
SOCROBUST

Final report



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SOCROBUST PROJECT — AN ABSTRACT

This project concerns the management of especially risky and uncertain forms of innovation. More precisely, it concentrates on architectural or radical innovations which by their nature challenge existing technological conventions, regulatory frameworks, and established relations between consumers and producers.

Public and private sector managers of research and development projects have ready access to a range of tools and techniques with which to inform and evaluate decisions about the relative merits of competing projects and proposals. The trouble is that conventional management methods assume the stability of technological, regulatory and market environments. As a result, they are of limited value when these dimensions are uncertain. The core problem is this: what can managers do to enhance societal robustness (and hence the chances of social and political success) when dealing with "architectural" innovation.

In response, we devised a feasibility study through which to develop and test a new kit of tools for use in such situations. The tool kit, informed by literature reviews in the sociology of innovation, evolutionary economics, and management and organisational science, helps managers better understand the history and present positioning of their project and determine appropriate next steps to promote and enhance its social viability.

Still in the early stages of development, the SOCROBUST tool kit has been prepared for use in a consultancy style interaction involving two parties: a SOCROBUST assessor and the project manager. It consists of four steps and ten tools, many of which have been designed from scratch. The basic sequence is as follows.

The initial step is to describe the project from different angles: first a narrative of events to date; second a mapping of the cast of actors currently implicated in the project; and third a detailing of key events or turning points along the way. Having established a picture of the past, the next challenge is to imagine and describe a future world in which the project has succeeded and its goals have been achieved. This future working world is represented in different ways: via a revised mapping of the actors who will be involved and a more precise specification of anticipated relations between them. The second step is to look back over this descriptive material and identify the key changes which will have to take place if the gap between the present and the future working world is to be closed. The third step homes in on these key changes but from a new perspective. The purpose here is to put the key changes in context, to check on their viability given events in the world beyond the project, and to thereby assess and evaluate the project's present positioning and the key assumptions on which it depends. Having made this assessment, the final step is one of identifying plausible and relevant next steps and of identifying those on which the project manager can act.

This method has been tested on five on-going cases. In all of these it proved to be of practical value for the project managers involved, leading some to revise their views of the project in question and inspiring others to take different actions as a result. Organised as a method for periodically checking, assessing and evaluating societal robustness, SOCROBUST offers a way of managing what have hitherto been inherently unmanageable processes of uncertain innovation.

The feasibility study has demonstrated what promises to be of the lasting value of the SOCROBUST approach. Further work is required to explore the possibility of producing a self-administered version —that is of designing a SOCROBUST process which project managers could follow on their own —and of testing the method on a complete portfolio of current projects.

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SOCROBUST PROJECT — SUMMARY

BACKGROUNDING THE PROJECT OR HOW TO COPE WITH BREAKTHROUGH PROJECTS AND ARCHITECTURAL INNOVATIONS

The SOCROBUST methodology is designed to assess the potential for socio-economic success of a particular set of projects defined as radical or architectural innovations, involving technological discontinuities and breakthrough products/services.

The argument is that this type of innovation (which often represents around a tenth of the R&D portfolio in a large established firm) cannot be managed in the same way as on-going, incremental, sustaining or continuous innovations (the terminology depends on the author) which build a gradual accumulation of useful variations (Cooper, 2000). Risks taken in the latter can be calculated and thus comparisons between projects and the selection of one or another can be based upon calculations (such as estimated ROI). By contrast, the former face such great uncertainty (while also often bearing far greater potential) that applying traditional calculations is at best a formal game and at worst a proof of the distance between funders and project promoters. This class of projects requires specific management practices. Some analysts (e.g. Colarelli O Connor, 1998) go so far as to say that sound management practices for the development of incremental improvements may well be detrimental to the development of discontinuous, breakthrough innovation.

Such a positioning opens up a set of questions: what is meant by uncertainties? How can we know when calculations are no longer relevant (in other words, what characteristics should projects have if meaningful calculations are to be made)? On what should we base decisions about such projects? Few authors from management and organizational sciences have addressed these problems. Bower and Christensen (1995), Courtney et al (1997), Colarelli O Connor (1998) and more recently Hamel (2000) have all underlined the role of breakthrough innovations in securing the long-term future of firms. They follow the analysis of the emergence of dominant designs proposed by Abernathy and Clark (1985) and Tushman and Anderson (1986): the initial years correspond to a period of technological ferment when the technology remains fluid and when actors undergo technological experimentation and competition with a substantial rate of product variation (as alternative forms compete for dominance) until a dominant design emerges as a synthesis of a number of proven concepts. This is associated with the emergence of product-class standards (Tushman and Anderson, 1986).

How can firms manage such situations? One answer is to take a different approach to the management of incremental as compared to radical innovation. This is the strategy which Bower and Christensen suggest after examining numerous instances in which large firms fail to exploit the new technologies they have actively developed. Other authors—not many, and most of them only recently—have tried to analyze how established firms succeed in making radical breakthroughs. Their conclusions can be grouped under three headings: the competences needed by individuals, the capabilities firms must enhance through developing appropriate organisational settings, and the project management and monitoring environment. One interpretation of this is that the managers of radical projects require rather specific

capacities and capabilities. Chen and Van de Ven (1996) speak of a charismatic leader with enough imagination to create a new vision which narrows attention and rallies unity out of diversity. Tushman and Reilly (1998) speak of ambidextrous managers characterised by relatively long tenure and the will to be constantly striving to renew themselves. Collarelli O Connor and Rice (2001) add to these points that the individuals they label as opportunity recognizers must have boundary spanning capabilities. A second interpretation —often complementary to the first one —highlights the organisational features that help in fostering the management of breakthrough innovations. But as mentioned by Collarelli O Connor and Rice, most authors make such suggestions without offering guidelines on how they might operate in practice.

These analyses have one attribute in common: they focus on project management and the environment in which projects are monitored or evaluated. Even so, the issue of managing architectural innovation had hardly been addressed until Noori and colleagues proposed an umbrella methodology (1999) and Cooper put forward a strategic marketing planning approach for radically new products (2000). These approaches constitute the third stream, and the one in which we locate our own elaboration. Both Cooper and Noori share the idea that what is required is not a one-off action, but a management framework which provides a place to start, a direction for improvement and a way to update continually a dynamic planning document (Cooper, 2000).

Through very different channels, both works highlight three core principles: (i) Scenarios have to be made about the future world in order that uncertainties can be identified. (ii) By taking into account the present situation and the firm's competitive advantages, it is possible to identify steps which can be taken in order to clarify these uncertainties, (iii) The approach must provide for periodic repetition because the development path is generally discontinuous and because additional moments of opportunity recognition are therefore required.

THE NEED FOR NEW IMPLEMENTATION STRATEGIES: LOCATING THE SOCROBUST PROJECT WITHIN THE PROTEE APPROACH TO PERIODIC PRO-ACTIVE EVALUATION

Such conclusions were also the starting point for the SOCROBUST project prepared in 1997, submitted to the EC TSER programme in 1998 and funded from 1999 to 2001. It was important for the participants to clearly locate the project in the wider world of on-going academic production.

The works done on breakthrough innovations all insist upon the need for a specific positioning of the project within the firm which facilitates its dynamic monitoring. However the solutions put forward remain very traditional. Cooper locates such processes within the organised marketing function which he describes as one that regulates the flow of resources (in both directions) across the organizational boundary, that is in a functional position within or along the project. Other authors recognize the need for specific organisational arrangements. However their answer remains the classic one of relying upon (mostly external) experts: the team of experts is essential to the success of the approach says Noori who has developed designs for the management of such groups (Noori, 1995). Collarelli O Connor and Rice (2001) suggest that each radical innovation project should be attached to a project oversight

board staffed with company members who can make the long-term commitment needed by such innovation and by appropriate company outsiders (to foster commitment by alliance partners and avoid bureaucratic routines). In our view, such solutions have three limitations. Recognition of these limitations informs the work undertaken by Latour and his colleagues, and the development of the PROTEE approach based upon pro-active periodic evaluation and the establishment of a learning pact (cf. Duret et al., 2000).

(i) The first limitation lies in the fact that neither decision makers within the firm nor project managers are entrusted with, or believed to have the necessary competences. However, if we follow Abernathy and the need for firms to simultaneously manage incremental and radical innovation projects, such projects have to be included in the processes used to determine the allocation of investment money, on top of whatever other advisory committee might be established. They need to enter into a competitive process, the objective of which is to determine whether or not projects should be allocated the funds and means asked for. We thus propose that, for breakthrough innovation projects, a specific evaluation procedure replaces that normally used for allocating funding. Such a conclusion has far reaching implications for the selection of projects which follow this second investment track, for the criterion of success, for the frequency with which projects are reviewed and for the nature of the evaluation itself.

(ii) The second limitation is that conventional management solutions do not offer any guidance on how to examine and interrogate project development: instead, the right answer simply depends upon gathering together the right bunch of experts. If we accept the idea of a second evaluation track, the issue is then one of equipping the evaluator so that he/she can make informed and well founded decisions about which projects to proceed with and in what direction. The process of equipping the evaluator is of procedural and not substantial meaning in the sense that, as when calculations such as ROI are used, the evaluator is not required to know about the specificities of the project. However the new tools differ from the traditional armoury of instruments used for calculation and monitoring. In this case, the evaluation process does not end with the production of figures describing costs, future sales, profits ... and estimated returns from the final output of the investment (which are then regularly updated). Rather, it concludes with a description of the project and the risks taken. The evaluation exercise is, in other words, part of the process of developing the vision of the future market, identifying the uncertainties faced, selecting issues in urgent need of clarification and defining the next round of actions through which to further explore and clarify the possibilities. This second track differs from normal procedures on two counts: (i) it is not only a method for determining the allocation of resources: it also helps to specify the next steps to be taken and the direction to be followed and (ii) it does not commit the parties involved until the end of the entire process (modulo periodic control), but only until the end of the next step (at which point a new evaluation will determine the next course of action). Decisions taken in these evaluations are therefore based upon a joint assessment of the uncertainties faced and an agreement about the exploration required to learn more about them. This is why PROTEE speaks of a learning pact .

