UNIVERSITY OF CAMBRIDGE

University of Cambridge

Centre for Technology Management

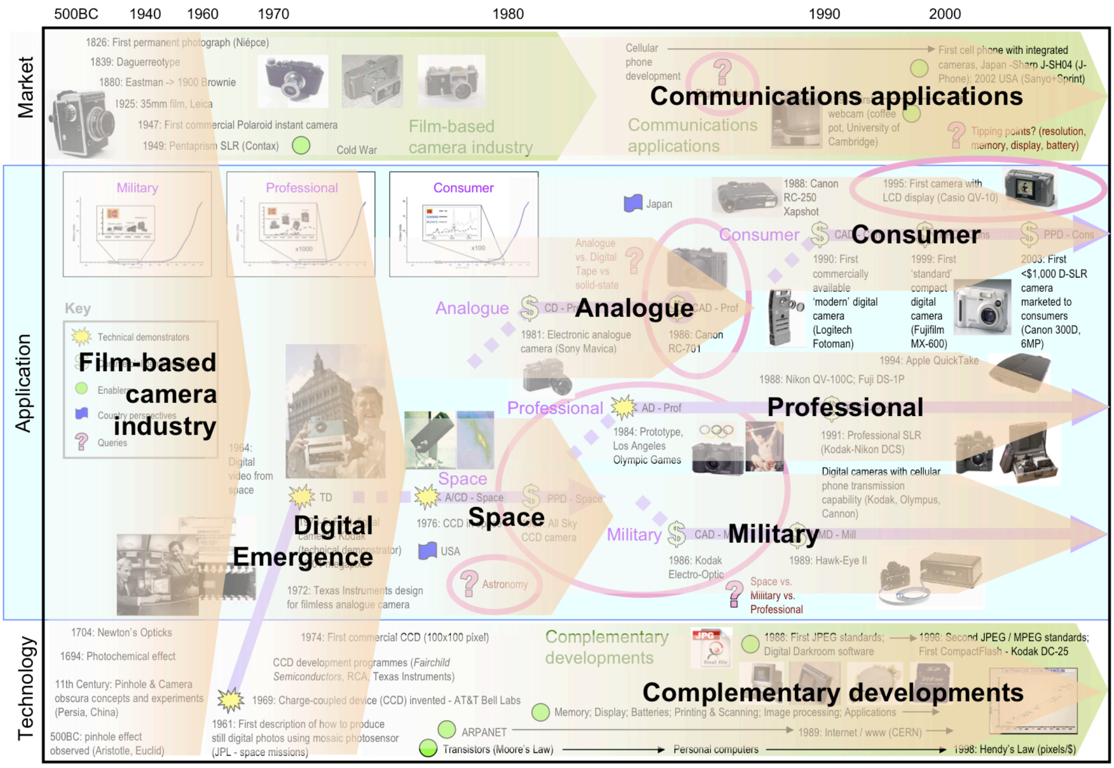
IfM MANAGEMENT TECHNOLOGY POLICY

Institute for Manufacturing Emerging Industries Programme

Managing Creation and Transitions Project

Industry Scan

Guidance for mapping historical industrial emergence, evolution, development and change



R. Phaal, E. O'Sullivan, M. Routley, S. Ford and D. Probert

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1. Overview

The Industry Scan method described in this document was developed as part of the Institute for Manufacturing's Emerging Industries Programme (EIP)[1], as a deliverable from the Managing Creation and Transitions Project[2]. It forms part of a suite of related approaches, underpinned by a conceptual framework, with a particular focus on technology-intensive innovation:

a) *Industry Scan:* mapping and understanding historical industrial emergence, evolution, development and change.
b) *Expert Scan:* interview-based mapping of historical industrial emergence, evolution, development and change.
c) *Organisation Scan:* multifunctional workshop method for mapping organisation development and change, capturing lessons learned.
d) *Emergence Roadmap:* workshop method for mapping an emergent commercial opportunity through demonstrators and actions.

The purpose of the Industry Scan method, its context and relationships to other approaches is described below, with detailed guidance provided in subsequent sections.

1.1 Purpose

Industry Scan is a research instrument that can be used to explore, depict and communicate the evolution and development of complex industrial systems, at industry, firm and product levels. Analysis of such maps can enable the identification of patterns, enablers, barriers and other phenomena associated with such systems. This understanding can be used to support strategy and policy dialogue and decision-making looking forward. The approach has been designed for rapid application, as a learning process, to provide context and focus for further investigation.

The Industry Scan approach is intended for use by academics, analysts, consultants, policy makers, managers and technologists to address issues such as:

- The processes through which industrial value is generated from scientific and technological progress.
- The mechanisms associated with the development of regional industrial clusters.
- The enablers and barriers that affect successful technological innovation in firms.

1.2 Background

The approach described in this document is based on roadmapping principles. Roadmaps are structured time-based graphical representations of strategy, illustrated in Figure 1, widely used to support strategic planning at product, firm and sector levels[3]. The layers in a roadmap represent key dimensions of the system being considered, enabling stakeholder perspectives to be presented in a structured way.

[1] www.ifm.eng.cam.ac.uk/imrc/eip
[2] www.ifm.eng.cam.ac.uk/imrc/eip/transitions.html
[3] Phaal, R., Farrukh, C. and Probert, D. (2010), *Roadmapping for strategy and innovation – aligning technology and markets in a dynamic world,* Institute for Manufacturing, University of Cambridge, ISBN 978-1-902546-82-7, www.amazon.co.uk.

The roadmapping method has been used within the Emerging Industries Programme to map historical examples of technology-intensive industrial emergence and development in a wide variety of contexts. Learning from these maps has helped to understand the underlying principles and patterns of such emergence, to improve planning for the future. Key aspects of the resulting framework for mapping industrial emergence are summarised below, together with the set of practical methods that has been developed.

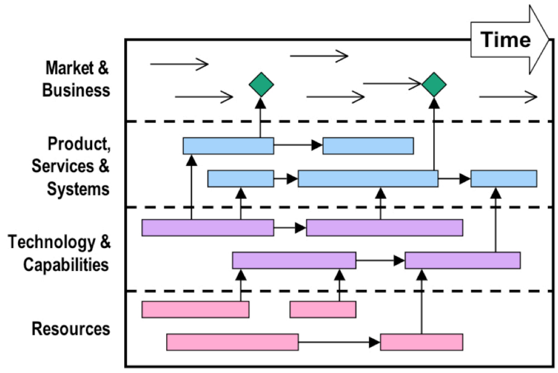

Figure 1 – Schematic roadmap

1.3 Framework for industrial emergence

Key aspects of the industrial emergence framework[4] are highlighted in Figure 2:

- *Industry lifecycle,* with an emphasis on technology-intensive industries that emerge from the science base, structured according to key phases and transitions, associated with science, technology, application and market dominated activity.
- *'Demonstrator chain',* demarcating the phases and transitions of industrial emergence, providing tangible intermediate targets that can be used to focus strategy.

