Institution: University of Cambridge
Unit of Assessment: UoA 12 Engineering
Title of case study: Roadmapping for Strategic Technology and Innovation Management
Period when the underpinning research was undertaken: 2004 – 2019

Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Dr Robert Phaal	Director of Research	1997 – present
David Probert	Reader in Technology Management	1991 - 2018

Period when the claimed impact occurred: August 2013-July 2020
Is this case study continued from a case study submitted in 2014? No

1. Summary of the impact (indicative maximum 100 words)

Research into Strategic Technology and Innovation Management approaches and tools at the Institute for Manufacturing (IfM) at the University of Cambridge has benefitted businesses, non-profit organisations and charities in developing strategies and plans for shaping the future of their organisations. **[text redacted for publication],** was instrumental in developing the successful EUR1,000,000,000 proposal for the EU Graphene Flagship which currently has a workforce of 1675, is driving new approaches to workplace well-being in the rail sector and creating jobs, and is guiding the deployment of new technologies for search and rescue by the Royal National Lifeboat Institution. IfM supports translation of the research into practice by working collaboratively with organisations to develop strategy 'roadmaps' and by helping organisations develop in-house roadmapping capabilities.

2. Underpinning research (indicative maximum 500 words)

Research at the Institute for Manufacturing (IfM) at the University of Cambridge has led to new planning methods and tools that support organisational strategy and decision making. Structured approaches to planning developed in the research aid organisations in developing 'roadmaps' for identifying new opportunities for growth and support the management of risk. The structured roadmapping approaches are underpinned by visual toolkits developed in the research.

Early research focussed on roadmapping approaches for strategy and planning for businesses in technology-intensive fields where the rate of change is high and markets can be disruptive. In [R1], general characteristics of technology roadmaps were identified and a 'fast-start' roadmapping process was introduced. The developed roadmapping approach is a combination of process, e.g. structured workshops, and visual tools for articulating and communicating a roadmap. The fast-start method was illustrated in [R1] for two cases in the context of disruptive technological trends. The research in [R1] was developed into the concept of integrated toolkits in [R2] for technology management. The plethora of tools and processes that are available to support management decisions may not interact consistently, robustly or transparently, and [R2] addressed this issue and proposed how to work consistently and robustly across management planning tools.

Further research focussed on the effective development and application of strategic technology management tools in industrial settings based on collaborative deployments with industry [R3]. This included the roadmapping toolkits themselves, managing the complexity of roadmapping, and the social aspect of how groups within a business can best collaboratively develop effective and successful roadmaps for technology management. Seven principles were defined in [R3] – human-centric, workshop-based, neutrally facilitated, lightly processed, modular, scalable, visual – for the development of strategic technology toolkits that are industrially relevant and academically robust.

Roadmaps are visual tools, and the value of visual tools were advocated and demonstrated in [R1, R2, R3]. In [R4] the visual/graphic design of roadmaps, which had been largely overlooked, was considered. The research investigated the importance of graphic design in communicating roadmaps effectively, and in particular how design supports alignment of the roadmap presentation with the target audience. The research proposed a methodology for developing visual designs driven by a set questions for the designer. The design approach was demonstrated in [R4] using roadmaps for the EU-funded Graphene Flagship (a EUR 1 billion programme, launched in 2013), with designs considered for two groups: programme funders and industrial stakeholders. A roadmap for the Graphene Flagship is shown in Figure 1.
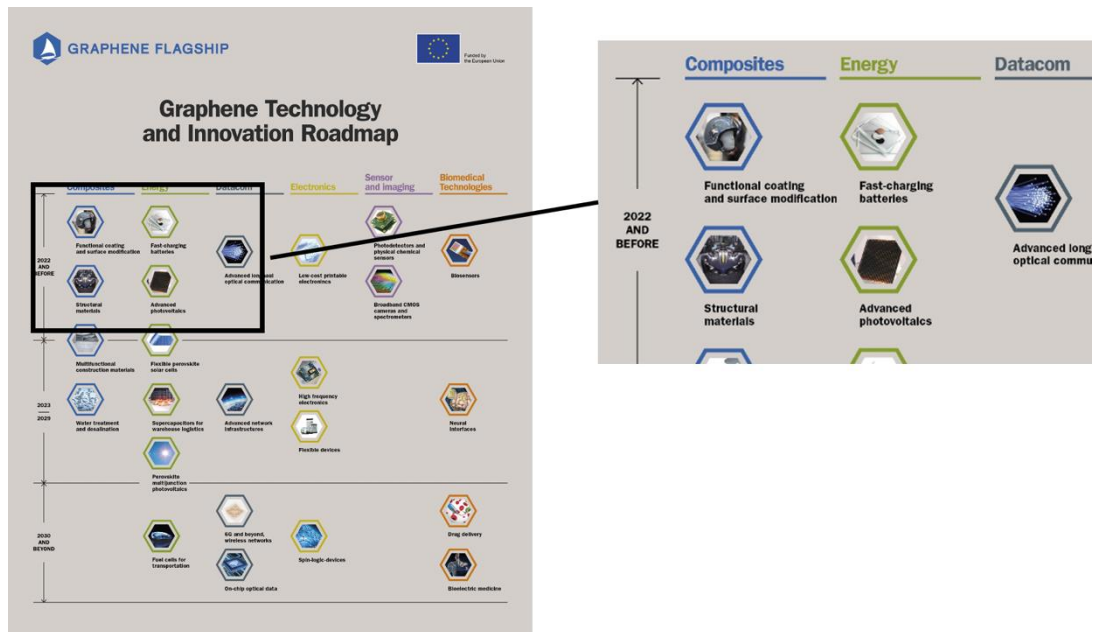