(iii) The third limitation of traditional expert committee approaches is that they are costly, and thus de facto tend to be focused on the development phase (when there is a good chance

that the project will exist), and not the exploration one (where elements of what could form a project are still being explored). The prospect of following a second evaluation track depends upon providing the evaluator with relevant tools with which to monitor the exploration phase. How can the evaluator be sure that critical issues linked to the identification and characterization of uncertainties have been addressed, and that he/she is faced with a relevant description of the project on which he/she can make or propose decisions about its future? In one word how can he/she ensure the relevant descriptibility of proposed breakthrough innovations?

Of course, his/her knowledge is based upon his/her own previous experience (as project manager and as project evaluator). The issue is however to avoid a situation in which the evaluator wants to impose his/her views derived from previous experience or to put it crudely to simply apply the recipes, may they be from his/her own experience or from so called best practice. When dealing with breakthrough innovations, one lesson not to forget is that best practices are unlikely to apply since the well defined situations and stabilised settings which such strategies propose are themselves being questioned. This explains the need for equipping the evaluator with a specific questioning frame on the one hand, and a guide for assessment, on the other.

The objective of the questioning frame is to help articulate both the project and the issues which it faces. Latour has identified, from numerous studies of failed projects, three main pathologies which projects generally face and which must be guarded against. These are, following Latour's terminology, lack of realism, lack of strategy and lack of falsifiability. A set of descriptors has been developed to address these three issues and the prototype of a manual for handling the successive interactions has been produced (Bijker et al., 1999). The following box briefly summarises these points.

Box 1 — The three main pathologies faced by innovation projects

Source: Latour, 2000.

The first pathology is linked to the supposed superiority of the solution proposed: it is so good that users will adopt it as soon as they see/test it. This means that project promoters are certain that there is no other competing solution, and no other path to follow for solving the problem addressed. In one word the danger is in developing ballistic and consequently unrealistic projects. To be sure that the project is not facing one or the other risk, the PROTEE methodology suggests that descriptors are based upon analysis of the project script, that is of its future world. They are designed to check the richness and the heterogeneity of the project, to identify the nature of uncertainties faced (referring for instance to Courtney's classification) and to assess the degree of flexibility of the project: what are the possibilities of one or another outcome for a given uncertainty, what aspects must remain for the project to survive? (what is called irreversibilities by economists and obligatory passage points by sociologists).

The second pathology deals with the very frequent problem of paranoia, that is the inability of the project to absorb opposition other than by saying that the opponents are irrational, and thus to remain in ignorance of all the good reasons opponents might have for not co-operating. The descriptors are there to insure that project acquires knowledge of relevant anti-programmes (that is not only opposition to, but other proposals to address the same issue and other articulations than the one which the project represents) and is in a position to develop a coherent view of such opposition. Case studies have also shown that swallowing opposition often requires a measure of substitution and perhaps some transformation of the project itself. It is thus important, having described anti-programmes, to assess the negotiability of the project, that is its degree of modularity or to use an economic image, its absorption capacity. Analysing the transformations that can and can not be introduced (perhaps as a means of enrolling opponents) obliges project managers to determine the essential ingredients of the project core, i.e. those aspects that cannot be transformed without endangering the coherence, identity and integrity of the project as a whole.

The third pathology deals with closeness. Another important lesson derived from case studies is that innovators tend to remain in their technical world and only consider other types of trials once all technical issues will have been solved. How can the evaluator be sure that the trials proposed are relevant, that they will test critical dimensions of the project and that they will identify new allies to be enrolled (and not remain within the sphere

of those already convinced)? The questioning frame proposed is designed to: verify the scope of the uncertainties identified; highlight issues raised by anti-programmes; ensure that the expertise mobilised in defining trials is heterogeneous (that is comes from different sources not all linked to the project —avoid the lobby effect); and make explicit the translation proposed (that is the articulation made between the issues raised and the expected results from the trial, between the enrolment sought and that which is achieved). Together these descriptors make it possible to assess what Latour has proposed to label the *criticity* of the trials proposed.

These descriptors help to determine the project's ability to guard against the main risks of failure associated with project management. They have been used to organise a questioning canvas and to keep track of the agreed description. This makes it possible to compare two successive descriptions. Evaluation is thus not absolute but relative to the previous description. Such comparison makes it possible to grade or assess the learning curve of the project. This grading constitutes the assessment part of the interaction. This assessment is in four parts. (i) It first considers the project's capacity to react: if nothing is learnt from the trials made, if nothing is changed in the project's life, it either means that the project environment can be considered stable enough for the project to enter into normal channels of investment appraisal, or that conditions for learning are no longer present and that it is useless to continue the exploration. (ii) When learning occurs, one central question is whether the project is still able to integrate the often contradictory results of the exploration: is there still an object — a project — capable of holding all the recognised tensions together —what is termed in the sociology of science, a *hopeful monster*? (iii) If this is the case, it is important to assess the capacity of the project to remain flexible: are irreversibilities built so strong as to require unlikely societal changes —what American analysts call *white elephants* and French engineers refer to as *usines gaz*? And (iv), if we face a learning project, able to integrate all tensions identified and which is still adaptable enough to cope with dimensions which remain uncertain, the last aspect to consider is the relevance of the next steps proposed: will they help to determine and address the uncertainties identified? In the final encounter both the evaluator and the evaluatee should reach the conclusion that anti-programmes have been incorporated and uncertainties solved to the point that the project is no longer a *hopeful monster* but a *tamed animal* that can enter into normal company life and be subject to the usual processes of investment selection.

The dual orientation of the descriptors, partly assessing the health of the project, partly determining the conditions for continuation, gives shape to a procedural approach which does not generate recipes for handling critical issues but which does ensure they are addressed. The experience of testing this method in one real situation with an on-going project, showed that, to prove fruitful, it was also necessary to equip the project manager (the evaluatee) so as to put him/her in a position to address the questions posed. For this purpose a different approach was needed. The job of developing such an approach has become the focus of the SOCROBUST project. The ambition was thus to develop a methodology which makes it possible to **describe** the risks taken and to follow the **exploration** made.

SOCROBUST AS A RESEARCH PROJECT

The project objective, as expressed in the technical annex, focused on developing a management framework for architectural innovations. It is interesting to see that the same

ideas were being pursued on the other side of the Atlantic ocean, giving rise to relevant publications during the life of the project. However, none referred to the central hypothesis made here, namely that of societal robustness — a term which justifies the acronym selected. Our starting point, and our interest in societal robustness, relates to and builds upon the major lessons from innovations studies. The project recognized that every technological choice is simultaneously a social choice, through the script of the future world it includes. Thus embedment in society is not an end of pipe issue, a question of acceptability, but is created in the same movement as that which shapes the objects, processes or services in question. In one word, an innovation's capacity to find its way in society is co-constructed during the project through the tests and trials which it undergoes. In addressing this issue, the project made use of work done on constructive technology assessment which stresses the role of hybrid fora where stakeholders and interested parties in a given project, through controversies and compromises, alliances and alignments, progressively establish the conditions under which the project can develop. Societal robustness is then not given ex-ante, nor a set of criteria along which to measure projects, it identifies the agreements arrived at and the corresponding embedment in society promoted (Technical annex). This central hypothesis is at the core of the method developed and tested on real-time projects.

It is important, at this stage, for the reader to appreciate the status of the SOCROBUST methodology presented below. Given the many methods of research evaluation and technology assessment that have been developed during the last 20 years¹, it was initially thought that the central task was to determine which existing tools should be used, when, and how to tailor and integrate them to fit the problem in hand. SOCROBUST was thus only a feasibility study (which nonetheless ran over a two year period and involved 6 academic teams from 5 countries) designed to verify such assertions and develop an adequate architecture or framework with which to monitor the embedment of projects within society and to assess their societal robustness.

An initial literature review revealed an overwhelming number of potentially relevant concepts but at the same time showed that relatively few were either derived from empirical studies (observed reality) or had been tested (meaning translated one way or another and implemented in reality). We thus entered into an unanticipated form of exploration which led us to make two important simplifications (see box 2 for an overview of the project dynamics).

(a) We limited our selection of concepts to those already used in practice (at least for the analysis of past cases, and at best used in given organisations in a partly routinised way). This selection was tried out and further hardened through an extensive thought experiment based upon one in-depth case study on the deployment of large scale wind mills and on the emergence of the market for wind energy in most European countries. There were, however, a number of aspects not covered by existing tools (especially relating to the assessment *per se*) and in dealing with these we constructed a handful of new techniques (at present still at the state of laboratory pilots).

(b) We organised our main trial as a form of consultancy interaction between the SOCROBUST team and project managers responsible for five on-going cases. The projects

¹ For a review see among others Callon et al. (1997), Georghiou and Roessner (1999) for programme evaluation, Schot and Rip (1997) for constructive technology assessment, and the works of the ASTPP network for a full state of the art (summed up in the final report, Kuhlmann et al., 1999).

selected correspond to EU supported projects in three areas: new energy sources, telematics application in health and telematics for public administrations. The selection was arrived at through discussion with EC programme managers (selecting within their portfolio of projects those they consider to be of the breakthrough variety). 8 projects were identified and gave rise to initial contacts. Because of funding and time constraints, only 5 (as initially planned) were fully developed. We had two objectives in mind. One was to test the technical feasibility of the proposed scheme —would it be possible to product an assessment report along the lines we had envisaged? The second was to test the strategic capability of the method: would the SOCROBUST assessment report provide the project manager with a relevant description of his/her project? Did the process and the robustness assessment generate new insights for the project manager ? Did it change his/her way of thinking about the next steps to take?

The testing process went as follows: for each project a consulting team of two persons was formed. This team was responsible for getting hold of existing literature on the project and for undertaking two interviews designed to sketch out the innovation journey and to unfold critical aspects of the project (future world, present TEN), always remaining within the logic of the project manager. The consulting team was also in charge of making the external check (a web search conducted with the assistance of a specialist team), and of drafting the assessment report. In order to monitor difficulties encountered along the way, for example, in explaining the approach and working with it, and in order to learn from the process of interaction, the two interviews were followed by an observer . A third meeting was held between the project manager and another member of the SOCROBUST team after the assessment report had been completed and sent out. The purpose of this final meeting was to consider the relevance of the method and the process. In practice, most also turned into strategy making discussions involving consideration of the results of the consultation and their meaning for the future course of the project.

Box 2 -The project dynamics (as compared with the initial expectations)

WP1 - Development of a preliminary framework.

