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Methods and tools contributing to FTA: A knowledge-based perspective

A. Eerola [a,*], I. Miles [b]

[a] VTT Technical Research Centre of Finland, Espoo, Finland
[b] Manchester Institute of Innovation Research, Manchester, United Kingdom

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ABSTRACT

Future oriented technology analysis (FTA) applied to innovation policy and practice often goes well beyond the narrow domain of technology forecasting. It is oriented to supporting the functioning and development of innovation systems, and involves mutual learning processes, involving stakeholders and experts of many kinds. Such FTA calls for crossing the boundaries of disciplines, research traditions, and professional activities FTA then necessarily involves knowledge management (whether this be formal or implicit); and this knowledge management has to confront the challenges created by FTA's call for engagement across different – and across potentially competing – corporate, sectoral, and public interests. This paper explores the consequences of this view of FTA and how the roles of various FTA methods and tools are seen in terms of knowledge management. It goes on to discuss the implications that follow for FTA design, and the methodological challenges, and requirements for development of tools, techniques and principles, for FTA. The challenges of participatory knowledge management are seen to be particularly important ones to tackle.

1. Introduction

Future oriented technology analysis (FTA) is an umbrella term for a broad set of activities that facilitate decision-making and coordinated action, especially in science, technology and innovation policy-making. In the last decade, FTA activities – and in particular national and regional Foresight programmes – have often been oriented to supporting the functioning and development of innovation systems. This moves well beyond the narrow domain basic technology forecasting, important though that this. Indeed, understanding the dynamics of technological change is just one part of a broader mandate. This is in part because the innovation system is constituted by numerous social practices, networks, institutions, and stakeholders. The latter, for instance, extend well beyond the "usual suspects" of R&D-performing firms and public bodies, to include users, purchasers, regulators, trainers, media, and quite often non-governmental organisation and civil society stakeholders [1].

FTA, especially in the form of Foresight programmes, has come to be applied in the form of a mutual learning process, involving more or fewer of these stakeholders across different cases. Learning implies the production and reproduction of knowledge, and this in turn implies that FTA necessarily involves knowledge management – whether this is formally acknowledged or more implicit. This knowledge management has to confront the challenges created by FTA's call for engagement across different disciplines, research traditions, and professional activities – and across potentially competing corporate, sectoral, and public interests.

* Corresponding author.
E-mail addresses: Annele.Eerola@vtt.fi (A. Eerola), Ian.Miles@mbs.ac.uk (I. Miles).

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2. FTA and knowledge management

Talking about FTA in terms of "knowledge" may seem to risk dealing in oxymorons. After all, the future has not yet been created, so how can there be have knowledge about it – unless we believe in divinely inspired prophets or gods (and even then there are many problems and paradoxes to confront)?[1] Surely this was one of the reasons for the widespread aversion to the term "futurology" – along with the hubris and pretentiousness of creating another "-ology". But, brief reflection on FTA practice rapidly reveals that FTA is nevertheless very much a process that involves finding, deploying, using and fusing – and, yes, even creating – knowledge. The whole point of FTA is to better inform our decisions, and this involves knowledge of historical and contemporary dynamics and developments, and what their implications may be for future circumstances.

Take a simple example. We may not be able to know what the world population will be in 2050. There are reputable estimates, and we can bring knowledge to bear on determining who these experts are, how valid their methods are, and what degree of plausibility should be accorded the body of forecasts and associated assumptions and conclusions that they typically come packaged with. We can know what the values of key parameters will be in the event of these assumptions applying, taking into account long-term trends and fairly well-understood processes such as the demographic transition. This is not the same as knowing what the future will hold, of course, and even if our models are fit for purpose, there are always factors that lie outside of these models that may intervene. In the case in question, we are typically led to think of the "obvious catastrophes" and more or less wild cards – mass epidemics, asteroid impacts, supervolcanoes, accelerating climate change, and the like. Often we may doubt the adequacy of our models, of course, and not only because we believe that they should be able to incorporate at least some of the exogenous factors. A whole class of economic models, routinely used to inform policy, are based on assumptions about economic affairs tending towards equilibrium that have very little relation with the behaviour of businesses (especially innovating enterprises). Of course, Newtonian mechanics work well enough for everyday purposes, so their displacement of Einstein's theory of relativity may not be too bothersome. A similar case could be argued when invoking conventional economic models for short-term analysis and forecasting, at least in less turbulent times.

Another sort of knowledge we can have is knowledge about the views that others have (or profess) about the nature of the current situation, and about future prospects. Methods like Delphi are designed to elicit evidence about expert judgement concerning such prospects. Recourse to such expert judgement is often the logical step when there is a real difficulty with applying formal modelling approaches to the topic in question.[2] Such methods allow us to explore the structure of opinion and expectation – what proportions of a given (usually, a supposedly expert) population anticipate various types of outcome or rates of development, what key influencing factors are seen as being, and so on. This sort of knowledge may be little more than a specialised form of opinion poll analysis: many Delphi studies do take this form, having retained the name but stripped away much of the practice instituted by the Delphi pioneers.[3] At best, it may involve interaction with the experts in question that allow for some validation and/or additional articulation of their views.

Bell and Olick [2] reframe the discussion about "knowledge of the future" by arguing that we posit the future (and make posits about alternative futures). This has similarities to, but also differences from, the ways in which we create knowledge about the past and present. 'Knowing' the future is better thought of as knowing about future possibilities, rather than knowledge of the future. It includes the formulation, elaboration, and explication of knowledge surrogates, and their use to support decision-making. Posits are such 'knowledge surrogates', for Bell and Olick [2]. We can have knowledge about the posts themselves. We can examine their plausibility and limits, their internal consistency and conformity with models and data, the extent to which they are consistent with expert judgement, etc. Posits are based on knowledge of (or assumptions about) past and present, and analysis of posits and their implications for action requires examination of this underlying knowledge base, its limits and quality, and its use in the generation of posits.

The idea of posits provides us with a label for specific sets of knowledge. These are the sets of knowledge that are to do with the consequences that our models of situations and systems imply, when we bring various assumptions to bear about how these situations and systems may evolve into the future. We can establish and know things about posits. Various tasks for knowledge management in respect of such "knowledge surrogates" can be identified. Posits need to be created, explicated, communicated; the assumptions and models they embody should be explicit and intelligible, open to being critically assessed by participants in, and users of, the FTA process; posits can be organised in relation to, and compared with, others (including posits developed in other exercises), and be re-examined in the light of emerging data on circumstances and trends, and on ways of thinking about problem situations. Since FTA involves engaging with stakeholders – or at least with the decision-makers that the exercise is intended to inform – the scope of knowledge management (KM) has to extend

[1] The application of evolutionary theory within theology has led to notions of an "evolving god" (or gods) too, whose knowledge of the future may well be far less than omniscient, and whose acts of creation are undertaken for the purpose of learning. (An alternative approach – the application of evolutionary theories to human faith, spirituality and religion – is not necessarily incompatible with this.) In an FTA context, it is worth noting that an early proponent of this view was Olaf Stapledon, whose far-future and cosmological "novels" such as Star Maker (1937) dramatise these notions (even introducing ideas of a multiverse). For a more conventional far-future vision Last and First Men (1930) is a good introduction to this great author. Novels such as Sirius (1944) – dealing with a cognitively enhanced dog – are highly topical [28–30].

