COMMERCIAL INTERVIEW

The Pransky interview: Dr Rob Buckingham, Director at UK Atomic Energy Authority and Robotics Pioneer

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Abstract

Purpose – The following article is a "Q&A interview" conducted by Joanne Pransky of *Industrial Robot* journal as a method to impart the combined technological, business and personal experience of a prominent, robotic industry engineer-turned successful business leader, regarding the commercialization and challenges of bringing technological inventions to market while overseeing a company. The paper aims to discuss these issues.

Design/methodology/approach – The interviewee is Dr Rob Buckingham, Director at UK Atomic Energy Authority (UKAEA) and Robotics Pioneer. Dr Buckingham is an innovator of snake-arm robotics for confined and hazardous environments. In this interview, Dr Buckingham shares some of his 30+ year personal and business experiences of working in industry, academia, co-founding and directing a robotics company and heading up a new UK government-funded organization for remote handling.

Findings – Dr Buckingham received his BSc and his MEng in the Special Engineering Programme at Brunel University in London. The program's objective was to train engineers for the industry by developing problem-solving abilities and decision-making skills of students, which Buckingham accomplished while being sponsored by the UKAEA and as a National Engineering Scholar. After obtaining his PhD in robotics at the University of Bristol, Buckingham, he remained at Bristol for two years as a lecturer in mechanical engineering. In 1997, he co-founded OC Robotics, a private company that designs snake-arm robots specifically to operate in confined spaces. Buckingham directed OC until 2014, when he returned to where he began his early career, UKAEA Culham, this time as a Director and Head of the new Remote Applications in Challenging Environments (RACE) Centre. Under Buckingham's leadership, RACE is involved in exploring many areas of remote operations, including inspection, maintenance and decommissioning and will be instrumental in developing new remote tools and techniques for academia and industry.

Originality/value – With the unique experience of studying at a university's distinctive engineering program while working as a young engineer for the UKAEA who sponsored him, Dr Buckingham found his lifelong passion and career in robotics for remote handling. He was one of the creators of the emerging field of snake-arm robotics. He is now applying his innovative, commercial technologies and strategies from working in the nuclear, aerospace, construction and petrochemicals sectors to the industry of nuclear fusion. Dr Buckingham was awarded The Royal Academy of Engineering Silver Medal in 2009. In the same year, his company OC Robotics won the Queen's Award for Enterprise in the category of Innovation. Buckingham is also a Fellow of the UK Institute of Engineering Technology, a Fellow of the Royal Academy of Engineering and a visiting professor at the Bristol Robotics Laboratory. He was co-chair of the Robotics and Autonomous Systems (RAS) Special Interest Group Steering Group during the preparation of the influential UK RAS strategy, which has since been adopted by UK Government.

Keywords Robotics, Inspection, Robot design, Nuclear, Actuators, Hazardous

Paper type Case study

Pransky: What led you to the field of robotics?

Buckingham: I always loved engineering. I chose Brunel University in London because it provided a special course which combined mechanical, electrical and production engineering. I focused on math(s) and control theory in the final years. My undergraduate degree project was on collision avoidance of robots, and thus my engagement in robotics started early on (Figure 1).

I was also very lucky to have been sponsored all the way through university by the UK Atomic Energy Authority (UKAEA; www.gov.uk/government/organisations/uk-atomic-energy-authority) in a "sandwich" course in which I spent six months studying at university and the other six months each year working at UKAEA around the UK and Europe.

I spent quite a bit of time within the JET (Joint European Torus; www.euro-fusion.org/jet/) remote handling group,

The current issue and full text archive of this journal is available on Emerald Insight at: **www.emeraldinsight.com/0143-991X.htm**

Industrial Robot: An International Journal
43/6 (2016) 577–582

[DOI 10.1108/IR-08-2016-0209]

Received 8 August 2016
Accepted 9 August 2016

Figure 1 Dr Rob Buckingham, Director of UKAEA's Remote Applications in Challenging Environments at Culham Centre for Fusion Energy

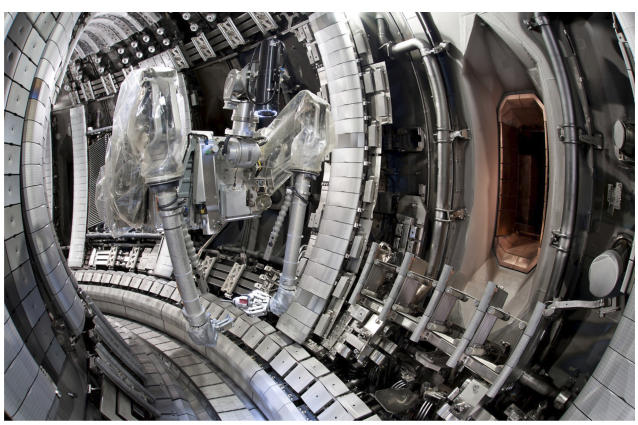
Source: UKAEA

which I now run, so things have gone full circle, but it was there that I saw some amazing robotics. That was really what inspired me right from the age of 18/19.