Initial duration: 4 months.

Process: literature reviews

Objective: canvas to follow for studying retrospective cases.

The MF was adopted in September 1999 (2nd project meeting, in Toulouse). However, literature review was expanded. It was updated and discussed in January 2000 (3rd project meeting, Twente). A full addition on knowledge management was then decided, discussed and incorporated in July 2000. A selection and further revision was made in 2001 for establishing the position paper.

WP2 - Criteria for identifying architectural innovation and selection of cases

Initial duration: 4 months. Effective duration: 12 months.

Objective: Selection of 6 cases. Retrospective case (Wind energy) selected in September 1999. On-going cases selected between January and May 2000, through a pro-active process with managers of IST —key action 1 (telematics for health and administration).

WP3 - Learning from retrospective cases

Initial and effective duration: 9 months.

Process: use of 3 cases and of thought experiment (reconstruction of choices at turning points/critical moments in the life of projects).

Objective: revised canvas to apply on on-going cases.

Effective activity: from October 1999 to June 2000. The first thought experiment done on Wind energy (Petten workshop, december 1999) drove to a full reconsideration of the approach. No other retrospective case was initiated and a completely revised method was discussed through one project meeting (Twente, January 2000),

two working sessions (January and May 2000) and one experiment on the future of wind energy (Paris workshop, March 2000). A full methodological note was issued in June 2000, tested on the first on-going case study (EUROVET) and adopted in July 2000 (4th project meeting, Paris) for all other cases.

WP4 - Test on recently started cases of the revised management framework

Initial duration: 6 months.

Process: use of the method as a consulting interaction.

End result: a consultation for each project (with an assessment report) and a revised final management framework.

The method required two successive interviews with the project manager, one external check, the writing of an assessment report and an evaluation session with the project manager to discuss the report, its usefulness and limits. The first meetings started in June 2000 (Eurovet) and were only closed in January 2001. A 5th project meeting (Roma, September, 2000) finalised the process. The first reports were delivered in November 2000 and by the 6th project meeting (Lancaster, January 2001), 3 evaluation sessions had taken place. Two other reports were finished between March and April 2001 and evaluation sessions took place in May 2001. It was then decided to stop the work on the 3 remaining projects.

WP5 - Final report and preparation of next steps

Initial duration: 6 months

Planned Process: the preparation of a book, an evaluation workshop.

The Amsterdam workshop (October 2000) and the 6th project meeting (Lancaster, January 2001) drove to a full reshuffle of the initially planned approach. It considered evaluation done through the evaluation meetings undertaken. It was thus decided

* to organise the final report around 3 elements: (i) a more academic paper positioning the issue and the approach developed (the present chapter 1 of the final report), (ii) an operational description of the present method with the project appreciation of its present status of validation (chapter 2), (iii) the inclusion of a chapter dedicated to the dynamics of the Socrobust project, so as to apply to ourselves the lessons learnt in the project (and thus prepare for a pro-active evaluation!).

* to initiate the two actions around which we consider the next development step should focus. See conclusion below.

THE SOCROBUST METHOD: MAIN PRINCIPLES

The project undertaken with the support of the EU (1999-2001) sought to test the feasibility of developing a methodology that would allow project managers to prepare a description of their project that would be relevant and useful in the proposed evaluation process.

Chen and Van de Ven (1996) consider that the critical issue in innovation journeys lies in the initial phases and the management of the period of ambiguity, that is the period when traditional mechanisms of accumulation do not apply. They suggest that exploration is at the heart of the initial phases of breakthrough projects. The PROTEE case studies demonstrated that the result of this exploration is to learn whether or not there is a possible project and if so, which one it might be. It is only then that the narrowing process proposed by Chen and Van de Ven, usually involving sequences of trial and error, can take place and only then that the traditional management tools apply (not forgetting lessons embedded in the chain-linked model and the notions of lead-users and co-conception or co-design). This line of reasoning led us to focus on means of tracking and monitoring the positive development of such projects during their exploration phase. In addressing this question we extracted four complementary resources from the sociology of innovation.

(i) Rather than anticipating external events, as proposed in scenario making, the central anticipatory task, for SOCROBUST, is that of rendering visible the **script** of the future world already embedded in the positioning of the project, and already implied in choices made by the project manager.

(ii) The process of project development is no longer explained in terms of a sequence of states (e.g. concept, pilot, prototype, industrial development) which projects are expected to go through (however many times and in whatever order) but, rather, in terms of the **trail of trials** to which projects subject themselves in the course of progressively testing the relevance of hypothesised configurations of human and non human actors (this is what organizational colleagues refer to as the action-outcome relationship). Put briefly, what Chen and Van de Ven term prerequisite knowledge is the outcome of what the sociology of innovation labels a trail of trials the role of which is to discover whether actors (human and non human) can be enrolled and how they can be articulated together.

(iii) The question of how one might know that actors are enrolled and that uncertainties are indeed clarified becomes a central issue. There are two aspects to this. The first lies in what the sociology of science calls the **robustness** of propositions. Propositions can be said to be robust when the assumptions on which they depend are no longer challenged. To grasp the extent of robustness — that is to determine the range of situations across which assumptions are no longer challenged — it is important to characterize the **fora** arenas in which they have been debated, accepted, and come to be taken for granted (naturalised following Latour).

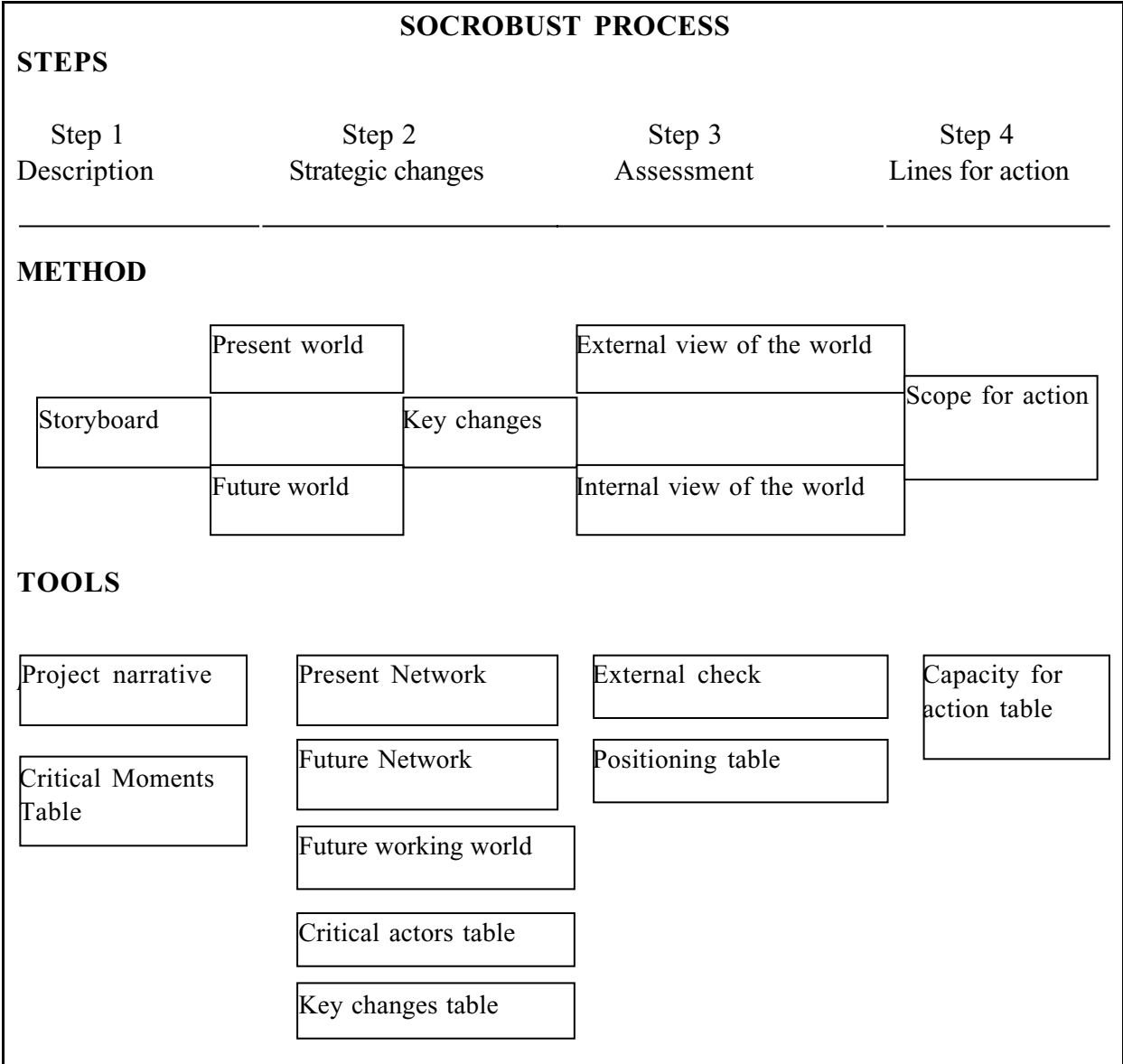
(iv) The second aspect of monitoring enrolment has to do with following the **techno-economic network** that supports the project. The key move here is to equate the state of a project to the network that supports it. Having taken this step it is possible to progressively map the results and consequences of each exploration by recording and characterizing the consequent transformation of the network.

These lessons have helped establish the four main elements of the SOCROBUST methodology which seeks to (i) unfold and render visible the future world inscribed in the project, (ii) identify the key changes required (by comparing the future world with the present project network), (iii) assess the robustness of the assumptions made about the key changes, and especially identify competing views of the world or of ways to address these key changes, and (iv) identify/evaluate the project's current margins for manoeuvre.

THE SOCROBUST METHOD: 4 STEPS AND 10 TOOLS

Going from principles to a first operationalisation was not straightforward as explained above. We have however chosen to skip the painful learning process (which the final report reviews in detail) and present the SOCROBUST method as it stands now, taking into account not only the lessons of the retrospective case studies done (which helped establishing a first process) but also the results of the test made on 5 on-going cases. What follows is thus the result of a first demonstration, of a first trial in the real world.

