

Roadmapping Integrates Business and Technology

At Philips Electronics, roadmapping may be applied to systems, to a product range, to individual projects, to components, or to production processes.

Pieter Groenveld

OVERVIEW: The product-technology roadmap process developed at Philips Electronics aims at better integration of business and technology strategy and improvement of the front end of the product creation process (the concept and idea phase). The outcomes are roadmaps that present products and technologies required to realize these products, as well as their mutual relationship over a five-year period. Teamwork, integral involvement by the organization and good communication are essential characteristics of the process. Benefits include a shared product-technology strategy and a cross-functional approach to product and technology planning and vision building. The roadmap drafting process can be supported by such tools as maturity grid, Quality Function Deployment and the Innovation Matrix.

The electronics business environment, in which Philips Electronics is active, is characterized by ever-more-demanding customers, increasingly shorter product life cycles and fast-changing technologies. This has a significant impact on the product creation process because current management practices often fail to recognize far enough in advance which new products and technologies should be available and when. Instead of planning-oriented product development activities, a long-term view is required, based on close cooperation among all disciplines.

Roadmapping is one of the improvement actions that was initiated to meet these demands. As I shall explain, roadmapping was chosen in order to develop a stronger awareness of how to serve important markets with the right products at the right time and to improve the cross-functional processes required for new product creation.

The roadmapping approach described in this article is based upon the limited information available (1) and experience elsewhere in technology management (2). This approach is characterized by the integration of

Pieter Groenveld is senior staff officer with Philips Electronics in Eindhoven, The Netherlands. He is involved in various technology management activities that aim at improvement of the product creation process. Prior to his current activities, he held positions in research, international standardization and operations. He received his M.Sc. degree from Delft University of Technology. E-mail: P. Groenveld @ cpdc.corp.philips.com

technology, product and market/application, paying due attention to how requirements and opportunities change over time. "Product" in this article means any component, product, system or production process. At the same time, the importance of process aspects such as multidisciplinary team building and cross-functional cooperation are emphasized. Roadmapping stimulates organizational learning through the encouragement of openness and ways of doing things better. It also supports people at all levels in achieving milestones and becoming committed to their role in the overall process.

The Roadmapping Concept

In simple terms, roadmapping is a process that contributes to the integration of business and technology and to the definition of technology strategy by displaying the interaction between products and technologies over time, taking into account both short- and long-term product and technology aspects. The principle of a product-technology roadmap is illustrated in Figure 1. The products A, B, ... and the technologies aa, pp, ... required to develop and produce these products are shown for roughly five years ahead. Products A3, A4, ... and technologies bb, qq, ... evolve from the earlier products A1, A2, ... and technologies aa, pp, respectively. Note that technology qq "kills" technology bb.

Product-technology roadmaps require a good understanding of markets and applications in order to define the products in terms of customer requirements. From these requirements, the technical product functions are determined and then, the technologies needed to realize these functions. All these activities help to improve, in particular, the front end of the product creation process (the concept and idea phase) by providing better information. The R&D projects help to build up the necessary technology capabilities. Figure 2 shows how these areas are related.

The time interval that will be shown on a roadmap depends on the type of products as well as the aggregation level considered. Roadmaps describing specific products with short product life cycles (e.g., portable audio products) will often not cover more than three-to-four years, whereas roadmaps presenting

information about a generic product category (e.g., optical storage) may extend to ten years.

Both high-aggregation-level roadmaps (serving business strategy discussions) and related specific roadmaps (oriented toward the operational business) are necessary to ensure in-depth roadmapping processes in the organization.

The initial 2-3 years is the so-called planning phase. It is driven by predetermined product programs and allocated resources for development. The vision phase lies farther out (3-6 years); the roadmapping process depends strongly on vision-building.

Roadmapping can be applied to systems, to a product range or specific products, to components, or to production-related processes. A roadmap may belong to different organizational units. Philips television display tubes, for example, are made by Philips Components but used in television sets developed and manufactured by the separately-managed Philips Television group. A roadmap for television display tubes requires cooperation between both groups because its functionality in terms of customer benefits (daylight view, quick start, power consumption) is determined by the user of the television set. This example also demonstrates how roadmapping supports strategic supplier relationships.