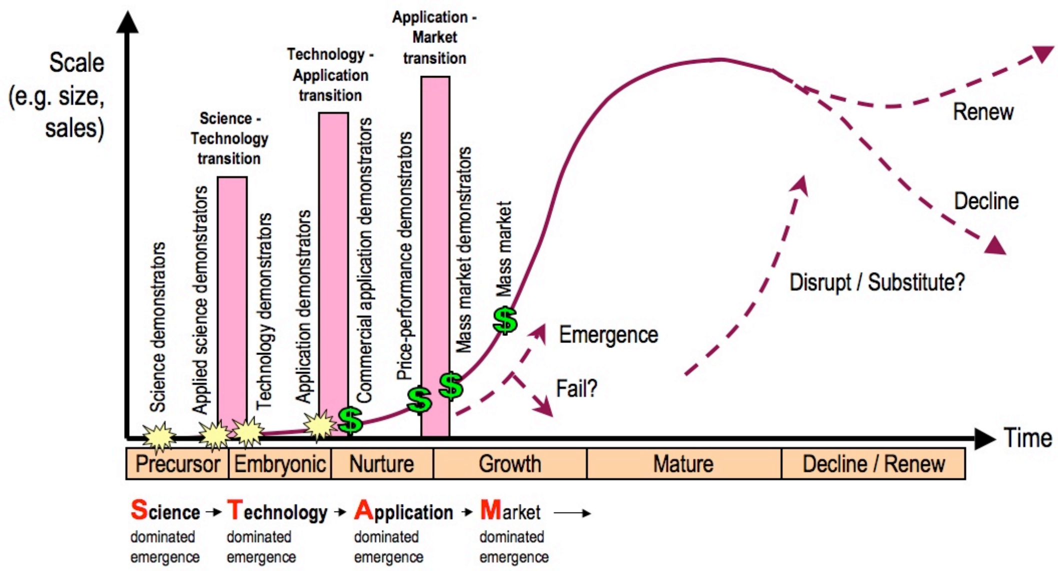

Figure 2 - Phases and transitions of technology-intensive industrial emergence, highlighting the 'demonstrator chain' that demarcates the phases and transitions

[4] Phaal, R., O'Sullivan, E., Routley, M., Ford, S. and Probert, D. (2011), 'A framework for mapping industrial emergence', *Technological Forecasting & Social Change,* 78, pp. 217-230.

The framework emphasises the early stages of technology-intensive industrial emergence, focusing on four phases and the three intermediate transitions *(S-T-A-M)*, together with associated demonstrators:

1. *Precursor phase* (science-dominated emergence): Activities that establish the supporting scientific phenomena (and/or underpinning technology platform), extending through to the first demonstrator(s) of application potential, which stimulate industrial interest and investment in particular market-directed technology feasibility studies.

2. *Science-technology transition* (S-T): Demonstrating the feasibility of a scientific phenomenon (and/or underpinning technology) to support a new market-directed technology platform, showing the feasibility of the supporting science and technology to be integrated into an application-specific functional technology system.

3. *Embryonic phase* (technology-dominated emergence): Improving the reliability and performance of the market-directed technology to a point where it can be demonstrated in a market-specific environment.

4. *Technology–application transition* (T–A): Developing the technology and application to a point where commercial potential can be demonstrated through revenue generation.

5. *Nurture phase* (application-dominated emergence): Improving the price and performance of the application to a point where sustainable business potential can be demonstrated.

6. *Application–market transition* (A–M): Translating price-performance demonstrators into a market with mass growth potential.

7. *Growth phase* (market-dominated emergence): Marketing, commercial and business development leading to sustainable industrial growth.

8. *Mature phase:* Refining established applications, production processes and business models.

9. *Decline / renew phase:* The industry either declines (through competitive disruption) or is sustained or renewed through the development of new science-based technologies that repeat the above phases.

The above framework is a simplified representation of the complex reality of industrial emergence, which is a product of the many decisions and actions of the actors involved, ranging from researchers to firms, government agencies and consumers. However, the framework provides structure within which the behaviour of such systems can be mapped, understood and communicated, and a basis for strategy development and decision-making.

1.4 Toolset

A set of four practical methods (tools) has been developed within the EIP project, building on the framework for industrial emergence: a) Industry Scan, b) Expert Scan, c) Organisation Scan, and d) Emergence Roadmap. The methods are specifically designed for technology-intensive industrial emergence, and can also be applied in other situations with appropriate adaptation (where different patterns, phases, transitions, events and milestones may have relevance) – for example:

- Exploring the evolution of technologies, applications and markets to understand how industries develop and emerge.

- Mapping the progress of a corporate venture, to identify learning points for future such initiatives.
- Investigating the various experiences of stakeholders in a regional industrial cluster, to build up a picture of how the set of firms co-evolved.
- Capturing workshop participant perspectives on past innovation initiatives in a firm, to identify strengths and weaknesses as an input into innovation strategy.
- Strategic planning for early stage technology ventures, building consensus about the long term goals and intermediate steps and actions required to move forward.

A modular philosophy has been adopted, in the sense that the methods can be used in isolation or in various combinations, with each other and with other tools and processes. Three of the methods support mapping of the historical emergence and development of industrial systems, to identify patterns, enablers and barriers – the learning from these approaches can be a useful input to strategic planning, which is the focus for the fourth method:

a) *Industry Scan (IS):* a research method for exploring, understanding and communicating patterns, enablers and barriers associated with historical industrial emergence, supporting policy, strategy and innovation processes (the subject of this guide).

b) *Expert Scan (ES):* an interview-based technique for capturing personal perspectives of historical industrial emergence, which can be combined to understand patterns, enablers and barriers, as an input to strategy, policy and innovation processes.

c) *Organisation Scan (OS):* a workshop-based approach for mapping and sharing experience of a specific historical development within an organisation, to capture lessons learned, from multiple perspectives, as an input to strategy, policy and innovation processes.

d) *Emergence Roadmap (ER):* a workshop-based roadmapping method, configured to support organisations navigating science and technology-based industrial emergence, clarifying decision making and action plans. Multifunctional workshops enable priority steps to be identified through focussing on a demonstrator chain to commercialisation.

The Emergence Roadmap method requires a relatively clear focus, in terms of an identified future opportunity. It can be used in conjunction with the Value Roadmap (VR) workshop-based approach for exploring, identifying and prioritising future opportunities for early-stage technology[5].

The relationships between these tool modules are shown in Figure 3, all of which are based on roadmapping principles[6], enhanced by the industrial emergence framework where appropriate. The tools are positioned against two dimensions:

1. *Time:* past (learning from previous experience) and future (strategy).

2. *Level:* focus for application, ranging from industry/sector to firm and product.

As noted above, the EIP tools can be applied separately or in combination, depending on context and purpose, with the positioning in Figure 3 indicating potentially useful interactions when used together or in combination with other tools and processes. The set of three historical mapping tools can be used separately or together, and are 'scaleable' in the sense that they can be applied at industry, firm and product levels, The Expert and Organisation Scan approaches provide guidance on how to engage with experts through interviews and workshops. The Industry Scan

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[5] Dissel, M.C., Phaal, R., Farrukh, C.J. and Probert, D.R. (2009), 'Value roadmapping: a systematic approach for early stage technology investment decisions', Research Technology Management, Nov-Dec, pp. 45-53.
[6] Phaal, R., Muller, G. (2009), 'An architectural framework for roadmapping: towards visual strategy', *Technology Forecasting & Social Change,* 76 (1), pp. 39-49.

focuses on the map itself, in terms of how to gather, organise and represent information relating to the development and evolution of a complex system, with particular reference to industrial emergence. Learning from the historical scanning methods is a useful input into future-oriented strategic planning processes, including the Emergence Roadmap and other tools and methods such as portfolio management.