The basics of SOCROBUST can be explained relatively simply. It is a four-step process backed by the use of 10 tools. The 10 tools each contain some kind of image or visualisation like a map, a table or a graph. These are deployed in a pre-determined order in which the result of one tool are taken up by the next. The sequence corresponds to the principles mentioned above, and the tools together help build the four main steps of the protocol: description, key changes, assessment, capacity for action. The following paragraphs provide a brief outline of the process and of each tool (the final report devotes a full chapter to these aspects).



Step 1 - Description

At any moment in time, a project manager is in a position to provide a narrative account of his/her project. This enables him/her to trace both the past trajectory of the project (with its turning points or critical moments where branching occurred) and to consider its future path, the next step being quite precisely specified, later ones being more tentative, assuming all goes as hoped/expected (sometimes the project manager may envisage several possible futures, any and all of which would constitute success). Two tools support this preliminary effort: the **project narrative (tool 1)** and the **critical moments table (tool 2)**.

The project narrative is the starting point for unfolding the project. In developing the method we felt it was important to start from safe ground, that is from where the project stands now. The first unfolding action is thus to review the present project network, using a simplified TEN approach for this purpose. We have selected the STUR network based on four poles —science, technology, user and regulation—which has been extensively used by

public agencies such as ADEME in France and can thus be considered operational. This exercise results in a map showing which actors are involved, where they are positioned how they relate to each other and which intermediaries bind them together. This map provides a first **visualisation of the present network (tool 3)** and the raw material for a first **table of critical actors (tool 4)**.

This first mapping helps in questioning the richness and heterogeneity of the network and the nature and durability of the actors' involvement. It also reveals the existence of other actors located at the different poles and pursuing similar goals (either as competitors with similar interests in market shaping; or representing anti-programmes proposing different avenues and approaches to market shaping). In addition, it helps identify blanks or poles so weakly or so generically developed that no spoke persons of interest for the project can be identified.

The next action uses the same network visualisation and the same mapping method to describe the composition of **the future network (tool 5)**: that is the future network as it would be should the project have succeeded. This future oriented exercise helps to identify new critical actors who should be enrolled and aligned, and it provides a point of reference for further discussion of relevant spoke persons and/or relevant actions which might be undertaken to better identify competing views and approaches (in which these actors are often already involved). Developing these issues further, this exercise also provides a basis from which to sketch the **future working world (tool 6)** in order to better assess the extent of necessary or assumed changes in the market infrastructure (be that the physical infrastructure, or the infrastructure of norms, standards, rules, codes of conduct), in the user knowledge base and in producer-user relationships.

Step 2 - Strategic changes

As a result of step 1 it is possible to compare the present state of the network and the hoped for future working world. This in turn makes it possible to identify the key changes that will have to take place before this future working world exists. In some cases, we have used another tool —the **boundary map** —to offer a visualised recapitulation of the project dynamics. It is made of three nested squares: square 1 of the boundary map indicates what the project has already acquired, aligned, or achieved. Square 2 indicates the directions for change, while square 3 highlights what is to be monitored (passively or actively).

Identification is not enough. Key changes have to be characterised more precisely, for example through specifying new practices that will have to become taken for granted and present practices that will have to be discarded (with implications for actors likely to represent either a source of opposition/compromise). It will also be necessary to specify actors outside the project who share similar visions and (if any) to look for and detail fora in which such changes are already discussed. Key changes have also to be considered in terms of how they might be addressed: can they be addressed within the present network (what is at stake is then convergence within an existing network), or is there a need to enrol new actors, that is for extending the boundaries of the present network? And what are the project manager's views of these options: can the project be pro-active, that is can it actively enrol adequate spokepersons and thus shape the issue (or at least participate in its shaping)? Or is it only in a position to monitor / watch developments made elsewhere, and outside the borders of the project network? In which case, the challenge is to remain flexible and adaptable and to have early warning especially of negative shaping. The key changes so characterised are encapsulated in the **key changes table (tool 7)**. Specification of these changes helps in

articulating the project's core assumptions, the robustness of which is critical for its future development. The careful detailing of key changes is thus a precondition for embarking on an assessment of the project's societal robustness.

Step 3 - Assessment

Once key changes have been identified and characterised, the methodology then opens up to take account of the wider world in which the project is located. It does so not in general terms but with reference to a central question: what can be said about the probability the key changes (specified above) will come about? It is not a general check (for example, on the implications of mad cow disease) but a check which focuses on issues which have been quite precisely identified through the analysis of key changes (what animal tracking systems exist which incorporate health issues? what governments have passed relevant legislation? which countries have tracking systems already in place? are there other actors, either at regional, sectoral or functional levels, also interested in animal tracking?). The objective is to know, for each key change, what can be found through a search for other actors having the same approach, for actors proposing other strategies and for studies, debates, and positions taken about the transformations (that is new market infrastructures) required, and hence about the direction to take. While we have labelled this phase an **external check (tool 8)**, we only focus on the critical assumptions made by the project.

In checking these assumptions, the method makes the following supposition: any antiprogramme that has taken shape, any competitor that follows similar goals, any organised group that positions itself with respect to one of the key changes (and uncertainties) will by now be visible on the worldwide web. The external check is thus focused on internet searching. Devoting even limited resources to such searches (on average between 3 and 5 person days) and using only standard search tools and procedures were however sufficient, in the 5 case studies made, to bring to the fore an extensive body of material much of which helped to reshape the project manager's approach to, and view of, the key changes required.

By assessing the grounding of the project's key assumptions, the external check helps in constructing the central tool of the assessment, which we have labelled the **project positioning table (tool 9)**. Up to this stage, all elements mobilised in the SOCROBUST method have been developed and used before (even if in other contexts and even if not labelled as such). We are now entering the part of the process for which we found no relevant approach, even though the concepts involved are quite well established. The positioning table sums up where the project stands. It shows whether (or not) there are other approaches to handling the necessary key changes, it shows how the project stands with respect to these alternatives, and as well as identifying potential allies and opponents, it shows the extent to which they have expressed their views and/or organised themselves. This provides an overall assessment of the project positioning vis-à-vis the related key changes. The table shows how the project is positioned with respect to key changes relating to the following dimensions:

- changes in the technological landscape (for breakthrough innovations these are often associated with new paradigms or new dominant designs, in other words, to the development of new shared knowledge about what the technology can do and how to do it),
- changes in user-producer relationships (this includes all aspects of customer preferences, market segmentation, new knowledge which customers will require to value the qualities of the new products proposed and to be in a position to use them —We were also struck by the

importance of new activities required to service the new products and by the importance given to intermediate bodies and prescribers in most of our case studies),

- changes in the legal, administrative and regulatory environment (this includes all well-known issues about norms and standards, but also ethical issues, issues about the environment, and about quality and consumer safety. We were struck, in quite a number of the case studies, by the importance given to the effective structuring of markets by public intervention such as pricing issues for wind energy, priority setting in health which in turn has important economic effects, etc.).

Step 4 - Lines of actions

The final step of the methodology tries to assess the margins for manoeuvre, that is the room for action within, and for the project. What is the project's capacity for action with respect to each key change? This is where we mobilise the results of the external check regarding the robustness of the constructions made or envisaged. The likelihood that a key change will come about as expected relates to the nature and scope of collective agreement. Amongst other things, this depends upon the existence of a space for debate, a forum, where the required reshaping is discussed. The actors that make up the forum (thus its hybridity and representativeness), the arguments exchanged, the solutions sketched and the actions / directions defined, are all ingredients of the potential robustness of the outcome arrived at. A further element concerns the centrality of the project within the forum, that is its capacity to enlist key actors in the forum, to ensure that the project's position is not marginalised and that its goals are internalised by relevant groups in the forum. These features are represented in the **capacity for action table (tool 10)** which helps specify practical next steps for fostering the societal embedment of the project and enhancing its societal robustness.

These conclusions are of course focused on the next step since this is the central issue of the learning pact. In some cases the recommendations are active: to build, test, demonstrate etc. Yet they may include precautionary measures especially regarding features which remain beyond the scope of direct influence. In these cases, the watching might remain traditional, that is passive. But it might also be much more pro-active, for example, monitoring specific developments (including participation in existing fora to make sure that events flow in the preferred direction), reflecting upon routes not taken (and the potential weaknesses that may result from others having selected these routes) or specifying alternative definitions of the project (depending on its flexibility), organising internal debate about the positioning of the project (in one case, this highlighted what might be gained by incremental adjustments in the project).

RESULTS ACHIEVED AND PROPOSED NEXT STEPS

What have we done to prepare our own next steps and how do we see them? These are the two questions which we would like to answer in concluding this part of the project. Let us begin by summing up where we stand today (that is what the final report offers).

1- We have forced ourselves to completely rewrite a positioning paper which locates the work done and the results achieved in the context of relevant management literature. This paper clearly identifies the new elements we have brought to this debate. The positioning paper, which is the present chapter 1 of the final report, has already been circulated and discussed

not only with colleagues in the field but also with managers (with an established background in project management).

2- We have tried to set out in as operational a manner as possible the method as we see it now and as we would like to experiment with it on a wider scale (see below). We have done so since we consider that the project permitted significant developments which the tests made have shown to be both useful and relevant, and which have helped to consolidate the method as a whole.

3- From the start we tried to be reflexive about the process per se. This has become all the more important in that: (i) there has been a significant change in the approach adopted during the lifetime of the project, (ii) we have been obliged to make sometimes drastic choices between potentially attractive concepts, and the reasons why we opted for one rather than another route had to be rendered explicit, (iii) we have connected this project to another developed within a different frame with a different approach, so as to redefine what we consider to be a relevant management framework, and (iv) it is through this process that we have progressively outlined what we now consider to be the relevant trials to enter into to test whether we can develop a SOCROBUST prototype and in our own terms, return to normal project calculability .

The two main trials we consider are closely linked to the nature of the feasibility study we have undertaken. They concern, on the one hand, a clarification of our targeted audience and the users of the method, and on the other hand a further elaboration of examples and reference cases to help develop the skills and capacities required to make assessments of societal robustness.

