HAVE SOMETHING TO SAY?
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LETTERS

RESPONSE TO CATAPULT CENTRES

I am confident that the Catapult centres featured in *Ingenia* 58 are oases of creativity, reinvigorating much of the related industrial region by providing invaluable R&D support to many single-product or niche-market companies and essential assistance to some start-ups.

However, to thrive in a competitive world, we need more than this: we need the vigorous growth of innovation throughout our industrial landscape. We should recognise that not all industrial needs can be covered by, or are amenable to, such centralised coordination or support, and that not all the Catapult centres' target users will be suitable recipients and gain full benefit. All creative projects, even those benefiting from a Catapult-boost, will need their own sustained innovative drive. This often entails unscheduled effort, unbudgeted expenditure and uncertain outcomes for the company concerned.

We need a culture, particularly in reasonably-sized companies with ambitious research and development programmes, where managers accept the need for some flexibility in plans and budgets, and engineers do their best to fit their innovative creativity into a framework of structured planning and resource management. In my experience, reasonably flexible resource allocation, with a margin for self-initiated work, enables creativity. To accommodate radical innovation, contingency funding on projects must also provide for the opportunities opened up by lateral thinking, and sufficient staff have to be employed on research so that some can be redeployed at need.

The development of an engineering product proceeds from basic concept via proof of principle, development and production to deployment, in-service maintenance and logistic support, and finally to technical and functional updating and upgrading. Awareness of all phases ensures that early work lays sound foundations for the later ones, and later work understands the reasons for earlier decisions. This requires good documentation and cradle-to-grave project management, complementary to specialised research, development, production, maintenance, and post-design engineers. Hence, R&D programmes should be evolutionary, each step maximising the options for subsequent steps.

Completing a long-term research project to spec, on time and on budget may merely reflect a lack of ambition in planning and execution for all three targets. Of course there must be a plan and budget, but they should exist for guidance, not as a rigid straitjacket.

Just as multiple companies may call upon the support of a given Catapult centre, so, within a single company, a programme of research projects should draw on the support of a common set of expert technology groups, and expert groups in production engineering, maintenance of the end product, and provision for eventual technical updates and functional upgrades, each providing expertise and know-how in its specialised area. These expert support groups may also conduct or sponsor their own research, to expand their knowledge base, or cooperate with a relevant Catapult centre.

The matrix structure of projects and supporting expert groups in larger companies weaves the warp of projects and the weft of technologies into the fabric of an integrated overall programme and organisation, fostering problem awareness, cross-fertilisation, and innovation, and generating synergies.

My experience, gained over many decades in government R&D establishments, was that virtually all game-changing innovation sprang from self-initiated work, from which I conclude that it is easier for an engineer to visualise a client's problems and potential solutions than for the customer – or administrator – to visualise what technology might do for them.

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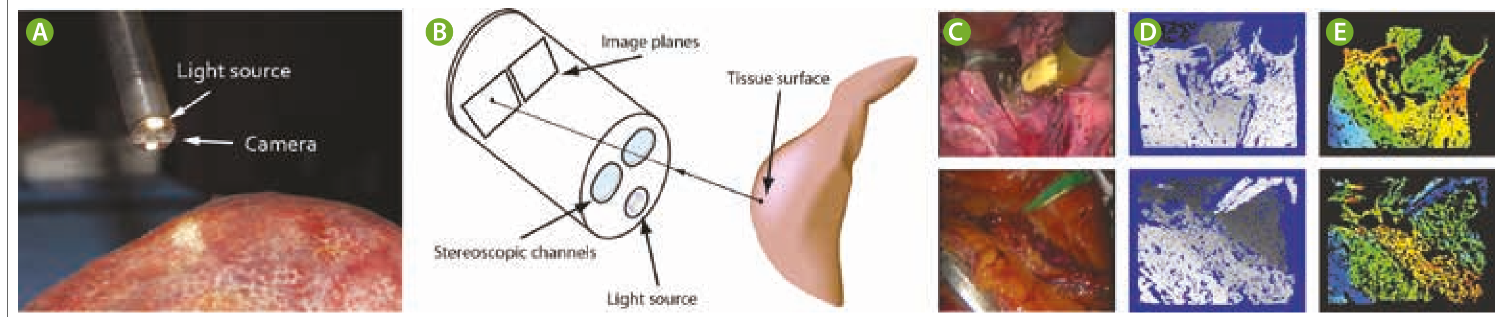
This is an edited version of the author's letter. The full version is available as The Managerial Challenge of Fostering and Exploiting Engineering Creativity *at www.ingenia.org.uk*



A Image of the stereo laparoscope of the da Vinci Surgical System (Intuitive Surgical, CA, USA)
B Schematic showing how light reflected at the tissue surface forms an image observed by the surgeon
C Two example laparoscopic images taken from robotic surgery
D Depth maps showing the distance of tissue away from the camera as a grey scale computed from the images in C using surgical vision
E Motion heat maps representing the motion of tissue between consecutive image frames for the surgical scenes shown in C computed using surgical vision
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RESPONSE TO ROBOTS IN THEATRE

The perspective on robotic surgery given by Professor Davies FREng (in *Ingenia* 58) highlights some key issues in a rapidly developing field. I think that while the term robotic surgery is undoubtedly exciting and eye-catching, it is important to recognise that the robot is only one component of a wider computerised process where diagnosis, planning, intervention and patient follow-up are all increasingly dependent on computing technologies. It is the synergy between these technologies that offers the most exciting possibilities through the convergence of software, imaging, robotics, sensing, haptics and visualisation.

The mechanical capabilities of the instruments are crucial. With robotics, the tools have the potential to offer high degrees of flexibility and articulation within confined anatomical spaces, allowing surgeons to perform procedures with minimal access trauma. However, for these capabilities to be meaningfully utilised and adopted in clinical practice, they must be adapted to the surgeon who is the end user. The surgeon must master control of the system's functionality and be able to comfortably, precisely and repeatedly manoeuvre instruments to interact with tissues. In this way, the robots' function will be to extend the surgeon's operating skills. With the growing complexity of robotic instrumentation, this human-machine coupling will become increasingly important to get right. It will require, and be dependent on, appropriate training and education programmes.

Another critical consideration is that instrumentation is only valuable when the surgeon is able to clearly see the operating site. Surgical actions are predominantly driven by clear visualisation, not always via visible light, and the surgeon's understanding of the spatial position of anatomical structures. Therefore, real-time surgical imaging, sensing and vision are crucial to provide the surgeon with the information required for making decisions and taking action. Laparoscopic imaging in particular has been a key factor in the current success enjoyed by tele-manipulator robotic systems. To enable the full capabilities of future dexterous instrumentation, it is critical to develop new ways of acquiring and processing information beyond what is visible to the naked eye. Exciting possibilities in this area are offered by biophotonics and studying the interaction between tissue and non-harmful energies such as light or sound and advanced computational processing of the resulting signals. These can be combined with the wealth of pre-operative patient information to inform the surgeon about the structure, characteristics and function of the anatomy during surgery.

With the appropriate interface and vision capabilities, robotic devices can transform surgical practice. Of course, there are still significant questions about the role, cost and ultimate patient benefit resulting from the use of robotics in surgery. Debate on these is likely to continue for some time; however, to me it is clear that surgical robots are here to stay and their role in modern interventional healthcare will be increasingly significant.

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