An exploration into the visual aspects of roadmaps: The views from a panel of experts

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Abstract: Roadmapping is an established and popular method for strategic planning. Its strength is often characterised in terms of the visual way in which it can embody future plans and present pathways to realising an organisation's vision. However, although a roadmap is a visual management tool, the visual aspects from a graphic design perspective have been largely overlooked. In order to explore this perspective, a panel of experts was brought together for a research workshop which consisted of a focus group activity and a visual critique. The focus group elicited the good versus bad visual features of roadmap visualisations. This was followed by a critique exercise where a sample set of representative roadmaps were examined in terms of their structural layout, graphical objects and population with content. These roadmaps were also empirically assessed (scored and ranked) to give an indication of their 'visual design goodness'.

Keywords: roadmapping; strategic planning; visual communication; visualisation; aesthetics; information design; technology management.

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1 Introduction

Within the domain of technology management, roadmapping has become an established strategic planning method – it is seen as a powerful planning technique and as a widely adopted approach for supporting strategy development (Kerr et al., 2012a; Lee and Park, 2005; Lee et al., 2007; Lee et al., 2012; Phaal et al., 2003). The concept of technology roadmapping was originally developed by Motorola in the 1970s as a technique to improve the alignment between technology and product development (Willyard and McClees, 1987). Several decades later, it has been adopted by numerous organisations and further adapted to span the range of strategic planning activities from the technology-product views through to the firm/network/sector and up to the national/international levels (Phaal et al., 2007; 2009). More recently, the profile of the technique has been further heightened with the increasing trend to implement open innovation. For example, roadmapping has been identified as a key integrative mechanism for partners involved in open innovation processes (Caetano and Amaral, 2011). The popularity of the roadmapping approach emanates from its inherent ability to be both a focal point (Phaal et al., 2006) and an integrating device (Phaal et al., 2004a) for the various stakeholders involved in strategy-making.

The communication aspect of roadmapping is often considered as being a key benefit of the approach. Willyard and McClees (1987) originally saw roadmaps as a means of communication between R&D and marketing personnel. This audience-orientated perspective was broadened by both Groenveld (1997) and then Phaal (Phaal et al., 2007; Phaal and Muller,

2009) who noted that the development and dissemination of roadmaps communicated the alignment between the technology and commercial perspectives to all stakeholders. Taking a functional definition of communication, Kostoff and Schaller (2001) stated that "roadmaps communicate visions, attract resources from business and government, stimulate investigations and monitor progress". The importance of communication in roadmapping is more fully acknowledged in the psychosocial framework developed by Kerr et al. (2012b) where roadmapping/roadmaps provide a mechanism/vehicle to cogitate, articulate and communicate. The communication element represents roadmapping as an activity for participants to actively converse in a meaningful strategic dialogue and the associated roadmap as a vehicle to convey the results of the discussion that connects with the array of stakeholders via a living document.

Yoon et al. (2008) acknowledge that the key features and benefits of roadmapping typically relate to visualisation and communication. This is readily apparent since a roadmap is basically a visual tool (Strauss and Radnor, 2004) that supports technology-related decision-making. According to Kostoff and Schaller (2001) "roadmaps are fundamentally visual display aids that crystallise the linkages among the existing or proposed research programs, development programs, capability targets and requirements". The visual aspect of roadmapping is an inherent factor for the appeal of the technique (Phaal et al., 2008) and its success for the purposes of communication emanates from its graphical form. A roadmap is essentially a visual artefact whose graphical representation conveys meaning and is therefore a boundary object since it depicts the links between the differing stakeholders and communicates their shared viewpoints (Kerr et al., 2012b). It is a visual communication device that helps not only to share information with other parties but also, more importantly, to mobilise action (Kerr et al., 2012b). Thus, a roadmap can be considered to be a narrative graphic that depicts a strategic discourse. This requires a "synthesis of the main elements of the strategic plan into a simple high-level visual representation" (Blackwell et al., 2008). The visualisation can present information in a highly synthesised and condensed form (Phaal et al., 2004a). In order to allow such content to be readily digestible and comprehended, the conceptual structure of the visualisation is critical (Kazmierczak, 2001). The conceptual structure of a roadmap visual is essentially its architecture. Edward Tufte (2001), a recognised authority on the presentation of information graphics, states that space-time-story illustrations of multivariate complexity can be overlaid on graphical architectures. From a roadmapping perspective and building upon the work of Groenveld (1997), the framework of Phaal and Muller (2009) represents the most concise and inclusive architecture where all the key perspectives (market, business, service, product, technology, resources) can be charted as a function of time. This framework addresses the basic architecture of a roadmap visualisation (i.e. its representation); however, Phaal and Muller (2009) did identify the need to consider a roadmap's graphical style. Despite the acknowledgment of roadmapping as a powerful visual tool, research on the visual appearance of roadmaps is severely lacking. Phaal et al. (2009) noted that the body of literature focuses on the process of roadmapping and the reporting of case studies – but there is a lack of treatment on the graphical elements. Additionally, it is clear from the numerous examples of published roadmaps that the quality of their visual presentation is highly variable (Phaal et al., 2008; Phaal and Muller, 2009). Given such a degree of variability in the quality of published roadmaps in terms of their visual depiction, it is apparent that there is a general lack of graphical design practice applied to a roadmap's visual expression (Kerr et al., 2012c). Thus, there is a need for research on the graphical components of a roadmap and a call for discussions on good/bad design examples (Phaal et al., 2009; Phaal and Muller, 2009).

As an initial exploration into the visual aspects of roadmaps, a research workshop was conducted with a group of roadmapping experts to elicit the key features, both good and bad, exhibited by a representative sample set of published roadmaps. These sample roadmaps act as exemplars and allow a baseline calibration of the visual representation and presentation of technology roadmaps to be established. It must be acknowledged that the design reasoning (choices and rationale) behind these visuals is not known from the position of their creators/owners. However, the creators of the visuals have manifested their conceptual constructs into tangible forms in order to communicate with an audience and thus their designs can be assessed from the receivers' position. Therefore, the aim of this paper is to take the first step in appreciating the visual depictions of roadmaps from the audience perspective. This is effectively an introspective approach by the roadmapping community to reflect upon the visuals/graphics embodied by those designs as produced by their fellow practitioners. In regard to professional practice, Blackwell et al. (2008) highlighted that the roadmapping community operates largely without the support of relevant diagrammatic knowledge. Therefore such an explicit consideration of the visual aspects as reported in this paper provides the opportunity to identify key learning points that according to Moere and Purchase (2011) can inform and improve future design practice of new visualisations. As stated by Tufte (2001), "graphical excellence consists of complex ideas communicated with clarity, precision and efficiency". This paper makes the first known attempt to both define and empirically assess the 'visual design goodness' of a roadmap. The visual designs are rated in terms of their structural layout, presentation graphics and narrative content through a practitioner appraisal exercise. An important element of such an investigation is the visual aesthetic of the roadmaps. As highlighted by Owens (2009), the aesthetic often frames how well the form embodies content or fits function. Thus, it is necessary to explore the contribution of a roadmap's visual aesthetic to its potential power in informing and even persuading the stakeholders of the strategy communicated by the roadmap.

2 Visual aspects

Phaal and Muller (2009) have positioned roadmapping as a strategic lens due to the condensed visual format that can be achieved through the production of a single page high-level systems view. This perspective has been further defined by Kerr et al. (2012c) who see a roadmap as being "a visual canvas upon which a depiction of business strategy can be articulated and shared both within and between organisations". The idea of a roadmap being a canvas allows for visual objects to be overlaid forming a narrative composition that is then used to illustrate the strategic plan (Kerr et al., 2012c). The narrative is embodied by the connections of the visual objects and can be thought of as a causally related chain (Segel and Heer, 2010). The act of visualising has been considered by Kerr et al. (2013) and they identified two fundamental manifestations to a visual tool such as a roadmap, namely: there is a visual form for the application of the tool and then there is the visual form of its resulting output. As highlighted by Phaal et al. (2008): "visualisation is a key aspect of effective roadmapping, both in terms of the elicitation of information from groups (workshops), and also analysis and representation for communication purposes". This translates to a roadmap visualisation in the form of: i) an appropriately architected template for use in workshops, and then ii) the associated workshop output being synthesised into a communications visual for the purposes of dissemination. Phaal and Muller (2009) use the terms 'knowledge elicitation' and 'knowledge communication' to differentiate between these two visual manifestations.

