Visualizing Roadmaps

A Design-Driven Approach

A process methodology can help craft roadmap visualizations that communicate plans and insights to key stakeholder audiences more effectively.

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Overview: Because they are highly visual, roadmaps can be a strong enabler of communication between different stakeholder groups and across organizations. However, the visual design of roadmaps has been largely overlooked, with little attention given to their graphic design, undermining their value as communication tools. A design-driven approach to developing a roadmap template can help practitioners create a roadmap whose visual elements support their communication goals. The design process methodology begins by eliciting the key information that needs to be conveyed by the roadmap, so that content can be aligned to audience requirements. This distills a common voice and a set of consistent messages. The approach finishes with the design of tailored visual representations that can be used to present clear and meaningful narratives to specific stakeholders.

Keywords: Roadmapping; Strategic planning; Visualization; Visual communication

From its origins, at Motorola in the 1970s, roadmapping has been adopted for its utility as an effective means of planning and communication, especially between the technical and commercial functions in an organization (Willyard and McClees 1987). Well-constructed roadmaps offer visualizations that allow managers and technologists to see data in context, identify patterns and connections, and highlight critical issues.

Although roadmaps have been widely recognized as powerful visual devices for communicating strategy, their graphic design – the visual element – has been generally ignored by both practitioners and academic researchers, and often has been poorly executed. As Blackwell et al. (2008) comment, the roadmapping community operates "largely without the support of relevant diagrammatic knowledge" (p. 128) – in other words, without established best practice and with an insufficient level of visual literacy. Kerr, Phaal, and Probert (2012a) also note the lack of design sensibilities in most roadmaps and suggest that "the high degree of variability in the quality of published roadmaps in terms of their graphical content and layout" indicates "a general lack of graphical design practice applied to their visual expression" (p. 4).

The lack of attention to the visual design of roadmaps diminishes their potential for communication. Common problems include information overload, distracting visual clutter that obscures the key messages, and poor visual layout that fails to structure a meaningful narrative. Applying some fundamental graphic design principles and adopting relevant design thinking practices can harness the power of visual communication to create more effective roadmaps – representations that can unravel complexity and filter noise to articulate concise, meaningful narratives. A design-driven roadmap visualization methodology, like the one we have developed at the University of Cambridge, can enable those generating roadmaps to craft appropriate visual forms that present clear and coherent messages.

Roadmaps as Visual Tools

From a tool-oriented perspective, roadmaps fall under one of two classes: the workshop chart and the communication graphic. These two types of visualization are distinctly different, as they support different types of tasks; Phaal and Muller (2009) distinguish between them using the terms *knowledge elicitation* and *knowledge communication.* The workshop chart is a knowledge elicitation tool, typically used to support collaborative planning. It captures information as it emerges, depicts the situational dynamics, and enables decision support. The outputs from that process may then be synthesized into communication graphics, or knowledge communication visualizations. These tools summarize and communicate the results of the planning activities and highlight the important issues.

The design-driven process elaborated here applies to roadmap visuals for knowledge communication. While workshop charts – knowledge elicitation tools – are contingent and evolving, emerging from participant interactions and follow-up discussions, communication graphics must be carefully developed to distill "the main elements of the strategic plan into a simple high-level visual representation" (Blackwell et al. 2008, p. 128). Applied as a strategic lens – that is, a condensed high-level systems view (Phaal

and Muller 2009) – the final roadmap visualization becomes a communication device that helps to promote strategic dialogue and, more importantly, coordinate action (Kerr, Phaal, and Probert 2012b).

Roadmap visuals may take a variety of forms. These include anything from simple tables and graphs, Gantt chart-based schedules, multilayer block diagrams, and bubble charts to more expressive forms, such as Sankey diagrams, tree diagrams, and flow-based pictorials and schematics, or even geographic maps or metaphor-based illustrations. A roadmap visualization can also be a composite arrangement that integrates a number of different forms (Kerr, Phaal, and Probert 2014).

Creators of roadmap visualizations must engage in a dynamic balancing act between the functional aims of the roadmap – what and to whom it is intended to communicate – and its aesthetics. The challenge is to communicate a significant amount of potentially complex information in an intuitive format, ensuring that the intended audiences can quickly identify and process the pertinent data. To accomplish these goals, the communication graphic must be appropriately designed, with visual form tailored to both its content and the intended audience.

