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STEEL CITY PUSHES THE
FRONTIERS OF NEW INDUSTRY

Pittsburgh powers up

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Photo: Dave DiCello, courtesy of Allegheny Conference

PITTSBURGH

From steel city to tech titan

FORMERLY AN INDUSTRIAL POWERHOUSE, IN THE 1970s PITTSBURGH WENT INTO A DECLINE. THEN DIVERSE LOCAL INTERESTS CAME TOGETHER TO REBUILD THE CITY INTO A TECH, HEALTHCARE AND FINANCIAL SERVICES HUB, ENSURING ITS SURVIVAL THROUGH EDUCATION AND INNOVATION. NATASHA TURAK REPORTS

For evidence that the city of Pittsburgh leads the frontline of new industry, look no further than its selection as the site of the first ever White House Frontiers Conference in October 2016, a high-profile event focused on building the US's capacity in science, technology and innovation.

Hosted by the University of Pittsburgh and Carnegie Mellon University (CMU), the conference focused on the capacity of technology to improve lives and create jobs and investment, exploring fields from healthcare innovation, clean energy and the Internet of Things to robotics, artificial intelligence and space exploration.

Speaking at the event, US president Barack Obama called Pittsburgh "a city that has harnessed innovation to redefine itself as a centre for technology, healthcare and education".

"Pittsburgh has been revitalising itself through technology for a very long time," said Mr Obama. "That's how this city came back after an iconic industry fell on tougher times, doubling down on science, on tech, on innovation – all of which can create amazing new jobs and opportunities."

From steel to tech

Few places embody the phenomenon of a comeback city quite like Pittsburgh. Known historically for its dominance as a steel-pro-

ducing city – a driving force for industry and manufacturing around the world from the mid-19th century onward – global economic change forced Pittsburgh into dramatic decline before its ultimate turnaround.

Beginning in the 1970s, manufacturing plants and steel mills, the engines of the region's economy and employment, began shutting their doors. By 1983, 250,000 people had left the city and the unemployment level had reached 18.3%.

Today, the Pittsburgh region (comprising 10 counties in south-western Pennsylvania) tells a story of striking resilience, an example of what can happen when a diverse group of stakeholders come together to invest their work and inventiveness into reviving a community.

It started in the 1990s, says Dennis Yablonsky, CEO of the Allegheny Conference on Community Development (ACCD), which serves the Pittsburgh region. "Led by the then-president of CMU, literally a few hundred leaders – government, business, academic, philanthropic – came together and concluded that through innovation and collaboration between institutions, we could develop our cluster of industries to be productive again," he recalls.

The region became the third in the US to fully recover from the 2008 recession, its

unemployment rate is now below the national average, and it is one of the country's fastest growing destinations for millennials.

A combination of academic institutions, private enterprise, historic philanthropy and new industry innovators – and a spirit of pulling oneself up by one's bootstraps – is due credit for the remarkable renaissance of Pittsburgh from former steel town to one of the world's premier destinations for advanced industries such as cyber security, artificial intelligence and robotics. Google and Uber are just a few of the many blue-chip companies that have set up operations in the city in recent years.

A smart ecosystem

The base of Pittsburgh's power, its business residents say, is its human talent. Annually, 35,000 students graduate from Pittsburgh's 35-college university network. Some 50% of young adults in Pittsburgh have a bachelor's degree, compared with the national average of 35%.

CMU and the University of Pittsburgh, both tier-one research institutions and incubators for numerous start-up companies, are among the city's most vital assets, internationally reputed for their technology and science programmes. And the city's wage rates are 95% of the national average. In Silicon Valley the figure is about 158% of the national average, according to the US Bureau of Labor Statistics.

Pittsburgh's present-day economic foundation lies on five pillars: financial and business services, advanced manufacturing, IT, healthcare and life sciences, and energy.

"We have this whole knowledge-based industry," says Mr Yablonsky. "We went from a place that was totally dependent on one sector – 50% of the economy was heavy manufacturing – to an economy that is very balanced. The largest sector – financial services – now [makes up] 23% [of the economy]. It's very diversified, and all driven by innovation."