[2] See Scapolo and Miles [33] for a detailed comparison of two different approaches to eliciting expert opinion (cross-impact versus Delphi method). It is startling how few systematic comparisons have been made about the consequences of employing specific techniques in the course of FTA.

[3] It is striking that much of the work collected in Linstone and Turoff [34] has never been surpassed.

beyond organising exchanges among (more or less closely associated) experts. It will require managing knowledge in a wider community – albeit that the precise community in question may have been partly constructed by the exercise itself. Determining the contours and structuring of this community is itself a task that requires knowledge. And this knowledge involves knowledge management too, concerning, for example, the methods of stakeholder mapping that are employed, the ways in which suggestions for participants and dissemination approaches are elicited.

3. Methods and tools

So, FTA has many faces and comes in many "flavours", drawing on many different research traditions and methods. Practically any source of insight into the dynamics of science and technology (S&T) – their production, communication, application – can be utilised as knowledge inputs into FTA. Porter et al. [3] (the report of the Technology Futures Analysis Methods Working Group) reviewed many of the tools used and issues arising here. Tools that have been developed in such contexts for horizon scanning, trend extrapolation, stakeholder mapping, eliciting expert opinion, and so on are among the panoply of FTA methods. Indeed, each of the sets of tools just mentioned can be used in applications other than FTA – in demographic forecasting, in assessing market potentials, in various fields of applied social research. Many sorts of research tool can be sources of the insights required for FTA. Other tools can help us visualise issues, make choices among competing priorities, and the like. We can point here to such approaches as risk assessment, roadmapping, and some specific tools of operations management and operational research (such as DEMATEL, AHP, ANP, MCA methods for priority-setting);[4] or to tools for mapping and displaying information, such as network analysis, dynamic graphs and charts, even computer simulations and use of images and dramatic interpretations of posits and the events and vignettes they might entail.

FTA's subfields include technology foresight, technology forecasting and technology assessment, and of course futures research with its emphasis on explicating long-term alternative development prospects. There are quite distinct communities at work in different areas of practice, for example environmental/climatological, employment/skills, security/defence, and market/product development communities. These all contribute to the knowledge base and methodological development of FTA [3–7]. The result is a proliferation of tools. However, the accumulation and integration of knowledge about different tools and approaches is very uneven.

Many (probably the great majority of) FTA practitioners are familiar with only a limited number of these tools. The tools and approaches have been created in very diverse contexts and by different communities; they feature different philosophies. Most of us will have a limited grasp of the contexts from which specific tools derive, and the assumptions that may be carried along with standard practice. We could wish that a blind watchmaker had been at work, selecting the best-fitting and most generally useful methods out of this pool of proliferation. But anecdotal evidence suggests that many FTA practitioners are simply reiterating the particular approaches with which they have been familiar for many years, with little acquisition of new approaches and little awareness of the costs, benefits and broader implications of alternative methods. The selection environment is more of a chain of fairly contained niches, than it is a free market of ideas of a level playing field. Matters have improved over recent years with more journals, more conferences and symposia providing opportunities for mutual learning and exchange of ideas across communities of research and practice in FTA. But huge knowledge gaps are apparent, often stemming from the fact that much FTA work is conducted under pressure to provide results to inform urgent decisions. This means that it is possible to reflect upon the lessons provided by this experience, but it is extraordinarily difficult to build in sufficient opportunity to experiment with alternative methods, and assess the effects of different ways of implementing given methods. Our evidence base as to good practice is more often based upon "gut feelings" about what has and has not worked well over a series of FTA experiences, than on more systematic accumulation of data about comparable cases, varying in terms of specific features. Thus the FTA field itself resembles many of the challenging problems, which are the subject of FTA analysis.

It is typical for decision-making about S&T-related issues to require intelligence that extends well beyond what scientific analysis itself can provide. Weinberg [8] wrote of "trans-science", the need for experts to go well beyond the conclusions that can be substantively supported by research and even by well-grounded theory, in order to provide the sorts of advice decision-makers require.[5] FTA users and practitioners are in the same situation themselves, where it comes to deciding what sort of FTA to apply. We can see learning processes at work in the successive generations of several national Foresight programmes. Often there have been extensive processes of reflection and discussion when a new cycle of the foresight activity is to be launched. We also often see a hasty scramble and a set of rapid decisions being made, as the need for concrete plans becomes pressing. National Foresight programmes share these features of technocratic rationality, democratic deliberation, bureaucratic timetables, and political expediency, combining in an unholy melee, in common with many other policy initiatives. Similar conflicting forces will affect many smaller-scale FTA activities, in private organisations as well as in the policy sphere.

[4] DEMATEL = decision making trial and evaluation laboratory, a structural modelling technique; AHP = analytic hierarchy process; ANP = analytic network process; MCA = multiple criteria analysis.

[5] Thus the likely incidence of disease following a radioactive leak of a specific amount can be estimated on the basis of laboratory research and epidemiology; the likelihood of nuclear accidents is another matter altogether, even if we can identify many factors that make this more or less probable in given circumstances.

As with other practices, FTA activities involve several phases, especially when they involve multiple methods as in the more substantive FTA exercises such as Foresight programmes. Most trivially they have a beginning, middle, and end! Several authors have suggested ways of understanding these phases in a little more depth. Thus Horton [9] depicted foresight as moving through three phases – the chronological order is somewhat flexible, with scope for reiteration and overlap of these phases:

- *Phase One*: the (i) collection, (ii) collation and (iii) summarisation of available *information* (trends, expected and unusual developments, etc.), and thereby producing foresight knowledge (some of this will be posits, in Bell and Olick's terminology).
- *Phase Two*: the (iv) translation and (v) interpretation of this *knowledge* to create *understanding* of its implications for the future of the organisation in question (further posits).
- *Phase Three*: the (vi) assimilation and (vii) evaluation of this *understanding* to produce a *commitment* to *action* in a particular organisation.

Horton notes that various methods are brought to bear in the various subtasks listed above. For example, methods are indicated for each of the subtasks of collection, collation and summarisation of information. Of particular interest is the discussion of the subtask of interpretation, subtask (v). She portrays this as the conversion of translated knowledge into understanding. It uses of methods such as roadmapping and scenario development relevant to the particular organisation/stakeholder. An important point stressed in this context is the vital role that third parties can play in interpretation, by facilitating the processes of creative and lateral thinking, and asking difficult questions. The value-added here can be substantial. Horton suggests, however, that many governmental foresight exercises fail to provide the necessary support for interpretation to a wide range of stakeholders, which is liable to impede the effective use of the knowledge and posits generated. There is a missing KM link, in effect, which good design could deal with.