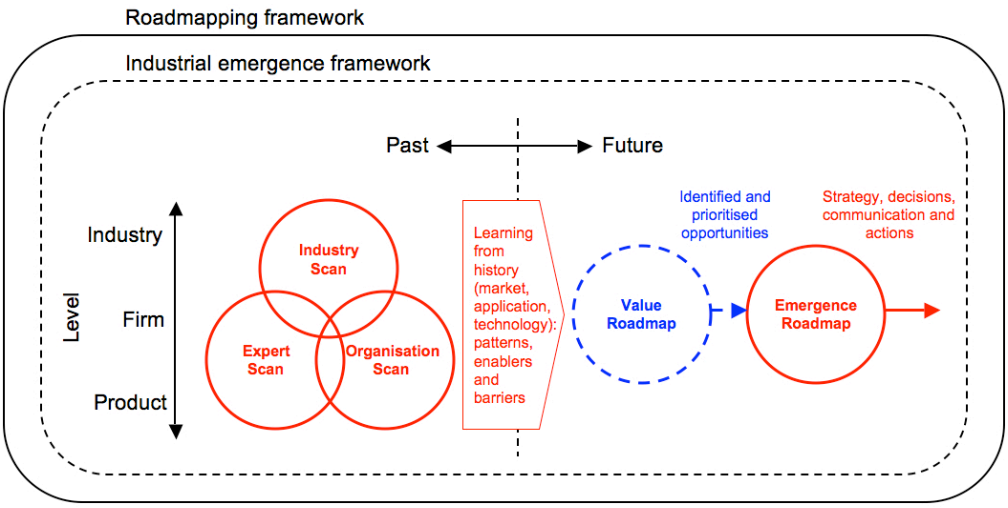

Figure 3 – Tool modules and relationships, positioned against time (past and future) and level (industry, firm and product); the Value Roadmap method (dashed circle) can be used in conjunction with the Emergence Roadmap approach if helpful, to provide focus

In terms of other tools, of particular note is the Value Roadmap method, which is an adaptation of the more general S-Plan roadmap approach, used for general strategic planning at firm and sector levels[7]. The VR and ER methods are particularly suited for strategic planning of early-stage technology, providing alternatives to the 'Strategic Landscape' and 'Topic Roadmap' modules in S-Plan for this context.

The workshop-based S-Plan approach is based on a modular philosophy, enabling management tools to be combined in various ways around a core roadmapping process. The roadmapping modules operate at two levels: business and topic (option) – see #3 and 7 in Figure 4. Other tool modules that have been incorporated include: intelligence map depicting external drivers (#1), scenario matrix (#2), QFD-style linkage grids (#4), innovation matrix (#5), portfolio matrix (#6) and business case templates (#8). Figure 4 relates to business strategy and innovation applications of S-Plan, which can also be applied at the sector level.

The EIP tool modules can also be positioned within the S-Plan process framework as shown in Figure 4:

- The historical mapping methods can provide an input to roadmapping modules to improve understanding of the past and current situation, so that learning points (development patterns, enablers and barriers) can be taken into account, at both business (#3) and topic (#7) levels. For example, the three methods (ES, OS and IS) might be used together where a clear depiction of the historical emergence of a sector is desired (#3), incorporating perspectives from both expert interviews and workshop engagements. When focusing on a particular innovation opportunity (#7), incorporating a workshop module (OS) prior to the topic roadmapping activity may be desirable to ensure that learning from previous developments is identified and incorporated.

[7] Phaal, R., Farrukh, C.J.P. and Probert, D.R. (2007), 'Strategic roadmapping: a workshop-based approach for identifying and exploring innovation issues and opportunities', *Engineering Management Journal,* 19 (1), pp. 16-24.

- The Emergence Roadmap method can replace the topic roadmap module (#7) for early-stage technology exploitation strategy development (or where more structure than provided by the topic roadmapping approach is desired). Similarly, the Value Roadmap method can replace the Strategic Landscape module (#3), providing a means for identifying and prioritising application opportunities for early-stage technologies, where there may be many potential routes to market, with substantial commercial and technical uncertainties.

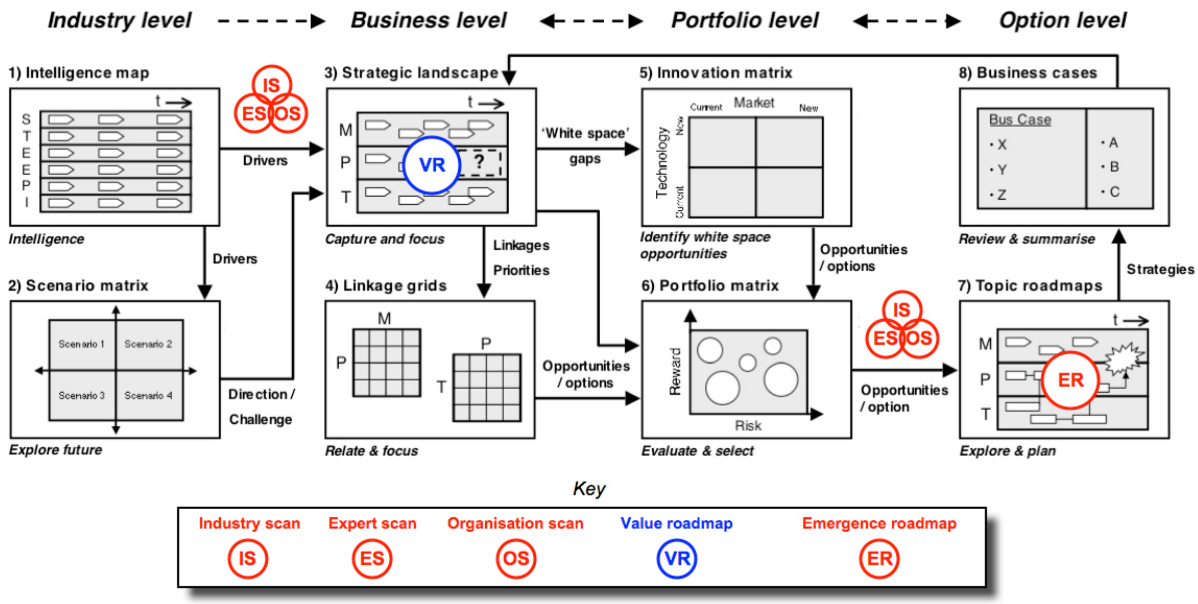

Figure 4 – Positioning of EIP and other strategic management tool modules within the S-Plan strategic roadmapping workshop-based method (business and innovation strategy)

2. Industry Scan Guidance

2.1 Introduction

As stated in Section 1, the purpose of the Industry Scan method is to map historical developments of complex industrial systems, at industry, firm and product levels. The approach has been designed for rapid application as a learning process, to provide context and focus for further investigation. It provides a basis for identifying patterns and issues for understanding future developments, as an input to strategy. The output is a visual depiction (map) and its associated narrative, intended for supporting communication and dialogue.