(i) In its present form, the SOCROBUST methodology cannot be self-operated by the project manager. A consultancy style interaction is considered central. This means that the method still requires and relies upon specific knowledge about innovation processes. Is this knowledge so specialist that it cannot be absorbed by project managers? Or is this conclusion, rather, a reflection of the fact that further effort is required to formalise the process so that it can be self operated? If so, and this is a rather common situation when dealing with a feasibility study, additional exploration is needed to establish the possibility of developing such a stand-alone method. We consider that a relevant test would be to require foreigners, or newcomers, to be set free to use the method on their own in order to see what they get out of the experience and how those interested in it wish to continue learning. We see the development of a website dedicated to the presentation of the method, accompanied by a systematic tracking / follow-up of visitors to this site, as a way to provide such a proof. The initial work of functional design which we have already undertaken (see specific annex to the final report) suggests that it is feasible to think of developing such a site, but that this would require a significant investment.

(ii) Clarification of the target audience (i.e. project managers or professional advisors) is one issue. The second concerns the need for references and worked examples. In all evaluation sessions with project managers, it proved important to locate and recognise certain types of achievements, to identify typical situations likely to be encountered during the course of a project learning curve and to give examples which, on the basis of past experience, contain clues as to the chances of successful embedding, if not success per se. The questions of how to consider the achievements made to date and of what can be considered relevant action in

given situations remain. But it is not sufficient to say, in response, that decision makers (and to a lesser extent project managers) only option is to learn from experience, capitalising upon the numerous projects they have to monitor. Is there only learning by doing? In acquiring experience, do they build up a totally specific asset which mixes a dual contingency, that of an organisation trajectory/history and that of the current activity in question? Or is there room for inter-organisation and cross-sectoral learning? If we assume that this is in fact possible, then one crucial issue is to consider a revised taxonomy of project states (a static description) and possible next steps (a dynamic one), so as to produce a preliminary taxonomy of trials and so as to consider means of mapping typical trails. The literature mainly focuses on the well established technical states (concept, pilot, prototype, development, introduction, adoption/diffusion) yet there are a few elements of what might be developed into a typology of trials (for example, Rip's protected spaces and strategic niches, and Latour's collective experiments). We consider it necessary to enrich the vocabulary in this field through two complementary strategies. One is to embark on a re-reading of major monographs of innovation stories. The other is to conduct a transversal assessment — a real size experiment in monitoring an array of radical innovation projects either within a public authority supporting such projects or at the corporate level of a large firm involved in fostering such activities. We have been discussing this prospect for over a year now with one national programme on transport technologies. And we are negotiating a similar experiment with a large multinational firm. In both cases, this involves at least two teams from different countries. Since the method is quite unusual for our partners, it requires important initial investment, and in particular the development of training courses².

The feasibility study has proven fruitful, even if the fruit is quite unlike that which we expected. We consider that we have proven our capacity to learn and adapt. The method proposed is still able to integrate all tensions it is faced with, and should therefore be considered as a hopeful monster. Not only that, the two trials we propose take us far away from our previous circles (so the project is not yet a white elephant). According to all the PROTEE criteria, our funders should continue to support us! At least that is the conclusion we hope they will reach.

² The latter are the most concrete and visible output of the method. Two complementary courses have been devised based upon an initial exposition of the issues, problems and principles. One involves students in looking at a fresh case (with which we already have some connection and for which we have at least partly done the work ourselves), applying the process (the method is cut short in that students are provided with the results of an external check on the issues they have identified) and then entering into a discussion with the project manager about the issues the project confronts. This was done on the French *telebilletique* project managed by the Parisian transport utilities. Another more confined exercise, consists of using the existing cases as a point of reference. In this exercise, two actors are needed, one acts as teacher, the other as project manager (which enables mimicking interactions), the students then undertaking the web search and producing a report (transparencies) which they present to the manager. These courses remain experimental, and they require further development for entering the normal framework of master's courses in the management of innovation.

CONTENTS

Abstract	i
SOCROBUST Partnership	ii
SOCROBUST Project – A Summary	iii

Contents	1
Presentation	4

Chapter 1– The societal robustness of breakthrough innovations: a positioning paper about the socrobust methodology

1- The issue	7
2- The need for architectural / breakthrough / discontinuous innovations	8
3- Managerial challenges: A progressive focus on project management and their monitoring /evaluation environment	10
4- Three core principles for a “management framework”	11
5- Implementation strategies: the need for another approach	13
6 - The dynamic adaptation and monitoring of breakthrough projects: a “learning pact”	15
7- Approaching the whirling dimension of the innovation journey	19
7.1 - From “exogenous” to “endogenous” scenarios	22
7.2 – The dynamics of project exploration: a trail of trials	24
7.3 – Controversies and the “robustness” of trials made	26
7.4 – The project “techno-economic network” as a marker of its development/progress/status	27
7.5 – Where do we stand	30
8- Equipping the evaluator: the PROTEE questioning frame	31
9- Equipping the project manager: the SOCROBUST methodology	36
9.1 - Socrobust as a research project	36
9.2 - SOCROBUST method: a four step process.	38
10 – To recapitulate	44

Chapter 2 – The socrobust methodology, a description

1- Introduction	47
2- The principles underlying the proposed methodology	48
2.1- Recalling the challenge faced	48
2.2- The nature of the challenge we faced	49
2.3 - The principles of the SOCROBUST process	50
3- The SOCROBUST process: 4 steps and 10 tools	54

SOCROBUST Final report	1
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Step 1 - Description	55
Step 2 - Strategic changes	55
Step 3 - Assessment	56
Step 4 - Lines of actions	57
4 – A tour of the SOCROBUST tools	58
4.1- Tool 1 – Project narrative	59
4.2- Tool 2 - Critical Moments Table	61
4.3- Tool 3 – Present network	63
4.4 - Tool 4 – Future Network	66
4.5 - Tool 5 – Critical actors table	68
4.6 - Tool 6 – Future working world	71
4.7 - Tool 7 – Key changes table	73
4.8- Tool 8 – External check	75
4.9 - Tool 9 – Positioning table	78
4.10 - Tool 10 – Capacity for action table	81
4.11- Formatting recommendations	84

Chapter 3 – The Socrobust project process, dynamics and proposed next steps

1- A summary of expected vs achieved results	87
2- The project life at a glance	90
3- Selecting EC projects as case studies: A two-step process	93
4- Establishing the “management framework” or the painful learning about the managerial uptake of literature based concepts	94
4.1- Literature review: an on-going (rather than a one-off) activity	96
4.2-The initial framework or dealing with the multiplication of concepts addressing technological change	98
4.3 – The thought experiment on wind energy or how to reconsider the catalogue of tools and concepts	105
4.3.1- Positioning the intervention of the MF	
4.3.2- Mapping and diagnosing the innovation journey in context. Lessons derived from the application of proposed tools.	
4.3.3- Tracing internal and external alignments	
4.3.4- Conclusions arrived at (debriefing of the experiment at the Twente meeting, January 2000): the need for a full redefinition of the management framework	
4.3.5- A first on-going check before the final shaping of the tool	
5- A protocol for interaction with managers	115
5.1- A Protocol for interaction as the cornerstone of the Method	115
5.2- A Consultancy based protocol	115
5.3- A light and compact version of Socrobust as experimental test bed	116
5.4- A three step protocol	117

5.5- An overview of the tools for steps 1 and 2 (as they were formalised before the on-going tests)	119
5.6- An open issue: how to implement the assessment	122
6- The case studies and the lessons learnt	124
6.1- Producing the assessment: from principles to the positioning and capacity for action tables	125
6.2- From an evaluation session to a strategic interaction	137
6.3 – Other lessons derived from the experiment	141
7- Return to the management framework and the insertion of SOCROBUST in a wider framework	148
7.1- Architectural innovations, uncertainty and their “corporate monitoring”	148
7.2- SOCROBUST and prerequisite knowledge of innovation dynamics	150
8- To conclude: Next steps	153
Productions of the Socrobust project	155
Bibliography	156
Annex: Functional definition of a SOCROBUST web site	161

DOCUMENT 2 (15 pages) presents the graphs and tables of the SOCROBUST method

PRESENTATION OF THE FINAL REPORT

The SOCROBUST methodology is designed to assess the potential for socio-economic success of a particular set of projects defined as “radical”, “breakthrough” or “architectural” innovations.

The purpose of this project was to test the feasibility of developing such a method. It lasted two and a half years. It was organised in two parts: first the initial development of the methodology tested on past cases through a special experimental design (involving thought experiments), and, second, testing the revised methodology on on-going projects supported by the EC and selected in association with interested programme managers.

The project initially assumed the existence of a wealth of ready-made “tools” with which to address specific aspects of societal robustness. The task was therefore not one of developing new tools per se but of designing a “management framework” with which to articulate them together and organise their deployment. The first phase of the project showed that while there was a wealth of “concepts”, very few of them were operational or even “operationalisable” within a reasonable time scale. It also demonstrated that although the notion of “management framework” was valuable, its effective design involved more than simply organising a set of tools; it also required an appropriate organisational setting at firm or institution level. This aspect was being dealt with in another EC supported project, PROTEE, which concentrated on the “monitoring” of innovations. SOCROBUST was by contrast focused on the central task of preparing and equipping project managers, through the development of a methodology which would help them assess their project’s potential to become embedded in society.

As SOCROBUST developed, interest in these questions increased, with new analyses and proposals being put forward, mainly by US colleagues. These renewed approaches to the construction of a “management framework” with which to address the strategic and operational management of breakthrough innovations are nonetheless limited in terms of their potential for practical implementation. We consider that the approaches of both PROTEE and SOCROBUST address these limitations. This is why we have devoted the first part of this final report to a “positioning paper” presenting the state of the art and the answers we propose. The positioning paper relocates the objectives of the project in a wider context than that initially considered relevant, it presents the conclusions we reached, and considers their strategic/policy implications. The result of the project is a “standard” methodology involving four steps and ten tools, many of which had to be developed from scratch. Chapter 2 describes this process. The “feasibility study” was rich enough to allow us to design a first version of the standard methodology. This has already been tried outside of “the laboratory” and proven operational in (and may be useful for) the 5 case studies done on on-going projects.

However the method remains at the development stage, since there are many issues still to be resolved. As a means of identifying these and highlighting points requiring further research and development, Chapter 3 reviews the process through which results have been arrived at to date. It details the choices we had to make and the reasons why we did so. It also identifies the two main problems which must be addressed for a full establishment of the methodology. The methodology was developed in a consultancy style interaction, and we do not as yet know what

new knowledge and skills project managers would require if they were to administer the methodology themselves. To stabilise some of the tools and their operational procedure, there is still a need for a “real size demonstration” involving a large subset of projects, monitored over a period of time and within one given institutional setting. Chapter 3 presents these issues more in detail and describes the work that has already been done and is still going on to foster further development.