It is critical to understand that the roadmapping visuals for elicitation and communication of a strategic plan are different – they, after all, serve different purposes. For knowledge elicitation, the visual template of the roadmap provides a framing mechanism to help contextualise the strategic challenges facing an organisation (Kerr et al., 2013). The architecture of the template helps to focus the workshop activities through a decomposition of the strategic challenges into manageable chunks. From a psychosocial perspective, this reduces the potentially negative effects from cognitive inertia and fixation that could emerge by attempting to immediately develop solutions and action plans (Kerr et al., 2012a). The roadmap template, which is usually a wall chart, is populated with content by the workshop participants. In terms of creativity and brainstorming, the participants are encouraged to get up and look over the roadmapping wall chart between iterations of ideation so that this visual depiction of the group's collective thoughts provides additional social stimulation and priming of associative memory (Kerr et al., 2012a). Additionally, the visual nature of the sticky notes on the wall chart adds another sensory input to facilitate cognition since it further eases cognitive load by allowing the clustering of ideas into theme-based sets (Kerr et al., 2012a). Thus, the tool becomes a visual medium that is physically interacted with by the workshop participants (Kerr et al., 2013).

This paper is concerned with the second manifestation whereby the output, from applying the roadmapping workshop tool, is synthesised into a distinct visualisation – this form of visual expression is for communication purposes in order to disseminate the results of the workshop and mobilise action in the wider organisation (Kerr et al., 2013). In this regard, Phaal et al. (2008) recommend the design of roadmaps as one-page views. The constraint of a single page ensures that the key issues are focused upon as set against the context of the 'big picture' (Phaal et al., 2008). Additionally, to paraphrase Phaal et al. (2008): one-page views are more easily updated, allowing the process to be more agile, and so enabling the roadmaps to keep pace with the rapidly changing business situations. The roadmap becomes an information graphic, i.e. infographic (Kerr et al., 2012c) – this is a term from the information design sub-domain of the graphic design field. In the context of an organisational setting, this infographic perspective positions a roadmap as a diagram rather than an image. The distinction between diagrams versus images was made by Amare and Manning (2007) who state that images typically lack clear contrasts, have no explicit filter for irrelevant detail and can embody unreliable generalisations; whereas, diagrams provide clear contrasts, have the mechanisms to only show relevant details, they can present a unified and reliable generalisation of the situation.

According to Blackwell et al. (2008), roadmaps are "a class of abstract visual representation that is unusually diverse in diagrammatic style". One possible explanation for the large range of visual depictions is the "lack of clear and accepted standards or protocols for their construction" (Phaal et al., 2004a). This is also acknowledged by Blackwell et al. (2008) who state that "in the absence of established and consensual best practice, those creating strategy roadmaps have collectively generated a large body of diagrams that are highly heterogeneous in form whilst being highly homogeneous in function". It is worthy to note that there has recently been a paper published which, to the best of our knowledge, provides the first known/reported design methodology for formally generating roadmap visualisations (Kerr and Phaal, 2015) – that specific approach now provides a common reference process and may even have the potential to become an established standard method.

Although there is diversity in specific graphical characteristics and syntax, roadmaps do have a specific role in the organisational context because the common issue is to visually depict and communicate information related to plans for the future (Blackwell et al., 2008). So when considering the diagrammatic aspects of a roadmap, there is a common feature shared by all roadmap visualisations – namely, they are comprised of two distinct visual layers (Phaal and Muller, 2009):

- An underlying information-based structure (i.e. the architectural format) – this defines how the information contained within the roadmap is organised in order to represent the important elements of the system charted against time.
- An overlaying graphical layer (i.e. the presentational format) – this defines the aesthetic style chosen to present the roadmap structure and give emphasis to its contents for communication purposes.

Given the widely diverse range of roadmap visuals, Phaal et al. (2004a) have attempted to categorise the architectural forms that are present in the public domain; they identified eight types:

- Text-based depictions
- Tables
- Graphs
- Bars (i.e. similar in style to Gantt charts)
- Single layer (e.g. step/state diagrams)
- Multiple layers (e.g. adoption of the Phaal and Muller (2009) framework)
- Flow charts
- Pictorial (e.g. visual metaphors, schematics)

Phaal et al. (2004a) do acknowledge that not all roadmaps will fit neatly within their categorisation scheme. They also highlight the additional class of hybrid forms which contain elements of more than one of the basic types. Such hybrid forms are called visual composites due to the modular fashion in which the different elements are readily integrated with one another (Kerr et al., 2013). Phaal et al. (2009) later produced a distillation of the visual representations (i.e. architectural forms) which resulted in three broad types being articulated, namely:

- Temporal
- System/process
- Metaphor

The temporal type is based on the traditional approach originally developed by Motorola (Willyard and McClees, 1987) and where the adoption of the Groenveld (1997) / Phaal and Muller (2009) framework has become the conventional norm for industrial adoption. This temporal type, where time is an explicit primary dimension (usually the horizontal axis), is the most common form of roadmap layout by far as it accounts for over 80% of the examples found in the public domain (Phaal et al., 2009). Although there exists no consistent visual platform for a roadmap, the temporal type comprising of a time-based, multi-layered diagrammatic chart offers the most general and flexible approach (Phaal and Muller, 2009). The system/process type is a more recent interpretation of the term roadmap (Phaal et al., 2009); it encompasses system pictures and business process diagrams. This type typically depicts system states, interactions and process flows. Whereas the metaphor type consists of various visual metaphorical devices to depict strategy: they range from the obvious use of cartographical roadmap elements (e.g. roads, road signs, traffic lights, etc.), to elements from nature (e.g. landscapes, mountains, rivers, trees, etc.), and man-made devices (e.g. funnels, wheels, levers, etc.).

It is critical to highlight that in both the system/process and metaphor types of architectural forms, a measure of time must be made visible (either explicitly or implicitly) in order that they are indeed acting as roadmaps. The danger is that often these types remain only to be seen as system diagrams, flow charts and visual metaphors because they do not visually articulate the current state, intermediate states and final future state vision. In order to be considered roadmaps they must have the strategic narrative as a function of time. Time is the critical measure that provides the ‘know-when’ dimension in roadmaps (Phaal et al., 2004b). Without a visible measure of time (know-when) being articulated and presented, such ‘so-called roadmaps’ are actually strategy maps not strategic planning roadmaps.

3 Expert panel

To initiate an exploratory investigation into the visual aspects of roadmaps, a panel of roadmapping experts was convened to participate in a research workshop. The workshop consisted of a focus group and a visual critique. The aim of the focus group was to elicit from the panel their experiences of both good and bad visual features of roadmaps when attempting to communicate a strategic narrative. Also, the focus group acted as a priming activity for the later critique exercise. The aim of the visual critique was to have the panel examine a sample set of published roadmaps to highlight their positive/negative features and to then empirically assess their 'visual design goodness' through a set of rating scales. It is hoped that the assessment from this expert panel will act as an initial baseline which future investigations, with different types of participants and/or other roadmap visualisations, can then use for comparator studies.