A framework for mapping industrial emergence has been developed (summarised in Sections 1.3 and 2.2), based on the application of future-centric roadmapping principles to the past, as illustrated in Figure 5. The roadmapping technique is widely used at both firm and sector levels to support strategic planning[8]. Roadmaps provide a structured visual representation that supports the development, communication and deployment of strategy. Extending the timeline to the past enables the current situation to be established, together with the past events and activities that led to this position. The learning from this can then be applied to current and future strategic deliberations, facilitated by consistency of approach (coherent architecture for roadmaps and industry scans).

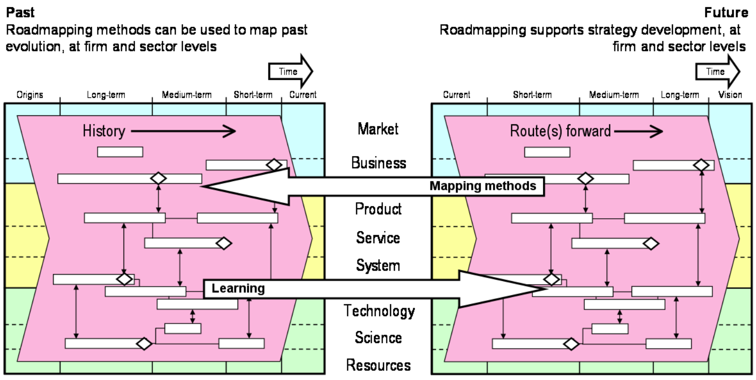

Figure 5 – Applying roadmapping principles to the past

The 'fast-start' roadmapping philosophy[9] has been extended to historical mapping, where the initial map is created quickly, as the first step in an iterative process. Inevitably, it is not possible to cover everything in this first iteration, and identifying learning points to direct activities for a second iteration is a key outcome of the approach. Applying constraints in terms of both time and space ('one day, one page') encourages a strategic view to be taken, to develop an holistic map ('big picture view') that is used as a basis for further investigation as part of an ongoing process. The industry scanning approach is scaleable, in the sense that it can be applied at various levels (units of analysis), ranging from entire sectors to firms and applications, and from entire lifecycles to particular time periods of interest. This is integral to

[8] Phaal, R., Muller, G. (2009), 'An architectural framework for roadmapping: towards visual strategy', *Technology Forecasting & Social Change,* 76 (1), pp. 39-49.

[9] Phaal, R., Farrukh, C.J.P. and Probert, D.R. (2000), 'Fast-Start Technology Roadmapping', *Proceedings of the 9th International Conference on Management of Technology (IAMOT 2000)*, 21-25 February 2000, Miami. Published in Khalil, T.M., Lefebvre, L.A. and Mason, R.M. (Ed.) (2001), *Management of technology: the key to prosperity in the third millennium,* Selected papers from IAMOT 2000, Pergamon Press, Amsterdam, pp. 275-284.

the iterative approach, as an outcome of the first map should be a depiction of particular events and transitions of interest, which can be the basis of further one page maps, focusing in on particular themes and time periods, with the broader map providing the context for these subsequent investigations ('pan and zoom').

In summary, the purpose of the industrial scan is to rapidly create a map of historical developments (potentially also the current situation) for a complex industrial system, providing context and focus, as a first step of a process. The maps can be used to provide understanding about the industrial landscape and the patterns of its development for both policy and firm level applications, and as a learning process for firm and product level strategy initiatives.

The underpinning framework for mapping industrial emergence has been introduced in Section 1.3 and is described further in Section 2.2, with an example industrial scan (for digital cameras) provided in Section 2.3 to illustrate the process guidance in Section 2.4.

2.2 Framework for mapping industrial emergence

The framework for mapping industrial emergence has been developed on the basis of more than 25 maps[10]. This framework, summarised in Figure 6, provides an architecture that can be used to depict the evolution of complex technology-based industrial systems, in terms of:

- Phases and transitions, from science- to technology-, application- and market-dominated emergence (horizontal axis of Figure 6, defined in Section 1.3).
- A chain of 'demonstrators' that delineate the phases and transitions (embedded diagram in Figure 6).
- Dimensions that may be important for understanding and representing industrial emergence (layers associated with vertical axis of Figure 6; see also Figure 7 and Appendix 1).

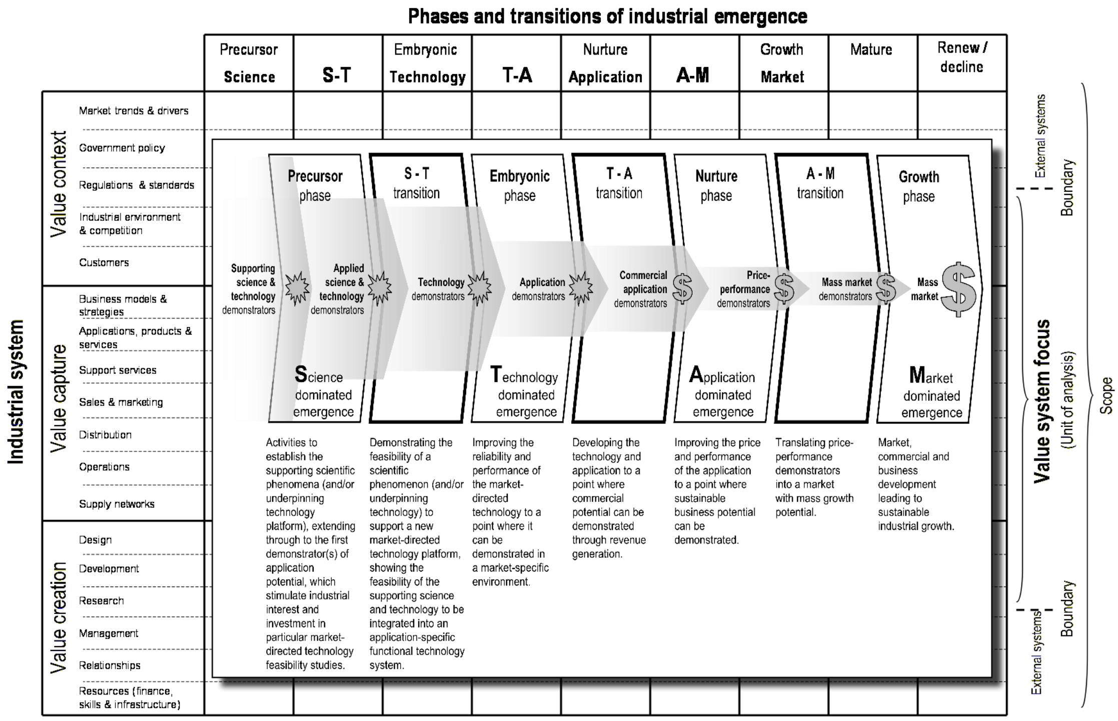

Figure 6 – Framework for mapping industrial emergence

[10] Phaal, R., O'Sullivan, E., Routley, M., Ford, S. and Probert, D. (2011), 'A framework for mapping industrial emergence', *Technological Forecasting & Social Change,* 78, pp. 217-230.