Achieving effective visual communication requires an engaging representation that depicts the narrative of the strategic plan, developed through a design process that configures form and matches content to the needs of the intended audience. Kerr, Phaal, and Probert (2012a) suggest considering the roadmap representation as a canvas upon which visual objects are overlaid to create a composition. It is the composition – the combination of form and content – that conveys the story and supports the emphasis on the key messages.

As Phaal, Farrukh, and Probert (2009) point out, although much has been published on the process of roadmapping, there are very few sources of specific advice on how to generate effective visual representations. We sought to address this gap by developing a process methodology for the visual design of roadmaps. The aim of this approach is to enable the development of more meaningful roadmap visualizations through attention to the layout of information, the depiction of connections between objects, and the portrayal of strategic narratives.

The approach has been extensively deployed in both research and consulting engagements across the spectrum of organizational levels (project, program, portfolio, business unit, firm, sector, national, international) in major companies. Direct feedback from participants (via questionnaires) and clients (via review meetings) has been very positive in terms of the usefulness and effectiveness of the process. Informal follow-ups have provided anecdotal evidence that the visualizations developed using the methodology helped to reinforce common messages across organizational boundaries, reduced the barriers to stakeholder buy-in, and positively engaged decision makers.

A Design-Driven Approach to Generating Visualizations

The design-driven approach we have developed consists of four process steps (Table 1):

1. Defining the *frame* for the roadmap
2. Establishing the *structure* of the layout for the roadmap
3. Depicting the *relationships* that connect various elements of the roadmap
4. Articulating a *direction* for the strategic narrative captured by the roadmap

The approach involves generating visualization concepts and refining them in an iterative manner that moves forward through sketching to produce customized representations that become templates into which the relevant content elements are entered. To produce the final graphics, the templates are populated with the appropriate content and their aesthetic presentation is finalized.

The roadmap visualizations created by the Graphene Flagship program provide an exemplar of the process. The Graphene Future Emerging Technology Flagship is a €1 billion consortium-based research program involving 75 academic and industrial research groups from 17 countries. The aim of the program is to take graphene from its current state of raw potential to industrially viable applications. The consortium required a set of roadmap visualizations to communicate the benefits that could be achieved from exploiting graphene's unique properties. There were two critical audiences: the program funders and the industrial stakeholders. The process methodology was applied at a one-day, studio-based workshop whose goal was to design and prototype visual representations for each of these groups. Nine participants from across the program's functional areas (consortium leadership, program management, science/technology/engineering, research, and commercial interests) gathered to produce two views of the program: a high-level strategic overview and a systems-focused tactical view, using the frame–structure–relationship–direction process (Table 2).

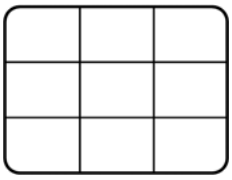
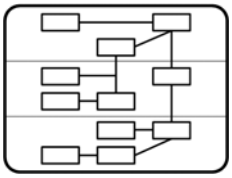
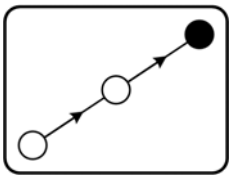
Defining the Frame

The first step in the approach is defining a frame of reference and relating it to the lenses favored by the intended audiences. This may be accomplished by exploring key questions through a structured discussion with a focus group of six to eight participants, including the roadmap owner (that is, the program leader), the roadmap's champion (a senior manager), relevant technology managers, the lead technical expert, an appropriate representative from business development and commercial functions, and, where possible, one or more members of the primary audience.

The frame of reference is composed of three constituent parts: what, why, and how. For instance, if the roadmap is exploring a new opportunity, then the following set of questions must be answered:

- What is the opportunity? What are its characteristics, features, and intent?
- Why is the opportunity exciting? What is the rationale for pursuing it?
- How is the opportunity going to be realized? What are the critical actions, key deliverables, significant resources required to realize it?