When a focus group is being employed as a research method, the critical factor is the composition of the group in terms of both the number and type of people (Given, 2008; Mazza, 2009). In terms of numbers, the recommendation is between 6 to 12 participants (Krahn and Putnam, 2003; Mazza, 2009; Stewart et al., 2007). In this study, eight participants took part. They were recruited from the 'Visual Strategy Network' which is a community of interest in roadmapping and related visual techniques for supporting strategy and innovation. Its membership spans industry, academia and government. Table 1 provides an overview of the participants. The panel was composed of representatives from industry, government, consulting, software providers and academia. The participants collectively have a breadth and depth of roadmapping experience ranging from international collaborations, national-level activities, industry consortia, corporate/divisional programs, consultative engagements, training and research activities. It must be highlighted that the expertise of the participants was in roadmapping and not necessarily on the subject matter of the sample set of published roadmaps examined during the study. They were asked to use their expertise to assess the visuals of the roadmaps and not to test or validate any of the data or knowledge embedded on specific examples for accuracy. They did however make an assessment of the content in terms of how it was visually presented and how well it portrayed a narrative (i.e. a clear and coherent visual story).

3.1 Focus group

The first part of the workshop was the focus group. Running a focus group is recommended as an initial activity when a new subject needs to be explored (Bloor and Wood, 2006; Stewart et al., 2007) – as in this case of exploring the visual features of roadmaps. A focus group is a "powerful social interviewing technique that allows researchers to elicit several viewpoints from users at the same time" (Mazza and Berrè, 2007). It provides a means to collect a rich/detailed set of qualitative data, through a group interview, where the emphasis is on the thoughts and experiences of the participants (Jupp, 2006; Mazza, 2009; Stewart et al., 2007). A key benefit is that the dataset is in the participants' own words (Mazza and Berrè, 2007; Stewart et al., 2007).

The process for the focus group activity is outlined in Figure 1. "A focus group is not a freewheeling conversation among group members, it has focus and a clearly identifiable agenda" (Stewart et al., 2007). It is a task-oriented activity where the task is to orient the participant discussions to produce opinions on the specific subject (Puchta and Potter, 2004). As can be seen in Figure 1, the central question for the focus group to explore was:

> *What visual features support or hinder effective representation/communication?*

The participants were prompted to articulate the good and bad features in terms of both their professional experiences and personal preferences. Typically, focus groups are highly interactive (Krahn and Putnam, 2003; Marshall and Rossman, 1995) and a moderator is recommended. Thus, the process was facilitated by a moderator whose role was to stimulate the interaction among the participants, keep the discussion focused on the topic of investigation and make sure that the activity ran to schedule (Bloor and Wood, 2006; Krahn and Putnam, 2003; Mazza, 2009; Mazza and Berrè, 2007). The moderator also ensured that no single individual was allowed to dominate the discussion and that every participant had an opportunity to share their views. Additionally, the spatial layout of the seating in the room was arranged in a semi-circular fashion. This ensured that all participants could see one another and so better enable group discussions (Stewart et al., 2007).

The focus group started with a brainstorm (Figure 1). This had two phases. First, the workshop participants were formed into pairs to discuss the research question in order to elicit their views. This data was captured by the participants writing on sticky notes. Such a step allows participants to freely capture their thoughts/views without any pre-judgement and minimises the negative potential for dominance by specific individual participants. It also allows data to be obtained very quickly. However, it must be remembered that a focus group is centred on participant conversations and these must be both shared and compared (Jupp, 2006). So after this initial priming step, the discussion was then opened to the wider group in order to allow further social discussion (Step 2 in Figure 1). Such a dynamic in the group discussion both broadens and deepens the information gathered (Krahn and Putnam, 2003; Stewart et al., 2007) as it allows participants to reflect/comment on the ideas of others and to generate additional insights that might have not been uncovered (Mazza and Berrè, 2007).

Once the views were elicited from the participants, the associated sticky note responses were pooled together and put up onto two flip charts – one for the 'good' features and the other for 'bad'. Sticky notes with similar comments were then clustered into theme sets. The final step in the focus group, as can be seen in Figure 1, was a dot voting exercise; such a mechanism provides an overall view of the 'value' relationships between the articulated themes and allows the group to identify the top-priority issues (Tharenou et al., 2007). In the analysis of the focus group data, it is the topics that consistently generate the high levels of interest from almost every participant that are of greatest concern (Given, 2008).

The force-field diagram of Figure 2 gives a visual summary of the results from the focus group. In terms of the 'good' visual features, the themes ranged from: user-friendly formats, explicit timelines, customised views, clear linkages and one-page summaries. The top item, having 25% of the vote, was that the visual forms usually have a high degree of user-friendliness. This is manifested through having an intuitive format/structure which is easy to follow and supported with an associated chart legend which identifies the key visual objects. Additionally, the usability of a roadmap is often reinforced by the effective use of colour to either highlight the important issues or emphasise certain attributes such as decision points. Colour coding is also used to provide a ranking of the data elements. The timeline was a prominent theme for discussion in the focus group; as one participant stated: '*a good roadmap always conveys a sense of time or direction of progress*'. This may be depicted through visual objects such as outcome milestones, decision points and sequencing of projects/products/technologies. The critical visual challenge is to ensure that a storyline or narrative is seen across the explicit time dimension on the roadmap canvas. Another feature of good roadmaps is the use of customised views, as acknowledged by the participants with positive comments such as '*different views for different audiences*' and '*tailored to an audience but communicates to all*'. Both the visual form and content of a roadmap must be tailored to a specific audience, whether it be the Board of Directors or an engineering project team, in order for it to be an effective communication medium. It is about providing '*clarity at a specific level*'. The use of bespoke views/layers and different presentational objects allows for a tailoring or configuring of a roadmap's visuals to connect with different stakeholder groups. The depiction of linkages in a roadmap is another feature observed in good roadmaps, as the focus group highlighted: '*linkages are important*', '*it is about seeing the connection to resources*', '*the elements shown on a roadmap must link* *to the strategic vision*'. The final theme of discussion concerning positive visual features of roadmaps (Figure 2) was the provision of a one-page summary and this aspect was aptly described by a participant as: '*needs to fit on one page in a report and presented as a single slide in a presentation*'.

In terms of the 'bad' visual features exhibited by roadmaps, the themes ranged from: information dense, jargon-laden, inappropriate typeface, lack of a supporting legend, poor use of colour, fixed 2D representation. The top item, having 31% of the vote (Figure 2), was that too much information was being crammed into visualisations that should be for communication as opposed to a form of visual reporting. Common comments made by the participants were: '*too much information*' and '*data overload*'. This means that the content embodied in the roadmap visual was difficult to digest. Often it's too much of a cognitive burden in just attempting to read the visual, as one participant stated: it is even '*difficult to find a starting point*' in order to navigate through the content of the visualisation. This aspect of too much content (data overload) or too much visual clutter (noise) was also identified by Blackwell et al. (2008) as being the greatest pitfall in the design of roadmaps. Related to the information density issue was that the content can be heavily laden with technical jargon, which is either industry-specific or specialist terminology within a specific science/engineering discipline. Additionally, there were lots of negative comments by the focus group on the overuse of abbreviations and acronyms. Perhaps there is an overreliance on the use of abbreviations/acronyms in an attempt to save space on the visual 'real estate' of the roadmap canvas. Another concern of the participants was in regards to typeface; the biggest negative issue within this theme was the use of a font size that was too small to be clearly readable. Also, there is the factor of poor choice in selecting a typeface so making annotations difficult to read. Participants expressed that poor roadmaps also lack the provision of supporting information such as a chart legend or key in order that the viewer can understand what the visual objects (e.g. symbols/shapes) are meant to represent. When initially viewing a roadmap, one of the factors, which done poorly, that can have a significant effect on the viewers' perception is colour. The focus group highlighted that a poor choice of colour palette can have a detrimental impact; it is '*off-putting*' in the sense that the graphic as a whole is '*not attractive to the eye*' and '*so much so that viewers don't want to engage with it*'. These statements from the focus group indicate that colour is a driver in an audience's initial reaction to a roadmap visual. Colour appears to be an important element in terms of the degree to which a roadmap is perceived as aesthetically pleasing enough as to attract a viewer's attention before they focus on the layout and content. The final theme of discussion concerning the negative visual features of roadmaps (Figure 2) related to the actual medium itself – that is, a fixed representation on the two-dimensional page. Particularly in relation to the sharing of a roadmap, the static nature of the visuals on a page is not as engaging from an interaction perspective as some software embodiments which have the functionality to allow users to explore the content of the roadmap. Although this issue was acknowledged by some participants in the focus group, it was however outside the scope of this study (where the research exploration of the visual aspects of roadmaps is limited to static versions – this style of presentation is still the most common method).