The architecture and definitions provided in the framework are not intended to be prescriptive; rather, they provide principles and structures to aid the mapping of industrial emergence phenomena. Not all dimensions, phases or demonstrator types will be relevant to all maps, each of which will require customisation. Other events, phases, transitions and dimensions may be important, in which case the structure and representation should be adapted to reflect this. To emphasise the non-prescriptive nature of the dimensions shown in Figure 6 and described in Appendix 1, the representation shown in Figure 7 may be useful for design purposes, where the question of which dimensions are important to depict must be considered. The focus, scope and system boundaries should be carefully considered during the design phase (at each iteration), as this will determine the structure and organisation of the map, and the relevant sources of data.

Figure 7 – Dimensions of industrial emergence, for design purposes

2.3 Example Industry Scan

Figure 8 (and Appendix 2) shows an example of an industrial scan for the digital camera industry, with the associated (summary) narrative provided below. Figure 9 depicts two animated overlays, highlighting key chapters in the narrative and the associated phases and transitions of industrial emergence with reference to the framework described in Section 2.2. The information contained in the map was sourced from public-domain internet sources – primarily wikipedia.org.

The focus of the map is the digital camera in the consumer market, typified by the Fujifilm MX-600, released in 1999 in the first wave of 'modern' digital cameras that have a feature set that would be recognised today: compact format, 1.5 megapixel sensor, 3x autofocus zoom lens, built-in flash, memory card and display screen, priced at about $800 for the consumer market. The scope of the map includes digital and associated imaging technologies and markets, which provide context for understanding the evolution of digital consumer cameras.

Precursor (supporting science- and technology-dominated) phase: Of course, there was a thriving market for film-based cameras before the advent of digital technology, and the map includes highlights from these earlier developments, which defined the market and technological context. Although the core technology and business models shifted (from chemical to digital, and away from film processing), market expectations were set by these earlier 20th century developments, and some technologies were directly relevant (for example, optics and flash). Digital technology emerged from the wider developments in semiconductor and transistor technology, with the first description of how to produce still digital photographs using mosaic photo-sensors by the Jet Propulsion Laboratory in 1961 (applied science demonstrator).

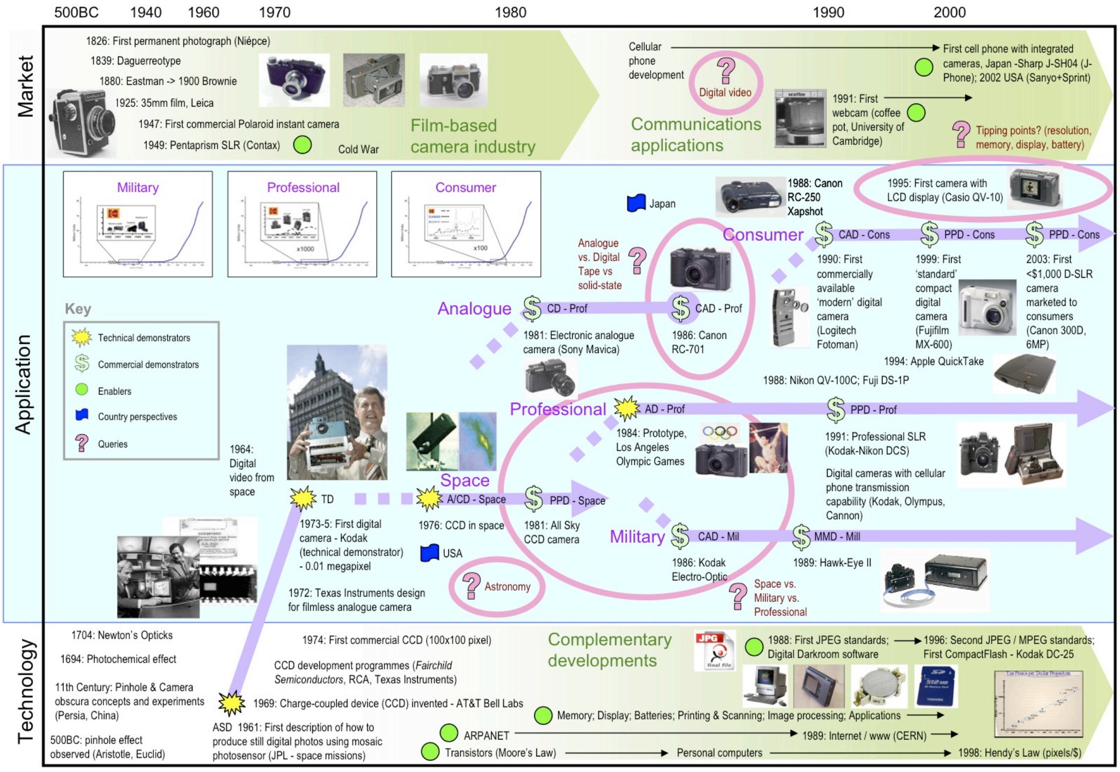

Figure 8 – Industry scan: consumer digital cameras (see Appendix 2)

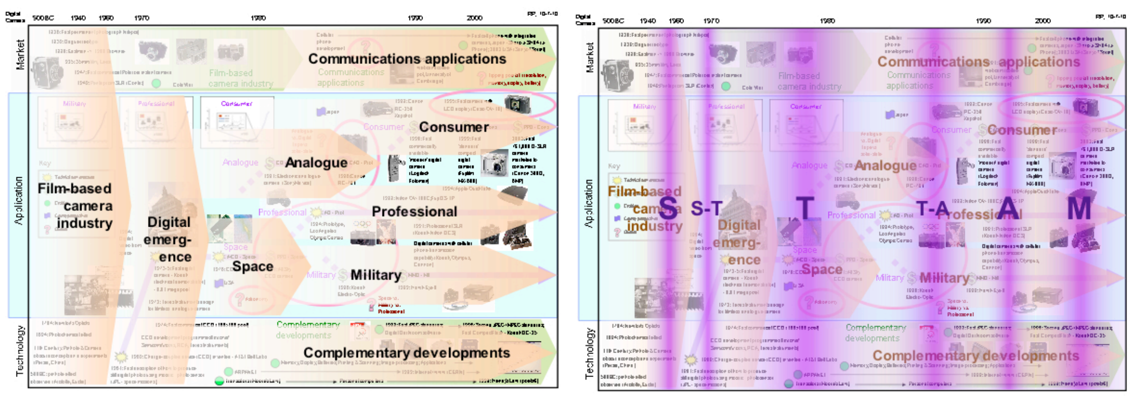

Figure 9 – Emergence of the digital camera industry: a) Narrative chapters, and b) Phases and transitions of emergence (see Figure 6)

Science to technology transition: Building on the concepts proposed by the JPL paper, the charged-coupled device (CCD) photo-sensor was invented at the AT&T Bell Laboratories in 1969, enabled by further developments in transistor and related technologies. This generated substantial industrial interest in developing this technology, leading to the first commercially available sensor in 1974, which was rapidly incorporated into a prototype camera by Kodak in 1975 (technology demonstrator).