Weick's influential sensemaking in organisations [32] also outlines a three-step process. In the original formulation this is not specific to FTA, but Warden [31] has related Weick's activities of enactment, selection and retention to three phases of foresight processes[6],resulting in a structure rather similar to Horton's:

- *Enactment* – participants identify information that influences their view of an issue and then 'bracket' and 'label' it, so that its implications of potential actions and trends can be visualised.
- *Selection* – participants consider the significance of these implications, deciding and focusing on the most critical conclusions – ones that are plausible, believed to be highly likely, that involve major challenges, and so on. (Unfortunately, some valuable ideas may be selected out as being too challenging – sometimes they are postponed for later analysis, but the postponement becomes indefinite.) For selection to be successful, this step results in a model of what is expected to take place (under various contingencies), and how this comes to be.
- *Retention* – the products of the two preceding steps are stored (as published information or individual experience) so that they can be retrieved and reused. They may be employed in later stages of a wider FTA process, which this activity is embedded in, in later FTA activities, or in the organisations from which stakeholder participants have been drawn.

Saritas (2007) provides a rather more detailed account of five stages in FTA, expanding the first and third of the sensemaking steps (and the first and second of Horton's). He also suggests the tools and methods that are often associated with each stage:

- *Understanding*: creation of a shared understanding and mutual appreciation of the topics in question, the factors influencing them, the wider systems in which they are embedded. Typical methods employed here are literature reviews, interviews with experts, horizon scanning. (Roughly – Horton's subtasks (i), (ii) and (iii).)
- *Synthesis*: exploration of alternative paths of future development, and how they are integrated into designs for a new context. Scenario development is commonly used here, along with formal modelling of one sort or another, and less common techniques such as gaming, (Roughly – Horton's subtask (iv).)
- *Analysis and Selection*: comparison of alternative futures that have been posited, and selection of what might be the preferable future given one or other sets of criteria. Methods such as MCA, SWOT analysis, cross impact and trend impact analysis apply here. (Roughly – more of Horton's subtask (iv).)
- *Transformation*: examination of what the relationships would be between the present and the key future or futures that have been posited (and possibly some other possibilities). Roadmapping has become a very popular tool used at this stage, while many instruments of normative forecasting and planning (e.g. relevance trees) are also part of the toolkit. (Roughly – Horton's subtask (v).)
- *Action*: creation of plans to inform decisions in the present day and near future concerning actions to shape the future. Various approaches to prioritisation (such as key technologies analysis, plotting feasibility against impact of various actions, MCA, and the like may be used here. (Roughly – Horton's subtasks (v) and (vi).)

[6] Warden [31] draws on Choo [35] elaboration of Weick's account; and he actually specifies technology foresight, but the argument remains the same when we replace TF with FTA.

Many of the individual methods may be associated with more than one of the five steps, and indeed many specific methods involve cycles of data production and analysis, modelling, choice among alternatives, and other steps in sensemaking. (We explore this in the case of scenario workshops, below.) Yet other methods are brought into play in the broader design, organisation and management of an FTA programme, including, in addition to standard project management methods, approaches needed for the selection, recruitment and mobilisation of participants in the process. Popper [10] relates methods to a yet wider account of the stages through which Foresight programmes typically pass. (This includes the preForesight phase, where the activity is scoped and designed, and the implementation phases, where actions are (hopefully) carried out and assessed, and even later stages involving the embedding of FTA practices and approaches.) The selection of methods is a task, which should be undertaken not by simply copying the methods used in previous studies, but with clarity about the KM tasks involved, and what the objectives of these are – what sorts of output should be feeding into what subsequent activities.

4. Expertise and interaction

Popper [10], with his well-known "diamond" of methods, differentiates between methods in terms of two dimensions that, in terms of knowledge and posits, we can interpret as follows. The first dimension reflects how far the method relies on eliciting, working with, and synthesising expert knowledge, as opposed to mobilising and fostering interaction within stakeholder groups. The second dimension reflects how far the method involves formal analytic techniques such as statistical trend or system dynamics simulation modelling (whether using codified statistical data or inputs may be more based on group or individual judgement), as opposed to techniques that are designed to foster creative thinking and explore possibilities that are hard to capture in the more formal techniques. Some combination of methods that span these dimensions is recommended as helping maximise the scope for FTA to draw on expert knowledge, apply systematic analysis, encourage unconventional thinking, and engage key stakeholders. The two dimensions might be seen as reflecting the balance between knowledge from experts and knowledge within communities, and that between posits produced by formal procedures and those produced by creative insight. Individual methods may be implemented so as to be located in somewhat different positions in the two dimensions, while a large-scale FTA activity may well encompass a sequence of steps that move around in Popper's diamond.

Classically FTA often involved the work of small expert groups – or even solitary experts sitting at their desks engaged in "genius forecasting". Once we go beyond extrapolating specific trends or devising imaginative scenarios based on historical analogy or generalisation from supposed vanguards, towards thinking about innovation systems more generally, such means look limited – which is not to deny that can be very helpful inputs to wider FTA. These approaches assume that one person, or a small group, can be sufficiently well informed about numerous issues so that they can develop and apply an effective systemic understanding of the interplay of major social and technological developments. Despite the phenomenal complexity of the contemporary world, there are possibilities for such individuals and groups to make really significant contributions. Typically, these contributions will involve grasping one set of issues and explicating just how important and potentially transformative these will be. Occasionally we may see some broader overview coming from such sources – often on the basis of the authors having absorbed a great deal of FTA thinking from other sources – such as Naisbitt's *Megatrends* or Coates' 2025 [11].[7] This is not to endorse all of the specific conclusions or forecasts of either study. We are merely pointing out that there is still considerable scope for visionary individuals to provide grand syntheses, which can contribute important contributions to debate about future prospects and possibilities. Unfortunately, for every study of this sort there are typically, however, a dozen less-qualified books by political or management gurus – and even from countercultural or radical thinkers – that are hyped up well beyond their deserts. The quality control mechanism for popular FTA literature are practically nonexistent, and it would be valuable if FTA practitioners could develop more rapid and effective ways of directing attention to the well-grounded (if generally less-hyped) publications – and modes of study.

With the rise of Foresight programmes, and "fully fledged foresight" as an ideal,[8] FTA often involves much wider engagement and involvement of stakeholders, and of sources of specialised knowledge about the issues and actions in focus, than characterised many earlier futures studies. (It should be noted that "prospective strategique" in Francophone countries often stressed these elements, as did occasional futures studies elsewhere.) This wider participation is not, of course, a matter of participatory democracy as commonly understood – though such FTA could be an important contributor to establishing more deliberative democracy in S&T policy areas that have – on account of the expert knowledge associated with them – historically been dominated by vested interests and technocratic elites. The widening of participation in FTA reflects important social developments, and serves several associated goals (see e.g. [12]).

Drawing on Miles [13], these goals can be summarised as:

- *Enlarging* the available knowledge base. This can be seen as a reflection of the growing complexity of S&T decisions, which is associated with such factors as the combination of multiple scientific and technological knowledge bases in many

[7] Naisbitt [36], Coates et al. [11].

