-end workstations, so this is quite exceptional for a machine of this class.

Despite the high-end storage capabilities, most CAD users will be more than adequately served by one or two drives.

Our test machine's 512GB 2.5-inch SSD gives ample space for OS, applications and current datasets, but a secondary 1TB or 2TB Hard disk Drive (HDD) wouldn't go amiss if you have a lot of data. Those on a budget may consider dropping down to a 256GB SSD, which will save £120.

Despite packing in graphics and storage, the Celsius J550 still compares favourably in terms of size. At 332mm (w) x 338mm (d) x 89mm (h), it is only slightly bigger than the Dell Precision Tower 3420 (290mm x 292mm x 93mm) and actually smaller than both the HP Z240 SFF (338mm x 381mm x 100mm) and Lenovo ThinkStation P310 (338mm x 394.5mm x 102mm).

The chassis is reassuringly solid, weighing close to 9kg. It can sit horizontally or vertically on the desk, with detachable feet for added stability. There's no shortage of USB 3.0 ports, with two at the front and six at the rear.

For everyday CAD work, performance is excellent. There's virtually nothing to separate it from the significantly larger HP Z240 Tower we reviewed in December 2015 (although the Z240 Tower does have optional higher end graphics, up to the AMD FirePro W7100 or Nvidia Quadro M4000).

With four cores and a clock speed of 3.6GHz, the Intel Xeon E3-1275 v5 is ideal for performance CAD, though the built-in Intel HD Graphics P530 is somewhat redundant with the add-in AMD FirePro W5100.

Depending on budget, there are over ten other CPUs to choose from, including a range of quad core Xeon E3-1200 v5 and Intel Core i3, Core i5 and Core i7.

Our test machine felt very responsive when working inside SolidWorks and PTC Creo, even when manipulating large assemblies with realistic materials, shadows and reflections.

With only 8GB DDR4 RAM, we did hit the memory limits from time to time, so would definitely recommend an upgrade to 16GB, adding £50 to the cost of the machine.

With a maximum capacity of 64GB there's plenty of scope for future upgrades.

The one downside is fan noise. While there was only a gentle hum in day-to-day CAD work, noise became more noticeable when rendering or hammering both CPU and GPU in our graphics benchmarks. It's not loud by any means, but there are certainly quieter machines out there.

CONCLUSION

Fujitsu may be late to the party with its SFF workstation, but blows the competition out of the water when it comes to 3D graphics. By offering a choice of full height mid-range GPUs inside the Celsius J550, power CAD users can now have it all: the performance of a tower in a chassis less than half the size. For this reason alone, Fujitsu's machine demands close attention.

With a huge choice of drives and CPUs, and a well-engineered chassis, there's plenty more to like about the Celsius J550. Unless your workflow demands more CPU cores for simulation or rendering, or higher end graphics for design viz, the SFF workstation now presents a truly tempting alternative to the deskspace-hungry tower.

- **» Intel Xeon E3-1275 v5 (3.6GHz up to 4.0GHz) (Quad Core) processor**
- **» 8GB (2 x 4GB) DDR4 2,133MHz ECC memory**
- **» 512GB SSD**
- **» AMD FirePro W5100 (4GB GDDR5) GPU (15.201 driver)**
- **» Microsoft Windows 7 Professional 64-bit**
- **» 332mm (w) x 338mm (d) x 89mm (h)**
- **» 3 years bring-in/ onsite service warranty**

£1.450

fujitsu.co.uk

» CPU benchmarks (secs - smaller is better)

CAM (Delcam PowerMill 2016) i) 107 ii) 167 iii) 231

Rendering (3ds Max Design 2015) - 199

» Graphics benchmarks (bigger is better)

CAD (SolidWorks 2015 - SPECapc graphics composite noFSAA) - 6.79

CAD (SolidWorks 2015 - SPECapc graphics composite FSAA) - 6.18

CAD (Creo 3.0 - SPECapc graphics composite) - 5.07

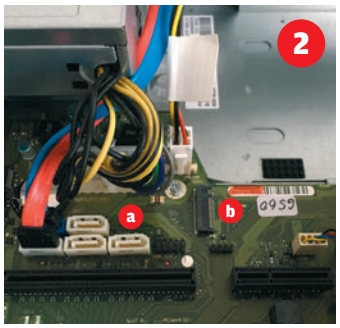
1 The Celsius J550 with detachable feet

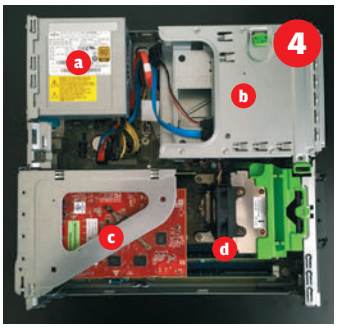
2 Five SATA ports (a) **and on-board M.2 slot** (b) **for NVMe or SATA SSDs**

3 The drive cage rotates through 90° for easy access

4 Power Supply (a)**, storage** (b)**, graphics card** (c) **CPU and memory** (d)

5 GPU mounted on riser card





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At the end of last year, Al Dean **discussed the potential benefit of having a wider range of third-party apps available via the cloud. This month, he's pondering how effective the user experience will be compared to the desktop**

This month, I've been preparing a feature on the range of third-party, cloud-accessible applications available for Onshape. While it's an interesting proposition, it's worth asking how cloud-based apps like these compare to existing desktop software options.