Embryonic (technology-dominated) phase: Despite Kodak demonstrating that it was possible to produce a digital camera, it would be more than two decades before this technology was widely available to consumers. The performance and price of the core technology required substantial improvements, enabled by specialist markets in the aerospace and defence sectors. Eventually, the first 'mass' market (professional press) was stimulated by a demonstration of the technology by Canon, where a photograph taken at the 1984 Olympic Games in Los Angeles was transmitted and printed in a Tokyo newspaper (application demonstrator). While the performance, in terms of image quality, and price did not compete with the incumbent film-based cameras, the ability to rapidly process, transmit and publish the images was revolutionary.

Technology to application transition: The development of a market for professional digital cameras, combined with further developments in defence and other specialist markets, led to rapid advances in the performance of the core technology, and reductions in cost. In parallel, developments in electronics, software and computing advanced rapidly, leading to the first consumer digital camera product being released by Logitech in 1990 (commercial application demonstrator).

Nurture (application-dominated) phase: Although digital imaging technology was available to consumers, it was not in a practical format that could challenge the dominant film-based camera industry. The core sensor technology continued to develop, along with related electronics and complementary developments. Key to the emergence of the consumer digital camera was the underpinning computing and communications architecture provided by personal computers and the internet, combined with standards (jpeg), displays, batteries, printing and scanning systems, leading eventually to cameras that could compete with and displace film-based technology (i.e. the Fujifilm MX-600 in 1999 – a price-performance demonstrator, and similar cameras).

Growth (market-dominated) phase: Once digital cameras had been established in the market place they rapidly displaced film-based cameras during the period 2000-2005, due to the relentless advances in semiconductor and related technologies, and the considerable advantages offered by the new technology. The dominance of digital cameras was highlighted in 2003 with the release of the first sub-$1000 SLR (single lens reflex) camera with interchangeable lenses aimed at the consumer market. In parallel, applications of digital imaging technology in mobile phone, computer (webcams) and video systems accelerated the process.

2.4 Producing an Industry Scan

The key principle of the industry scan is rapid iteration, constrained by time and space ('one day, one page'), producing a first draft map, learning points and actions (see Figure 10). Although desirable, one day is not a literal constraint – the key point is that rapid iteration is beneficial. Inherent in this philosophy is that the first map will be not be 'perfect', but will provide a basis for identifying what further work is needed to improve the map, or areas of interest for more detailed investigation.

The following guidance is not prescriptive – every map will be different, depending on purpose, focus and scope. These aspects, together with the structure and content of the map should be reviewed and refined on the basis of the first iteration.

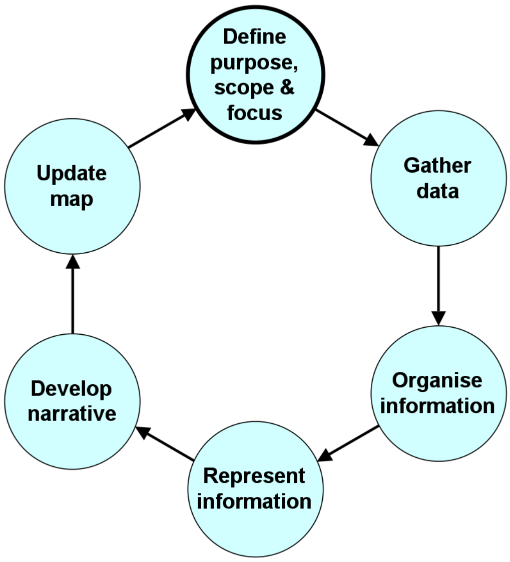

Figure 10 – Process for developing industrial emergence map

1. Define purpose, scope and focus

The purpose and unit of analysis should be clearly defined, in terms of the focal system and the factors that influence it. The intended purpose will dictate the primary focus of the map, together with the scope and architecture (see Figure 6), the kind of data that needs to be collected and therefore likely sources. The focus of the map is closely related to the 'beginning' and 'end' points (for example in the case of the digital camera the emergence of digital image sensors and the development of the first modern consumer camera). Linking these together is a key goal of the mapping process, defining the core narrative 'backbone' of the map. The scope is defined by considering the other dimensions and time frames necessary to depict and set the context of the focal narrative. The focus and scope combine to define architecture of the map (horizontal and vertical axes).

2. Gather data

Following the 'one day, one page' ethos, it is recommended that approximately half a day is devoted to data collection, focusing initially on readily available data, with half a day to create the first draft map. Temporal data is of particular relevance, as time is an explicit dimension of the mapping framework. Sources of data may include the internet, documents (reports, scholarly papers and other published sources) and interviews / workshops with experts. Figures 6 and 7 (and Appendix 1) provide a checklist that can be used to support data collection, and as a basis for a template for interactive data capture in interviews and workshops using paper and sticky notes (for example, see Figure 11).

Where possible, use multiple sources for triangulation purposes, and be aware of possible bias. Expert accounts will tend to be biased towards personal history, organisations and functions. Hence, multi-organisation perspectives are desirable for industry level maps, and multifunctional perspectives for firm level maps – particularly commercial and technical. Web sites and documents may also demonstrate bias (e.g. a regional perspective). Further guidance on interview protocols for case studies is provided by the Expert Scan method described in Section 1.

Figure 11 – Example of data capture in interview (1.5 hours)

3. Organise information

Analyse and organise the information gathered, according to theme and chronology. The aim is to articulate (through text and map) the evolution of activity and events over time, from beginning (including precursor events and initial conditions) to end, including key linkages and causal relationships. Of particular importance is the core 'narrative thread', which acts a 'backbone' around which the story hangs (this is clearly visible in the digital camera case in Figure 8). The visual and verbal narratives go hand-in-hand, each supporting the other, and they should be developed in parallel, iteratively.

The positioning of the text and objects will be approximate at first, and will typically need to be adjusted as the map is created, owing to the space constraints of the one page view. The process is somewhat iterative, and information will need to be reorganised as the map is created to make the best use of the space available. Too much structure imposed by the canvas will overly constrain positioning of the objects within the map, and may lead to poor visualisation of the narrative. It can be helpful to use paper and sticky notes during the initial design phase.

4. Represent information

Once the basic map has been created it needs to be refined to most effectively support the associated narrative. PowerPoint or similar software is recommended, enabling the narrative to be presented and communicated, supported by suitable animation. Detailed principles and practices of visual design and graphic representation are beyond the scope of this guide, and professional support may be beneficial for the creation of truly compelling maps. However, the basic principles of good graphic design and information visualisation are well established[11].

[11] Dondis, D.A. (1973), *A primer of visual literacy,* The MIT Press, MA.
Tufte, E.R. (1990), *Envisioning information,* Graphics Press, Cheshire, Connecticut.
Ware, C. (2008), *Visual thinking for design,* Morgan Kaufmann Publishers, Burlington MA.
Lidwell, W., Holden, K. and Butler, J. (2003), *Universal principles of design,* Rockport Publishers, Beverly MA.
Bertin, J. (2010), *Semiology of graphics: diagrams, networks,* maps, ESRI Press.