[8] See Miles [13] and Georghiou et al. [37] for accounts of "fully-fledged foresight" – a concept taken up by several other authors, as a google scholar search will confirm.

programmes and projects (discussed, for example, in the literatures on complex product systems, digital convergence, and convergent technologies) and the extensive and far-reaching implications of increasing capabilities to transform the natural and human environments (giving rise at one extreme to concerns about threats to human existence – or celebrations of transhumanism – but also to more "mundane" exploration of future opportunities and risks associated with large-scale projects and with large-scale use of new technological knowledge). Even technocratic FTA has to confront the likelihood that no single organisation will itself contain expertise on all of the matters that bear intimately on a specific set of S&T issues – it will be necessary to go out to a wider set of communities. Quite often, too, there will be nobody that is really expert on the social issues connected with emerging S&T developments, in the sense of having systematically researched these issues and being able to draw on a well-established literature concerning them. The knowledge and mental models of practitioners and stakeholders may have to be brought into play in such cases. Methods for identifying key sources of knowledge, and eliciting information from them in a form that can be readily used, are important here.

- *Engaging* a wider range of stakeholders is also important as a means of providing more legitimacy for FTA processes, and for the conclusions and recommendations derived from them. Several factors have combined to make this more salient in contemporary FTA. Perhaps the least important – but quite possibly a factor whose importance will grow in coming years – is the rise of public concerns and associated social movements around many S&T issues. These include issues that centrally involve the application of new knowledge, as in the case of genomics (controversies over stem cells, use of genetic information, etc.); issues where S&T "solutions" to widely shared problems may well be contentious (geoengineering and other technological solutions to the climate change crisis as opposed to change in lifestyle and corporate practice); and those which involve controversial decisions about risks and impacts of development (for example, nuclear technology, or the location of renewable energy projects such as windfarms and biofuel plants). We may anticipate that developments in S&T that profoundly affect our understanding of what it is to be human (e.g. cognitive enhancement, artificial intelligence, human cloning and chimeras) are especially liable to fuel more extensive public engagement in S&T topics. Two other factors have probably been more significant in recent FTA, however. One is the need to avoid alienating the scientific and engineering professions, whose numbers and organisation have grown, and who often have an almost innate suspicion of politicians that make decisions affecting them. (Just as there has been growing scepticism about "experts" in the general population, so it would appear from anecdotal evidence that many professionals are somewhat distrustful of public representatives whom they perceive to be at risk of being co-opted by those in power.) The second important factor is the "crisis of science policy" more generally – as pressures to restrict burgeoning public expenditure collided with demands from Big Science and more routine research alike for continuing increases in funding. Decisions about funding could no longer be left to the traditional small circles of scientific experts, since tougher priority-setting was required – and in several countries these small inner circles were also seen to have let down policymakers, by failing to highlight critical emerging areas (notably microelectronics and advanced IT in the early 1980s). Policymakers thus sought more transparency in decision-making, with foresight, technology assessment, and key technologies approaches coming to the fore, alongside other tools such as research evaluation and impact assessment.
- *Enlisting* those involved in the process in action: the aim is to embed the knowledge that has been generated in the programme into their own organisations and practices. This reflects awareness that it is impossible for one all-knowing policy organisation or level of government to grasp all of the intelligence that is needed to make sense of future challenges and opportunities. As well as knowledge being widely distributed, so are power and action. (Of course both are unevenly distributed: some actors have more access to sources of information and information-processing capabilities, and to the levers of power and capacities to command and control others. But there is no monopoly of these resources, and even the best-informed and most powerful actors have to work with others – to a limited extent in totalitarian regimes, to a huge extent in liberal democracies.) FTA activities aim to inform decisions that will help shape, or adapt to, future circumstances, providing and working with relevant knowledge to build capabilities for better action. Since these decisions and actions involve many actors, there is often need for concerted action, and shared visions of what futures to seek or avoid. Having key actors, or influential members from key organisations, engaged in the FTA process means that they can develop a much deeper understanding of the process itself, of the key judgements and assumptions that entered into it, of the perspectives and likely reactions of other stakeholders, of the implications for their own and other organisations. This is liable to go well beyond the knowledge that can be gained from poring over a report, let alone just reading an executive summary. The deeper understanding means that when contingencies change – as they almost certainly will – the participant will be able to assess their implications for the FTA conclusions and for the orientations of other actors. Hopefully they will not be isolated, but will be carriers of this FTA knowledge into their own organisations, working to create decisions and action within it that can contribute to the construction of the future. (Involvement in the FTA process thus increases the understanding of its outcomes and their relevance in various situations, and is also likely to increase the commitment to making use of the foresight knowledge). Methods such as working within panels, workshops (scenario workshops in particular), are critical here, and in designing the FTA process it may be effective to appoint very senior members of key organisations to steering or advisory committees, with less senior members of the organisations embedded into panels and workshops. The senior actors will thus be primed to receive the detailed knowledge that is gained by the more junior actors.

Design of the FTA process also depends on its specific objectives: FTA processes striving for consensus differ from those welcoming diverse views on future developments; and instrumental FTA processes differ from merely informative ones. Furthermore, adaptation to new opportunities and needs might be needed during the FTA process [14,15]

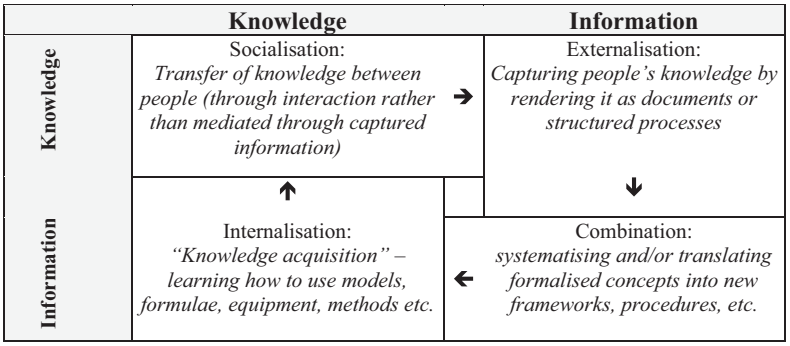

Fig. 1. The knowledge cycle. *Source*: Dawson [20] after Nonka and Takeuchi [19].

Whatever mixture of the three goals is being pursued, KM and organisational learning are central. Jaspers et al. [16] contrast two "ideal types" – technological knowledge management and participatory knowledge management (TKM and PKM, respectively). In TKM, what is at stake is ways of handling "hard facts", through, for example, websites, databases, publications, dissemination procedures, etc. FTA is liable to involve large volumes of information that can be processed through such TKM systems. Such formal systems are being used increasingly as computer tools and communication infrastructures are upgraded. (One interesting phenomenon is the evolution of websites for national Foresight programmes, as decisions are made about how to represent current activities and how far to retain material produced in earlier phases of the programme.) The "T" in TKM could also stand for "technocratic", since this is typically highly top-down and expert-based. PKM involves more stress on social practices and interactions among the individuals and groups who create, develop and use knowledge, coming close to Boisot's idea of social learning cycle ([17,18]). Taking account of cultural factors, values and opinions, and the like, PKM includes personal modes of exchange and communication (these may use communications media as well as face-to-face meetings), and wider networking activities. Discussions of knowledge management, and efforts to plan relevant systems, may well focus on one or other of these polar types. But in practice some mixture of the two will often be required, as Jaspers et al. [16] discuss in the case of Germany's Future programme.

