EASYMILE/ALAIN HERZOG

Driverless buses are being tested by an innovation consortium in Kista, Sweden.

Twelve principles for open innovation 2.0

Evolve governance structures, practices and metrics to accelerate innovation in an era of digital connectivity, writes **Martin Curley**.

A new mode of innovation is emerging that blurs the lines between universities, industry, governments and communities. It exploits disruptive technologies — such as cloud computing, the Internet of Things and big data — to solve societal challenges sustainably and profitably, and more quickly and ably than before. It is called open innovation 2.0 (ref. 1).

The promise is sustainable, intelligent living: innovations drive economic growth and improve quality of life while reducing environmental impact and resource use. For example, a dynamic congestion-charging system can adjust traffic flow and offer incentives to use park-and-ride schemes, guided by real-time traffic levels and air quality. Car-to-car communication could manage traffic to minimize transit times and emissions and eliminate road deaths from collisions. Smart electricity grids lower costs, integrate renewable energies and balance loads. Health-care monitoring enables early interventions, improving life quality and reducing care costs.

Such innovations are being tested in 'living labs' in hundreds of cities. In Dublin, for example, the city council has partnered with my company, the technology firm Intel (of which I am a vice-president), to install a pilot network of sensors to improve flood management by measuring local rain fall and river levels, and detecting blocked drains. Eindhoven in the Netherlands is working with electronics firm Philips and others to develop intelligent street lighting. Communications-technology firm Ericsson, the KTH Royal Institute of Technology, IBM and others are collaborating to test self-driving buses in Kista, Sweden.

Yet many institutions and companies remain unaware of this radical shift. They often confuse invention and innovation. Invention is the creation of a technology or method. Innovation concerns the use of that technology or method to create value. The agile approaches needed for open innovation 2.0 conflict with the 'command and control' organizations of the industrial age (see 'How innovation modes have evolved'). Institutional or societal cultures can inhibit user and citizen involvement. Intellectual-property (IP) models may inhibit collaboration. Government funders can stifle the emergence

of ideas by requiring that detailed descriptions of proposed work are specified before research can begin. Measures of success, such as citations, discount innovation and impact. Policymaking lags behind the market place.

The challenge is how to execute and govern the new mode. Innovation is a risky business that has high failure rates — 96% of all innovations do not return their capital cost, and 66% of new products fail within two years. But the potential benefits are vast. Innovation policies should recognize that the linear research-and-development model will be outpaced by a nonlinear, open and collaborative innovation process where the mantra is 'fail fast, scale fast'.

"The mantra is 'fail fast, scale fast'."

Awareness of open innovation 2.0 needs to be raised across industry and society. Here I outline the concept and how it works, and offer a set of 'design patterns' — general solutions to common problems. Adopting these can accelerate the move from conceptual to concrete. The European Union's Open Innovation Strategy and Policy Group, of which I am a chair, is a global leader in distilling its knowledge in this way. The goal is that open innovation 2.0 will become a discipline practised by many rather than an art mastered by few.

DIVERSITY COUNTS

Technical innovation is no longer solely the domain of lone scientists in labs. Scientists in the mid-twentieth century at Bell Labs in Murray Hill, New Jersey, are credited with inventing the transistor, the laser and the Unix computer operating system. Today, a more than one-third of the product launches by consumer-goods firm Procter & Gamble — including the fabric softener Bounce — emanate from ideas that started outside the company.

The term open innovation — where ideas pass between different organizations to create value — was coined by organizational theorist Henry Chesbrough[2] in 2003. Today, the concept is evolving fast. Driven by plummeting communication costs and the ever increasing numbers of connected people and devices, it has never been so easy to exchange information and ideas.

For example, InnoCentive, founded by US drug company Eli Lilly, is a website that matches problems posted by companies with scientists who can potentially solve them. So far, more than 59,000 solutions have been proposed in response to about 2,000 challenges with US$48 million paid to solvers. The GreenTouch consortium, led by telecommunications company Alcatel-Lucent, set a goal of community-sourcing ways to improve the energy efficiency of communication networks by a factor of 1,000 by 2020. It delivered a road map for a factor of 10,000. And the ▶

TWELVE PATTERNS

Keys to collaborative innovation

1 **Purpose.** Efforts and intellects aligned through commitment rather than compliance deliver an impact greater than the sum of their parts. A great example is former US President John F. Kennedy's vision of putting a man on the Moon. Articulating a shared value[4] that can be created is important. A win–win scenario is more sustainable than a win–lose outcome.