Figure 1: An example of one of the roadmaps from the EU Graphene Flagship.

A feature of the underpinning research is that the early developments have been further developed and refined in close collaboration with businesses from a wide range of sectors, and the necessary adaptions for different sectors investigated. In [R5] Kerr and Phaal explored with the LEGO Group the deployment and customisation of roadmapping processes, starting from reference approaches [R1] and investigating and reporting on adaptions and implementation in LEGO context. This research provided guidance on how organisations can approach the adaption and configuration of reference strategic roadmapping approaches and tools for their specific circumstances.

3. References to the research (indicative maximum of six references) **bold = Cambridge**

R1. **Phaal, R., Farrukh, C.J.P. & Probert, D.R**. (2004), 'Technology roadmapping – a planning framework for evolution and revolution', Technological Forecasting & Social Change, 71(1-2), pp. 5-26. DOI: 10.1016/S0040-1625(03)00072-6.

R2. **Phaal, R., Farrukh, C.J.P. and Probert, D.R.** (2006), 'Technology management tools: generalization, integration and configuration', International Journal of Innovation and Technology Management, 3 (3), pp. 1-19, DOI: 10.1142/S021987700600082X.

R3. **Kerr, C., Farrukh, C., Phaal, R. and Probert, D**. (2013), 'Key principles for developing industrially relevant strategic technology management toolkits', Technology Forecasting & Social Change, 80(6), pp. 1050-1070, DOI: 10.1016/j.techfore.2012.09.006.

R4. **Kerr, C. and Phaal, R**. (2015), 'Visualizing roadmaps: a design-driven approach', Research-Technology Management, 58 (4), pp. 45-54, DOI: 10.5437/08956308X5804253.

R5. **Kerr, C., Phaal, R**. and Thams, K. (2019), 'Customising and deploying roadmapping in an organisational setting: the LEGO Group experience', Journal of Engineering and Technology Management 52:48-60, DOI: 10.1016/j.jengtecman.2017.10.003.

Research outputs have been published in peer-reviewed journals. Research also supported by competitively won grants. Grants:
  (a) EPSRC GR/L62900/01, STRATEGIC TECHNOLOGY MANAGEMENT: LINKING TECHNOLOGY RESOURCES TO COMPANY OBJECTIVES (1998 to 2001), GBP271,948

  (b) EPSRC GR/R64919/01, Innovative Manufacturing Research Centre Renewal (2004 to 2012), GBP419,000

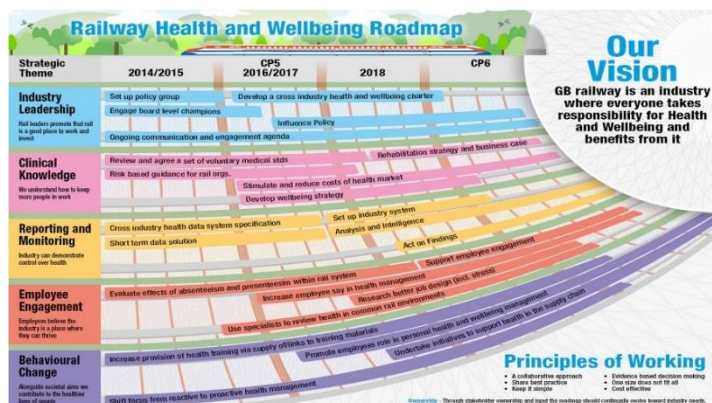**4. Details of the impact** (indicative maximum 750 words)

The application of roadmapping research conducted at the University of Cambridge has led to improved business performance and practices, and the adoption of new technologies for businesses and non-profit organisations. The translation of roadmapping research into practice is accelerated by IfM's Education and Consultancy Services through training courses and consultancy. Between 2014 and 2019, IfM has supported organisations through over 400 roadmapping and visualisation projects, generating over GBP5,000,000 in project revenue, and training courses for over 500 participants [E1]. The Strategic Technology and Innovation Management Consortium was formed at IfM in 2013 to connect roadmapping research to practice. In 2020 the consortium had 20 members, including De Beers, GlaxoSmithKline, Huawei, Johnson Matthey, Michelin and Subsea 7.

