Checklists, rules and creativity

Hi-tech businesses are well known for having to be innovative to stay ahead of the competition, but as **Thomas Glasmacher** argues, university research labs could take a leaf out of industry's book

National Superconducting Cyclotron Laboratory

Keying in to process control Management tools from industry can bring real dividends in academia.

Universities have something that private industry wants – a unique culture of continuous learning, curiosity-driven research and international collaboration. According to an unending string of accounts in the business press, adopting this university culture is imperative for survival and success in the "technology-driven" 21st-century economy. The industry poster child for this idea is the IT giant Google. Its success undoubtedly buys the company increasing freedom to experiment with and nurture its own unique culture. But Google is routinely lauded for fostering academic-style debate in meetings, maintaining a fluid organization chart that allows employees to try other roles, and giving its engineers one day a week to pursue their own creative ideas for advancing the company's interests.

As a lifelong academic, I can only conjecture about the private sector. In more mature organizations there may well be some tension between nurturing experimentation and innovation on the one hand, while maintaining a firm-handed approach to operational discipline on the other. I know for a fact that many researchers in large universities seek the same tenuous balance of discipline and creativity, though we often approach the problem from the opposite direction. Namely, we seek to preserve our tradition of blue-sky research even as we put in place processes to eke out new efficiencies in a time of rising international competition and dwindling budgets.

In recent years, the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University, where I work, has sought the right mix of strict process and creative inquiry. The NSCL is a user facility that serves a community of more than 700 scientists from 32 countries studying fast beams of isotopes by accelerating nuclei to half the speed of light, smashing them into a thin target foil, and then using magnets to filter out the few desired exotic atoms from the reaction products. In many respects these researchers are our "customers", counting on us to make and meet commitments regarding the performance of our "products" – the fast beams of exotic atomic nuclei used in nuclear science.

In 2001 we added several layers of complexity to our operations when we coupled our two superconducting cyclotrons to create what was then the world's leading rare-isotope user facility. We had to improve performance, as measured by beam intensity and experimental uptime, while simultaneously preserving our unique university-style culture of creativity and learning. To do this, we took a number of steps, starting in 2003, to streamline operations at the NSCL but maintain creativity.

Operational overhauls

The first step we took was to move the creative work, such as the design of new magnets and detectors, from the lab's "implementers" – engineers who build 3D models of new devices – to its "innovators", who are senior physicists and faculty members. Historically, innovators would stay involved in projects well into the building and testing phase of new devices. This was a problem because innovators who conceive new technologies are more valuable to the lab when they are running calculations and simulations than when they are reaching for a wrench to debug a new temperamental magnet. So we freed physicists from many of the tasks associated with implementation. Although these researchers continued working with our engineering department to help see projects through to completion, they were relieved from much of the rote work associated with building and testing new technical systems.

There are some signs that the new roles are paying off. The innovators, for example, have recently come up with a new efficient "reacceleration concept", which makes it possible to measure the structure of rare isotopes with in-flight separated, reaccelerated beams, which is especially relevant in nuclear astrophysics. When complete in 2010, the NCSL will be the only facility in the world that can do this.

A second approach has been to streamline the system of accountability associated with operating the scientific heart of our facility: the Coupled Cyclotron Facility (CCF). The CCF is a network of particle accelerators and fragment separators that produces exotic nuclei. Previously, CCF operations were performed by separate groups of engineers, technicians and skilled tradespersons. This inefficient division of labour meant that the responsibility of each group was narrowly defined. The costs associated with mistakes were relatively hidden, since one group of operations personnel was in charge of running the beam through the CCF, while another was responsible for fixing things when the CCF malfunctioned.

Now we have taken a "systems-owner" approach, which requires all operators to be in a single group and be collectively responsible for running and maintaining the CCF. As a result, the costs of mistakes have become clear to all involved and unscheduled downtime has decreased so that the beam is now routinely running above 90% of scheduled time (up from 68% in 2002). Of course, we still want our operators to try new methods of increasing rare-isotope yields or even creating previously unseen isotopes, so managers are instructed to reward and encourage calculated risk taking even as they attempt to drive down costs. Currently, we estimate that the cost of running the beam for a user is about $3000 per hour.