State and local community leaders have developed a strong ecosystem to support new companies. The ACCD and the 300-member Regional Investors Council work with state-level players to ensure businesses have what they need to grow and stay in the area. And a \$3bn investment in university, corporate and government R&D annually underscores the region's commitment to leading innovation. Thanks to this, Pittsburgh is home to more than 400 foreign-owned firms employing more than 50,000 people.

"We have a unique asset in that we have the second highest concentration of philanthropic assets in the country," says Mr Yablonsky. "There is more than \$6bn dollars of philanthropic assets here." The foundations left by prominent industrialists such as HJ Heinz, George Westinghouse and Andrew Carnegie invest solely in Pittsburgh. "So we

have \$300m every year in grant making that goes on here," adds Mr Yablonsky.

Building for the future

Building on its manufacturing history, Pittsburgh is carrying that spirit of creativity into the future. It is a venture embodied in Pittsburgh 4.0, the city's own contribution to Industry 4.0, so named to describe the newest industrial revolution toward automation and increased data exchange in manufacturing.

The Pittsburgh Regional Alliance describes Pittsburgh 4.0 as the synergy between manufacturing prowess, energy, technology and innovation – assets the city aims to utilise to automate and revolutionise manufacturing around the world.

Multinational 3D design, engineering and entertainment software corporation Autodesk, which employs nearly 8000 worldwide and has an annual revenue of more than \$2.5bn, acquired Pittsburgh start-up Allpoint in 2013. Senior manager Aaron Morris, who earned his PhD at CMU, says the city has been waiting for its moment to shine again.

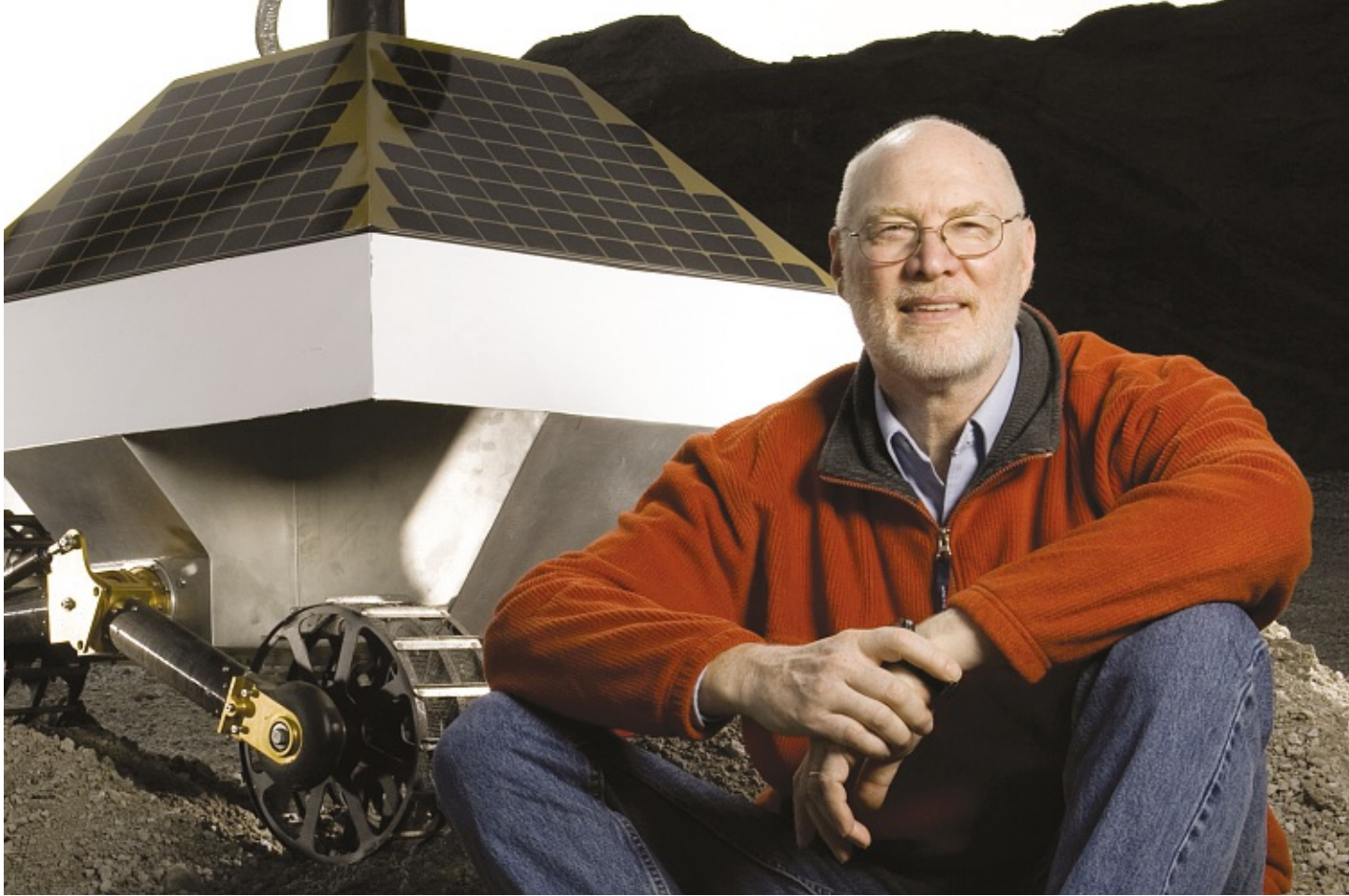
"As you can see, Industry 4.0 is the future of everything: it deals with data, security and all the things Pittsburgh has been sitting on for a while," he says. "We got into robotics in the early 2000s, we thought it was going to bust loose. So we've been waiting a long time, and now this is the world. You've got to have faith. The world is ready and starting to recognise it, which is why companies such as Autodesk are able to get investment."