Figure 3 shows a roadmap for cordless telephone handsets in which reduction of the number of plastic parts is essential to continuously lowering the cost. The required technologies are depicted in the lower part of the roadmap. The black rectangle indicates a problem area:

Product-technology roadmaps require a good understanding of markets and applications in order to define the products in terms of customer requirements.

The required technology needs to be available well in advance of the corresponding product.

Roadmaps can show alternative product or technology developments over time, thereby clarifying the options that are available. Roadmaps should also have standardized formats describing the product characteristics and technologies over time in order that technology sublevels may be added to describe the technologies in further detail. Standardized formats are important for improved communication and better recognition of technology synergies. If related roadmaps are to be developed, the relationship between the different ones should be clearly defined.

Building the Roadmap

Although it is relatively easy to describe the principles of roadmapping, the process of building a roadmap (in short, roadmapping) is less simple. Differences in background, thinking and ways of working among different departments (marketing, development,

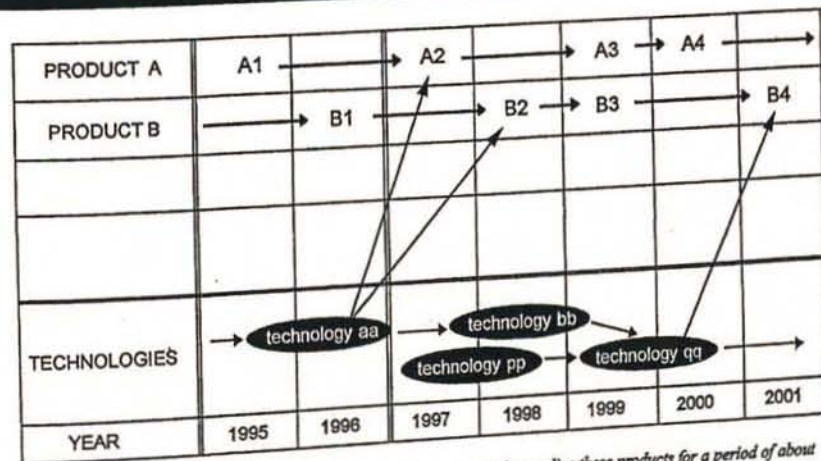


Figure 1.—The roadmap presents products and technologies required to realize these products for a period of about five years ahead, as well as the relationships between products and technologies over time.

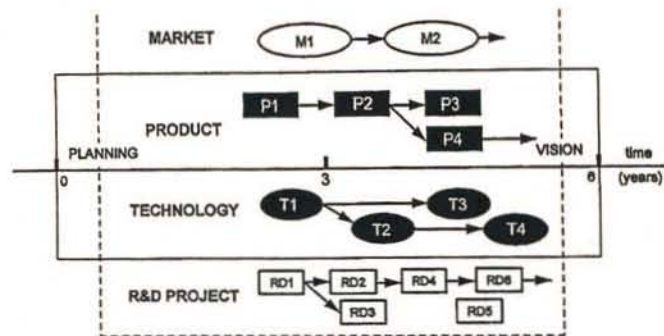


Figure 2.—Product-technology roadmaps are the central part of the market-product-technology-development chain. Constructing roadmaps demands close cooperation between the functions responsible for these areas.

manufacture, etc.) need to be reconciled. A degree of trust needs to be built up and nurtured by management to ensure both a successful start and completion. Lack of openness may block the whole process, as occurred in a situation in which management prohibited the circulation of a set of draft roadmaps showing weak product and technology areas.

The roadmapping process will differ from one organization to the other because organizations serve different markets and have different cultures. Roadmapping must be seen as an ongoing process that is a part of the business cycle.

One can often start by establishing a small project team in which (strategic) marketing, product management, research, development and engineering participate. The team looks for a leader who preferably should become the "sheet-owner" after roadmaps have been drafted. The sheet-owner is responsible for maintenance of the roadmap(s). He or she initiates appropriate updating actions and is the focal point for providing additional information as required. The team needs to consider such items as:

- What do we want to achieve?
- For which products do we need roadmaps?
- What is the relationship between roadmaps?
- How do we organize the process of roadmapping?
- How do we ensure follow-up?

The team activities can then be followed by workshops to ensure integral involvement of, and input by, the organization. The project team uses the outcome of the workshops to prepare draft roadmaps, or parts of them. Figure 4 outlines how the overall roadmap-building process can be structured.