Table 1. Design-driven methodology for developing roadmap visualizations

Step	Tasks	Key Questions
Frame 	- Agree on the unit of analysis - Identify the target audience - Determine the audience's information requirements	- What is the unit of analysis? - Who needs to see the roadmap? - Who are the key stakeholders? - What are their lenses of interpretation? - What perspectives/dimensions are to be included? - What is the most important information?
Structure 	- Develop an appropriate layout for each key audience	- What form should the representation take? - How much physical real estate is available? - How much of the page should be dedicated to outlining a sense of context/vision/action? - What are the key axes? - What is the appropriate information hierarchy? - What is the logic driving the layout?
Relationship 	- Elicit a dynamic systems model - Distinguish the important pathways	- How can the dynamics of the situation be depicted? - What is the best way to articulate linkages? - How should relationships be shown? - How can cause–effect pathways be made visible? - What are the pertinent connections?
Direction 	- Establish the narrative sequence - Emphasize the narrative	- How can the overall direction be best depicted? - What are the main narrative threads? - What is an appropriate narrative sequence to reflect the strategic dialogue? - How can the narrative be emphasized?

The unit of analysis must be reaffirmed or clarified at the outset of the discussion, as it sets the boundaries of the audience's frame of reference: is the roadmap concerned with a specific technology, a program or portfolio of projects, a business unit, a market, or the whole organization? Phaal and Muller (2009), in their work on architecting systems-based hierarchical taxonomies for roadmaps, provide a concise treatment of the unit of analysis concept that roadmap developers may find useful at this stage.

Once the unit of analysis is agreed upon, the focus group must determine who will need to see and act on the roadmap and then capture the information requirements of that group (or groups). In other words, the focus group must define the target audience or audiences (Ambrose and Harris 2010). Similar types of people can be clustered into one of two fundamental classes: senior stakeholders, who typically need a high-level strategic view that conveys the overall plan and highlights the key impacts and benefits, and tactical stakeholders, who typically need a detailed view that shows the priorities, critical pathways, and actions driving the overall plan.

Next, the focus group must select the most important people (in terms of influencing or needing to be convinced) within both classes and specify their information requirements, given the framing of the unit of analysis. What information is crucial when a key audience member looks at the roadmap – is it about highlighting decision points? Funding levels? Knowledge gaps? Technology readiness? This includes determining the perspectives that must be shown in terms of a number of factors:

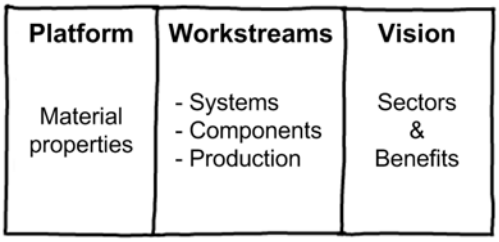
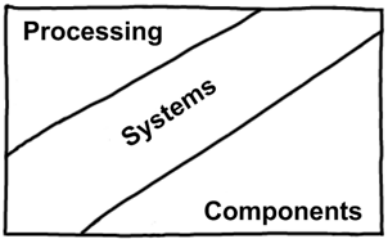
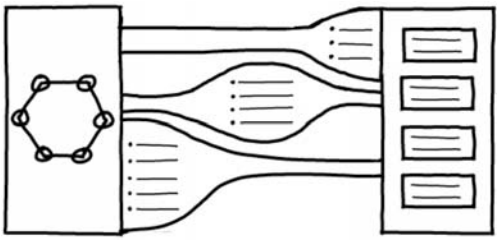
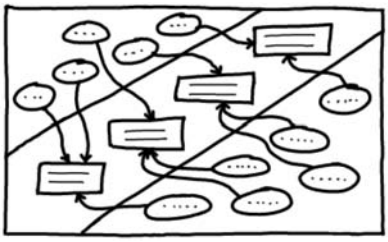
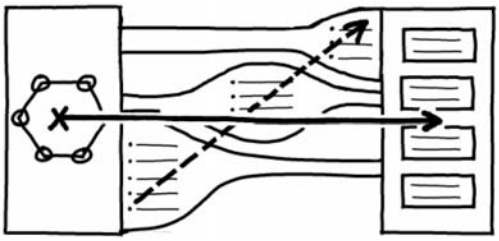
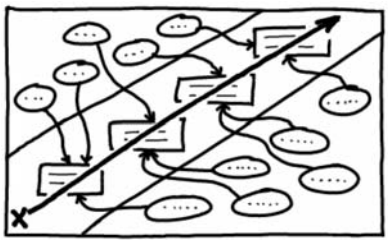
- Technology (features, performance)
- Business (financing, intellectual property, other business considerations)
- Function (design, production, manufacturing)
- Organization (skills, training, resources)

In the case of the Graphene Flagship program, the frame had to be defined for the two viewpoints: the funding body and its political masters (strategic view) and the industrial supply chain (tactical view). For the strategic stakeholders, the message to be conveyed was, graphene has the potential to become the next big disruptive technology and it can be expected to have a significant impact across a wide range of applications in key sectors, including ICT, energy, and health. The frame of reference consisted of the partnership between academia and industry (the how) for developing devices, systems, components, and production techniques (the what) to deliver sector-level benefits (the why).