2 **Partner.** The 'quadruple helix' of government, industry, academia and citizens joining forces aligns goals, amplifies resources, attenuates risk and accelerates progress. A collaboration between Intel, University College London, Imperial College London and Innovate UK's Future Cities Catapult is working in the Intel Collaborative Research Institute to improve people's well-being in cities, for example to enable reduction of air pollution.

3 **Platform.** An environment for collaboration is a basic requirement[5]. Platforms should be integrated and modular, allowing a plug-and-play approach. They must be open to ensure low barriers to use, catalysing the evolution of a community. Challenges in security, standards, trust and privacy need to be addressed. For example, the Open Connectivity Foundation is securing interoperability for the Internet of Things.

4 **Possibilities.** Returns may not come from a product but from the business model that enabled it, a better process or a new user experience. Strategic tools are available, such as industrial designer Larry Keeley's breakdown of innovations into ten types in four categories: finance, process, offerings and delivery[6].

5 **Plan.** Adoption and scale should be the focus of innovation efforts, not product creation. Around 20% of value is created when an innovation is established; more than 80% comes when it is widely adopted[7]. Focus on the 'four Us': utility (value to the user); usability; user experience; and ubiquity (designing in network effects).

6 **Pyramid.** Enable users to drive innovation[8]. They inspired two-thirds of innovations in semiconductors and printed circuit boards, for example. Lego Ideas encourages children and others to submit product proposals — submitters must get 10,000 supporters for their idea to be reviewed. Successful inventors get 1% of royalties.

7 **Problem.** Most innovations come from a stated need. Ethnographic research with users, customers or the environment can identify problems and support brainstorming of solutions. Create a road map to ensure the shortest path to a solution.

8 **Prototype.** Solutions need to be tested and improved through rapid experimentation with users and citizens. Prototyping shows how applicable a solution is, reduces the risks of failures and can reveal pain points. 'Hackathons', where developers come together to rapidly try things, are increasingly common.

9 **Pilot.** Projects need to be implemented in the real world on small scales first. The Intel Collaborative Research Institute runs research projects in London's parks, neighbourhoods and schools. Barcelona's Laboratori — which involves the quadruple helix — is pioneering open 'living lab' methods in the city to boost culture, knowledge, creativity and innovation.

10 **Product.** Prototypes need to be converted into viable commercial products or services through scaling up and new infrastructure globally. Cloud computing allows even small start-ups to scale with volume, velocity and resilience.

11 **Product service systems.** Organizations need to move from just delivering products to also delivering related services that improve sustainability as well as profitability. Rolls-Royce sells 'power by the hour' — hours of flight time rather than jet engines — enabled by advanced telemetry. The ultimate goal of open innovation 2.0 is a circular or performance economy[9], focused on services and reuse rather than consumption and waste.

12 **Process.** Innovation is a team sport. Organizations, ecosystems and communities should measure, manage and improve their innovation processes to deliver results that are predictable, probable and profitable. Agile methods supported by automation shorten the time from idea to implementation.

Innovation Value Institute at Maynooth University in Ireland worked internationally and with competing companies to develop a framework for measuring and improving IT capability, which is now used by hundreds of organizations worldwide.

Companies are opening up their research labs. Philips has converted its research facility in Eindhoven, which had 2,400 employees in 2001, to an open research campus (High Tech Campus Eindhoven) that now houses more than 140 firms and around 10,000 researchers. Breakthrough ideas often emerge at the intersection of disciplines. For example, Keenan, an Irish agricultural-equipment supplier, and telephone company Vodafone have worked with Intel to develop an online service that uses real-time information to provide farmers with nutritional advice for livestock.

Open innovation 2.0 is neither easy nor is it a panacea. It requires courage and energy. But once a critical mass is achieved, innovation can catalyse itself[3]. Just as momentum is the product of mass and velocity, the ecosystem with the most participants and fastest turnover of ideas will be the most successful. Participating organizations must create synergies rather than cancel each other out. High levels of trust and conviction in the shared vision are predictors for eventual success.

A common language helps. Just as architects and engineers can refer to canonical designs when building a bridge, social and technological innovators can improve productivity by following design patterns. These heuristics summarize insights about the innovation process and can be combined (see 'Keys to collaborative innovation'). They shorten learning times and improve the results and pace of innovation.

NEXT STEPS

We have all witnessed how the music and book industries have been transformed by companies such as Apple and Amazon through digitization. Transforming cities, energy grids and health-care systems will be harder. It will need technology breakthroughs, alignment of interests, investment and collaboration across many stakeholders.