FTA activities necessarily involve, in a very central position, engaging knowledgeable agents, and deploying the knowledge and posits that they make available and that are generated during the FTA process. Several influential approaches to KM and organisational learning have emerged in recent years, and we turn briefly to these.[9]

5. Methods and knowledge

One of the most influential contributions to thinking about organisational learning and KM has been the model of the dynamics of shared knowledge creation developed by Nonaka and Takeuchi [19]. This model has been used to characterise a wide range of innovation processes, including FTA activities. The four steps, captured under the label SECI (socialisation, externalisation, combination and internalisation) represent a knowledge cycle undertaken in the course of organisational learning. Two dimensions underlie the Nonaka and Takeuchi [19] account: one is essentially ontological – is the knowledge known at the individual level only, at the group level, or at organisation, or inter-organisation levels? – and the other is more epistemological – is the knowledge tacit or explicit? In fact, a spiral of several successive cycles is usually needed for innovation and FTA processes – moving between so-called tacit and explicit knowledge. Interacting individuals share their knowledge, linking, presenting and discussing information and insights with each other. This also enables them to internalise this knowledge through interpretations in specific contexts. This is highly reminiscent of what takes place in FTA, even if the four knowledge conversion modes in the Nonaka model do not correspond precisely with the three steps of Horton and Weick, or the five of Saritas.

While there is great value in the distinction between tacit and explicit knowledge, a more practical distinction in the context of FTA would perhaps be the distinction between knowing individuals and information codified in reports, lists, and other such external manifestations and products of knowledge as suggested by Dawson [20]. Dawson also reformulates the Nonaka framework accordingly (Fig. 1), as representing movement between knowledge (which requires knowing agents, and is thus human-embodied), and information (that can be codified and embodied in texts and other artefacts). The tacit/explicit terminology is so well embedded, along with ideas about knowledge being "contained" in things and knowledge flows happening (e.g. in technology transfer), that it is hard to shift. The critique of this terminology is mentioned here to highlight "knowledge" as a property of knowing individuals. This emphasis is highly relevant for FTA. Individual actors in FTA organise information in ways that are relevant to their purposes – practical problems, conceptual challenges,

[9] For a much fuller survey of the field, though one with a high orientation to IT solutions, see Alavi and Leidner [38].

understanding themselves and their worlds, or whatever. Codifying this knowledge (and posits) as written insights, sets of procedure, and the like, provides *information* resulting from the knowledge. This information *may* be an account of the knowledge and/or posits, or may simply imply such an account (which an observer equipped with relevant knowledge will be able to reconstruct). Different agents may interpret and organise the information in different ways, deriving different sorts of knowledge from it. For example, a detailed account of a scenario represents a codification of posits, from which it is possible to reverse engineer at least some of the knowledge that informed the scenario work. Good FTA practice will make it easy for later users of the work to assess the validity of its knowledge base and the derivations that have been made from it.

What then of concepts like "knowledge transfer"? Since knowledge is not a "thing" out there, it cannot simply be transferred like a document or technological artefact. People can gain knowledge from the act of interpreting, reading, reverse engineering texts and other artefacts; and they can also gain knowledge by examining nature. Knowledge is not simply deposited in texts and machines, or embedded in the natural world, for that matter. Knowledge is achieved through an interrogation of these things. Well-designed texts are particularly useful in how they have been designed for interrogation. Where the issues at hand are complex, involving overlapping fields of expertise, ill-defined, and so on – as is the case for many of the core topics that FTA addresses –design of such texts can be very challenging. This is one reason for the stress on stakeholder engagement.

Mutual learning can be accomplished in the interaction between knowing agents. Briefly put, these agents engage in a process of comparison and modelling – they can determine to what extent each is interpreting given material in the same way, discuss and debate the cues and frameworks they are using, account for their practices. This is certainly explication, and allows (when things work well) for mutual understanding. What is transferred is information about knowledge, rather than the knowledge itself. New knowledge and posits is constructed on the basis of this new information and past knowledge. The agents in question may well make use of technological aids and texts – notably whiteboards and flip-charts on which diagrams, illustrations, keywords, etc. can be created to clarify the main points at stake. The joint construction of knowledge by participants may result in a great deal of the key knowledge being shared within the team or workshop involved. (The same points can be made in respect of posits.)

The idea that knowledge development takes place through a (typically clockwise) multi-cycle spiral movement through these different SECI cycle categories is a powerful heuristic for explicating FTA exercises and activities. Nonaka's SECI framework has been applied, for instance, to understanding and guiding the shared knowledge creation of key actors (industry, academia and policymakers) in the context of Nordic foresight activities [21,22]. When the FTA process involves a wide range of key actors – in the case of the Nordic H_2 energy foresight coming from several countries – there are special challenges confronted in shared knowledge creation (even in agreeing upon which of Bell's "posits" to explore), which thus called for careful design of the process and the tools and techniques it involved.

The SECI framework portrays the knowledge cycle of organisational learning as a dynamic interaction process. The design and planning of the FTA can be interpreted as the preliminary "S" phase of the knowledge cycle. Then dynamic interaction becomes more intense. This involves sharing information, not only about the results of research but also about the views and opinions (preferably well-grounded ones) that participants hold; it involves creating spaces and opportunities for such sharing. Specific methods – Delphi surveys, brainstorming, scenario workshops, etc. – may be used to elicit and share such information, although it may be less easy to capture in a structured way as would be the information from, for example, statistical data or trend extrapolations. Some of these methods yield relatively unstructured information; some organise this information into lists or more structured frameworks – even models; some allow for synthesising information into posits, views of alternative futures, such as those incorporated into scenarios and roadmaps. Eerola suggests that these activities of capturing information and forging posits from it can be seen as the "E" and "C" stages of the SECI model.

The cycle continues with "I" and a new "S" stage, as the posits are put into the context of specific stakeholders' circumstances, and in turn used for formulating explicit priorities, recommendations and decisions. In the Nordic H_2 energy foresight, the appropriation of the knowledge from the foresight process into various stakeholder organisations was seen as being accomplished through such activities as pilot projects, R&D projects, and strategy development within these organisations. Eerola's account of the various steps and procedures of the Nordic H_2 energy foresight are located in terms of the SECI model in Fig. 2 (which retains the tacit/explicit terminology used in the original publication).