Forthcoming challenges include increasing the millennial retention rate beyond university and ensuring education keeps pace with changing industry demands. Regional players are teaming up with schools and businesses to introduce new career opportunities to young people, from CMU's Cyburgh PA Initiative 2016 for cyber security learning to ShaleNet's engineering training for the natural gas industry.

When Mr Yablonsky began his own artificial intelligence start-up in the 1990s, there were 50 tech companies in the region. Now there are 1600, along with 500 life sciences companies and a thriving healthcare sector, the largest employer in the area.

Mr Yablonsky also highlights the local quality of life. Living costs are 96% the national average, and Pittsburgh offers more than 500 arts and cultural organisations, three professional sports franchises, and plentiful green space for a healthy and active lifestyle.

Pittsburghers say that the steel made in the city's mills was exported to "build the world" in the 20th century. Those business and trade connections remain, but have now expanded into new sectors that define the frontiers of advanced industry. Led by its work ethic, scientific prowess and history of resilience, Pittsburgh's rich ecosystem is helping lead the US through the 21st century. ■



Infinity and beyond: William 'Red' Whittaker and his planetary rover prototype

The robot revolution

PITTSBURGH IS A GLOBAL LEADER WHEN IT COMES TO ROBOTICS RESEARCH AND DEVELOPMENT, HOSTING NUMEROUS COMPANIES IN THE FIELD DRAWN TO THE CITY'S RICH INDUSTRIAL HERITAGE, HIGHLY SKILLED WORKFORCE AND THE EXPERTISE COMING OUT OF CARNEGIE MELLON UNIVERSITY. **NATASHA TURAK** LOOKS AT HOW THE CITY IS BUILDING ON THIS REPUTATION

There is a reason why international transportation network Uber chose Pittsburgh as the launch city for its autonomous vehicles lab and the site of its first public unveiling of driverless cars. Raffi Krikorian, engineering director at Uber's Advanced Technologies Center and the man behind the company's driverless revolution, spoke to **fDi** at the White House Frontiers Conference in Pittsburgh. "Being here with the Carnegie Mellon University [CMU] robotics centre, one of the best robotics departments in the world, gives us access to so much talent. We have a really close partnership, which enables us to work with research and industry right here in the city."

Pittsburgh stands out as one of the top robotics research hubs in the US, making it a leader worldwide. A ranking by design and technology website Gizmodo named Pittsburgh the second best city in

the world for robotics, following only Boston but ahead of San Francisco, Tokyo and Seoul.

A robo-hub

Robust R&D, a broad array of private-public partnerships and abundant human talent are counted among the resources that make Pittsburgh fertile ground for robotics companies. Some of the city's most prominent players in the field are Uber Technologies, RedZone Robotics, Astrobotic Technologies, Carnegie Robotics, the CMU National Robotics Engineering Center and the CMU Robotics Institute.