The detailed implementation of this roadmap-building process will differ from one group to the other, depending on the type of roadmap(s) to be developed (e.g., roadmaps describing a range of products rather than a specific component) and the communication structures and practices of the organization concerned. For example, Philips Lighting established small roadmap drafting groups for each market-application segment in order to better define application needs and appropriate technologies. In Philips Domestic Appliances, roadmapping was embedded in the existing structure of workshops that discuss and define future product functions. In Philips Semiconductors, large multidisciplinary workshops were organized to stimulate cross-communication among the various product groups that were serving related markets and using the same technology base.

Quite often these processes are supported by such tools as Quality Function Deployment, portfolio analysis, SWOT analysis, innovation matrix, etc., which are discussed later.

Benefits of Roadmapping

The essential benefits of roadmapping to the user are:

- *Establishment of a shared product-technology strategy.* (Which loudspeaker technologies are required to ensure the required sound functionality in PC monitors over a 5-6-year period?)
- *Set an interlinked approach for long-range product and technology planning and vision building.* (How will the optical storage function for consumer applications develop over the next 5-6 years and what are the customer benefits that will be possible and/or required?)
- *Stimulation of learning and improvement of cross-functional communication.* (How to define in a

timely manner the functionality of integrated circuits to be developed by Philips Semiconductors and to be applied by Philips Television in their products?)

• *Improvement of time-to-market and time-to-money, thereby achieving a better competitive edge.* (Speeding up the product definition process of, for example, shop lighting by applying Quality Function Deployment and roadmapping.)

• *Supporting working in the process way.* (Roadmapping contributes to a better quality product specification process.)

Benchmarking of the company's processes and technologies against best-in-class can further improve the roadmapping process.

Supporting Tools

Roadmapping is a complicated process, requiring the simultaneous consideration of markets/products, technologies and the interaction between them over time, as shown in Figure 5.

In the start-up phase, only one or two of the three parameters of *product, technology and time* can be considered simultaneously. This helps to structure the

Roadmapping must be seen as an ongoing process that is a part of the business cycle.

discussions and clarify which problems have to be addressed first. Tools such as QFD and the Innovation Matrix, which stem from technology management practices, can be used to determine one or more of these parameters (3).

Quality Function Deployment is a customer-oriented approach that guides product managers and design teams through the concept and idea phase of the product creation process. QFD helps to focus on the functional (customer) requirements (the *what*) and translates these requirements into appropriate (technical) product characteristics (the *how*). QFD has been extensively described in the literature (see, for example, 4). Similar to roadmapping, the QFD approach requires multidisciplinary communication and decision-making.

In QFD, process technologies and time dependency play a less important role. The process is, therefore, less

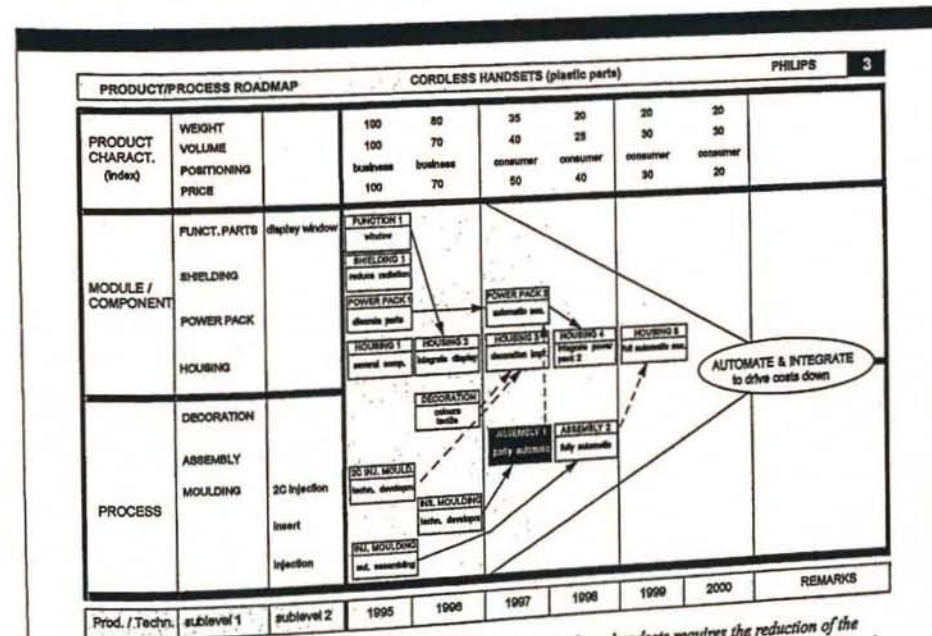


Figure 3.—Cost-effective production of plastic parts for wireless telephone handsets requires the reduction of the number of parts over time and the timely availability of advanced process technologies to produce these increasingly complex parts.