The reader will learn, in Chapter 3, of the importance of the uncertainties we faced: these are such that SOCROBUST is, like the projects we studied, a breakthrough project. We consider that we have succeeded in remaining as a coherent project while clarifying one major uncertainty. But others lie ahead!

A last word about the participants in the project. The project sought to mix competences from four specialties: sociology of innovation, evolutionary economics, management and organisational science. And it sought to do so while developing an “operational” approach. The reader can guess that this has not been an easy task at the level of every day interaction. Even so, the authors of this final report consider that the experience has been very fruitful and we hope that the results reflect this rather unique blend.

P. Larédo, E. Jolivet and E. Shove
Paris / Lancaster, January 10, 2002.

CHAPTER 1

THE SOCIETAL ROBUSTNESS OF BREAKTHROUGH INNOVATIONS: A POSITIONING PAPER ABOUT THE SOCROBUST METHODOLOGY

1- THE ISSUE

The Socrobust methodology is designed to assess the potential for socio-economic success of a particular set of projects defined as radical or architectural innovations, involving technological discontinuities and breakthrough products/services.

The argument is that this type of innovation (which often represents around a tenth of the R&D portfolio in a large established firm) cannot be managed in the same way as on-going, incremental, sustaining or continuous innovations (the terminology depends on the author) which build a gradual accumulation of useful variations (Cooper, 2000). Risks taken in the latter can be calculated and thus comparisons between projects and the selection of one or another can be based upon calculations (such as estimated ROI). By contrast, the former face such great uncertainty (while also often bearing far greater potential) that applying traditional calculations is at best a formal game and at worst a proof of the distance between funders and project promoters. This class of projects require specific management practices. Some analysts (e.g. Colarelli O Connor, 1998) go so far as to say that sound management practices for the development of incremental improvements may well be detrimental to the development of discontinuous, breakthrough innovation.

Such a positioning opens up a set of questions: what is meant by uncertainties? How can we know when calculations are no longer relevant (or said otherwise what characteristics should projects have if meaningful calculations are to be made)? On what should we base decisions about such projects? Few authors from management and organizational sciences have addressed these problems. They have helped to demonstrate their importance for firms (Point 2), to characterize the management challenges firms face when engaging in such innovation (Point 3) and in establishing the need for a management framework built on three core principles (Point 4). However the implementation proposed remains, in our view, lacunary (Point 5). The main lacunae lies in the dynamic monitoring of such ventures and in the decision-making framework. We therefore suggest the development of a second decision-making process based upon periodic pro-active evaluation which, due to its specificities, we propose to call a learning pact (Point 6). Point 8 and 9 are devoted to the practical implementation of such a process, based upon the descriptibility of projects, and the equipping of both parties in the learning pact, that is the evaluator (the PROTEE questioning frame) and the project manager (the SOCROBUST methodology). Before doing so Point 7

outlines four main results from the sociology of innovation that we mobilise in building these two methods by focusing on endogenous scenarios (instead of exogenous ones), by enriching the understanding of the innovation journey via its description as a trail of trials, by putting at the centre of assessment the "robustness" of the conclusions arrived at, and by analysing the unfolding of the project via the deployment of the Techno-economic network (TEN) which supports it.

The ambition is thus to develop methods which make it possible to **describe** the risks taken and to follow the **exploration** made.

2- THE NEED FOR ARCHITECTURAL / BREAKTHROUGH / DISCONTINUOUS INNOVATIONS

Most innovation projects developed by firms are based on extensions of existing capabilities / competences. These competences are not only technical (the technological knowledge and know how gathered in the enterprise), they also deal with uses and users, that is the knowledge and know how gathered in the firm about customers, their habits, practices and preferences (all that being most of the time labelled under the heading of marketing activity). When undertaking such activities, the firm takes risks about its capability to engineer the technology to arrive at the desired result and about its ability to anticipate the specific preferences of future users. These risks can however be calculated, roadmaps can be established, and clear enough costings (of the planned development) can be made, so that expected rates of return can be computed, thus making it possible to compare projects, select the most promising ones and build a portfolio of incremental projects.

However, and as exemplified by the events of recent years and by numerous managerial lessons (especially in the HBR, cf. for instance Bower and Christensen, 1995), this does not secure the long term future of the firm. Firms sooner or later reach the point of diminishing returns in their incremental improvement programs (so that) radical, non-linear innovation is the only way to escape the ruthless hyper-competition that has been hammering down margins, industry after industry (Hamel, 2000). Said otherwise and a few years earlier (Tushman and Anderson, 1986), technological change is a bit-by-bit process until it is punctuated by a major advance so significant that no increase in scale, efficiency or design can make other technologies competitive with the new technology.

There is thus a need for new lines of businesses, new for both the firm and the marketplace (Colarelli O Connor, 1998), new because (1) they typically present a different package of performance attributes (at the outset not valued by existing customers) and (2) (their) performance improves at such rapid rate that the new technology can later invade those established markets (Bower and Christensen, 1995).

Authors like Abernathy and Clark (1985) and Tushman and Anderson (1986) have analysed these long-term dynamics. They share a common view about the uncertainty of the initial

years (or even decades) when the technology remains fluid (Abernathy and Utterback), and when actors face a period of technological ferment, of technological experimentation and competition with a substantial rate of product variation (as alternative forms compete for dominance) until a dominant design emerges as a synthesis of a number of proven concepts. This is associated with the emergence of product-class standards (Tushman and Anderson, 1986).

Whatever the typology of innovation situations¹, both sets of authors put at the core of the process architectural innovations and technological breakthroughs, the attributes of which are described in the following table derived from Abernathy and Clark (1985).

Domain of innovation activity	Range of effects conservative end of the scale	Polar extremes radical (1)
<i>Factors that determine the capabilities of the firm in technology & production</i> - Individual/collective - Production factors & their deployment - Infrastructure of production		
* design/embodiment of technology * production system/organisation * skills (labor, managerial, technical) * materials/supplier relations * capital equipment * knowledge and experience base	Improves/perfects established design Strengthens existing structure Extends viability of existing skills Reinforces application of current materials, suppliers Extends existing capital Builds on a reinforced application of existing knowledge	Offers new design, radical departure from past embodiment Demands new system, procedures, organisation Destroys value of existing expertise Extensive material substitution; opening of new relations with new vendors. Extensive replacement of existing capital with new types of equipment Establishes links to whole new scientific discipline, destroys value of existing knowledge base
<i>Markets and Linkages to customers</i>		
* relationship with customer base * customer applications * channels of distribution and service * customer knowledge * modes of customer communication	Strengthens ties with established customers Improves service in established application Builds on and enhances the effectiveness of established distribution network/service organisation Uses and extends customer knowledge and experience in established product Reinforces existing modes	Attracts extensive new customer group, creates new market Creates new sets of applications, new sets of customer needs Requires new channels of distribution, new service, aftermarket support Intensive new knowledge demand of customer, destroys value of customer experience Totally new modes of

¹ Noteboom (1999), through a very different perspective, proposes a quite similar approach speaking of the exploration of novel combinations (which he calls accommodation, and which leads to a novel architecture), before consolidation via experimentation and repeated trials, generalisation and differentiation followed by reciprocation (when anomalies and misfits render visible the boundaries of the script's potential) as paving the road for another cycle. Its fourth figure (p 146) is however clear about the very macro application of his analysis. Exploration is linked to industrial districts and loose intra-firm networks, consolidation/generalisation is linked to mergers and acquisitions, MNE integration and tight intra-firm networks, differentiation and reciprocation to alliances.

3- MANAGERIAL CHALLENGES: A PROGRESSIVE FOCUS ON PROJECT MANAGEMENT AND THEIR MONITORING/EVALUATION ENVIRONMENT

Christensen, in a rather challenging book lists the numerous companies that have not been able to manage this transition and have disappeared (it is enough to take the lists of the top ranking producers of IT equipment over 30 years!). Being less extreme, Abernathy concluded the last article he wrote (in 1985) with the following: While a firm may have a dominant orientation, it is likely that the firm will face the task of managing different kinds of innovation at the same time. How to do it seems an important area for further works. Tushman and Reilly, a decade later (1998) insisted on the need for ambidextrous organisations able to manage evolutionary and revolutionary change.

But how can these different kinds of innovation be managed? One very clear answer comes from Bower and Christensen (1995) who conclude, long before start-ups had become the high fashion, that, once a firm has coined the strategic significance of a disruptive technology and located its initial market, it should establish an independent organization and keep it separate from present mainstream activities. Other authors — not many, and most of them only recently — have tried to analyze how established firms succeed in doing so. Their answers can be grouped under three streams: the competences needed by individuals, the capabilities firms must enhance through developing appropriate organisational settings, and the project management and monitoring environment. The following paragraphs highlight the central points put forward.

Van de Ven and colleagues have offered approaches with which to tackle the innovation journey. They conclude (Cheng and Van de Ven, 1996) that radical innovations demonstrate (until they stabilize) a **chaotic process**, meaning that, during this initial period, learning is not just about how action-outcome relationships develop (and thus focusing on learning through trials and errors) but also (and mainly in this initial period) about acquiring knowledge of alternative actions, outcomes and contexts (that is exploring the sphere of possible actions, before the traditional trial and error selection process can take place). The central point of their experimental results is to highlight the sensitivity to initial conditions, the **path dependence** (the origins of experience and knowledge are important) and the **ambiguity** managers face due to the often long temporal lag between developmental activities and implementation performance feedback.

How to handle such situations? Their answer reflects a first already well developed stream of thought. They claim that such issues require specific management capabilities to be embodied in the project manager. They speak of a charismatic leader with enough imagination to

create a new vision which narrows attention and rallies unity out of diversity . This focus on managers' capabilities is quite common. Kahane (2000) develops the approach, speaking of narration instead of vision (that is a vision embedding previous experimental results and developing a course of action which includes tests of its feasibility). Tushman and Reilly (1998) translate ambidextrous organisations into the need for ambidextrous managers characterised by relatively long tenure and the will to be constantly striving to renew themselves . Collarelli 0 Connor and Rice (2001) add to these points that these individuals they label as opportunity recognizers must have boundary spanning capabilities .