The tactical view of the Graphene Flagship program needed to provide a granular view of the three workstreams. The frame of reference was, graphene will provide a powerful platform (the why) for enabling new devices and applications (the what) through new technologies and radical advancements that must be prototyped and tested (the how).

As this example illustrates, the framing step provides contextualization for the visualizations, as it helps to determine the purpose of communicating to each audience and specifies the information that must be conveyed.

Table 2. Generating the visualization concepts for the Graphene Flagship program

Strategic View	**Step**	**Tactical View**
Audience: Politicians and funding body Why: Benefits to the EU What: Streams of work How: Academia/industry partnership	*Frame*	Audience: Industry Why: Graphene as platform What: Applications How: New technologies
	*Structure*	
	*Relationship*	
	*Direction*	

Establishing the Structure

The second step in the approach is to address the issue of structure. The design task is to develop a wireframe, or low-fidelity sketch, for each key audience view that illustrates the layout of the various content elements and their related visual objects in a way that meets the audience's information needs. Different stakeholders will have different information needs; this may mean that several wireframes must be developed, each tailored to the perspectives and needs of a specific audience. We recommend that teams start with two basic viewpoints: a high-level view that summarizes the overall benefits and shows the impact of the proposed plan, and a detailed view that captures the main activities and deliverables required to move forward. This basic set can be expanded to generate other tailored views directed to particular audiences.

There are two options for conducting this phase. The first is to continue the process with the focus group, which moves directly from the framing discussion into a workshop mode consisting of repeated cycles of prototyping through sketching. This is an appropriate route if the focus group includes some participants from the key audiences. The

alternative option is to separate the framing and template sketching activities in order to allow time to validate audience needs.

Whether the structuring happens immediately after the framing or only after additional validation is done, this part of the process is highly iterative and follows a simple cycle of sketching–presenting–critiquing, similar to that described by Warfel (2009). This allows participants the freedom and opportunity to explore different layouts. Iterating through a number of such cycles results in convergence on a relevant layout for each targeted audience.

The creation of an intuitive layout is the main objective of this step. The layout of a visual is a means of sensemaking (Barbatsis, Camacho, and Jackson 2004); the visual structure should reflect the conceptual framework of the roadmap. In a well-designed roadmap, the layout provides a coherent sense of the underlying structure of the plan. That underlying structure is typically defined through the axes (reflecting the dimensions of why–what–how against time) and sections (reflecting the information hierarchy) of the layout. Generally, this results in a grid-based design.

Practical considerations also guide the layout. A roadmap communication graphic typically needs to be producible as a single page, slide, or poster, which limits the amount of physical real estate available. This requires careful judgments about the amount of space that should be dedicated to different parts of the narrative in order to achieve a balanced visual story.

For the Graphene Flagship program's strategic view, the representation is structured as three columns. The left-hand column illustrates the potential of graphene, positioning it as a platform that offers numerous opportunities for exploitation. The middle column depicts the primary workstreams for accessing those opportunities – developing systems, components, and production techniques – and, within each stream, outlines the main areas of research and future applications. The right-hand column presents the potential impact and benefits for each sector of interest.

In contrast, the tactical view focuses primarily on the three workstreams, and its structure consists of three corresponding diagonal sections. This structure directs attention to the data elements within each workstream and the interactions between workstreams, with the central systems integration section being used to portray the overall development route. The structure is relatively simple because the visualization must convey the detailed content required by the industrial supply chain audience; if the structure were more elaborate, it could make the depiction of the content appear unduly complicated.