Pransky: Where did the idea of snake-arm robots for confined spaces come from? (Figure 2)

Buckingham: The original motivation traces all the way back to the remote handling systems at JET, the Joint European Torus that the UKAEA still operates. The JET manipulators are all planar. At the end of my PhD, which was in robot kinematics, I started exploring the maths of hyper-redundant mechanisms. On one of the student projects I ran, I was lucky enough to meet Andy Graham, who won all the engineering project prizes. We started thinking about whether we could design and control these robots. Later we wondered: How could you design mechanisms that would work in three dimensions? How would you solve the math(s)? Andy and I, after a number of years of working on independent projects, decided to focus on snakes and set up OC Robotics (www.ocrobotics.com/ (Figure 3).

Figure 2 The Joint European Torus (JET) planar snake manipulator within the JET vacuum vessel



Source: UKAEA

Pransky: What was the breakthrough moment when it switched from research to "We can do this"?

Buckingham: I don't think there was a particular moment; it was a gradual process. You have to believe right from the beginning that you can get there. If you are not convinced, you should not start, which implies that you have to be optimistic from the get-go. Today's snake arms are mature and robust. OC is probably now at version seven. They're products as opposed to prototypes.

Pransky: Snake robots use very different technology compared to more conventional robots. Could you use technology from other fields? Or were you really having to break new ground?

Buckingham: We had to continually break new ground. Andy led all the design work focusing on the mechanism, which shapes everything else. Mariusz Lichon worked on the software and Nick Parry, the electronics. Of course as with any hardware development, it all has to work, so there were lots of late nights. Moving the motors out of the arm and using wire ropes to deliver torque to the joints was a key step that happened very early on. Since then lots of people have made important incremental changes. The latest big snake has 16 joints which means 48 wire ropes and 48 independent actuators. The idea of wire drive systems is well accepted in some fields, but not particularly in robotics, apart from surgical robotics.

Figure 3 Andrew Graham and Rob Buckingham are the Co-founders of OC Robotics

Source: OC Robotics

Industrial Robot: An International Journal
Volume 43 · Number 6 · 2016 · 577–582

Pransky: With each joint having two degrees of freedom (DOF), what is the most degrees of freedom robot OC has ever built?

Buckingham: We got in the Guinness Book of Records with a 27 degrees of freedom system which was a snake on the end of a KUKA industrial robot arm. There's another one called X50 which is a snake on a mobile platform which is 22 DOF. The biggest snake is the one that OC has just built for the nuclear sector which has 16 joints, so that's 32 degrees of snake-arm plus the introduction axis, for a total 33 DOF (Figure 4).

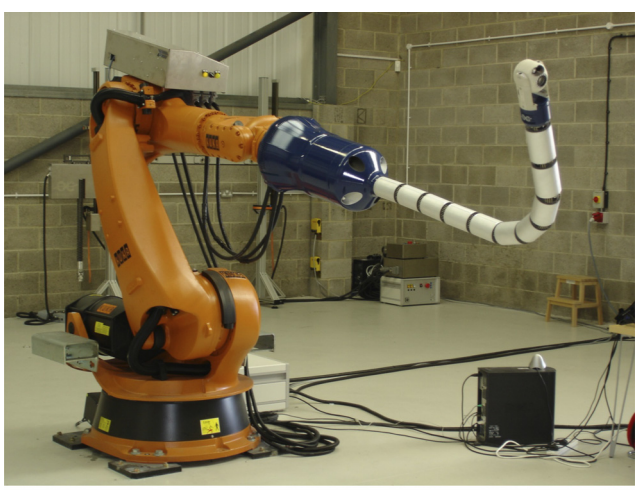
Pransky: Did you have to establish new standards for your new field of robotics, from meeting requirements in different countries and industries?

Buckingham: There's no fundamental difference between a snake-arm and another robot, except that they don't look the same, so new standards *per se* didn't need to be established. The inverse kinematics is very different. Little by little, people have caught on to the fact that this is a new way of doing things: "reaching the unreachable".

Pransky: OC Robotics is a small company. Do you think snake robotics could have been developed by a larger organization or do you think that a hardworking small company is the most effective and cost efficient way to undertake such projects?

Buckingham: I think it could only have happened in a startup primarily because you have to be personally invested to do truly innovative things. In a startup company, the buck stops with you. From the time when Andy and I were working originally in my attic, then the garage before moving on, there was a sense of teamwork that is essential to get you over the difficult things. If you were an employee of a large company, I think you would have to be continually convincing your management to carry on because the path is rarely straightforward. Of course, big companies are tremendously innovative and they mostly achieve this by creating small teams and giving them the air to breath. Still there's something special about a startup. There's a buzz.