It is recommended that the architecture (canvas) be created as the 'Slide Master' (PowerPoint), as a backdrop for the various objects with which the narrative will be constructed (the 'pallet'). A minimum of 8pt font (e.g. Arial or Helvetica) is recommended, which allows sufficient detail to adequately describe a fairly complex narrative on one A4 sheet of paper, legible for reading as a handout.

Some graphic design choices are highlighted in Figure 12 for the digital camera example from Figure 8:

- The map should include a title that is descriptive in terms of focus, together with information on author and date of creation.

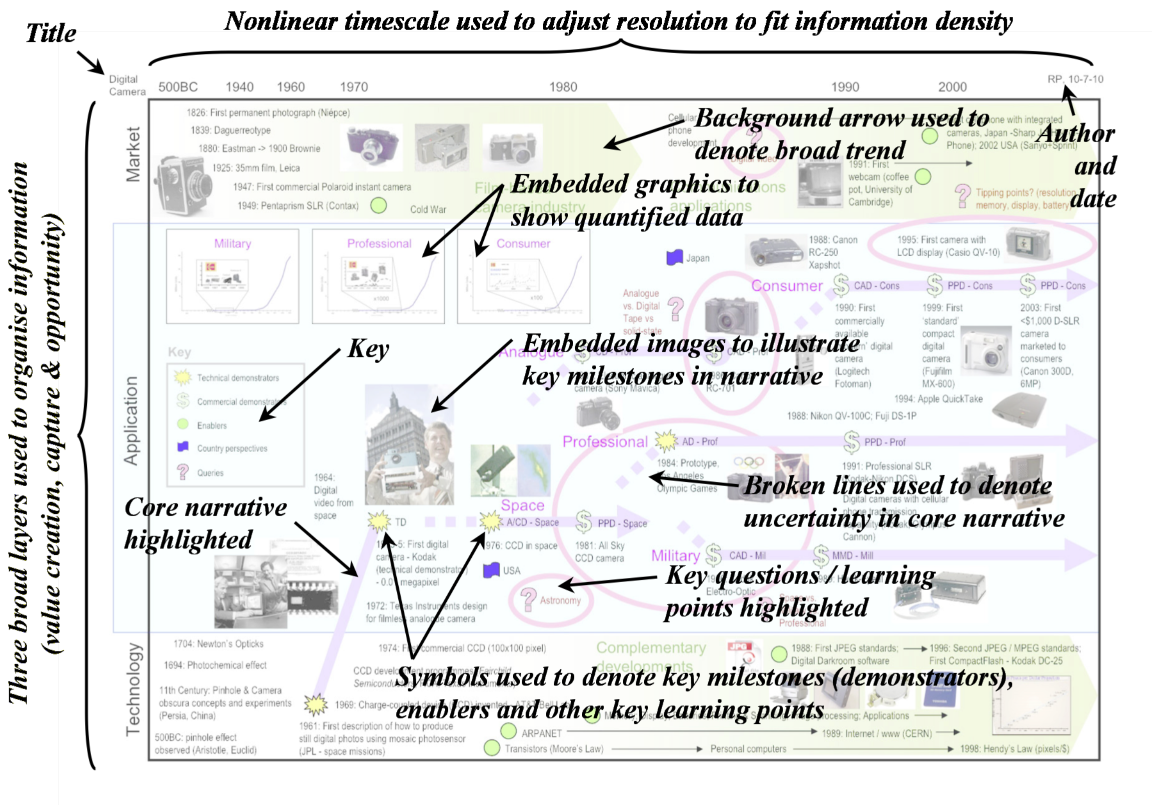

Figure 12 – Digital camera map (Figure 8), annotated to highlight graphic representation

- Although the framework depicted in Figure 6 includes many dimensions, represented as layers, this is intended as a checklist of *potential* dimensions. Fewer layers are normally appropriate for representational purposes, providing freedom to organise information in a way that supports the core narrative. Three layers are typically necessary and sufficient, representing value creation, capture and opportunity (e.g. market, application and technology). This portrays the focal system together with demand and supply side aspects. The space devoted to each theme will depend on the emphasis placed on each in the narrative, and the associated density of information displayed.

- Time is usually shown explicitly in the structure, at the top of the map (horizontal axis), using a nonlinear scale depending on the density of information, to ensure that the limited space available (one page) is utilised effectively. It is also possible to depict phases and transitions, although if multiple 'waves' or trajectories of emergence are shown then multiple phase / transition points may potentially need to be shown, or only for the primary 'lead wave'. The phase and transition definitions in the framework can be used independently of time (i.e. time is not depicted explicitly in Figure 6), in which case multiple trajectories can be shown on the map (incorporating dates within the map content), which can be useful for depicting the relative progress towards commercialisation. In some cases particular phases and transitions may not be relevant or important.

- The core narrative thread should be prominent in terms of representation, around which the rest of the map is organised.

- Appropriate symbols should be used to denote key milestones, enablers and other learning points. For the case of the digital camera a set of symbols associated with the framework for mapping industrial emergence is used, with a particular focus on the demonstrators that demarcate the S-T-A-M phases and transitions (see Sections 1.3 and 2.2).

- A key should be included with the map to explain the meaning of the symbols and other representational devices used in the map.

- Embedding appropriate images is helpful, to illustrate key milestones in the narrative. However, it should be recognised that 'white space' can be considered as a visual object as well, with meaning (for example, a period of time where little activity occurred). Illustrative images should be positioned with this in mind.

- Embedded graphs provide a means to show quantified data associated with the map (for example, sales and revenue). Although time is typically an explicit dimension of the industry scan, the scale used in the horizontal axis will not generally be appropriate for such graphs, in which case embedded boxed graphics can be used, as for the digital camera case.

- Arrows should be used to indicate trends, links and causal relationships in the map.

- Uncertainties, queries and learning points should be highlighted. For example, for the case of the digital camera, broken lines are used to indicate parts of the core narrative that are not well understood, and key questions arising at the end of the first iteration are clearly shown, indicating areas that would benefit from further investigation.

5. Develop narrative

An industry scan should include both visual and textual representations of the narrative. The case write up should include a descriptive title, author details and date, a full page version of the map, together with additional supporting figures where required. The introduction should include the background to the map, its purpose, focus and scope, data sources and any other relevant contextual information. The main part of the case should be organised according to the 'chapters' of the narrative (typically 5-10) – these may be associated with phases, transitions or other key periods of activity. Key learning points should be highlighted in the summary and conclusions as appropriate. Appendices can be used to store supplementary material.

The visual (PowerPoint) map should be animated according to the logic of these chapters, so that the visual and textual narratives are complementary. Semi-transparent overlays can be used to label the chapters and emphasise the overall flow of the narrative (see Figure 9). When presenting the map, paper copies of the detailed version should be distributed to the audience (the small text will not be easily legible on the screen).

When source information is obtained from interviews and workshops, the map and associated narrative should be reviewed by those involved for accuracy, and amended as appropriate.