As another example, a research-driven company needed a roadmap graphic that focused on the impact of a particular set of emerging technologies, to supplement its main product roadmaps. For an audience of R&D managers, the roadmapping team created a structural layout that split the page into four sections (Figure 1). The left-hand column started the narrative by providing the context, in the form of a description of the challenges faced and the main change drivers along with the Why – the rationale for pursuing the technologies. The middle of the page, which contains the bulk of the roadmap's content,

outlined both the What and How aspects and incorporated the timeline for the map. The What section attempted to align potential market applications with windows of opportunity that could be addressed through the integration of the emerging technologies into the product portfolio. The How section, below What, outlined the technology development programs (including technology maturity levels) against the background of the company's internal capabilities (both existing and to be developed). The structure, with How below What, reflects the reality that the How elements must feed up to inform and support the What elements. Finally, the right-hand column presents the vision driving the roadmap, in terms of future outcomes (linked positionally to the What) and future targets for technology development (linked to the How).

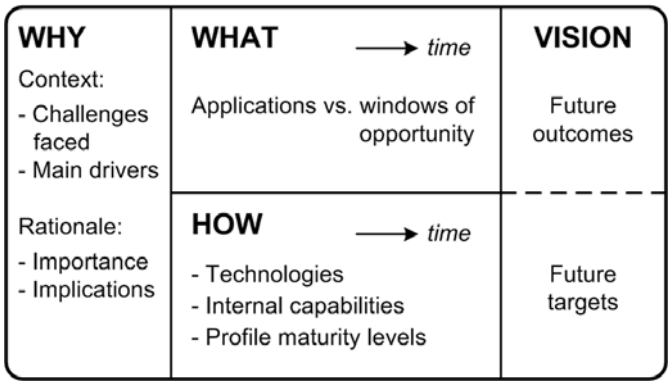


Figure 1. Example roadmap layout for an audience of R&D managers

Depicting the Relationships

The relationship step provides shape to the structure that has been developed and leads to the production of a more expressive representation. The output of the relationship analysis translates the basic structural layout into a visual composition. This is a crucial aspect of the design-driven approach, since "content without form is invisible and inaccessible" (Kazmierczak 2001, p. 98).

One of the major benefits of roadmapping is the ability to connect resources to products and services, and then to markets; it is therefore important to map the interconnections between these elements. In the relationship step, the objective is to elicit a dynamic systems model by making the connections, and the cause–effect pathways, visible. Such relationships can be shown either explicitly (using arrows or lines) or implicitly, through positioning and alignment.

In the case of the Graphene Flagship program, it was decided that the strategic view should deploy a set of implied relationships between the visual objects in order to help reinforce the strategic narrative. The structure provides a clear primary narrative, which reads left to right. In order to make the storyline more expressive, the relationship between the three workstreams is depicted through the relative shapes of the series of three corresponding Sankey diagrams. The varying width of these Sankey diagrams provides a sense of when the bulk of the work is to be conducted. At the start of the program the primary focus is on production techniques (bottommost channel), which then

transitions to components around 2016 (the middle channel), with the final phase oriented to systems integration (upper channel).

Visualizations can also capture much more involved sets of both explicit and implicit relationships. An organization with technology development activities in numerous component and subsystem levels wanted to construct a visualization to bring these varied activities together into a more integrated set of system demonstration projects, which would then feed the next generation of products across the portfolio. Working from conventional roadmap layouts, the team produced a sketch of a representation template consisting of three horizontal sections (Figure 2):

- The top section depicts the business strategy, which develops from a statement of the fundamental challenges in the industry through the corporate vision and strategic priorities to business-unit objectives, with each element driven by a clear logic. The relationships between these elements are explicitly shown in the form of arrows connecting each block.

- The middle section, which captures the program level, has two parts. The top part depicts the evolution of specific products through multiple generations. The bottom part depicts the rolling set of demonstrator projects that will feed into product development. Arrows explicitly indicate the flow between successive generations of products and an additional set of arrows shows how the demonstrator projects feed up into specific products. An implicit relationship, between the business unit's objectives in the last block of the top section and subsequent targets for each product line in the middle section, is indicated positionally (the targets fall directly under the objectives block).

- The bottom section is a tabular listing of the individual technology projects, categorized by domain, that need to be made ready for demonstration. There is an implicit, yet formalized, visual link between each demonstrator project (square block) and the associated technologies, captured by the alignment of the columns (check marks) with the projects they address. Performance targets for each of the technology projects are captured in a column on the right side of this section, again aligned with business unit objectives and product targets.

Once the relationships are elicited, it is important to step back and reflect upon the significance of the dynamic systems model by considering the pertinent cause–effect pathways that impart the major elements of the strategy.