Cloud applications, after all, should work together more efficiently than perhaps some of our desktop apps do. By way of evidence, look at the level of integration offered by consumer-focused cloud services: if I'm uploading a video from my Dropbox account to Vimeo, the transfer process is pretty painless and a lot more efficient than downloading the file to a local drive, then re-uploading it. And believe me, when it's your job to upload all of the videos taken at each year's DEVELOP3D Live event, you really do want to save as much time as possible.

What's interesting is that this kind of seamless integration experience is now being delivered by design and engineering tools in the cloud and there are some excellent examples of this out there.

This month, for example, we review SimScale (see page 58), which offers a connection to the data you keep inside Onshape, if you use that service. You authorise the application and can move the data from Onshape's server (presumably via some sort of STEP-based translation process) into a SimScale simulation study – job done.

There's no bi-directionality or linking to that file at present, so it's a bit of a one-hit wonder. If you want to update the geometry, you need to re-import it. But that's likely to change over time, as both services mature.

But when you start to look at the more tightly integrated services, where you're effectively using another service inside the Onshape window, a very different picture starts to emerge.

Let's take the example of SimulationHub, a new start-up that's focusing on making Comptuational Fluid Dynamics (CFD) more accessible. If you want to try it, you can, for free, on its own or connected to an Onshape account.

From within Onshape, you have your geometry, then kick off a SimulationHub session. This transfers the data into SimulationHub's environment (and maintains a link), but rather than opening in another window (or browser tab), it becomes part of the Onshape environment.

Even from looking at the screenshot in Figure 1, it's clear that SimulationHub's user interface is completely different from that of Onshape. The colours are different, the user interface is starkly different (you might spot that SimulationHub uses Autodesk's LMV API for its user interface), but you're still effectively in Onshape's window.

The differences, however, go way beyond pure aesthetics. Take mouse operations as an example: within Onshape, model rotation is performed using the right-hand mouse button. In SimulationHub, it's the left.

This, to my mind, is going to be an issue. Design and engineering is an iterative process and so is the way we use our tools. If those tools cause 'sticking points', with mismatched user interfaces and experiences, then workflow breaks down and becomes hampered by delays.

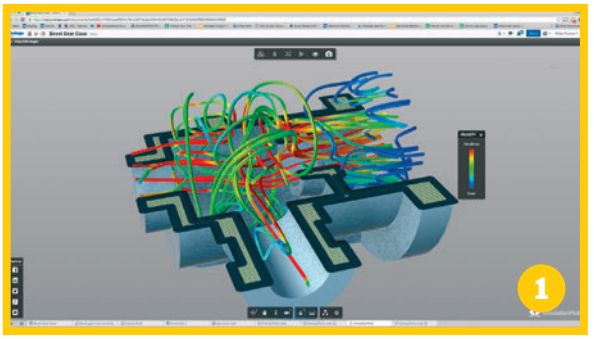
This is, by no means, a criticism of Onshape and its partners specifically. As I see it, it's going to become a much wider issue as more vendors (both existing and new) move to the cloud.

The smarter partners will develop tools that work inside the host applications and adopt their look, feel and interaction methods (as a bare minimum).

An excellent example we've already seen is the work that MIGenius has done with its RealityServer offering for Onshape. This adopts the same model control and user interface style right from the word go. As soon as you switch to RealityServer within Onshape, it feels more comfortable, familiar and productive.

But is this any different to how things are on the desktop? The answer is: "Not really." Yes, desktop software, particularly from the larger vendors, is mature enough for more strict guidelines to be enforced, demanding that third-party developers adhere to common user experiences. You can take SolidWorks' Gold Partner integrated applications as an example of this.

These are, of course, the best examples, but more often than not, we're looking at different workflows and different control methods between different vendors, if not between applications (often from the same vendor).



Will we see the same happen in the cloud, where we find differing levels of integration and more efficient workflows? I suspect it's going to take some time, but it's also something that must be addressed, sooner rather than later. This might take the form of a set of regulations that need to be adhered to – but perhaps a better approach would be if software vendors themselves recognise the benefit of adapting their offerings to ease that workflow.

After all, those third-party application or services vendors that go to the trouble of putting customers first will surely benefit as a result.

Vendors in the cloud apps space frequently use Apple's App Store business model as reference point. What Apple has done is build a successful ecosystem – one in which user experience is pretty much nailed down and enforced. What the vendors in our space need to do is replicate that aspect of the model, too.

1 SimulationHub's service offers CFD that's easy to use – but there's a sticking point with its user interaction standards

2 MIGenius' RealityServer add-on service for Onshape. Look and feel is the same with a much slicker workflow to boot

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