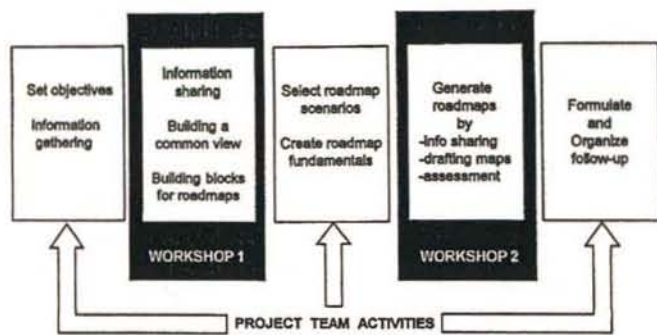


Figure 4.—Essential elements of the roadmap-building process are the establishment of a multidisciplinary project team that guides the process, and workshops that are organized to ensure integral involvement of, and input by, the organization.

complicated than roadmapping, where time is a crucial parameter and both products and technologies must be considered. QFD offers a reliable starting point for roadmapping and building the required cross-functional cooperation.

The outcome of the QFD process corresponds with the roadmap planning phase, which is completed by determining the corresponding technologies. Then, the drafting of roadmaps covering at least 4–6 years can start, with full attention devoted to the time aspect. Either in

multidisciplinary teams and/or workshops, roadmap scenarios are built to show how product functionality may develop over time and which technologies will be required (market pull, Figure 5), or else how technology will influence the product functionality (technology push). A common vision of what the future will look like for the products and technologies concerned is the primary goal of these activities.

The Innovation Matrix concept is derived from what is known in Philips as the Blue Box Model (because of the

box in the middle of Figure 6 usually being colored blue). This model as been suggested by Matthews (5) and was elaborated further by Philips. It shows the relationship between *uncertainty* of product feasibility and commitment to *resource allocation*. Three phases are distinguished in this model: the upper circle, the box in the middle and the lower circle; each has its own specific meaning (Figure 6).

In the *upper circle* phase, the question addressed is: Is it physically possible? Typically, research activities take place in this phase. The box in the middle considers such questions as: Is it attractive? Do we want it? In this phase, for example, product portfolio issues have to be addressed. The *lower circle* phase has to answer the question: How do we do it? Straightforward product development activities take place in this phase.

This model was introduced in Philips several years ago to improve the understanding of the integral product creation process; it is the basis for the Innovation Matrix concept that supports roadmapping. The Innovation Matrix shows *uncertainty* (vertically) and *required availability* (horizontally) for either technologies or products (Figure 7). Initially technologies, products and three time frames are considered (5–10 years, 3–5 years and 1–2 years), which are similar to the ones defined in the Matthews model. Products and technologies are then positioned in the nine sectors of the technology/product matrices based on the parameters “availability” and “uncertainty.” These sectors represent specific circumstances; for example:

Roadmapping requires the simultaneous consideration of markets/products, technologies and the interaction between them over time.

- *Missed opportunities* in the technology matrix means that a technology has become available that may not be required for 5–10 years from now, so that money has been spent in the wrong way.
- *Problem* in the product matrix implies that the product is needed in the short term but its feasibility is not proven.
- *Your future* shows the right balance between required availability and existing degree of uncertainty for either technologies or products.

After these two matrices have been completed, actions can be taken either to investigate specific problem areas or to commence actual roadmapping.

Specific actions may include:

1. Mapping the technology matrix onto the product matrix and analyzing possible discrepancies between the required availability of products and technologies. Such an analysis reveals, among other things, the areas of opportunities and major risks.