The second stream, often complementary to the first one, is to highlight the capabilities and/or organisational features that help in fostering the management of breakthrough innovations. As underlined by Collarelli 0 Connor and Rice (2001), most authors make such suggestions without offering guidelines for enabling them . Still they highlight certain characteristics which go beyond the well known answers of staying close to their customers and being quick to respond to market signals (Tushman and Reilly, 1998), and instead bring out specific organisational issues. Let us list some of them.

- Tushman and Reilly consider it crucial to have *clear mechanisms to kill products and projects* .
- Collarelli 0 Connor and Rice underline the importance of opportunity recognition . For them, this requires a *specific organisational setting* (they suggest that companies organise radical innovation hubs) .
- The same authors show, through their examples, that opportunity recognition is not a one-off action, but a repetitive one, with a set of key occurrences ... due to discontinuities in the project development path . They thus highlight the need to differentiate *between on-going project evaluation and additional occurrences of opportunity recognition* .

4- THREE CORE PRINCIPLES FOR A MANAGEMENT FRAMEWORK

These analyses have one attribute in common: they focus on project management and the environment in which projects are monitored or evaluated. Even so, this issue had hardly been addressed until Noori and colleagues proposed an umbrella methodology (1999) and Cooper put forward a strategic marketing planning approach for radically new products (2000). These approaches constitute the third stream in which we locate our own elaboration. Both Cooper and Noori share the idea that what is required is not a one-off action, hence the need for a management framework . And, through very different definitions, they highlight three core principles: the need for anticipating the future world, the need for consistency with the present situation so as to define a development path, and the requirement for dynamic adaptation.

Noori and colleagues insist on two main aspects which underpin their methodology.

(i) Consumers are generally not aware of the needs revolutionary products will meet. Furthermore, substantial customer learning is often a prerequisite for use. Different techniques have been developed to cope with these issues, such as information acceleration or lead-user analysis, methods which they consider useful but which, having only limited scope, fail to address the problem of managing the whole process.

(ii) Most of the time, the success of breakthrough products/services depends upon the existence of an enabling infrastructure (e.g. the existence of regulations that permit and/or encourage the use of the product and the development of social values consistent with market acceptance). This means that firms must develop an awareness ... to changes in the environment and even take a more proactive approach to control the evolution of their environment. They conclude that the project timing should be developed in accordance with the evolution of environmental factors and not according to an absolute time schedule with a goal of reducing time to market as is customary.

This drives them to propose an umbrella methodology based upon three elements:

(a) scenario analysis to define how the future might look like and limit the range of uncertainty. This requires them to characterise each scenario by both a set of trends which can be adequately forecasted quantitatively or qualitatively with some degree of confidence and by uncertainties whose values or outcomes are completely unknown.

(b) backcasting to determine how each future could evolve from and relate to the present in order to select pathways and stepping stones which are internally coherent and based upon firm specific capabilities and competences.

(c) continuous environmental monitoring to discover which future is actually unfolding.

Cooper (2000) proposes a similar framework when highlighting a planning process which provides a place to start, a direction for improvement and a way to update continually a dynamic planning document.

(a) The place to start is an extensive situation analysis which pays particular attention to environmental change that comes from political, behavioral, economic, sociological and technological sources at three complementary levels: the firm, the business ecosystem and the infrastructure. The objective is to help planners to stay divergent enough in their thinking (so) that the major potential threats and opportunities are more likely to be identified, and fundamental issues elicited. This helps in building a critical-issues grid which provides a framework that takes some of the randomness out of the process, or at least widens the scope for potential conclusions. Cooper considers that the proposed approach provides a partial answer to the analyses developed by Arthur (1988) or Van de Ven (cf above).

(b) It does so provided the stakeholders and factors identified are woven into economic webs surrounding the new product. Cooper suggests using Bayesian networks in which the arcs connecting nodes reflect the conditional probabilities of outcomes. For Cooper, the value of using Bayesian networks is that it forces consistency and completeness of storytelling. To build a complete Bayesian network involves a combination of knowledge engineering (i.e. a process of translating existing expertise into conditional probabilities) and specification of focused research projects to develop estimates for the unknown arcs. The latter helps identify directions for improvement.

(c) For Cooper this approach makes it possible to permanently adjust the economic web: at first numbers can be crude, only directional approximations of the underlying processes can be mapped. The accuracy of networks (will) improve as the experience and expertise (of the planning team) grows and as events unfold.

Through very different channels, both works highlight three core principles: (i) Scenarios (even Cooper uses the word) have to be made about the future world in order that uncertainties can be identified. (ii) By taking into account the present situation and the firm's competitive advantages, it is possible to identify steps which can be taken in order to clarify these uncertainties, (iii) The approach must provide for periodic repetition because the development path is generally discontinuous and because additional moments of opportunity recognition are therefore required.

5- IMPLEMENTATION STRATEGIES: THE NEED FOR ANOTHER APPROACH

The implementation strategies proposed by these authors appear to have significant limitations when compared with results of innovation studies:

(i) The works done on breakthrough innovations all insist upon the need for a specific positioning of the project within the firm which facilitates its dynamic monitoring. However the solutions put forward remain very traditional and do not address the central hierarchical issue of how funds/means are allocated. This requires, and this is our proposal, a means to clearly embed the project in the firm's decision-making process through a redefinition of what project evaluation is all about. This is what we call the PROTEE approach based upon pro-active periodic evaluation and the establishment of a learning pact.

(ii) This pro-active evaluation is based upon lessons learned about three main pitfalls encountered in the innovation journey: lessons which have been demonstrated through the numerous case studies of innovation processes. The insights derived from this work also require us to reconsider the central features of innovation journeys, this time incorporating the results of the sociology of science. The main interest here is to devise a way of following the exploration phase, this being a central problem already identified by management

/organisational studies. The main results are four fold. They first confirm the importance of scenarios as visions of the future working world, but they challenge the fact that scenarios have to do with external developments, as proposed in the above mentioned approaches; instead, scenarios are first and foremost inscribed in projects which consequently presume a script of the future, a script which it is important to de-script in order to measure the breadth of transformations/changes required. Second, they point to the need to complement the traditional classification of states (such as pilot, prototype, etc.) which remains static and technology bound, with the trials made: a move which focuses on the dynamics and which makes it possible to include other features put forward by analysts (cf. Noori's elements on user knowledge and on social and market infrastructures required). They thirdly offer a way of measuring the strength/durability of arrangements developed to cope with a given uncertainty by looking at the controversies which have arisen and at the fora in which they took place, and by using, as a core concept, the robustness of the outcomes from the controversy. Fourth they help define a method for monitoring the process of project exploration which involves tracking the development of the underlying techno-economic network (made of the participating actors and the intermediaries which circulate between them and bound them together).

(iii) These elements, approaches and ideas help to equip the evaluator within the firm (i.e. the actor in a position to decide or advise decision-makers about continuation of a project and, if so, about the efforts needed to mobilize resources and results). The process of "equipping" the evaluator is of procedural and not substantial meaning in the sense that, as when calculations such as ROI are used, the evaluator is not required to know about the specificities of the project. However this new "equipment" differs from the traditional armoury of tools for calculation and monitoring. In this case, the evaluation process does not end with the production of figures describing costs, future sales, profits ... and estimated returns from the final output of the investment (which are then regularly updated). Rather, it ends with a description of the project and the risks taken. The evaluation exercise is, in other words, part of the process of developing the vision of the future market, identifying the uncertainties faced, selecting issues in urgent need of clarification and defining the next round of actions through which to further explore and clarify the possibilities. And, since the evaluation is periodic, all this is based upon actions previously undertaken and the results of such action for clarifying the vision of the future market and in reducing the uncertainties faced. The newly "equipped" evaluator is well placed to ensure what we call the descriptibility of projects, that is to provide those types information about the project required in order to make decisions about the value of future exploration and the means/funds asked for.

(iv) This procedural approach generates a list of issues that the project manager must address in order to give an adequate account of his/her project, especially focusing on uncertainties and the nature of the further exploration required. However it does not provide him/her with ways

of tackling these issues. This has been the object of the project undertaken with the support of the EU (1999-2001): that is, to develop the SOCROBUST methodology so as to allow project managers to prepare a description of their project which is relevant for the proposed evaluation process. There are four main methodological dimensions involved in the development of a relevant description. These include (i) unfolding, and rendering visible the future world inscribed in the project, (ii) identifying the key changes required (by comparing the future world inscribed in the project with the present project network), (iii) assessing the robustness of assumptions (associated with anticipated key changes), and identifying competing views of the world or of ways in which key changes might be achieved, and (iv) identifying/evaluating the project's margins of manoeuvre. The description provided by SOCROBUST is the result of what can be considered as an exercise in boundary spanning, that is an exercise in which the effort required to embed the project in society is identified, and its feasibility assessed.

The following sections develop these four points, starting with a discussion of the limits of the operational management frameworks proposed up until now.

6 - THE DYNAMIC ADAPTATION AND MONITORING OF BREAKTHROUGH PROJECTS: A LEARNING PACT

The notion of a management framework has to do with recognising the dynamic component of project development, and the need for a form of periodic interaction that captures the whirling development path and that appreciates the repetition of occurrences of opportunity recognition. How to organise this kind of continuous monitoring and dynamic adaptation? Cooper locates such processes within the organised marketing function which he describes as one that regulates the flow of resources (in both directions) across the organizational boundary, that is in a functional position within or along the project. Other authors recognize the need for specific organisational arrangements. However their answer remains the classic one of relying upon (mostly external) experts: the team of experts is essential to the success of the approach says Noori who has developed designs for the management of such groups (Noori, 1995). Collarelli O Connor and Rice (2001) suggest that each radical innovation project should be attached to a project oversight board staffed with company members who can make the long-term commitment needed by such innovation and by appropriate company outsiders (to foster commitment by alliance partners and avoid bureaucratic routines).

In our view, such solutions have three limitations: (i) Neither decision makers within the firm nor project managers are entrusted with competences. (ii) They do not offer any guidance about ways of looking at the deployment of projects: instead, the right answer simply

depends upon gathering the right bunch of guys together. (iii) They are costly, and thus de facto tend to be limited to the development phase (when there are good chances that the project will exist) and not the exploration one (where elements of what could form a project are still being explored) yet as we shall see when addressing the innovation journey (point 7 below) this is the critical phase for the management of the project.