Founded in 1979, the CMU Robotics Institute consists of 76 faculty members, 94 PhD students and 132 master's students and it has produced a large number of robotics entrepreneurs. Big names include Chris Urmson, now head of Google's self-driving car programme; Mark Maimone, who

pilots NASA's Curiosity on Mars project; and William 'Red' Whittaker, a professor, the institute's father, and the founder of the discipline of field robotics.

Since the institute's founding, it has developed unmanned vehicles to clean up the infamous Three Mile Island nuclear accident site, it has brought CMU to victory in the \$2m Urban Challenge robotic autonomous vehicles race, and Mr Whittaker and his team now plan to land and operate a robot on the moon in pursuit of the \$20m Google Lunar XPrize.

Why Pittsburgh?

"I chose Pittsburgh both at a time of and because of declining traditional industry," says Mr Whittaker. "I was looking for a place that had a good technical base, tremendous work ethic, affordable living, where people could come from anywhere and make it big." One thing that stood

out to Mr Whittaker was the sites available for use. "One thing you can really find in this town is incredible buildings and sites," he says. "You can find acreage, which is so essential to the kind of technologies that matter in farming, mining and driving – these are applications you just can't do at a computer in a cubicle. Robotics has a physical manifestation beyond its intellectual content."

No sector will go untouched by robotics, according to Mr Whittaker. Whether it is innovations in mining, agriculture, advanced manufacturing, automobiles, healthcare or space and defence, he says "the common denominator in all of them is robotics".

"Pittsburgh is an incredible corner of the world for making things. You can make just about anything in this town. Electronics, precision mechanisms, sensors, software – robotics is the economic engine that drives investment forward," says Mr Whittaker. "General Motors has embarked on a \$1bn centre for autonomy, and the likes of Ford, Uber and Tesla are going after this revolution as well. That is billions and billions of dollars, that is jobs, and it's a huge investment in the kind of technologies that continue to push this along, where all of it begets more of it and it really builds on itself."

The bigger picture

While university research and government funding – particularly from the US Department of Defense and space agencies – have provided both the support and client base for the robotics community to thrive, Pittsburgh is now working to develop this expertise into commercial success.

"What's so important is that this gets beyond the doors of a university and into the world," says Mr Whittaker. "So we collaborate with [construction and engineering company] Caterpillar, and that is decades

of infusing automation features into machines for mining and construction. Caterpillar is the biggest and best in class in what it does in the world. It is clear that automation is its future." Mr Whittaker cites John Deere as another example of an agricultural machinery company that is leading the way when it comes to robotics.

"These are the companies who have the means to be first movers and to go big," he says. "They are all tremendous technological partners. That moves it along, and it isn't slowing down." The Pittsburgh Robotics network currently comprises about 20 companies and counting – in terms of tech firms in general, the Pittsburgh region counts about 1600.

The centre of robotics

Confirming Pittsburgh's allure for robotics companies is Jeff Christensen, vice-president at Seegrid, a firm developing autonomous 3D vision navigation in robotic machinery. Simply put, the company "teaches machines how to see". Seegrid's vision-guided industrial vehicles are now being deployed by major manufacturing and retail clients all over the world. Its partnerships with local supermarket chain Giant Eagle and forklift truck manufacturer Raymond support its development and funding.

"To me, Pittsburgh is the centre of robotics," says Mr Christensen, who is a Michigan native. "CMU is obviously a major driver for that; a lot of us went to school there, and there is a feeder programme for people who are really great in computer science and robotics."

Pittsburgh is an excellent place to live compared to Silicon Valley, he adds. "The cost of living compared to Silicon Valley is fantastic and all of the talent is here. Pittsburgh has a historical reputation for building things – that as a

mentality has stayed with the community, and I'm drawn to it."

A past and future

CMU has fostered numerous spin-off companies such as Near Earth Autonomy, which develops unmanned aerospace technology, and Edge Case Research, a custom software programming and testing firm. Edge Case uses its expertise in autonomous functional safety to help industrial clients manage the increasing complexity of machine-learning algorithms. It works in autonomous vehicles, the Internet of Things, consumer electronics and industrial power systems. The small team of 10 people serves 20 clients from both the commercial world – including Fortune 500 companies – and the US military.