The earlier discussion of sensemaking and foresight phases can readily be related to such a SECI approach. But, as is implied by the varying number of stages and lists of tasks that appear in different accounts of FTA, we might need to think of any large-scale FTA activity as likely to involve several intertwined SECI processes that go iteratively through the various transformation phases in a spiral-like process. The complexity of FTA processes means that they can involve application of similar techniques for different purposes, at different points in the foresight knowledge cycle. We may expect to see various types of KM activity taking place during the application of specific techniques. In the Nordic foresight exercise, the pilot studies and other "internalisation" activities were thus happening at the same time as the FTA process proceeded to the next circles of the externalisation and combination phases. Through most of the exercise's life, some members of stakeholder organisations were engaging with the foresight activity and necessarily internalising the knowledge and posits being developed in the foresight process, relating these to the interests and goals of their organisations. The boundaries between the phases of the SECI knowledge cycle may thus be rather permeable. We can even see some of the more ambitious FTA methods as themselves involving several or most of the knowledge conversion phases of the SECI spiral. This is particularly evident in multi-stakeholder and extensive activities such as scenario workshops, where a number of activities are organised into a sequence in which knowledge is exchanged and posits developed and assessed. The various phases of knowledge

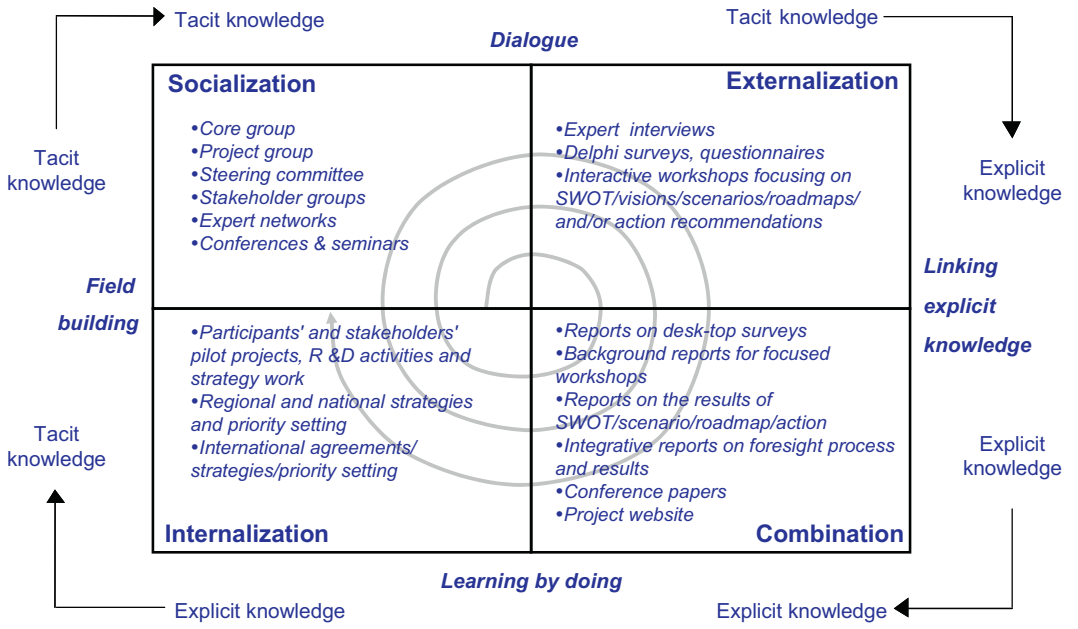

Fig. 2. Different foresight elements in a dynamic process of shared knowledge creation, a SECI perspective. *Source*: Eerola and Joergensen, [21,22]; SECI model adopted from [19].

management in a scenario workshop are discussed in the next section, in order to illustrate the relevance of the KM approach – even in the context of individual/specific FTA methods.

6. Scenario workshops as knowledge processes

Scenario workshops typically feature a sequence of activities. There are periods featuring extensive exchange of, and debate about, ideas. There are periods where ideas are being written down and listed and where different lists are combined. There are periods where narratives are constructed about possible trajectories of development; where policy or strategy implications and priorities are elaborated; and so on. The process usually involves much dialogue, assisted by facilitators with "scripts" (instructions and tasks) and with use of such instruments as whiteboards, flip charts, presentation graphics, and computer-based groupware tools. This kind of scenario workshop usually extends over at least one day, and may involve several dozen participants. Larger workshops employ "break-out groups" of say 6–12 people exploring different subscenarios or aspects of scenarios in detail. The workshop will be conducted with inputs from at least one facilitator, and often other helpers will take notes, record material from flip charts, and deal with logistic issues as they arise. Typically such facilitators have acquired their skills through involvement in these and similar group activities, though they may have received some training in facilitation processes and workshop methods (from T-groups through management workshops to academic seminars).

Before the scenario workshop is implemented, there will typically be a design process, to:

- identify participants for the scenario workshop – it is vital to include the right range of interests, knowledge and expertise, and as far as possible key end-users of the results.
- determine what background research might need to be conducted.
- define the workshop procedures (what scenario methodology is to be deployed; what areas of study within the domain of interest should be selected, what specific questions might be used in the workshop), allocate roles to facilitators and others.

This design process applies and often gathers knowledge – it may be undertaken with KM objectives firmly in mind, or this may be more implicit. The scenario workshop is typically supported by background research, to provide workshop participants with a common information base (and sometimes some shared terminology), or materials collated, to provide participants with some common informational resources and orientation materials – externalisation in the Nonaka terminology. This might include material such as a SWOT analysis related to the area of concern (how a country or organisation stands in relation to it, for example); statistics of major developments relevant to this area; Delphi or other

forecasts, even background scenarios (e.g. "starter scenarios" to be elaborated) prepared by an expert team or in earlier studies. As well as background reading, provision of information from research and analysis is often formally included in the workshop, which will often begin with a series of brief presentations on the topic under consideration and the wider context in which it is situated. After various introductory matters have been tidied up – setting out the mission statement for the exercise, introducing each other, etc. – it is typical for a scenario workshop to begin with participants reviewing the background material, and then proceeding to draw on this (critically) in subsequent activities where this formally presented material is added to by information and opinions input by participants, and is worked over in a "combinatorial" fashion to generate new or more detailed posits about the future. (Yet already some "combination" of information is likely to have been performed outside of the workshop, in the course of the preparation of the background material).

A common starting point in scenario workshops is to examine "drivers and shapers" – factors that could be critical to influencing the course of events, promote one or other sort of development, and lead to distinctive futures. Often, something like the STEEPV approach – in which people are asked to identify factors and issues under the headings social, technological, economic, environmental, political, and value-based factors – is used. This simple conceptual tool constitutes a useful way of ensuring that a broad range of issues is considered; it is also a helpful and generic classification framework. Other frameworks may be designed for specific workshops, and workshop participants themselves may be asked to – or request to – develop their own grouping of factors early on in the workshop.

Brainstorming or other ways of generating these "drivers and shapers" may be seen as an act of "externalisation", but the grouping of ideas into STEEPV or other categories is more like "combination"; often the two knowledge activities are hard to demarcate. We typically ask participants to brainstorm factors that are important under each of the STEEPV headings in turn, or allocate different categories to different break-out groups. Furthermore, throughout the scenario workshop, including this step of identifying and classifying drivers and shapers, there are liable to be moments of "internalisation" – as participants become more familiar with working with the background material and fitting it into their own conceptual frameworks and constellations of interests – and also, perhaps, "socialisation" as these ideas are chewed over, conceptual frameworks given a first airing, possible actions and implications for policy explored. The analysis of drivers and shapers may be conducted in plenary (in smaller workshops, in particular) but will often be approached by asking subgroups to elaborate lists of those falling into specific STEEPV categories or impacting up specific elements in the domain under consideration. Discussions are captured on groupware systems or, more traditionally, on wall posters which provide a record of development and material for presentational purposes, for other groups to inspect, for inclusion in final reports. After brainstorming, groups review their lists, and typically we ask them to cluster themes together. This is one of those valuable tasks that encourage participants to step away from their standard ways of thinking about and presenting their own disciplinary and practitioner knowledge. They have to work together to cluster ideas – which means debating the relationships between drivers and topics. Clusters are effectively boundary objects that participants from different epistemic communities or backgrounds can discuss and debate around. They will share ideas about how the contents of the cluster are interlinked and relate to the other themes being pursued.