Figure 4 OC Robotics innovative snake-arm robot is attached to a high payload KUKA arm for aerospace applications



Source: OC Robotics

Pransky: How did OC receive funding?

Buckingham: OC has only had one round of funding thus far, in 2001 from a dragons' den type pitch to a bunch of investors. Since then it's been self-financing.

Pransky: Did you ever consider becoming a public company and did you achieve your early goal of making money out of robots?

Buckingham: Never say never – it's not up to me now. Making money out of robots – now that's a question of the quantum. OC has done OK.

Pransky: If you were starting again today, would you try for crowd funding?

Buckingham: Investment goes hand in hand with control. So one question is: as founders are you able to actually direct and lead the company in a certain direction? I have no experience with crowd funding. OC investors have been very supportive.

Pransky: Did you ever feel like giving up?

Buckingham: Of course, but we didn't.

Pransky: Can you speak about why you left OC to head up RACE (Remote Applications in Challenging Environments)?

Buckingham: Leaving OC was a really tough decision. OC is still a massive part of my life - I would be deceiving you if I said anything else. Just a few weeks ago OC invited me to see the end of a big project that I helped initiate. The kit that they've made is just awesome. Craig Wilson, the new Managing Director, and the team have done a really great job. Seeing it working at Sellafield Ltd (www.sellafieldsites.com/) was one of those "yippee" moments. But, "life is short" and setting up RACE was another once in a lifetime opportunity.

I was intrigued to see what it is like in a government organization, and how the decision-making processes work. There's also the challenge of encouraging large end-user organizations to invest, and to pull robotics, so that it's less of a technology push. I think that we're at a critical stage in robotics around the world - close to a tipping point. We're seeing increasing levels of serious interest from end-user companies, from the military to the nuclear sector to transport systems. These industries are slowly realising the potential, but disruptive change is the hardest to deliver. Moving from an SME (small and medium-sized enterprise) into a national laboratory sounds like a huge change, but in a sense, all I've done is to adopt a different personal strategy to achieve the same end result.

Industrial Robot: An International Journal
Volume 43 · Number 6 · 2016 · 577–582

Pransky: Can you tell us a bit about UKAEA's RACE (www.ccfe.ac.uk/) and your role? (Figure 5)

Buckingham: UKAEA received about £10million to invest in a new building and expose the existing expertise in the JET remote handling group to other sectors. The team of 80 has now moved into the building, which was opened by science minister Jo Johnson in May 2016. Fusion is one of those humanity-changing ideas. All positive visions of future humanity rely on a plentiful supply of electricity. To generate electricity from fusion you have to get the physics right and you also need the engineering to get commercial plant availability. You're trying to get hydrogen to fuse, which happens naturally in the Sun and on Earth, at temperatures of 200 million degrees Kelvin. Fusion creates highly energetic neutrons which carry the energy that you want to convert into electricity. These and gamma radiation mean that everything close to the reactor has to be operated and maintained remotely. Fusion won't deliver electricity without robotics and automation. It's actually one of the most challenging robotics problems to solve – perhaps that's part of the appeal (Figure 6).

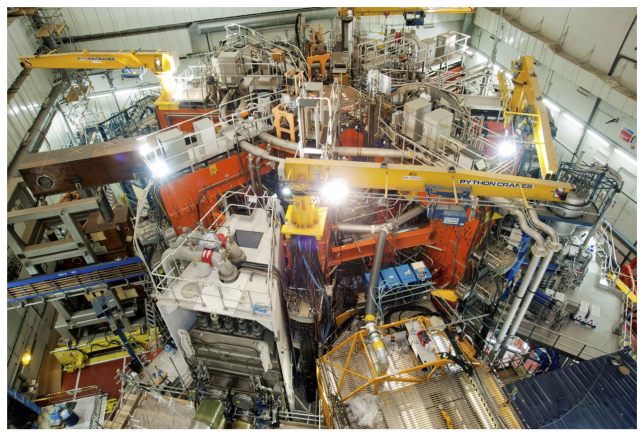
Previously, the UKAEA hasn't been well-connected with wider robotics communities because the fusion community has been somewhat self-contained. I'd like to put RACE at the heart of global robotics initiatives. Trying to implement robotics in really hostile environments, be it a fusion reactor, in space, down a mine or an autonomous vehicle on the road, is very demanding. We know there are lots of common challenges. We need to learn together to minimize costs and reduce time to market. It would be good to set up conferences and exchanges between some of the international labs. My hope is that I can create the space for some bright young people to do some really cool stuff.