"The base of industry here has been important to many of our programmes," says Mike Wagner, Edge Case CEO and CMU alumnus. "I've worked on several vehicles programmes where we needed welders, machinists and technicians, and having all those available was huge for us. Pittsburgh has always been a superstar for that kind of thing."

Representing the first generation of his family not to work for US Steel, Mr Wagner believes that these new ideas have been percolating in Pittsburgh for some time, but rest of the world had not been ready for them. "If you look at the kind of things that are being commercialised now, those were ideas developed here in the early 2000s," he says.

"I think a clear transformation has happened here," says Seegrid's Mr Christensen. "The hi-tech transformation is very strong across the whole region – robotics is really coming into its own. If Pittsburgh's reputation moves from steel to computer-guided steel – if that's what a robot is – that is a really healthy move, and it takes us into the next century." ■

A cyber security force

PITTSBURGH WAS AMONG THE EARLY LEADERS OF THE CYBER SECURITY INDUSTRY, A POSITION IT HAS ENHANCED IN RECENT YEARS. NATASHA TURAK LOOKS AT THE METHODS THE CITY IS USING TO STAY AHEAD OF THE GAME IN THIS INCREASINGLY RELEVANT FIELD

As the world becomes increasingly connected and technology permeates almost every aspect of business, so too does it become more vulnerable to attack. The market for cyber security services reached \$68bn in 2013; between 2017 and 2021, worldwide spending on cyber security products and services is expected to surpass \$1000bn, according to research firm Cybersecurity Ventures. It is predicted that cybercrime will cost the world \$6000bn annually by 2021.

In line with its mission to occupy the frontlines of technology, in 1988 Pittsburgh became home to the first Computer Emergency Response Team Coordination Center (Cert). There are now more than 200 Cert centres in the world focused on computer security response and research.

To serve and protect

Cert was set up by the US Defense Advanced Research Projects Agency, and stemmed from the Carnegie Mellon University (CMU) Software Engineering Institute (SEI), established by the US Department of Defense (DoD) in 1984. The DoD chose CMU to establish the federally funded R&D centre – now funded with between \$20m and \$25m annually – because of its reputation as having one of the best computer science departments nationally and its proximity to Washington, DC, a four-hour drive away.

“We work in support of the government and critical infrastructure,” says Summer Fowler, technical director of cyber security resilience and risk at CMU. “We have bodies of work that span everything from secure

coding to architecture, workforce development and malware analysis; we have one of the largest databases of malware in the world. One of our big areas is insider threat work, where we have liaisons with the Secret Service, the FBI and more. The beauty is we’re tied very closely to campus, so we work with the university’s teams in machine learning, artificial intelligence and statistics.”

The Collaborative Innovation Center, which houses the SEI, brings campus researchers and industry together under one roof. “Disney Research is here, CyLab is here, CMU SEI, Intel, Apple and more,” says Randall Trzeciak, a senior member of Cert’s technical staff. “We provide the students, and the companies fund the students and research effort as well.” In 2003, CMU invested \$6m to institute CyLab, one of the country’s largest university-based cyber security research centres. Almost entirely privately funded, its investors include Facebook, GM, Lockheed Martin, Motorola, Raytheon and Samsung.

Job opportunities

Dennis Yablonsky, CEO of the Allegheny Conference for Community Development, sees the field as a growing engine for job creation. “The first federal Cert was established here, and cyber security is becoming a bigger issue and an opportunity for jobs,” he says. Indeed, according to a recent Cisco Annual Security Report, there are

predicted to be more than 1 million unfilled cyber security positions worldwide by the end of 2016. In response to this, the Pittsburgh Technology Council launched the Cyburgh, PA Initiative 2016 to reach out to 100% of local high school students by 2019 to develop the next generation of cyber professionals and maintain Pittsburgh’s leading edge.

Already, the area hosts several cyber security spin-off companies with roots at CMU, some of whom have been acquired by larger multinationals. ABS Computer Technology, ForAllSecure, Netronome Systems, Wombat Security Technologies and Pittsburgh Pattern Recognition – recently acquired by Google – are just a few of the groups driving the region’s efforts in the sector. So far more than 40 businesses in south-western Pennsylvania offer cyber security expertise, and all are poised to take advantage of this rapid growth trend.