Different sectors should explore how disruptive technologies can transform their domain. For example in health care, wirelessly transmitting information from electrocardiograms (a heart-activity test), and using cloud-based analytics, could detect the early onset of conditions such as cardiac fibrillation.

Governments should create innovation strategies that build capacity and focus efforts on nationally important problems. Road maps that set out a sequence of problems to be solved and the innovations required — such as the International Technology Roadmap for Semiconductors — can direct efforts efficiently. Imagine the power of a European or globally agreed road map for smarter cities, more sustainable electrical grids or health-care transformation. The risks of collaboration can be reduced by publishing model contracts for public–private partnerships. Measurement instruments such as Europe's Innovation Union Scoreboard can identify which areas of a country's innovation ecosystem need to be strengthened.

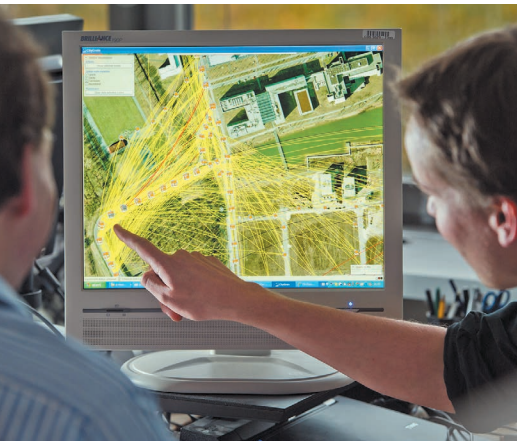
The EU should expand its ambition beyond creating a European Research Area to nurturing a European Innovation Ecosystem. It is promising that a priority for the current Dutch presidency of the EU is ensuring that all European funding instruments focus more on innovation. EU research commissioner Carlos Moedas proposed that the establishment of a European Innovation Council (EIC) would be an important intervention. The EIC could be the steward of an overall European innovation strategy and of societal-challenge road maps.

Governments should encourage the adoption of innovations as well as their creation. They should modulate spending, incentives and policy depending on technology maturity. Immature technologies with high potential need research and pilot projects funded; more-proven prototypes require support for capital deployment cost as well as incentives such as tax credits or loan guarantees. For example, in the United States, incentive payments were used to encourage physicians to adopt electronic health records. Leaders should note the public's increasing desire to be involved in innovation efforts, as exemplified by citizen-science initiatives.

A cultural shift is at the core of open innovation 2.0. The technology is ready — are we? ■

HOW INNOVATION MODES HAVE EVOLVED

Closed innovation	Open innovation	Open innovation 2.0
Dependency	Independency	Interdependency
Subcontracting	Cross-licensing	Cross-fertilization
Solo	Bilateral	Ecosystem
Linear	Linear, leaking	Nonlinear mash-up
Linear subcontracts	Bilateral	Triple or quadruple helix
Planning	Validation, pilots	Experimentation
Control	Management	Orchestration
Win–lose game	Win–win game	Win more–win more
Box thinking	Out of the box	No boxes!
Single entity	Single discipline	Interdisciplinary
Value chain	Value network	Value constellation



Intelligent-lighting sensors can collect useful data about urban activities for city planners.

FRANK VAN BEEK/PHILIPS LIGHTING

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1. Curley, M. & Salmelin, B. *Open Innovation 2.0 — A New Paradigm* (EU Open Innovation and Strategy Policy Group, 2013).
2. Chesbrough, H. *Open Innovation: The New Growth for Creating and Profiting from Technology* (Harvard Business School Press, 2003).
3. Curley, M. & Formica, P. (eds) *The Experimental Nature of New Venture Creation: Capitalizing on Open Innovation 2.0* (Springer, 2013).
4. Porter, M. E. & Kramer M. R. 'Creating Shared Value' *Harvard Bus. Rev.* (January–February 2011).
5. Gawer, A. (ed) *Platforms, Markets and Innovation* (Edward Elgar, 2011).
6. Keeley, L., Walters, H., Pikkel, R. & Quinn, B. *Ten Types of Innovation: The Discipline of Building Breakthroughs* (Wiley, 2013).
7. Rogers, E. M *Diffusion of Innovations* 5th edn (Simon and Schuster, 2003).
8. Von Hippel, E. *The Sources of Innovation* (Oxford University Press, 1988).
9. Stahel, W. *The Performance Economy* 2nd edn (Palgrave Macmillan, 2010).

CORRECTION

The Comment 'Seven chemical separations to change the world' (D. S. Sholl and R. P. Lively *Nature* **532,** 435–437; 2016) gave the incorrect units for atmospheric distillation. It should have read 230 GW globally.