Subsea 7 is a global engineering business with 14,000 employees delivering offshore projects and services. Since 2015, Subsea 7 has worked with IfM on roadmapping to guide their corporate strategy. **[text redacted for publication]** [E2].
[text redacted for publication]

Innovation and Technology Manager, Subsea 7 [E2]

The **Rail Safety and Standards Board (RSSB)** supports the rail industry in Great Britain in improving the health and safety performance. In 2013 the RSSB estimated that sickness and absenteeism was costing the industry GBP316,000,000 per year [E3]. In the Winter of 2013, IfM worked with RSSB to create a roadmap for the industry's strategy and vision for health and well-being (see opposite for the Roadmap itself). The Roadmap has been guiding initiatives to improve health and wellbeing since 2104.

"*Roadmapping enabled us to bring together views from over 60 organisations to create a plan that is guiding the direction of activity in relation to the key strategic themes. We have progressed significantly in the last four years from a situation where organisations were questioning the activity they should be doing to an acceptance of the importance of health and wellbeing across the rail sector. UK rail organisations are increasing the numbers of health experts and budgets for health initiatives within rail companies. As an example, one large organisation has gone from employing one person in occupational health to employing 18, with similar investment across a number of organisations. . . The roadmap has had the biggest single impact on what we are doing in health and wellbeing and is fundamental to the progress we have made and our plans moving forward.*"

Health and Wellbeing Programme Manager at RSSB [E3]

The **EU Graphene Flagship** used roadmapping in developing its successful 10-year, EUR1,000,000,000 Future and Emerging Technology Flagship programme bid [E4]. The industry-academic collaboration to develop and apply graphene in industry launched in October 2013. The Flagship workforce was 1,675 strong on March 2016 [E5], and it had 78 industrial partners in 2019 [E6]. Roadmapping is used in ongoing strategic planning, with in-house capacity now in place.

"The roadmap that we prepared together with the Cambridge team in connection with the flagship proposal has proven much more accurate and robust than anyone could expect. It summarizes our plans in a condensed, visually appealing way, and is still used when presenting the Graphene Flagship to diverse audiences. We have since formed our roadmapping activities to a tool that is continuously updated and provides key input when we plan the next stages of our work."

Director of the Graphene Flagship, Chalmers University of Technology [E4]

The Royal National Lifeboat Institution (RNLI) has used roadmapping since 2016 to support their goal of halving the number accidental coastal deaths by 2024 through technological advances. Outcomes of roadmapping include (i) establishment in April 2019 of a 12-month trial of unmanned aerial vehicles for searches in hazardous locations, (ii) withdrawal of RNLI investment in bespoke systems where commercial investment was increasing, and (iii) trialling of new systems for securing donations [E7].

"*Our use of current and emerging technologies will be more effective if we have a comprehensive view what's going on across the sector, helping us to collaborate with the right organisations on the right projects. Roadmapping is playing a significant part in how we are doing this.*"

Future Lifesaving Innovation Lead, RNLI [E7]

John Hogg Ltd, a manufacturer of chemical marking systems for protection against counterfeit and tampering, worked with IfM in 2017 to create a new business strategy and embed roadmapping within the organisation. Impacts include [E8]:

- Reallocation of GBP1,400,000 in R&D investment to focus on other key growth areas.
- Investments in new equipment and new staff to improve operation efficiency by 20%.

On the roadmapping approach:

"We felt that for us as an SME the return on our investment was high. Not only did it help crystallise our vision for the business, it gave us confidence in our decision-making."

Technical and Commercial Director, John Hogg Ltd [E8]

5. Sources to corroborate the impact (indicative maximum of 10 references)

E1: Consultancy and project data from IfM ECS (IfM Education and Consultancy Services).

E2. Confidential: Subsea 7 corroboration statement, 31-06-2019

E3. Rail Safety and Standards Board Case Study,
https://www.ifm.eng.cam.ac.uk/ifmecs/business-tools/roadmapping/roadmapping-case-studies/rssb-case-study/

E4. Graphene Flagship proposal preparation email.

E5. Graphene Flagship workforce numbers, https://graphene-flagship.eu/project/womeningraphene/Pages/Workforce-Statistics.aspx.

E6. Graphene Flagship industrial partners, https://graphene-flagship.eu/news/Pages/European-industries-lead-new-Graphene-Flagship-projects-to-shape-EU%E2%80%99s-environmental-future.aspx.

E7. The Royal National Lifeboat Institution Case Study.

E8: John Hogg Ltd Case Study, https://www.ifm.eng.cam.ac.uk/ifmecs/business-tools/roadmapping/roadmapping-case-studies/john-hogg/