In fact, the Pittsburgh region outbid other US regions to host a German Cyber Security mission in late 2016. The German American Chamber of Commerce wrote on the event’s page: “Since Pittsburgh is the ‘secret capital’ of cyber security on the east coast because of its many companies, like the security division of Google, it is the first destination for the German trade partner.” At its current rate, the region’s prowess will not remain a ‘secret’ for much longer. ■



Home security: the Collaborative Innovation Center, which houses the Software Engineering Institute

Another dimension

PITTSBURGH'S MANUFACTURING INDUSTRY HAS CHANGED WITH THE TIMES, MOVING FROM HEAVY INDUSTRY TO EMBRACE ADVANCED TECHNOLOGY SUCH AS 3D PRINTING. **NATASHA TURAK** REPORTS

Pittsburgh's long-standing reputation as a hub of manufacturing has followed it into the 21st century, despite the face of its traditional industry changing dramatically. Boasting more than 120 research centres, 3000 advanced manufacturing firms employing 96,000 people and more than 1600 engineering graduates per year, the Pittsburgh region's strength across areas such as industrial machinery, speciality metals, precision machining and electrical equipment is readily evident. In 2014 alone, it saw 68 advanced manufacturing projects worth more than \$450m in capital investment.

At the University of Pittsburgh's Swanson School of Engineering, sophisticated research partners with industry to explore the potential of advanced production technologies such as additive manufacturing (AM) – otherwise known as 3D printing – to transform the way the world makes things.

Collaborative thinking

Research in AM is accelerating in anticipation of greater market penetration. To plug some of the knowledge gaps in the new industry, Pennsylvania-based precision manufacturer Oberg Industries has partnered with the University of Pittsburgh's Ansys research lab, an AM facility equipped with some of the world's most advanced manufacturing equipment, using alloys, metals, polymers and other materials to print components for every industry. Since 2014, AM researchers at the Swanson School have attracted more than \$6m in grants from groups such as America Makes, the National Science Foundation and the National Energy Technology Laboratory.

"When we go out and talk to our Fortune 500 manufacturers, introduce them to what the University of Pittsburgh is doing and show them possible industry solutions, we continue to expand the knowledge base of AM within our customers," says Oberg vice president of sales and marketing David Rugaber. "This is really a win-win for



White heat of technology: a CATA employee checks the temperature of components leaving the oven

GE Reports/Chris New

the university and Oberg Industries."

Manufacturers remain the region's largest employers by revenue: Alcoa, US Steel and PPG Industries lead Pittsburgh's top five grossing companies. German manufacturers Bayer, Lanxess and Siemens are among the more than 394 foreign-owned companies in the area.

GE approval

Pittsburgh's latest anchor tenant is GE, whose massive \$39m greenfield investment in its 12,000-square-metre Center for Additive Technology Advancement (CATA) is developing 3D printing technologies for the aviation, oil and gas industries. The investment is building the area's reputation as an AM hub and bringing these technologies into the mainstream. GE joins 3D industry leaders such as ExOne and threeRivers 3D, already based in the Pittsburgh area, who are among the top 3D equipment builders in the country.

"One of the reasons we came here is for the workforce. The area has really exploded with technology in recent years, and many people are coming in with hi-tech backgrounds," says CATA site leader Jennifer Cipolla. "We have access to the universities. Carnegie Mellon

University, Pitt, Robert Morris, Youngstown State and Penn State all have good AM programmes, and we want to take advantage of that."

GE's site selection highlights the value of Pittsburgh's supply chain: providers of metal powders and other materials required for AM are abundant in Pittsburgh. At one time providers for the steel industry, local foundries and other smaller businesses are helping drive advanced manufacturing.

AM will penetrate and transform every industry sector, according to Ms Cipolla. "It allows us to create much more complex internal geometries at a lower cost, which means you're going to see the performance of industrial products improve very rapidly," she says. "GE is at the forefront of innovation in this area, pushing the boundaries and driving their industrialisation."

Ansys director of mechanical development Al Hancq is optimistic about the region's fast-growing AM network. "GE is a worldwide company, and it chose Pittsburgh as its centre of excellence for this technology," he says. "What does the future hold? I'm not sure, but I think Pittsburgh has a big chance to be at the centre of that." ■