3.2 Visual critique

The second part of the workshop was the visual critique. Its aim was to provide an empirical evaluation of a set of roadmap examples by the expert panel. It was both a practitioner evaluation (since actual 'real' users were involved) and a peer review due to the nature/composition of the workshop participants. It is important to note that the peer review was directed to the example roadmap visualisations and so the judgements should not be construed as a reflection on their owners. It was the designed visuals of the roadmaps that were assessed since these are tangible artefacts open to external scrutiny (Owens, 2009). The process for the visual critique is outlined in Figure 3. The participants were again formed into pairs and given instructions to critique a sample set of ten roadmap visualisations; spending approximately five minutes discussing each specific visual depiction before being rotated on to the next example. The participants were given a set of green (for 'good') and red (for 'bad') arrow-shaped sticky notes. They had to annotate the sticky notes with their comments and then position them pointing to the associated good/bad features on the roadmap. This part of the visual critique exercise is what Carroll (1999) would call 'design appreciation'. Next the participants were given sticky dots and asked to rate each example in terms of its overall visual appeal, structural layout, graphical elements and content presentation. This part of the visual critique provided a quantitative indication as to the 'goodness' of each example and a ranking within the sample set.

3.2.1 Roadmap sample set

When creating an information graphic, such as a roadmap, design decisions on the visuals often rely on precedent from practice and exemplars (Moere and Purchase, 2011). Therefore, in order to explore the visual aspects of 'real examples', a sample set of 10 visual roadmap depictions from the public domain were selected for analysis. Table 2 gives a numerical overview of the selection stages, with the filtering criteria as headings. The aim of selecting a representative sample set was to highlight both good and poor design features across the different visual forms. The starting point was the survey conducted by Phaal et al. (2009) who collated a set of 934 roadmapping documents through an extensive search of the internet. These documents were the products "of serious efforts by credible organisations and groups of people to understand the factors that influence their field of interest, to articulate a collective view of goals and aspirations, and to identify priority actions required to move forward" (Phaal et al., 2009). From this collection of documents, the corresponding visual depictions were extracted since they represent the unit of analysis for this study – the result was 398 figures. This first step was also implemented in a study by Blackwell et al. (2008) who noted that "many documents described as 'roadmaps' simply describe strategy in a text format". However, Blackwell et al. (2008) appear to have assumed that all of the extracted figures were roadmaps. Upon our analysis of the extracted figures, about a third of them (131) were found not to be actual roadmaps – just because an image is called a roadmap doesn't make it so. The primary reason for rejection was the lack of a time dimension. As stressed by Phaal et al. (2008) "time is a fundamental dimension that must be represented, generally explicitly or sometimes implicitly (for example, the sequence of events might be represented rather than actual dates if timing is uncertain)". The rejected figures were typically strategy maps, system state diagrams and business flow charts. There was a secondary group of figures that were rejected, due to the lack of a 'strategy' content and/or context. These were merely Gantt charts and product release schedules inappropriately titled as roadmaps. So of the 398 extracted figures, only 267 were visual roadmap depictions. This 'approved' set provided a corpus for the purposes of visual research. The corpus was surveyed to produce a pre-selection of 39 potential candidates for analysis based on:

- Representational type – temporal, system/process, metaphor
- Architectural style – table, graph, bar, single layer, multiple layer, flow, pictorial
- Narrative sequence – step, linear, convergent, divergent
- Visual objects – lines, blocks, symbols, icons, embedded images, annotation

From the 39 candidate figures, a representative sample set of 10 were chosen for the study – this is a manageable number to be analysed in-depth in a workshop environment by the group of roadmapping experts.

Figure 4 depicts each of the 10 roadmap visualisations. The presentation of the individual visualisations follows the approach of Lohse et al. (1994) and Phaal et al. (2009), where only a ‘thumbnail’ for each of the visualisations is given in the paper so as to provide an impression of the graphics; the reader is referred to the actual source documents for the detailed high-resolution figures. It is worthy to note that the 10 visualisations are from governmental bodies and research institutions – there were no specific company examples (as these are generally not publicly available/accessible due to confidentiality).

The first visual roadmap depiction in the sample set, labelled #007, is from an international effort of ten countries (Argentina, Brazil, Canada, France, Japan, the Republic of Korea, South Africa, Switzerland, the United Kingdom and the United States) to advance the state of nuclear energy to meet future energy needs (NERAC and GIF, 2002). The aim of this technology roadmap was to define and plan the necessary research and development to support the next generations of innovative nuclear energy systems. Its figure, whose original size is a third of a page, gives a high-level summary overview of the generations of nuclear reactors. Its focus is on the advances to Generation III underway, at that time, leading to Generation III+ and then to the Generation IV systems potentially available for deployment around 2030 (NERAC and GIF, 2002).

The second visual depiction, labelled #082, was produced by NASA’s Office of Space Sciences where their goal was to understand the Sun, heliosphere and planetary environments as a single connected system (NASA, 2003). The original size of the figure is half a page. This roadmap shows the future Sun-Earth connection missions that will be made possible or improved through the development of new enabling technologies for sensors and propulsion systems. The aim was to show the critical challenge of providing an economical number of spacecraft for future missions.

The third example, labelled #153, is also from NASA (1997). It presents the future directions for the gamma-ray astronomy program by showing the promising technologies against future priority missions. The original size of the figure is a full page.

The fourth roadmap visualisation, labelled #167, is from Japan (METI, 2005) and was developed cooperatively with industry, academia and public institutions. It is a strategic energy technology roadmap for the transport sector. The original size of the figure is a single page. It depicts the technology portfolio, for overcoming the future constraints in resources and the environment, and shows the priorities for long-term research and development out to 2100.

The fifth visualisation, labelled #212, is another example from NASA (2004). The original size of the figure spans two pages. It is entitled the

'Solar System and beyond' exploration roadmap. The intent of the figure is to show "a sustained and affordable human and robotic program to explore the solar system and beyond" (NASA, 2004). The goals are to visit the Moon, Mars, the Outer Moons and Extrasolar Planets by leveraging the capabilities of robotic explorers, based on breakthrough technologies, in order to enable follow-on human missions. In addition to the missions, the roadmap also visually depicts the key exploration building blocks including the capabilities needed for propulsion, power, communications, crew transport and launch (NASA, 2004).

The sixth roadmap depiction in the sample set, labelled #225, is from the Japanese New Energy and Industrial Technology Development Organisation (NEDO, 2004). It visually articulates the future research and technological development plans for the field of photovoltaic power generation. The original size of the figure is a single page.

The seventh visual depiction, labelled #290, is a roadmap from the mining industry. It was developed by the US National Mining Association and the US Department of Energy (NMA and DOE, 2002) in collaboration with mining companies, equipment suppliers, government agencies, research laboratories and universities. The original size of the figure is a single page and it visually shows the future pathways for process and technology research in order to improve the exploration and extraction of ore from the earth.

The eighth example, labelled #311, was produced by the UK's National Physical Laboratory (NPL, 2006) and is entitled the ultra-low temperature technology and application roadmap. It is intended to show "the paths and timelines for products through their various stages from the very underpinning technology to the final product, and relate the latter to the external triggers and targets" (NPL, 2006). The aim was to visually demonstrate the relations between the fundamental and applied research against the priority areas from the perspective of the government funding body. The original size of the figure is a single page.