Articulating a Direction

The fourth step in the approach is to articulate an overall direction of movement through the strategy captured by the roadmap. The metaphor of the roadmap is an indicator of its role: to map a route between positions. Thus, the roadmap visualization must capture not only present and future states, but also transitional pathways from the current position to the desired vision, and these pathways should be readily apparent to the audience. It is these time-based patterns that convey the literal intent of the roadmap as a representation of a coherent plan (Kerr, Phaal, and Probert 2012b).

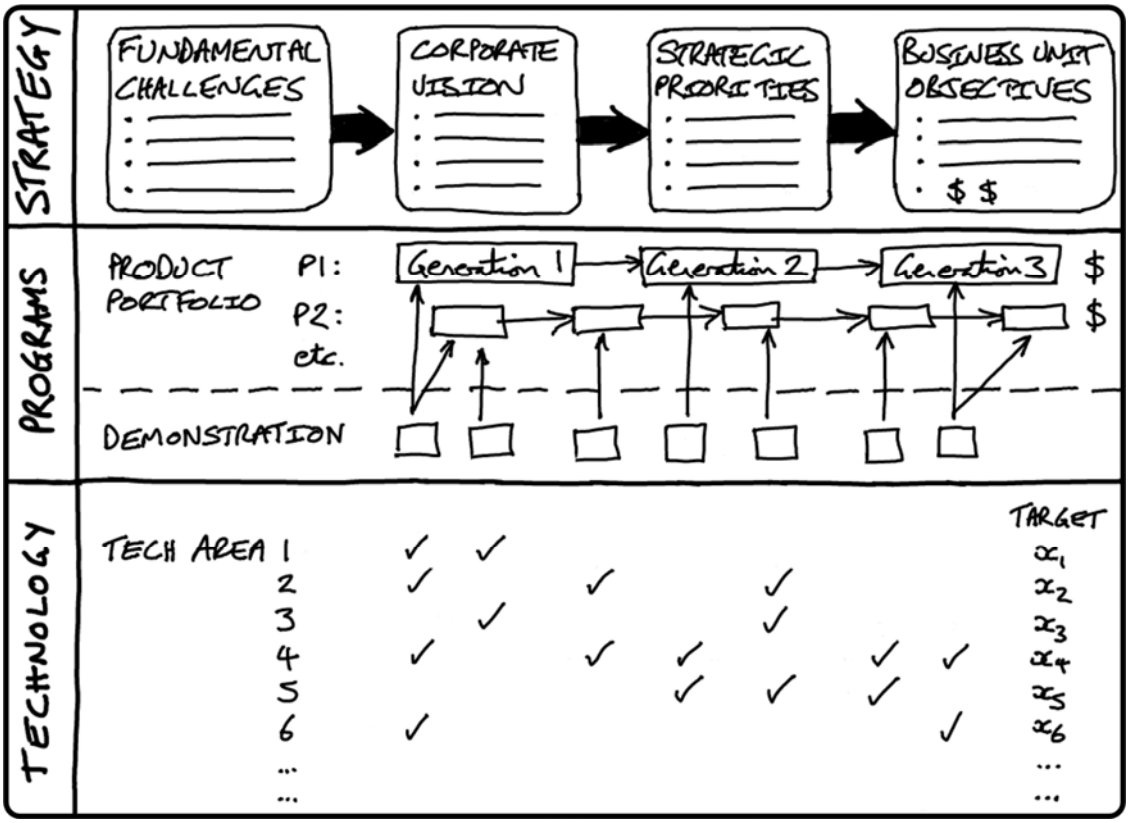


Figure 2. Prototype template sketch illustrating both explicit connections and implied interactions

The analogue to the route on a map is a narrative: a roadmap must capture the flow of an organization's desired narrative. For a visualization to truly embody a strategic dialogue, the flow of the narrative must be appropriately treated from a visual design perspective. This involves two important mechanisms – narrative sequence (the development of linear storylines, along with convergent and divergent alternatives) and narrative contrast (critical plot points where change is evident or where decisions need to be made).

In terms of narrative sequence, a good roadmap always conveys a sense of time or the direction of progress. The task is to identify those objects in the representation (such as milestones, decision points, or sequences of projects, products, or technologies) that thread together to create a storyline that spans the visualization. That storyline must be visible along an explicit time axis. Once the narrative sequence is established, it must be visually reinforced through pop-out effects – such as the use of prominent colors or bold annotations – that stress key moments. These are deployed to give emphasis to the principal narrative and ensure that it stands out clearly against the backdrop of the supporting information. In the final production of the communication graphic, pop-out effects give visual weight to the important narrative objects. This provides a means to lead an audience through the main elements of the plan.