The thinking about factors developed by different subgroups is typically written down in lists, with the most important drivers being earmarked (and perhaps also considered in terms of the main uncertainties associated with them) – they are "externalised" – and the outputs of subgroups can be collated together and "combined". There may well be more clustering of ideas, with discussion about the connections between ideas proving a good basis for exchanging information about implicit models and theories. Presentation and group discussion of the material provide further opportunities for "internalisation" and "socialisation".

Major "combination" moments come in the scenario construction sessions that constitute the heart of the workshop. In conventional multiple scenario workshops, a set of alternative scenarios are developed. Often each one is constructed by each of a number of break-out groups. These draw upon the analysis of drivers and shapers, and the implicit model of the system under consideration; scenarios may be differentiated in terms of key uncertain drivers, broad archetypes about system performance, "what–if" questions, etc. The scenario framework can be a valuable tool for encouraging people from very different backgrounds to apply their knowledge in new ways. Again we have boundary objects around which they strive to fuse their insights with those of others in the group, elaborating shared posits rather than simply reiterating standard presentations. One common task involves pinpointing the major drivers at play and how they interact to produce the scenario. Other tasks include: identifying turning points and indicators of change, developing narratives of future histories and accounts of affairs at a future point in time in a way enabling comparison across break-out groups, and so on. In more aspirational "success scenario" workshops – or vision workshops – it is more common for breakout groups to examine what a desirable future would look like in detail within specified subdomains, and to elaborate the path that would need to be taken to achieve this. In both types of workshop, plenary sessions will bring together the break-out groups to compare their results, explore inconsistencies and common features, and so on. At any of these points, members of the workshop may be introducing new insights and considerations, and linking the discussion of posits to practical actions in their own organisations.

It is common for a scenario workshop to conclude with some effort at defining key actions or priority areas for further work that emerge from the preceding discussions. This is typically a result of a major "socialisation" process in the workshop that can be externalised and published in form of reports and other tangible outputs that may enter into the processes of the sponsor and other stakeholders, or feed into a wider ongoing FTA exercise. A major task will be to move other parties through their own knowledge cycles, so that they can seriously incorporate the thinking of the workshop in their own decision-

making. This is most likely to be accomplished by those who have participated in or been in some way close to the workshop process. As discussed earlier, they will have much deeper knowledge of the underlying knowledge base, the assumptions and decisions that have gone into the posits, than could be gleaned from reading reports.

Thus the scenario workshop is in many ways a microcosm of a larger FTA programme. Both can be seen as organisational learning processes organised through a number of stages, and involving formal or informal KM. Several rounds of the SECI processes are usually needed to accomplish the required steps of the FTA activity. The broad spiral movement thus consists of many subcycles within the grand cycle, as described by Eerola and Jorgensen [22]. Understanding the knowledge objectives of the FTA processes we are embarked upon, and ensuring that the design is conducive to achieving these objectives, is critical.

7. Conclusions: posits about FTA

FTA can be examined from many several perspectives. Here we have related methods in FTA to knowledge and knowledge management issues. Even a cursory examination of the KM literature will confirm several things. This is an expanding field (with elements of fashion and faddishness). There are fissures between those practitioners and studies focusing on the application of IT systems for KM, and those stressing more organisational and managerial issues and social learning. Other divergences in practice and philosophy do not precisely map onto the IT versus organisational change fissure. For instance, there is the distinction between technological and participatory KM ([16]; and another differentiation between KM strategies emphasising codification (these are centred on IT systems, with extensive organisation of data and information resources, which are codified and stored in databases for rapid access) and those emphasising personalization (centred on direct person-to-person contacts – IT systems are here used to help communication and location of key informants). The labels of these two dichotomies are imperfect – technology can be and is used in PKM, while personalization usually involves some codification (for example, lists of areas of expertise and experience are created in order to allow people to locate relevant informants).[10]

When it comes to drivers and shapers of any KM process, it is inescapable that new IT, which continues to become more powerful and accessible, is being and – we can posit – will continue be, more widely applied for accessing, processing, and visualising data and information. Miles et al. [23] discuss numerous ways in which new IT is liable to be employed in FTA in coming years. Developments in text mining, visualisation, and related techniques will allow for enhanced use of new IT in scanning for scientific and technological developments and their implications. Modelling and simulation, using a wide variety of different approaches and methodologies (agent-based approaches, neural network-type approaches, fuzzy approaches, etc.) will also grow in significance. Technology Roadmapping and other ways of visualising future prospects are supported by improved tools, and Delphi and other methods for eliciting expert opinion are frequently put online. Knowledge Management can also draw on social networking and other tools to locate people with specific types of knowledge input. Social learning and "PKM" elements of FTA can be augmented by use of IT, though this may require careful design – and careful management of IT system designers who may lean more toward TKM frameworks. Again, the design of FTA needs to take into account the needs of KM, and the objectives that we have for various activities in terms of generating and using knowledge and posits.

Telepresence and virtual reality systems are enabling much more intensive person-to-person interaction through IT systems. Yet at present these remain quite limited. Only the most sophisticated telepresence systems can capture or simulate the nuances of face-to-face communication, and are typically so costly as to reduce their use to what are seen as the most critical communications. Even less sophisticated IT systems are liable to be seen by users as costly and resource-consuming media. The use of new media at present usually means less time allocated to purely social interaction, emotional work, coffee machine chat, and other sorts of highly unstructured and informal, and less task-oriented, interaction. Development of rapport and trust can be limited, and dialogue may correspondingly remain more superficial. We would hope that system designers and those responsible for establishing the steps and procedures to be used in FTA exercises will find ways of building in – and even enhancing – time and opportunity for such encounters. (There are probably lessons to be drawn from online gaming and other virtual communities in this respect.) The traditional techniques of face-to-face dialogue are not the only way in which we can engage in dialogue, debate, mutual learning, and the creation of shared understandings. There are many accounts of deep intellectual (and emotional) relationships sustained through written communication. But face-to-face dialogue is a particularly effective medium for (inter-) organisational learning, especially when participants are from different backgrounds and are not already familiar with each other. It still calls for skill and technique – good facilitation. And conventional meetings and workshops can benefit from technical support, for example to capture ideas and allow for rapid collation of views. Experience is accumulating about the use of tools for mindmapping, brainstorming, roadmapping, voting, and prioritisation in the course of scenario work, for example. Perhaps we should be establishing a roadmap for this sort of "enhanced reality" in FTA work.

[10] While this may be very informal codification – even involving user-generated tags and the development of tag clouds and "folksonomies", some classification is inherent in the system. Admittedly, the key information may be created "on the fly" in interaction between participants in the system.