Another thing, which is really important, is that you have to convince the investors, including politicians that the investment is actually worth it. People underestimate the time it takes to develop robust reliable hardware. I think there's a general misconception here. It feels like things are happening faster but actually I think that sense of speed is because more things are happening in parallel. Some things are taking longer. When you take robotics out of the research world and into the real world, some people are really excited, some don't always understand, some are a bit apprehensive and some are skeptical, so you have to win people over and prove to them that the robotic technology works.

Figure 5 The UKAEA Culham Centre for Fusion Energy's Remote Handling Unit is recognized within the global fusion community as lead specialists in the successful, on time delivery of practical solutions

Source: UKAEA

Figure 6 The world's largest and most powerful operating tokamak is located at UKAEA's Culham Centre for Fusion Energy



Source: UKAEA

Pransky: Will Brexit affect RACE at all and what are your general comments on Brexit for the European academic/research communities?

Ah, the Brexit question. The problems that face us all are increasingly global in nature. Someone said recently: "Brexit means Brexit and now we have to work out what Brexit means." My sense is that we will do OK, not least because we have no option! People talk about divorce but I think this is more like leaving home. I have kids doing just that - it's a very exciting time for them, still just as full of promise as it has always been. What we really need is a few Isambard Kingdom Brunel's, (https://en.wikipedia.org/wiki/Isambard_Kingdom_Brunel), brave long-term investors and some seriously good politicians and civil servants. We need visionaries and we need leaders. The UK will do OK.

Pransky: You've taught at a university. You've entrepreneured a successful startup in private industry. You're now leading a government organization. Can you talk about the pros and cons of these roles?

Buckingham: The most challenging by far is employing people and being responsible for paying their wages. That sense of responsibility is something that goes hand in hand with running a company and I suspect that that takes a certain type of character. When you're an academic or working for a government lab, you have more security. That can release you but it can also increase the damping coefficient.

Industrial Robot: An International Journal
Volume 43 · Number 6 · 2016 · 577–582

One of the reasons that I stopped being a researcher and lecturer – and I was enjoying being a lecturer as it was great fun working with smart students – was because we kept on doing things that gathered dust. We did great stuff that we were pleased and proud of and people would say, "Great. Well done." But there it stopped. There's a sense of frustration when you say, "Hang on, we can do this, so why are we not taking it further"? That is why I left academia. I wanted to do robotics for real and make it work.

Pransky: What is the biggest mistake you learned from?

Buckingham: Of course, you make mistakes in business and hindsight is cheap. The important thing is that the good decisions outnumber the less good!

Pransky: Is there a greatest lesson that you could share?

Buckingham: I think increasingly, it's all about people. When you are working in technology, people tend to think that it's all about the engineering. But engineering is a team game; the whole internal team working together. That internal team then extends to the people who are making decisions about how to use the equipment and these people are also very much a part of the process. The whole process involves a lot of people – it's all about the people.

Pransky: What is your proudest moment of your career?

Buckingham: The first is when Andy and I won the Royal Academy of Engineering Silver Medal (www.raeng.org.uk/). It was awarded to us jointly and that's indicative of a larger team effort. There are only four awards each year and that's for the whole of engineering. That was a bit special. The second one was realising that people thought the UK Robotics and Autonomous Systems (RAS) Strategy made sense. Most documents for government have a very short shelf life but this one is hanging around. My third proudest moment is seeing what the OC team has achieved in LaserSnake2 [Figure 7(a) and 7(b)].

Pransky: What do you think PhD and Masters of Engineering students should be doing while in school, to prepare them best for the commercial side of robotics?

Buckingham: I would encourage anybody who's doing a PhD to think about whether they can actually start their own business. It's never too early to try, and I really believe that you are better off learning by doing rather than trying to learn it from books. I would love to see some change to PhDs whereby there's a possibility, for instance, of a fourth year which is specifically to transition ideas into a product or service. Imagine if we had PhD candidates who have done some great stuff able to say, "OK, I'd like to have a go. Let's see if this works in the marketplace." If they had funding for a year to try, then one or two, or whatever percentage, might make it, and the whole bunch would learn about the challenges of running a business. The experience will enhance their curriculum vitae (CV), but having a go at their own company is what I would like people to have the opportunity to do.

About the author

Joanne Pransky has been an Associate Editor for *Industrial Robot* journal since 1995. Joanne was also one of the Co-founders and the Director of Marketing of the world's first medical robotics journal – *The International Journal of Medical Robotics and Computer Assisted Surgery*. Joanne served as the

Figure 7 (a) OC Robotics LaserSnake modular arm system; (b) LaserSnake cutting a nuclear steel cylinder

(a) (b)

Source: OC Robotics/TWI

Industrial Robot: An International Journal
Volume 43 · Number 6 · 2016 · 577–582

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