This is illustrated in a design developed by the roadmapping team for a research initiative tasked with mapping the future of systems-of-systems research needs and capability development across a set of related domains. The team produced a sketch intended to convey a central narrative for an audience of technical program leads (Figure 3). The purpose of the visualization was to show how each capability development activity contributes to the goals of the initiative and, more importantly, how these activities build upon each other to realize the overarching vision. The proposed representation included a left-hand section that listed the needs and compared them with the current state of the art, a central section that outlined capability development activities and their associated outputs along with drivers and enablers, and a right-hand section that defined the vision and benefits of the work. An implicit set of relationships extends horizontally across the page, linking particular needs to capability development activities and then to the associated benefits statement through the alignment of the relevant items.

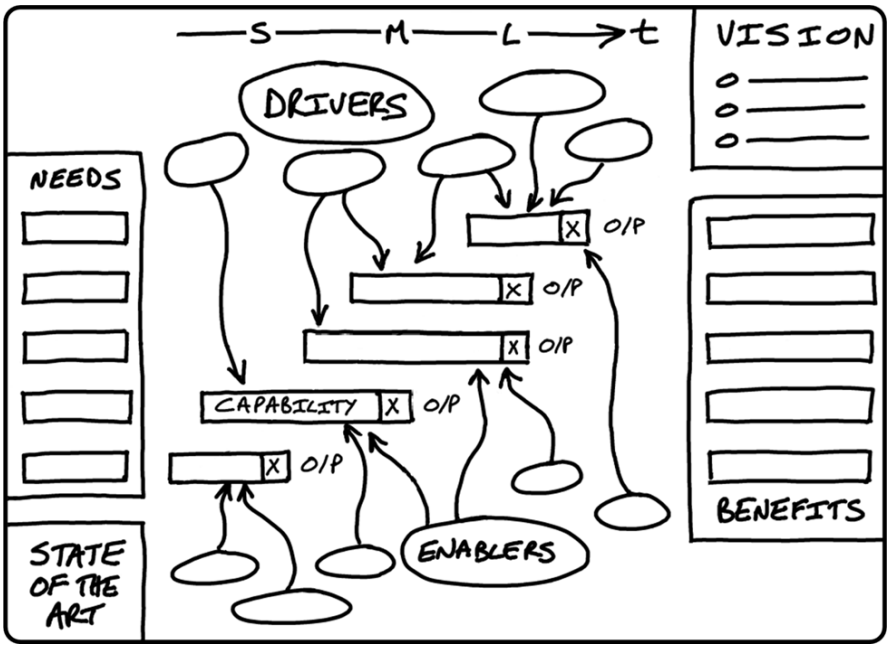


Figure 3. Visualization concept for a research initiative

However, while all of this information does form a narrative sequence, it is not the actual storyline captured by the overall direction of the roadmap. Rather, the principal narrative is indicated by the leading diagonal that starts at the bottom-left of the sketch, with the state of the art box, and then steps up through the capability blocks to the vision, at top right. In the final version, it will be critical to ensure that this overarching narrative is adequately highlighted and made intuitively obvious.

The Graphene Flagship's two roadmap visualizations illustrate different ways in which a graphic representation can indicate a narrative direction (Figure 4). In the strategic view, the horizontal flow across the graphic is the principal narrative direction. There is also a supporting narrative, created by the relationship between the workstreams as depicted by the shape of the three Sankey channels, which portrays a diagonal, stepped narrative

moving from bottom left to top right along the time axis of the roadmap. In the actual presentation, the narrative is reinforced by two-color shading in each channel that shows the share of work between academia and industry – academic research will be focused primarily on production techniques, while the major industrial contribution will be in systems integration, and both sets of actors will contribute equally to the components workstream. There are also a number of pictorial images overlaid on the workstreams to highlight some of the important applications to be developed.

In the tactical view, the graphic is structured into three diagonal sections overlaid on three time-based vertical columns. The principal narrative is the leading diagonal arrow depicting the stepped development route for systems integration. There are explicit connections from both the materials processing and components sections to the research work that needs to be fed into the central systems section. The key technological targets for materials development are given in the processing section.