The ninth visualisation, labelled #350, is another example from NASA (1998). It is essentially a visual summary that explains to Congress why the Agency exists and what its goals are over a 25-year future time frame. The original size of the figure spans two pages in which are defined NASA's vision, mission, scientific priorities, areas of business, near-/mid-/long-term goals and its contributions to the nation.

The tenth and final roadmap visualisation in the sample set, labelled #395, is focused on high-energy physics and produced by the OECD Global Science Forum (OECD-GSF, 2002). The original size of the figure is a single page. The roadmap is a projection of the future large energy-frontier, accelerator-based facilities likely to be sought by the world's high-energy physics community. The visual depiction relates the principal physics exploration goals to the accelerator projects against both explicit time (in years) and implicit time (i.e. sequential phases of R&D, decision and negotiation, facility construction, operation).

3.2.2 Quantitative rankings

In the process of providing an empirical evaluation of the roadmap visuals, some generalised assessment criteria had to be established. For example, Brinck et al. (2002) provide a general-purpose checklist of areas for consideration. These include:

- Architecture / layout design
- Graphics, colour, typography
- Content

These general issues are readily applicable to inferring a set of assessment areas. In this case, they have been adopted and refined to the specifics necessary for the consideration of roadmapping visualisations. These are given in Figure 5. Firstly, there is the structure of the roadmap in terms of its axes, key dimensions, layers, grid-based layout and corresponding information hierarchy. This first assessment area corresponds to what Barbatsis et al. (2004) equates as the sense-making through a visual's layout and the logic of the message design. The second area relates to the graphical elements and the sense of aesthetics attributable to those graphics. The graphical elements are essentially the basic building blocks or components of the visualisation. They include the use of colour, shapes, symbols, icons and the style in which these visual objects are both aligned and connected. The aesthetics of the visual depiction refers to how it is perceived in terms of attractiveness/beauty; Moere and Purchase (2011) state that this should include "fuzzy aspects such as originality, innovation and novelty" of the visualisation. The third area corresponds to the nature of how the content in the roadmap is presented and the strategic dialogue that it embodies. This includes the population of content on the canvas, the supporting use of white space and the placement of narrative objects. There is also the appropriate use of annotation; according to Kazmierczak (2001) diagrams are a blend of pictorial and linguistic elements where the visual discourse "requires linguistic support to gain a context to allocate the meaning of the otherwise abstract and arbitrary formation" of pictorial objects. Furthermore, there is the level of coherence in the visual narrative or storyline which is seen by the viewer. Finally, bringing these three constituent areas together (structure, graphics and content), there is the combined assessment of the overall visual impression/appeal of the roadmap depiction. As can be seen in Figure 3, an assessment of these areas was made for each of the sample roadmap visualisations (Figure 4) by placing sticky dots on an associated ratings sheet.

The ratings sheet used the semantic differential method (Osgood et al., 1957) presented in the form of visual analog scales. The semantic differential method employs a bipolar rating mechanism defined through a pair of adjective anchors which are at opposite ends of a continuum (DeVellis, 2003; Khan and Khan, 2006; Robson, 2002). In this case, the adjectives were 'good' versus 'bad'. Such an approach has been widely deployed in assessing the visual appearance of artefacts/objects (Kato and Saeki, 2008; Lindgaard et al., 2006; Park et al., 2004) and it is also the basis for judging aesthetic dimensions in Kansei engineering (Nagamachi, 1995). The visual analog scales use a continuous line between the two adjective anchors (DeVellis, 2003). The line itself is unmarked in that it doesn't display any increments along its length (Levin, 1975; 1976). Lindgaard et al. (2006) highly recommends the 'unmarked line' as the form of assessment scale (especially for making judgements in relation to visual objects) over the convention of using a Likert scale or numeric interval scale because it avoids issues such as: nonlinearity (Virtanen et al., 1995), psychological distance (Lindgaard et al., 2006), central tendency conservatism (Edwards 1982) and numerical subjectivity (Bruine de Bruin et al., 2000; Fischhoff and Bruine de Bruin, 1999). Beside each of the roadmap visualisations was a corresponding ratings sheet (an example of which is show in Figure 3). The workshop participants were instructed to place sticky dots on the respective scaling lines of the ratings sheet to reflect their judgement of how 'good' vs 'bad' each roadmap visualisation was in terms of overall visual appeal, structure, graphics and content. The participants individually scored all ten visualisations in their own time and it should be noted, that since a common ratings sheet was used for each specific roadmap, the results were visible so enabling a final discussion by the group on the outcomes and general impressions. Post-workshop, these ratings were then translated into numeric values for calculation purposes. The ratings were averaged, across the participant inputs, to generate an indicative score against each of the four assessment areas for the ten individual roadmaps. Figure 6 presents the results from the empirical evaluation; note that the quantitative rankings are based on a score out of 100.

There are two major findings from the visual critique activity of the sample set of roadmaps: i) there are those visual depictions that are clearly identified as being either 'good' or 'poor' for the purposes of communicating a strategic plan; and, ii) the key influencing factor in the perceived 'goodness' of a communication roadmap is its graphical design and visual aesthetics.

In terms of a 'good' roadmap visualisation, the results clearly identified that the top performer in terms of best graphics, best content and second-best structure is roadmap #212 (NASA, 2004). This roadmap was assessed as being the best overall amongst the sample set of ten. There were also a number of roadmaps that ranked consistently 'good' across the scoreboard (Figure 6). For instance, roadmaps #225 (NEDO, 2004) and #167 (METI, 2005) ranked third and fourth best across the areas of structure, graphics and content – both roadmaps were in the top five overall. It's interesting to note that #225 and #167 were from Japan. In regards to 'poor' visualisations, roadmap #290 (NMA and DOE, 2002) was rated the worst overall. It scored very poorly in terms of structure and graphics – although it did rank well in relation to content.

The results, in Figure 6, reflect an interesting interaction when considering the influence of the quality in the graphics on the overall score. For example, roadmap #350 (NASA, 1998) had the best structure and second-best content yet overall it ranked as second-from-last (9th position) – although it did, after all, have the worst graphics score. It seems that the 'goodness' of a roadmap visualisation is significantly influenced by how a viewer perceives the style of the graphical elements and their associated aesthetic qualities. This observation is reinforced when roadmap #395 (OECD-GSF, 2002) is considered. As can be seen in Figure 6, this roadmap was the worst in terms of structure and scored poorly for content (ranked 8th) but it ranked second-best in graphics – so, overall it was fourth best. These results indicate that the contribution of the visual aesthetics is a dominant factor in a viewer's perceived measure of 'goodness' for a roadmap. This may seem rather obvious given that the medium for transmitting the message is the visual depiction but both the academic and practitioner communities have largely ignored the graphic design of roadmaps – this study highlights the need for serious research efforts to be deployed toward understanding the effects of visualisation practices.

4 Future research

The results reported in this paper provide an initial exploration into the visual aspects of roadmaps. It was readily apparent in the visual critique which roadmaps had a 'good' level of graphic design and those which had 'poor' visual characteristics. However, it was not immediately obvious why specific visual elements appeared to work well together as a complete composition. There needs to be further research on the interplay of structure, graphics and content in order to develop an understanding of how to achieve an acceptable balance between these three areas so that a 'good' overall visual depiction can be generated. Additionally, each of the three areas needs to be investigated at a much deeper level. For example, in considering the structural layout of a roadmap, when is it more appropriate to adopt a tabular design as opposed to a more pictorial metaphor scheme? Or, what type of visual objects could be used to clearly represent milestones/deadlines?

Roadmaps are often convergent in form, as the output of a strategic planning process, filtered for communication, to drive programmes forward. However, the structure of the visual artefact can lead to the impression of a predictable, even fixed/static, path to the future. Additionally, there can be a lack of visual features/elements for conveying uncertainties/risks. For purposeful dialogue between stakeholders, the inclusion of uncertainties/risks is both a healthy and helpful basis for conversations and decision support in regards to conditional actions. Yet, few roadmaps explicitly depict the level of uncertainty and risks against given pathways/routes – this has been studied by Ilevbare (2014) and initial guidance is available for making roadmapping more 'risk-aware' (Ilevbare et al., 2014). There needs to be an accompanying study on the visual forms/structures (e.g. options-based tree diagrams) and visual indicators/annotations (e.g. risk-vs-readiness levels) in order for roadmap visualisations to embody and convey the inherent uncertainties and risks in an appropriate manner (i.e. not downplaying the level of uncertainties, but also not overly stressing all the associated risks).