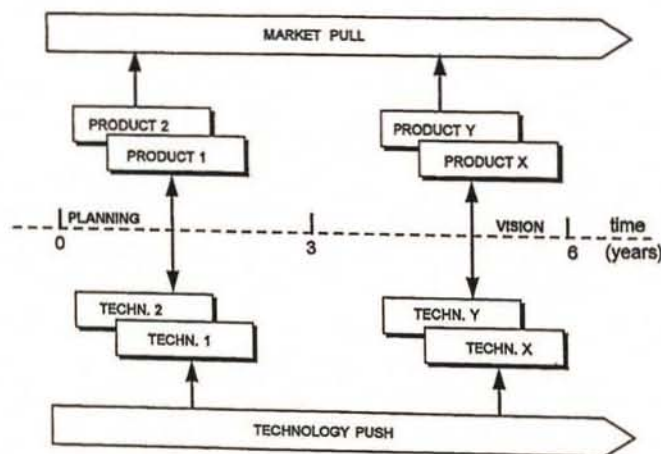


Figure 5.—Building product-technology roadmaps requires the simultaneous consideration of market pull, technology push and their interaction over time.

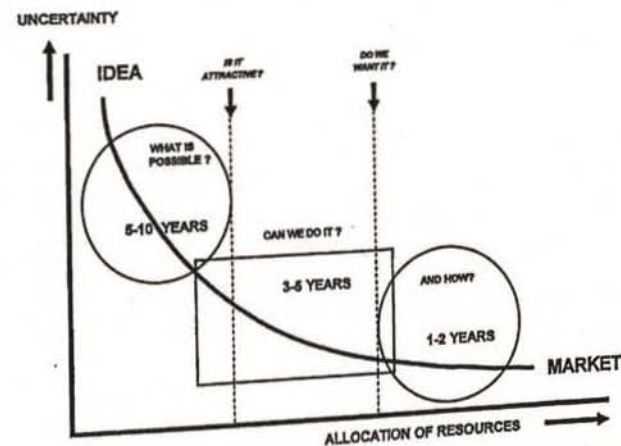


Figure 6.—The Blue Box Model relates uncertainty of product feasibility and commitment to (financial) resources allocated over time. It is characterized by three distinctive phases that address differently-oriented questions.

2. Conducting a portfolio analysis for the technologies. The analysis can show whether or not there is a good balance between short- and long-term R&D investments.

3. Conducting a portfolio analysis for the products, to reveal possible gaps in the availability of new products.

The information presented in the innovation matrices and, so far as available, the results of the actions listed above serve as inputs for the roadmapping process.

Roadmapping Practices

The following practices illustrate both differences and common aspects of the roadmapping process (6).

Philips Lighting began roadmapping by defining ten major application areas, deliberately ignoring technology impact. So-called "application roadmaps" were constructed to display current and future application requirements. These application roadmaps describe for each application area (e.g., shops, roads, offices) what the future customer requirements will be and how they interact with product design parameters. Considerable improvement in the definition of application requirements can be gained by applying QFD. All of these activities were undertaken by a team of application experts, product managers and representatives from market research and development.

In the next phase, product and technology gaps that needed to be filled were assessed, followed by the selection of the best product-technology choice for each application segment. Then, work on the product and

technology roadmaps was started for different product lines, e.g., fluorescent lighting, halogen lamps, high-pressure mercury lamps. These roadmaps serve as input for product program management, prioritization of R&D programs and technology synergy definition.

The roadmapping process in Philips Domestic Appliances is embedded in an existing structure of workshops aimed at better understanding market needs and improving the front end of the product creation process (the idea and concept phase). The different product groups, such as air treatment, shavers, floor care etc. organize their own workshops. A typical workshop starts with presentations on consumer needs and technology trends. It continues by translating defined consumer needs into functional specification elements, and from there into technologies.

After reaching a consensus, drafting of the long-term product-technology roadmaps starts. The roadmaps describe over a 5-7 year period the essential functional characteristics of a product (in terms of customer benefits), translate these requirements into technical product specifications and display the necessary technologies.

A next step is to optimize the use of related technologies across different product groups. So-called technology synergy platforms, in which representatives of the various product groups participate, define common technology programs for research and advanced development.

Philips Semiconductors is active in application-specific integrated circuits, a fast-moving market segment with an

obvious need for good applications knowledge, shorter time-to-market, in-time technology investments, and continuous cost reduction. Similar to the Lighting approach described above, a three-layer roadmap structure was introduced, consisting of market/applications, products and technologies. A seven-stage process was developed consisting of:

1. Problem recognition by management.
2. Development of the provisional three-layer roadmap by specialists.
3. Roadmap discussion and information-gathering by a small team.
4. Workshop(s) with multidisciplinary participation to draft roadmaps.
5. Upgrading of the roadmaps and their format (if necessary).
6. Improvement of supporting tools.
7. Stimulation of learning by repeating stages 2-6.