We have also worked hard to document our operational history and understand root causes of past periods of downtime. We now have an online intranet, which includes a network of "wikis" about group- and device-specific documentation. The intranet, which fosters transparency throughout the lab, has been allowed to grow as our organizational capacity has increased. The more individuals rely on these online tools, the more valuable the system is to the whole organization.

Documentation can be something of a challenge given the generally forward-looking orientation of a facility that is built around basic science. But the lab's administrators and users, while focused on the future of rare-isotope research, are also incredibly data-driven. Despite some initial reticence, all of them now appreciate how root-cause analysis helps to articulate the cost associated with each downtime, which in turn leads to rational prioritization of maintenance and upgrade tasks.

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Looking forward

The implementation of this work is still very much in progress. However, we have lots of evidence, anecdotal and otherwise, that we are on the right track. In late 2007 our users published a paper in *Nature* (**449** 1022) about the discovery of three unexpected isotopes of magnesium and aluminium that generated news coverage around the world (see *Physics World* December 2007 p4). The experiment, which involved dozens of technical improvements and a high-degree of precision, probably could not have been done prior to our ongoing operational overhaul.

Even during a difficult time in Michigan, which has one of the worst state economies in the US with high unemployment and current worries in the car industry, we remain the nation's second highest ranked graduate programme in nuclear science behind the Massachusetts Institute of Technology and are attracting many students, users and technical staff. Our beam intensities and uptime statistics continue to improve and we now routinely operate at more than 90% uptime, which is high given the complexity of experiments performed at the lab.

The NCSL's site in East Lansing 100 km from Detroit cannot compare with Mountain View, California, where Google is based, in terms of climate, cafes or pop culture; but our innovations have helped to attract to the lab some of the world's most innovative experimental nuclear scientists.

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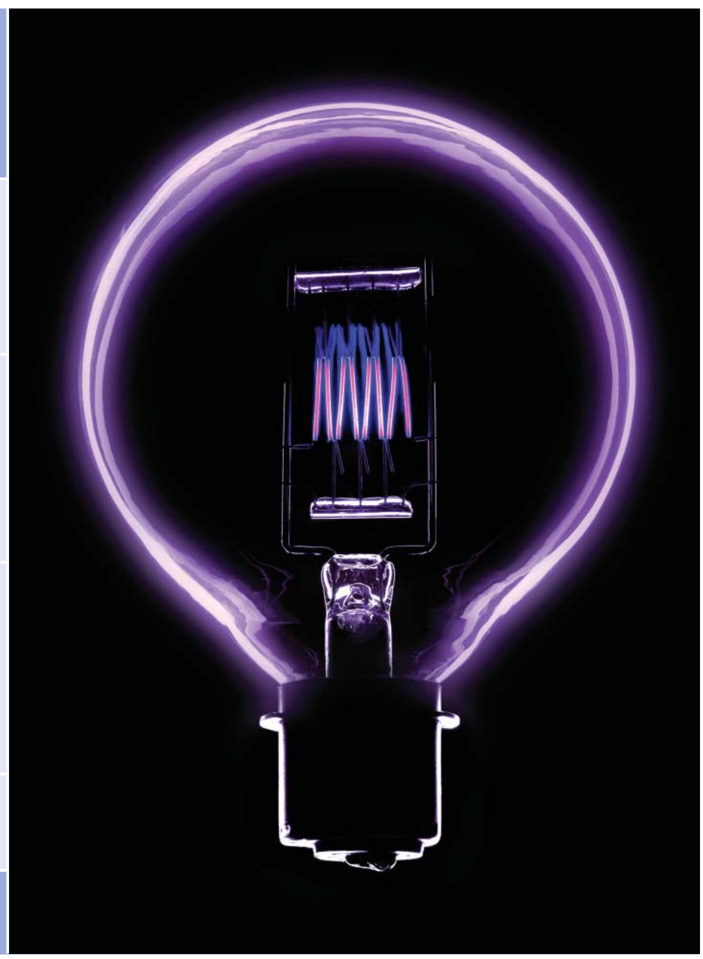

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