One of the biggest KM challenges that confront FTA, however, concerns the interrelation of Popper's poles of expertise and interaction, creativity and formality. The different sorts of posit that are involved at the extremes of these poles are valued differently in various communities – as is clear from the continued demand for more modelling and statistical analysis and less use of qualitative workshops and judgements that comes from some parts of the FTA user community. This is not an issue of technology versus interaction, since IT can be used to support activity at all poles of Popper's diamond. Nor is it a matter of approaches being mutually exclusive. Formal models (for example, diffusion and substitution analyses) can only go so far, for example, with more qualitative analysis required to explore possible factors shaping take-off points, ceilings, novel applications of the technology that is diffusing, and so on. But qualitative speculation about how and how far new technologies may be used will also do well to be grounded in terms of available understanding (i.e. models) of product cycles and diffusion curves. Serious FTA recognises that we can apply formal modelling to some features of the complex systems we encounter, while we need to rely upon far less formalised understanding of the interrelation of multiple poorly defined (and quite possibly qualitatively evolving) parameters to deal with other features.

Most FTA practitioners recognise this, and most FTA exercises use multiple methods: the way in which methods are combined and integrated is a topic richly deserving of further research. The problems arise when participants in, and users of, FTA exercises are confronted with the different methods and sorts of knowledge and posits that result from them. Different stakeholders have not only different interests, but they also have different modes of access to and use of knowledge: FTA practitioners thus confront the problematique of diverse social goals and power arrangements, whether they would rather avoid it (''we are simply serving our immediate client'') or face it directly (as implied by the slogan of ''anticipatory democracy'' and the characteristics of constructive technology assessment). Classic futures research was often criticised for elitism and subservience to military or corporate interests; more recent Foresight programmes have addressed broader participation more directly, though as much for technocratic reasons as for more democratic ones (leading to criticisms that this sort of FTA fails to explore prospects for radical social change, and thus serves to shore up received arrangements).

In terms of how knowledge is assessed in FTA, a number of points can be made. Experts (engineers, designers, social analysts, political actors) are seen as possessing particularly valued- and sometimes privileged – knowledge. They may thus be deferred to, with their claims and posits left unchallenged. It can require considerable technical expertise (and time) to examine the underpinning assumptions of models (not to mention intellectual familiarity with the conceptual underpinnings of social and economic models). Such issues do not only arise in the highly formal techniques of modelling. The influences of specific procedures (and the ''technical'' choices made in implementing them) on the outcomes of creativity sessions and other group work may not be apparent, even to participants. Indeed, there is only limited empirical evidence, as opposed to practitioner lore and hunches, about the implications of these choices and procedures. While the recent expansion in the FTA methodological literature is enabling us to say a good deal more about how methods can be used, and the new tools that are emerging, there is not a great deal of analysis of such issues. Our KM decisions are undertaken from a limited evidence base; we do not know how far the quality of FTA exercises is impaired, and whether or how far such factors are influencing key results and outcomes.

It would be helpful to discuss past exercises and the logic underpinning specific decisions in more detail. There are also opportunities for action (and action research). One strategy might be to seek to accompany FTA exercises with companion activities in which issue was taken with core assumptions, where alternative sources of expertise were mobilised, where dimensions of the system that were marginalised in the main work were highlighted. In addition to the general point about the need to integrate FTA and risk-assessment approaches (see [24]), two recent examples where a complementary approach was retroactively adopted come to mind:

In the UK, there had been major scenario work on strategies for developing a competitive edge in nanotechnology and literature/expert surveying of social issues associated with this field, in the early years of the present century. Following these, the Royal Society and Royal Academy of Engineering launched a major consultation exercise exploring risks as well as opportunities. These bodies set up an independent working group, involving nanoscience and engineering, social science, ethics, consumer protection and environmental interests. The working group issued a call for written evidence, held oral evidence sessions and workshops (aiming to include key stakeholders) and elicited public views via survey research and qualitative workshop methodologies. The resulting report put much more focus on ethical issues and hazards than the earlier work had done.[11]

A rather different tack was taken by the SWAMI study. This followed the much-publicised AmI (Ambient Intelligence) scenarios and roadmapping conducted for ISTAG (the Information Society Technologies Advisory Group) of the EC [26]. The AmI work had focused on the benefits of the emerging ubiquitous IT systems, and seen problems as mainly barriers and roadblocks needing to be overcome. SWAMI took a more critical approach to the social, economic, legal, technological and ethical implications surrounding such issues as privacy, control of information, and identity. An unusual step was taken: formulating adverse, ''dark scenarios'' explicating key risks and vulnerabilities associated with the use of AmI technologies and services. The project received EC funding – presumably because it could help ''identify research and policy options ...

[11] For an overview of the engagement process, see Rogers-Hayden and Pidgeon [39]; the main report was Royal Society and Royal Academy of Engineering [27]; the dissemination and follow-up to this is described (ands updated) at http://www.nanotec.org.uk/whathappen.htm (accessed 29/07/09); the earlier studies mentioned in the text are the ''Taylor Report'' (Advisory Group On Nanotechnology, 2002) [25] and ([40] – see also [41]).

safeguards and privacy-enhancing mechanisms ... thereby encouraging people to accept and trust AmI technology."[12] The dark scenarios were developed, via workshop and expert group analysis, on the basis of posits about technology development (how realistic these are given current knowledge and activities) and about possible outcomes (have similar things actually occurred). The impressive results of this work represent a refreshing counterpoint both to the techno-optimism of the main AmI literature, and the dystopian nightmares advanced by scaremongering commentators and SF authors.[13]

These are only two of many examples of lively debate being occasioned by efforts to bring FTA methods to bear on issues that have already been the subject of influential FTA studies. This is nothing new, of course – we recall the extensive critique of the limits to growth study, for example.[14] But such large-scale critical exercises and re-envisioning of the futures posited in major studies remains uncommon, with such re-positing being more usually a task restricted to reviewers (if indeed it is accomplished). Efforts to engage wider stakeholder communities in such deliberation – as in the nanotechnology exercise – remain rare (and even that exercise stopped short of deconstructing available scenarios or engaging in its own scenario analysis). Yet new means of communication – not just the internet, but Web2.0 social networking approaches, and collaborative modelling approaches – are creating opportunities for much broader engagement in FTA activities. This will pose considerable challenges for KM: not only will much of the relevant insight be generated on a bottom-up basis, but it is also quite possible that ways of classifying, collating, organising, and visualising the material will emerge from the user/participant community. It will be the task of the "knowledge manager" to design systems that can facilitate this, to effect moderation in such a way as to prevent abuse while not suppressing lively debate, and to support reflection on and learning from the process. If this posit materialises, FTA may be expected to be transformed in the coming years. Existing methods will be "democratised" – rendered more transparent and user-friendly – while new tools that support collaborative working will be introduced. "Open-source foresight" and "Open-source FTA" might be the terms by which this sort of KM becomes known[15] – but that is up to the wisdom (or otherwise|) of crowds.

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[12] Quoted from http://ec.europa.eu/research/fp6/ssp/swami_en.htm, accessed 29/07/09.
[13] The main publication from SWAMI is Wright et al. [42], though much other material is available in journal articles and online – a convenient brief report is on the EFMN website at http://www.efmn.info/files/EFMN%20Brief%20No.%20145_Dark%20Scenarios.pdf accessed 29/07/09, and much more content of the study can be located by use of search engines – including the presentation made at the FTA conference in 2006 [43].
[14] We refer to Cole et al. [44], discussing Meadows et al. [45].
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