The roadmapping activities in Semiconductors are, among other things, supported by Innovation Matrices (see Figure 7) to analyze product-realization risks. The use of Innovation Matrices begins by filling in the technology matrix. For example, if a "medium uncertainty" risk is assigned to a given technology that should be available within one year, additional actions need to be defined, such as acquisition of extra development capacity or technology. Then, a similar approach is applied to products in the product innovation matrix.

The next step is to compare the technology and product matrices and analyze whether the right technology (e.g., the 0.5-micron process technology) is available in time for the right products (e.g., integrated circuits for coding video signals).

What We Learned

The path to the results presented in the preceding sections was not always as smooth as it may look. Roadmapping may be hampered or even halted for different reasons, a few of which are briefly described below.

- Organizations with a functionally-oriented culture often have difficulty starting roadmapping. They tend to draft only independent, functionally-oriented roadmaps (e.g., technology roadmaps). Measures must be taken to encourage multifunctional cooperation. Management plays a crucial role here.
- Management commitment may not be obtained easily. Management may consider roadmapping to be merely another approach or tool for improving the strategy definition and communication processes. Starting the roadmapping process bottom-up may help to demonstrate its benefits.

Roadmapping has proved itself indispensable to improving the idea and concept phase of the product creation process.

■ The time and effort required for roadmapping is underestimated, and other activities receive priority after some time. This is even more likely when roadmapping is introduced as a quick solution to existing problems. If this is likely to occur, start the roadmapping process on a small scale and explain the roadmapping program to the organization in as much detail as possible.

■ Reorganizations will usually stop a roadmapping process unless it has become a common practice. It will then take quite some time to regain momentum. However, roadmapping helps to identify and emphasize capabilities of key personnel necessary to restart or continue the process.

Where the roadmapping process was conducted successfully, however, the earlier mentioned aspects like better strategy and technology synergy definition, improved communication and team building were evident. Roadmapping has proved itself indispensable to improving the idea and concept phase of the product creation process. But as one Lighting manager pointed out: "Don't think that roadmapping is a guarantee for success in itself. Continued alertness and benchmarking are required to make sure that you are on track. And never underestimate how much time and concentration are required to continuously optimize content and use of the roadmaps." ©

Acknowledgments

Roadmapping builds on continuous learning. I would not have been able to write this article without the support of Philips' former CTO Frank Carrubba and learning from several Philips colleagues. In particular, I would like to thank Ton van de Kraats (Philips Semiconductors) and Ruud Gal (Philips Centre for Manufacturing Technologies), with whom I had many interesting roadmapping discussions.

References

1. Willyard, C. H. and McClees, C. W. "Motorola's Technology Roadmap Process." *Research Management*, Sept/Oct. 1987, pp. 13-19.
2. Morone, Joseph. *Winning in High-Tech Markets*. Harvard Business School Press, Boston, 1993.
3. Roussel, P. A., Saad, K. A., Erickson, T. J. *Third Generation R&D*. Harvard Business School Press, Boston, 1991.
4. Yoji Akao, *Quality Function Deployment*. Productivity Press, Cambridge, 1990.
5. Matthews, W. M. "Kissing Technology Frogs: Managing Technology as a Strategic Resource." *IMD Perspective for Managers*, International Institute for Management, Lausanne, Switzerland, No 5, 1990.
6. Quality Matters, Special Issue on Roadmapping, Internal Philips Publication, no 73, April 1996.

TECHNOLOGY UNCERTAINTY

| | | | |
|-----------------|-----------------------|-------------|-------------|
| not proven | RESEARCH | | PROBLEM |
| proven | | YOUR FUTURE | |
| well understood | missed opportunities | | PROJECTS |
| | 5 - 10 years | 3 - 5 years | 1 - 2 years |
| | REQUIRED AVAILABILITY | | |

Figure 7.—The Innovation Matrix for technologies shows how the required availability of a technology corresponds with its current level of uncertainty. Such a matrix shows in a simple way where discrepancies occur between availability and uncertainty at a given point in time.