The nature of aesthetics and the role of aesthetically pleasing visual depictions is an important area in need of significant investigation. One key question is the degree to which a roadmap should be aesthetically pleasing, to a particular audience, in order to enhance the communication of a strategic plan in an effective and efficient manner. From a purely functional stance, the purpose of a roadmap visualisation is to adequately convey the informational content and strategic narrative – not necessarily to look 'pretty'. According to Gaviria (2008) functional visualisations are concerned with performance and their "visual form of representation matters only in how rapidly it helps communicate the underlying data" to the audience. In conveying information through visuals, there are tensions between the aesthetic and perceived usability of the visual artefacts. Kostelnick (2007) states that visual data displays are "quintessentially utilitarian in nature" where the principal issue is that of clarity since they must facilitate the comprehension of the data. Thus, non-utilitarian 'visual embellishments' (Moere and Purchase, 2011) or 'graphical decorations' (Tufte, 2001) tend to be deemed as detrimental to interpreting/understanding the data. However, the counter-argument is that such visual imagery may "compel the viewer to engage with the data" (Moere and Purchase, 2011). Potential benefits include drawing the viewer's eye to help convey a specific message or to make the chart more memorable (Bateman et al., 2010). So rather than causing comprehension problems, visual embellishments might actually provide additional information that is valuable for the viewer (Bateman et al., 2010). Gaviria (2008) postulates that aesthetic information visualisations, which appeal primarily in a visceral manner, aim to ignite a viewer's attention, curiosity, interest and enjoyment. According to Moshagen and Thielsch (2010), "visual aesthetics has been shown to critically affect a variety of constructs such as perceived usability, satisfaction and pleasure". Of course, "visualisation design is not art" (Moere and Purchase, 2011). However, the aesthetic dimension could be used to greater advantage. For instance, in communicating future strategic plans through a visualisation, the aesthetics of the roadmap's graphic design may allow the data to be presented in such a way that a positive subjective impression of the content elicits a strong emotive response from the audience. The tensions between the aesthetic and perceived usability is ultimately a matter of balance. As acknowledged by Norman (2002), "good design means that beauty and usability are in balance". "Visual design is thus simultaneously informative and artistic" (Dyrud and Worley, 2006).

5 Summary

Roadmaps are essentially a visual medium in which to both create and communicate strategic plans. They are often generated/populated in workshops using visual templates and must then be reported/disseminated to the appropriate stakeholder groups. This means that the roadmap is synthesised into a distinct visual artefact for the purposes of communication and ultimately to mobilise action. In regards to the communication function, a roadmap visualisation is actually an information graphic and so must be visually designed as such. However, the graphical presentation and associated visual appearance of roadmaps has been largely overlooked by academic researchers and inadequately treated by the practitioner community. As an initial exploration into the visual aspects of roadmaps, a panel of experts was convened in order to investigate the area of visual features and assess 'visual design goodness'. A focus group activity identified a set of key features that are attributable to the 'good' and 'bad' aspects. Good roadmap visualisations tend to have a user-friendly intuitive format, display an explicit timeline/narrative, have a customised viewpoint for the particular audience, clearly show linkages between technology/products/services/markets and provide concise summaries with clarity. Whereas poor roadmap visualisations tend to be crammed with too much information or visual clutter, laden with jargon/abbreviations/acronyms, lack supporting chart legends/annotation and display poor use of colour. A visual critique exercise was also conducted. It focused on a selection of roadmaps available in the public domain. A set of ten visual depictions were extracted from a corpus of roadmap visualisations. This sample set was representative in terms of type, architectural style, narrative sequence and array of visual objects. The visuals were appraised in regards to their structural layout, graphical objects and content population. Given the nature of the expert panel, the critique was both a practitioner evaluation and a peer review. It resulted in a ranking of each roadmap across the areas of structure/graphics/content and overall visual appeal/impression. The scores identified that the dominant factor in 'visual design goodness' was the aesthetic quality of the composition attributable to the graphics. Thus, the degree to which a roadmap is deemed aesthetically pleasing has a significant bearing on the viewer's level of engagement with the actual content and strategic narrative being portrayed. In addition to the findings and observations reported in this paper, the method used for critiquing visualisations and the associated ranking scheme (structure/graphics/content and overall visual appeal) can be employed by practitioners/companies to appraise and make assessments of their own roadmap visualisations.

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Table 1 Expert panel

Participant	*Type*	*Area*
1	Industry	Defence – electronics
2	Industry	Technology – devices
3	Industry	Defence – aerospace
4	Government	Transport – infrastructure
5	Consultant	Life Sciences – pharmaceutical
6	Consultant	Engineering – manufacturing
7	Software Vendor	Sales – training
8	Academic	Research – manufacturing