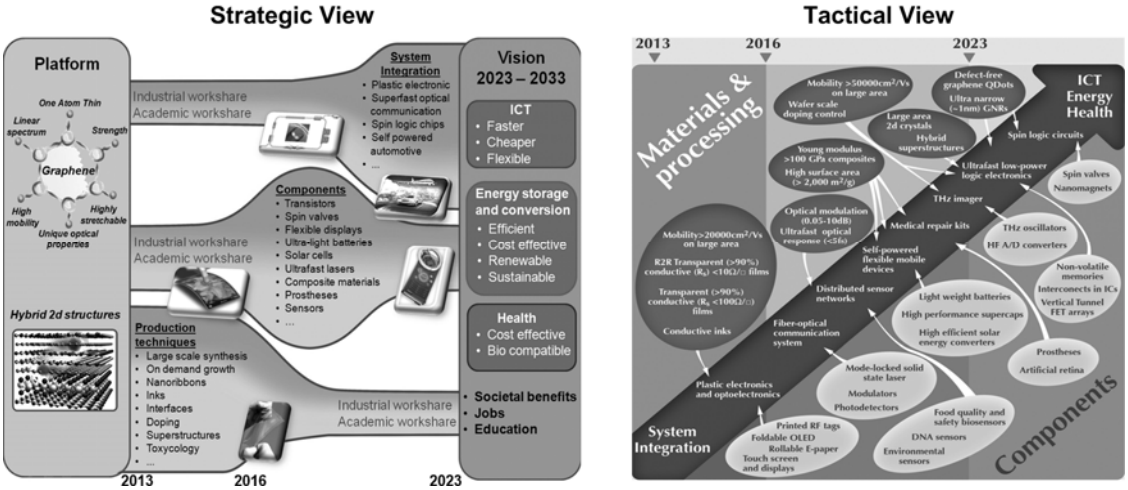


Figure 4. Final roadmap graphics for the Graphene Flagship program

Representation and Presentation

Visualizations are actually composed of two layers, representation and presentation (Phaal and Muller 2009). The representational layer contains the underlying structure and narrative sequences. The presentational layer defines the aesthetic style for the final communication graphic; this is where the rough sketch becomes a polished, attractive image. This dual-layer construction reflects Dyrud and Worley's (2006) view of visual design for business communication as being "simultaneously informative and artistic" (p. 397).

Although the frame–structure–relationship–direction process is primarily concerned with the representational layer, the presentational layer is important in ensuring the content is clearly presented and the narrative thrust is clearly emphasized. It is in creating the presentational layer that graphic design elements, such as color, balance, and weight, can be used to highlight key points and lead the audience along the desired narrative. In the final roadmap visualization for the research initiative, the leading diagonal narrative can

be given visual weight, so it is immediately obvious to the audience. For this reason, it is critical that those tasked with producing the final graphic are appropriately briefed and that close attention is given to the presentational elements to ensure that the principal narrative and key plot points are adequately emphasized in the final version.

Conclusion

The communication graphics produced by the Graphene Flagship team have been disseminated in a number of ways: they have been included in presentations at briefing days and review meetings, printed as posters and flyers, and posted on the program's website. The feedback from stakeholders has been very positive. A number of companies that have seen the strategic view have either attempted to imitate the format or used it as a source of visual inspiration in developing their own visualizations.

Roadmap visualizations are not objective artifacts; they convey particular viewpoints depending on the context of their creation and application. As a means to communicate strategic intent and associated plans, they should provide a clear, concise narrative expressed in a visual form that reflects the content and matches the intended audience's information needs.

Visualization is about making things visible – showing the essence of the plan as a sequenced narrative and emphasizing the critical points in the storyline. It's about conveying a set of messages in a way that allows an audience to understand their significance and providing the necessary insights to mobilize action. Developing powerful visual expressions requires careful attention to the selection of the medium of communication and the design of the visual representation – balancing context and content with a sense of the desired future state and action plan.

Our design-driven approach for creating roadmap visualizations offers a supportive methodology that steps through the concept development process to ensure the final representation captures the desired narrative and minimizes distracting background noise. Roadmaps can be powerful communication tools. However, they require thoughtful application of graphic design principles and good execution of the visual aspects of the presentation. This design-driven approach can help practitioners to more effectively exploit this often overlooked aspect of roadmapping.

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