It may be useful to develop a simplified visual version for communication purposes – e.g. for senior management or the public. An example for digital cameras is provided in Figure 13, which highlights important demonstration steps, together with a summary of key technical and commercial achievements.

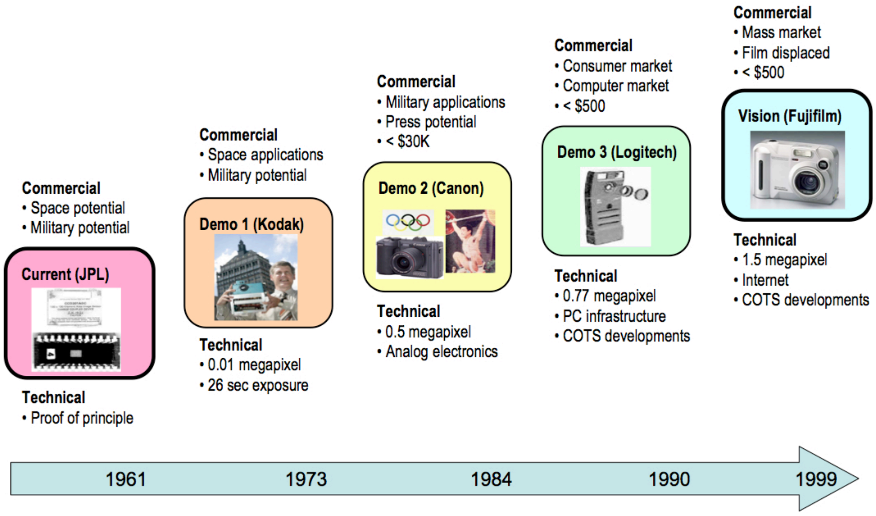

Figure 13 – Simplified digital camera map (based on detailed version shown in Figure 8)

6. *Update map*

The learning points identified during the mapping and reporting process should include any next steps and appropriate actions required. The purpose of the 'quick scan' approach is to provide an overall view of the domain and its evolution, and to highlight areas and issues of interest (for example, enablers and barriers, together with gaps in knowledge), and to identify actions required to move forward.

The framework is scaleable, and it is possible to focus on particular timeframes and themes to create sub-maps, provided information can be obtained.

Consideration should be given to improvement and validation of the map, as part of an iterative process that will lead to an improved second version. Independent sources and different perspectives can be used to verify, modify or add content (documentary and interview based).

Appendix 1 – Dimensions of industrial emergence

Meta-theme	Definition
Value context	The opportunities within the industrial landscape for creating and capturing value.
Value capture	The mechanisms and processes used by actors within the system to appropriate value through delivering products and services.
Value creation	The competences and capabilities used by actors within the system to generate products and services.

	Theme	Definition	Notes
Value Context	Market trends & drivers	Macroeconomic factors that cause change in the wider market and which affect the industry.	Includes technological, economic, environmental, political, legal, educational, demographic and cultural shifts.
	Government policy	The course of action or inaction taken by governmental entities with regard to a particular issue or set of issues.	Includes industrial policy to encourage R&D and technology transfer. Makes use of financial incentives to induce or motivate a particular behaviour. These incentives include: (1) procurement, (2) taxes and tax breaks, (3) grants, (4) programs to encourage industries, (5) loans, (6) rebates.
	Regulation	Imposition of rules by government which are intended to modify the behaviour of particular actors within the system.	Four main types of regulation: (1) control and command regulation (prescriptive regulation); (2) incentive, or performance, based regulation (industry allowed to develop their own approach to achieve the desired outcomes); (3) co-regulation (industry or professions regulators set the general framework and industry develops some specific rules); (4) self-regulation (industry manages and enforces its own requirements without regulators being involved).
	Standards	Codified technical document that establishes specifications for products, practices, or operations.	Categorisation of standards based on their economic effect: (1) compatibility/interface standards; (2) minimum quality/safety standards; (3) variety reduction; (4) information/measurement.
	Industrial environment & competition	The factors affecting the group of actors supplying a given market, offering identical or highly similar products and services using similar inputs.	Includes competitors, key players, scale, geographic distribution, market concentration, barriers to entry and existing infrastructure.
	Customers	Those who buy a particular product or service.	Customers define the market segment via buying habits, preferences, features and prices. Their profile specifies the revenue generation mechanisms for the firm: outright sale, renting, licensing, advertising and subscription models, selling and after-sales support models.

	Theme	Definition	Notes
Value Capture	Business models & strategies	How actors position themselves within a market and organise their activities to support their position.	Dimensions include: vision, goals, business model, specialisation, brand identification, channel selection, product type and quality, technological leadership, vertical integration, cost position, value proposition, value-added services, price policy, leverage, relationships with government.
	Applications	The products and services through which actors deliver value to customers.	Products include: physical goods, equipment and software. Services include: consultancy and financial services.
	Support services	Activities offered by actors to enhance or maintain the value of the product or service.	Ensures that the product or service delivers benefits through its useful life. Includes after-sales support services such as maintenance, diagnostics and servicing.
	Sales & marketing	Activities associated with the purchase of the product or service and the inducement to do so.	Requires identifying, anticipating and satisfying customer requirements. Achieved through: advertising, promotion, sales force, quoting, channel selection, channel relations and pricing.
	Distribution	Physical distribution of the product or delivery of the service to customers.	Activities include: finished goods warehousing, material handling, delivery vehicle operation, order processing and scheduling.
	Operations	The transformation of inputs into the final application form.	Manufacturing activities include: machining, packaging, assembly, equipment maintenance, testing, printing and facility operations.
	Supply networks	The networks through which inputs are purchased, received and stored.	Activities include: material handling, warehousing, inventory control, vehicle scheduling and returns to supplier, developing outsourcing strategies, qualifying new suppliers, procurement of different groups of purchased inputs, ongoing monitoring of supplier performance and the development of supplier associations.
Value creation	Design	The interpretation of customer/user needs into products and services, drawing on available technologies.	Defines the form and function of the product, or service. Requires consideration of market, social and technical aspects. Includes design for manufacturing, platform planning and component sharing.
	Development	The application of basic research to industrial or commercial purposes, integrating the research outputs into a functioning technology.	It may draw on the physical infrastructure supporting the activities of the actor, and other enabling technologies outside its boundaries.
	Research	Activities directed towards the advancement of knowledge through experimentation and theorising.	Basic research results in the creation of new intellectual capital. Processes include the creation, discovery, verification, collation, reorganisation, dissemination and patenting of knowledge.

	Theme	Definition	Notes
	Management	The processes through which actors organise their resources.	Activities include: general management, planning, performance measurement, human resource management, finance, accounting, legal, government affairs and quality management.
	Relationships	The partnerships and networks that actors draw on to acquire external resources that support and advance their research, development and design activities.	Includes: (1) industrial collaborations such as R&D consortia, joint ventures and alliances, and (2) financial sources such as venture capital funds, banks, Government grant schemes and licensees.
	Resources	The assets that are owned or controlled by actors within or outside the system.	Types include: financial, physical, human, technological, market, reputational and organisational. They differ in the degree of tangibility, mobility and imitability.

Appendix 2 – Digital camera industrial scan