Table 2 Roadmap sampling

Documents	*Figures*	*Roadmaps*	*Selection*	*Samples*
934	398	267	39	10

Figure 1 Focus group process

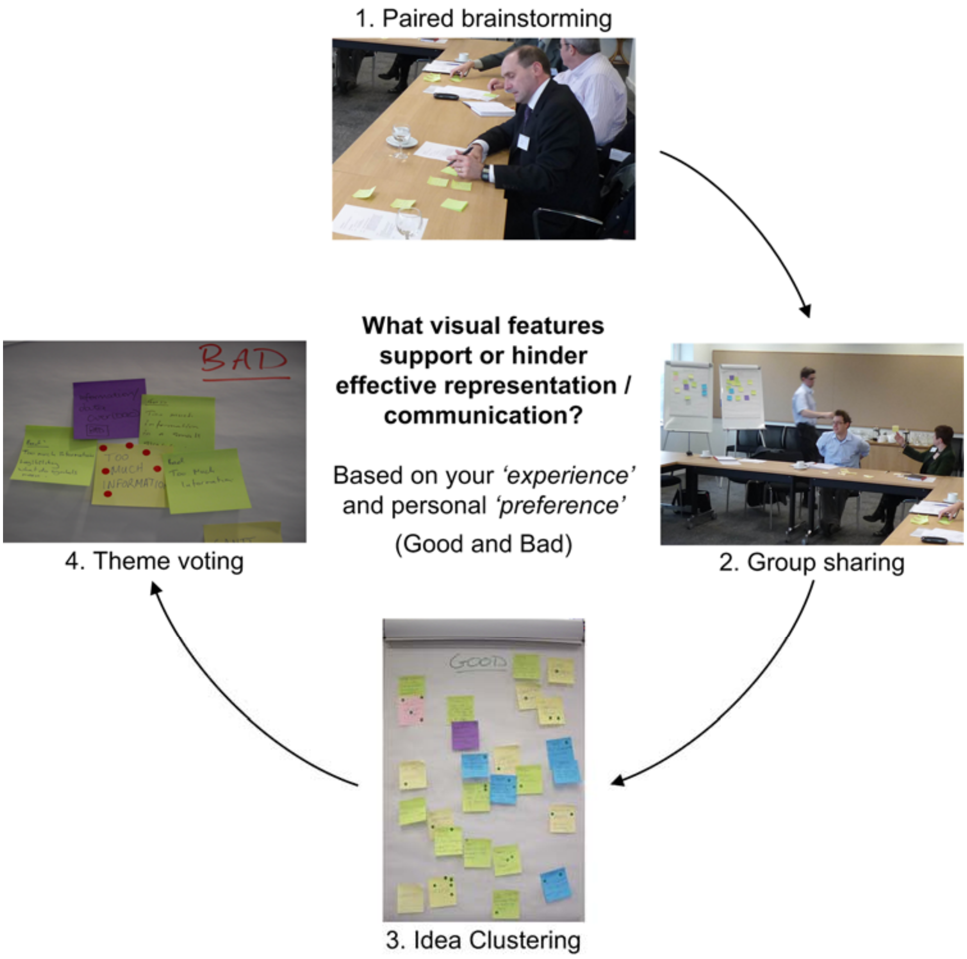


Figure 2 Focus group findings

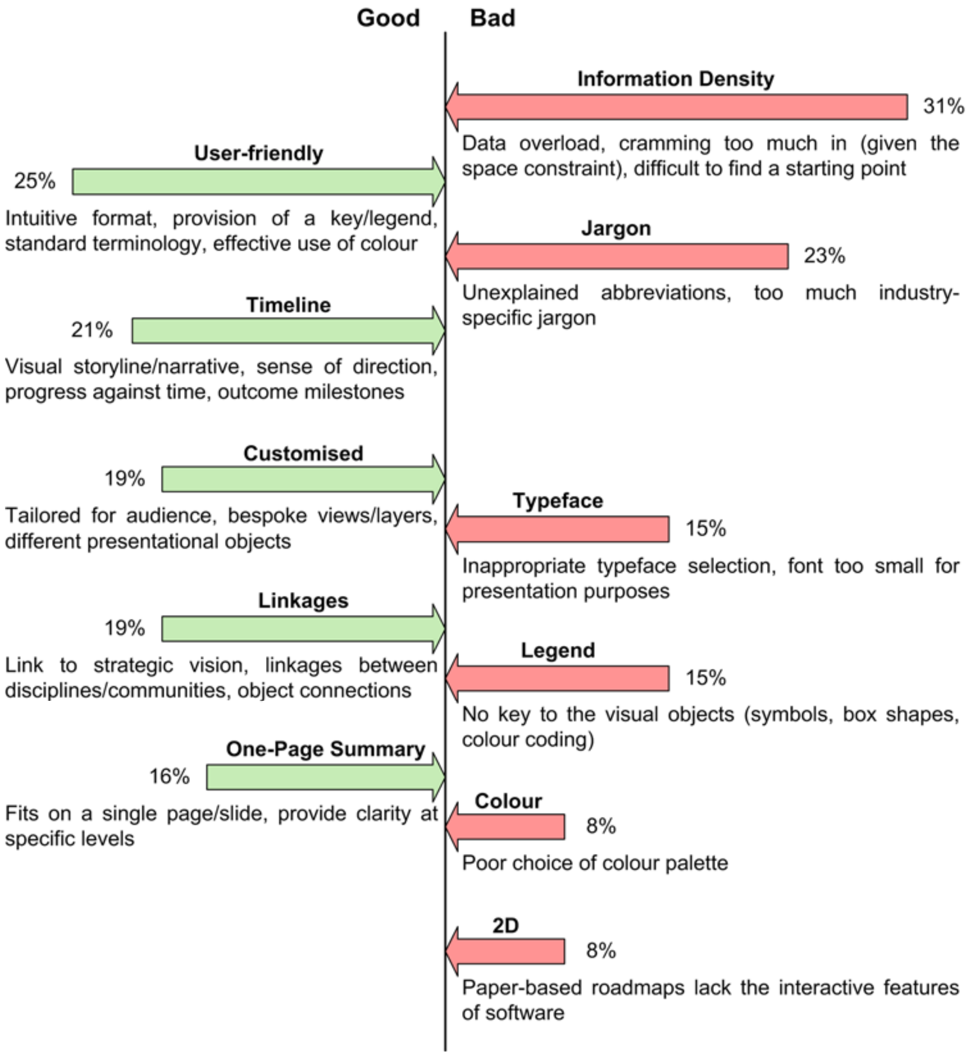


Figure 3 Visual critique process

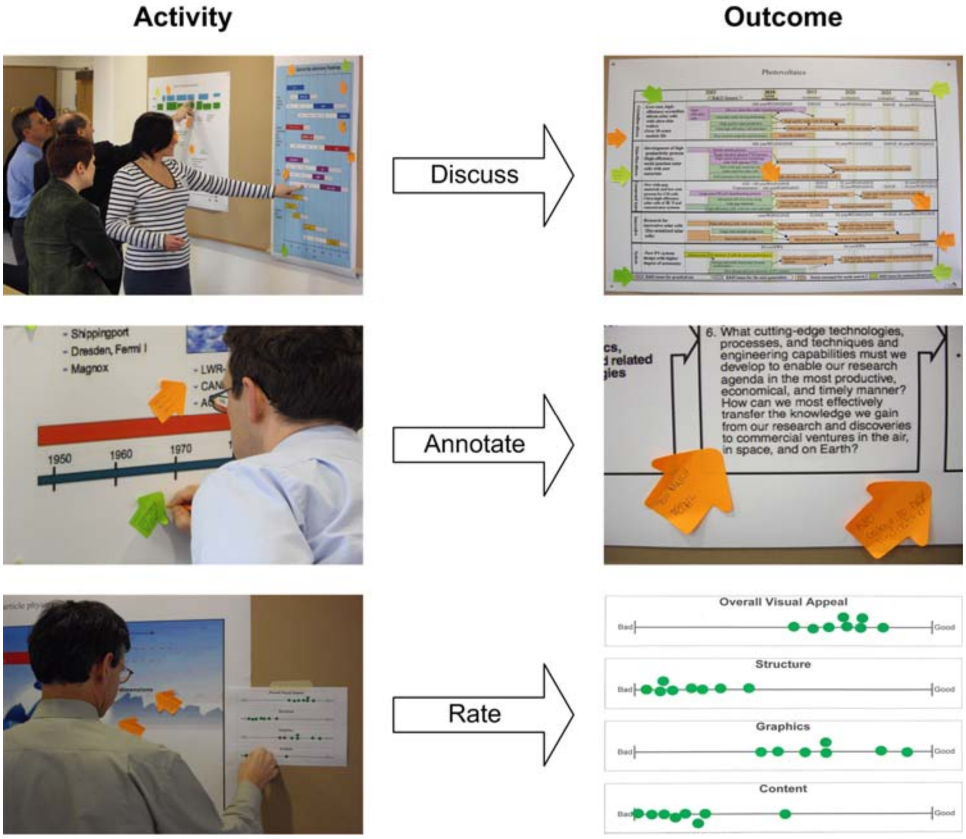


Figure 4 Roadmap sample set

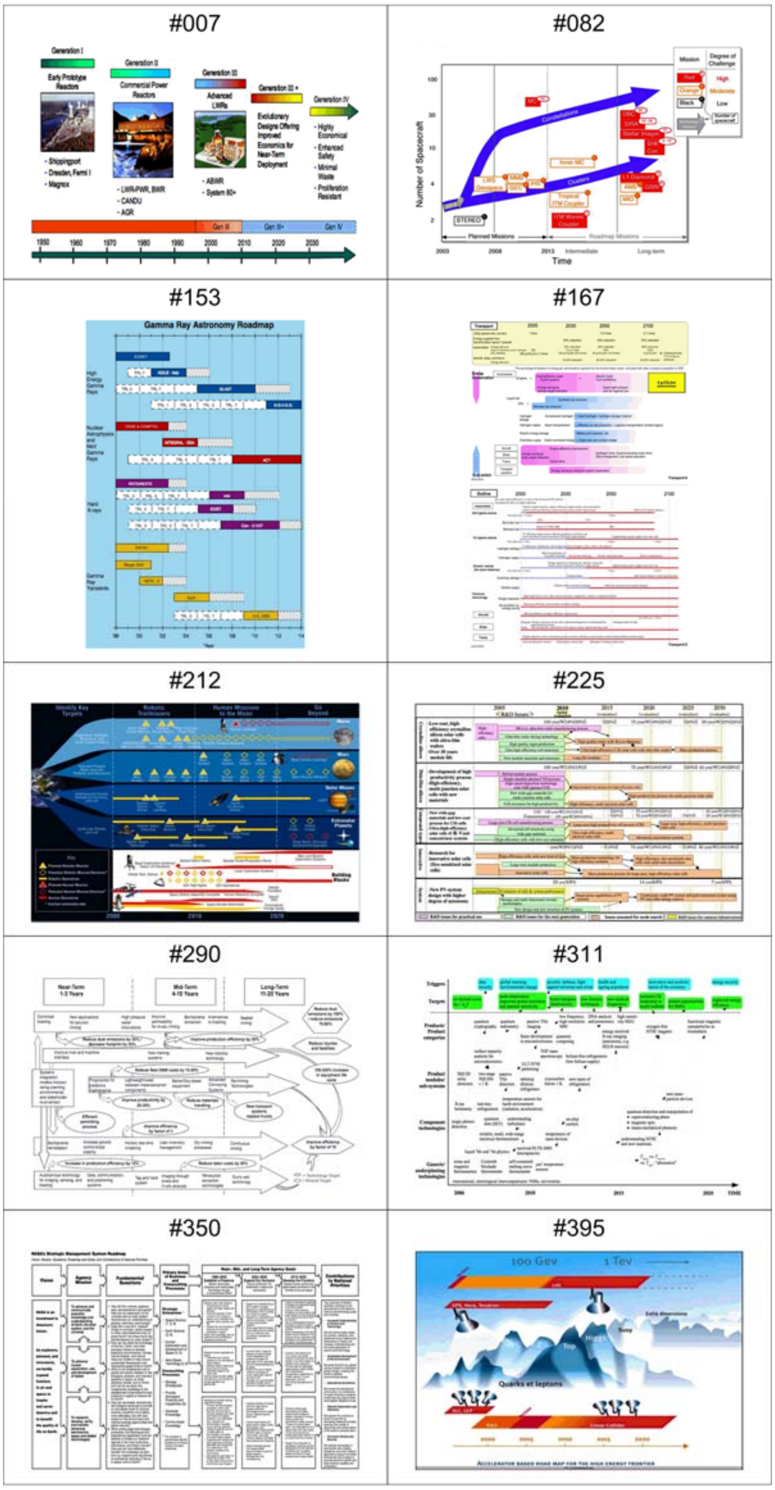


Figure 5 Visual assessment criteria

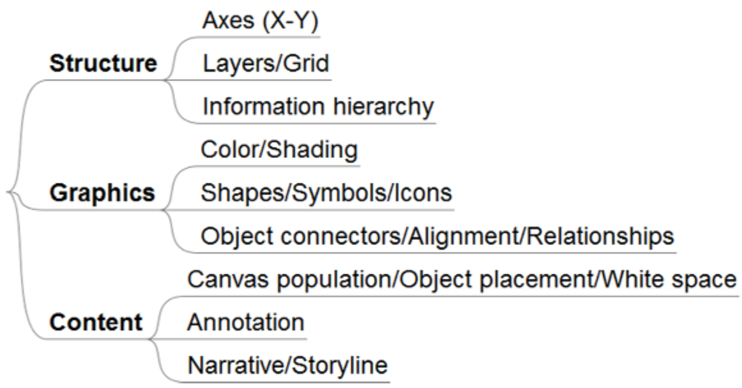
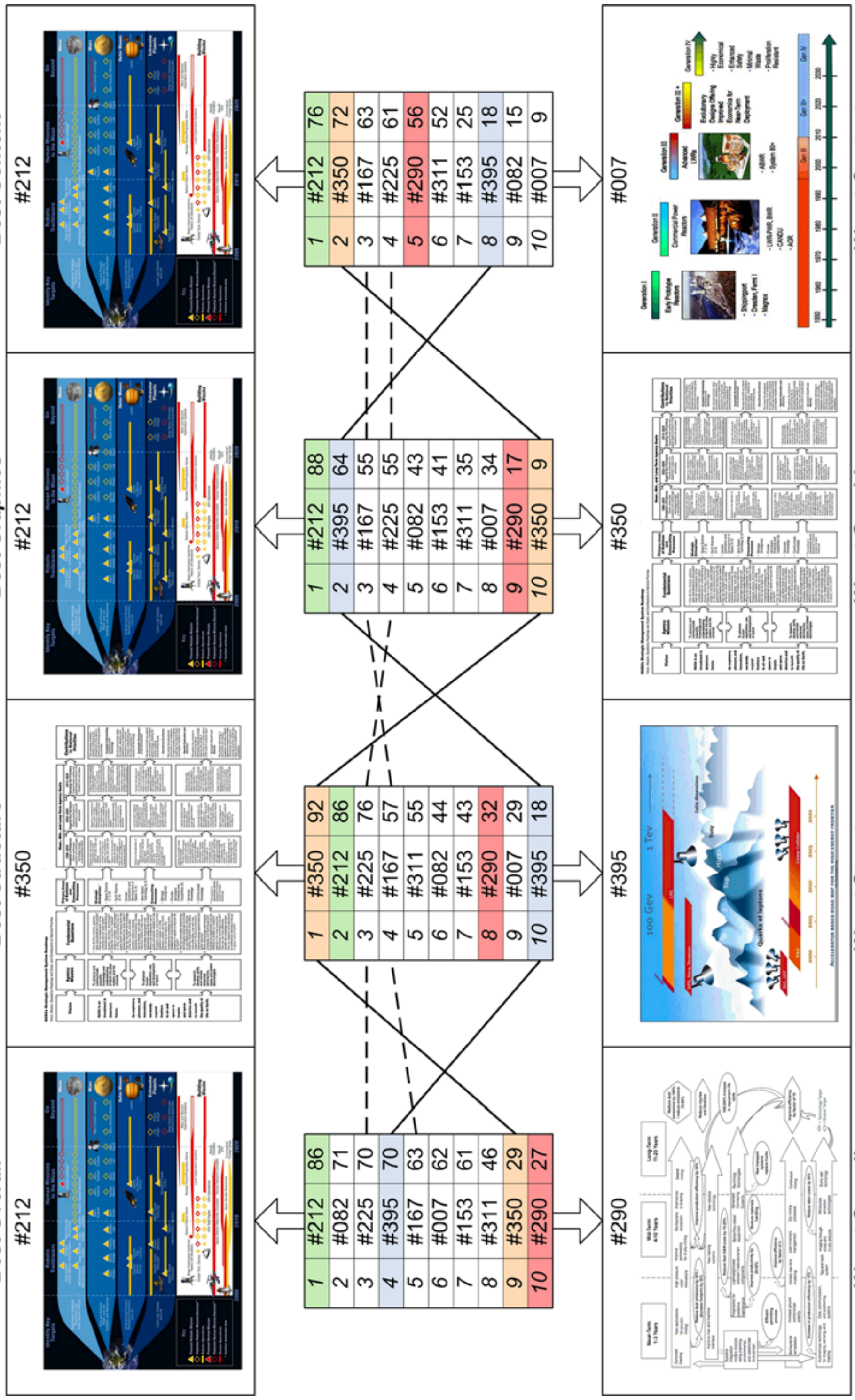


Figure 6 Roadmap rankings



Overall:

1	#212	86
2	#082	71
3	#225	70
4	#395	70
5	#167	63
6	#007	62
7	#153	61
8	#311	46
9	#350	29
10	#290	27

Structure:

1	#350	92
2	#212	86
3	#225	76
4	#167	57
5	#311	55
6	#082	44
7	#153	43
8	#290	32
9	#007	29
10	#395	18

Graphics:

1	#212	88
2	#395	64
3	#167	55
4	#225	55
5	#082	43
6	#153	41
7	#311	35
8	#007	34
9	#290	17
10	#350	9

Content:

1	#212	76
2	#350	72
3	#167	63
4	#225	61
5	#290	56
6	#311	52
7	#153	25
8	#395	18
9	#082	15
10	#007	9