These reasons explain the research work undertaken since 1995 by B. Latour and colleagues in association with industrial partners (mainly large engineering firms specialising in new transport infrastructures and equipment) to reconfigure this management relationship. In the PROTEE project (see final report, Duret et al., 2000), the analysis of actual decision making processes demonstrated that, when faced with uncertainty (that can be assimilated to Courtney's levels 4 —true ambiguity— and even 3—a range of futures, see point 7 below), decision-making remained formalised and continued to depend upon the normal financial methods for rating investments and calculating associated risks, despite the fact that no realistic probability could be given to any potential outcome of the process. Decisions were thus founded upon fictitious arguments and projects went ahead unchanged until they were brutally stopped, generally because their supporters within the decision-making staff moved on, a quite common situation according to the above-mentioned management literature. It was thus considered necessary to directly address this issue by proposing an alternative approach to investment decision making, replacing accepted in-house calculations by another regime, based upon two principles: periodic pro-active evaluation and project descriptibility.

Abernathy's conclusion is quite clear: companies (or public authorities) have to manage both incremental and radical innovation projects. Is it feasible to organise two completely separate approaches, especially when best practices for one type might prove to be detrimental for the other? Our practical answer, based upon the analysis of actual situations, is no. As soon as investments become significant, they have to be included in the processes used to manage the allocation of investment money, on top of whatever other managing or advisory committee might be established. They need to enter into a hierarchical relation, the objective of which is to determine whether or not projects should be allocated the funds and means asked for. We thus propose that, for breakthrough innovation projects, this form of evaluation replaces the normal fund allocation procedure. Such a conclusion has far reaching implications:

- (i) It must be decided when projects should follow such a procedure. One pragmatic answer is leave this up to project manager to decide. Recognising the existence of two possible modes of evaluation within the firm (the normal investment procedure in which competing projects are judged in terms of estimated rates of returns or similar calculations, or the breakthrough innovation track) the project manager is free to choose one or the other.
- (ii) Any process that requires ad-hoc arrangements to be established is, by definition, more costly than that of following traditional rules for investment. It is thus an objective to return as soon as possible to the mainstream approach. Success, for breakthrough projects, is thus

not defined as successful entry into the market, but as their capacity to enter into and be evaluated through normal investment procedures, i.e. a breakthrough project would be successful when its merits could be calculated in the terms normally used to assess investment². This answers one of the problems associated with the previous choice: if a project manager chooses the breakthrough track and if evaluation leads to the conclusion that the uncertainties are not that large, the project will then re-enter the normal process.

Under this definition, and following Van de Ven, success is defined as the outcome of the progressive learning of THE repertoire of actions, outcomes and contexts in which the redefined project can normally develop. Expressed in our terms (see point 7), success is manifested by the fact that trials produce results which match the expectations of those who designed them, and do not change the hypotheses made: the space of the project can then be considered as stable, opening the way for the adoption of the usual cost-benefit, ROI and related types of calculation. At this point, the project can enter the normal competition for investment and either succeed or fail to gain the funds/means needed³.

Failure is thus not the inability to penetrate a market, but the inability for a project to learn anymore. This is either because the trials failed to enrich the repertoire of actions, outcomes and contexts, or, and this was more common in our case studies, because the project could no longer contain or accommodate the contradictory tensions revealed by trials already made. As suggested by Latour, failure only means that the project is no longer a hopeful monster⁴, that there is no longer any possible project which might hold all the necessary dimensions together⁵.

(iii) This evaluation is not a one-off event. The existence of uncertainties does not only hinder the possibility of realistic calculation, it also means that any trajectory envisaged is conditional on the actual unfolding of these uncertainties. There is thus a need for periodic review. Periodicity is however a tricky issue and one which drove authors like Collarelli O Connor and Rice (2001) to propose a distinction between on-going project evaluation and the new occurrences of opportunity recognition. It is clear that traditional auditing procedures (about

² The cases made, especially those related to wind energy, tend to show that initial market sales organised within a niche cannot be accounted for as market entry. They relate more to collective experiments aimed at shaping enduring market rules than to inter-firm competition within an established market. Thus there should not be too fast assimilation between given states (especially those classified as industrial development) and ending of the learning pact / transfer to normal investment procedures.

³ Bower and Christensen consider that the competition is so biased that the project should be outsourced in a specific and autonomous structure, a new company or, as developed by Alcatel for ADSL, an intra-company. This remains an open question which we do not address here.

⁴ A monster because of the new arrangement it proposes (and which any mainstream analysts will start by reject because they are not realistic, thus the need for a specific pact), and hopeful because he succeeds in making converge enough elements and actors for a project to be feasible and a market (or a niche) to be aimed at.

⁵ Latour even suggests that these diverging dimensions build what is usually called a research programme, that is a set of autonomous projects which explore separately these diverging dimensions.

timing and expenditures) have to live their own life, but they should not be confused with evaluation. Evaluation is taken here as a strategic act the purpose of which is to say yes or no to the question should the project be continued, and if yes to define the conditions of continuation. This has one central consequence: as mentioned by Noori, evaluations do not occur according to an absolute time schedule with a goal of reducing time to market as is customary, but instead depend upon the project's own dynamics. One should not however fear that the periodicity will be too low. The projects followed within the PROTEE project (especially the Krupp Fast Handling System) showed that even though the overall timeframe was long, turning points happened sufficiently often that there was little difference between the frequency with which these and other normal investment projects required monitoring.

(iv) As just mentioned, the objective of the evaluation is pro-active, meaning that its purpose is not only to say yes and no to continuation, but also and mainly to define the conditions of continuation, and the achievements to be considered at the next evaluation. This answers one central requirement which Tushman and Reilly set for the management of breakthrough innovation projects: the existence of clear mechanisms to kill projects. Those projects which have been unable to learn from an exploration of their future world should be killed. It also contains a symmetrical obligation on the part of both the evaluator and the evaluatee (i.e. the person responsible within the company, and the project manager): that is of learning more about the feasibility of the project through a clearly defined next step. This is why, in the PROTEE project, we chose to speak of a **learning pact** involving both parties.

If we speak of a learning pact, it is to characterise the very specific nature of the evaluation rules that prevail in such an interaction. Because of the prevailing uncertainty, and the nature of the explorations to be made, the core requirement of the evaluation is that both parties confront each other views of the trials made to date. How did they help in testing the hypotheses made? Did assumptions about necessary competences and actors' enrolment prove true? What was learnt about the space in which the project might be deployed, and what are the implications for where to go next and how to progress? In one word, it is less an issue of judging against a benchmark, than of jointly assessing a situation, often reshaping the content of the project itself and thereby defining the way forward. What is at stake is both an appraisal of the potential of the project (what positions and benefits could be derived for the organisation if it proves successful) and of the risks taken. For example, it will work if ... there is a new regulation about the conditions under which utilities buy wind energy, if it is technologically possible to inject more than 150 kg of coal without endangering the stability of the blast furnace, if the interaction between insulin dependant patients and medical doctors can be mediated by a new medical service, and so forth. These examples (taken from case studies conducted by participants in the Socrobust project) highlight the changing nature of the evaluation: it is based upon a continually renewed description of the project.

In implementing the proposed management framework our first suggestion is to replace the distanced and dis-located approach of the expert committees by a clearly defined hierarchical interaction between those responsible for making decisions within the firm, and the managers of (potentially) breakthrough innovation projects. Due to the uncertainty faced, this interaction has to follow specific rules. These define a second track or process through which the allocation of funds and means can be determined, but which is distinct from usual company practices for calculating the financial attractiveness of competing projects. To be dynamic and offer ways of monitoring the unfolding of uncertainties and the extent of the risks being taken, this interaction takes the form of a periodic and pro-active evaluation (that is defining the next step, the trials to undertake until the next evaluation). It differs from normal procedures on two main counts: (i) it is not only a method for determining the allocation of resources: it also helps to specify the next steps to be taken and the direction to be followed and (ii) it does not commit the parties involved until the end of the entire process (modulo periodic control), but only until the end of the next step (at which point a new evaluation will determine the next course of action). Decisions taken in these evaluations are therefore based upon a joint assessment of the uncertainties faced and an agreement about the exploration required to learn more about them. This is why we propose calling this process a learning pact .

To function well, this pact requires the evaluator (who, at the start, knows nothing about the project) to ensure that critical issues relating to the identification and characterization of uncertainties are addressed, and that he is therefore faced with a relevant description of the project on which to base or propose decisions about its future. The definition of the principles underlying this renewed description, are addressed in the next two sections. First we need to re-address the issue of the innovation journey before presenting the lessons learnt about the "diseases" from which projects so often suffer. Discussion of both helps in defining a procedure for the evaluation of breakthrough projects.

7- APPROACHING THE WHIRLING DIMENSION OF THE INNOVATION JOURNEY

One of the major results of the work piloted by Van de Ven is to have focused management research on process and not outcome, and to have introduced the notion of the innovation journey. Seen ex-post, the innovation journey consists of a sequence of events that create and transform a new idea into an implemented reality . In real time this is an exploration into the unknown process by which novelty emerges .

Looking at the literature, Van de Ven and his colleagues identify two dominant approaches developed by organisational researchers: (i) View the process as a cyclical and deterministic pattern of learning by trial and error (where change is occurring through the positive or negative feedbacks between the actions undertaken and the outcomes experienced); (ii) View

innovation as a stochastic process of exogenous random events (where each innovative event represents an independent and equally likely draw from an underlying probability distribution of possible actions).

For managers, they consider that the second approach provides little intelligence for undertaking the innovation journey and leads to ad-hoc explanations of the innovation process. Their case studies showed that cyclical understandings (approach one) only came to the fore at the end of the process when actions and outcomes become tightly linked. At the same time they showed that either the innovation units learned nothing during the first years of development efforts, or that they engaged into some other type of knowledge not included in the definition of learning. Following March⁶, they propose an expanded definition of learning: The definition of learning presumes that learners have some a priori knowledge about (1) alternative courses of action that can be taken, (2) outcome preferences or goals that are desired, and (3) the institutional rules, resources, and setting in which the task is undertaken. An expanded definition of learning examines not only how action-outcome relationships develop, but also how prerequisite knowledge on alternative actions, outcomes and contexts emerges.

This prompts them to suggest a new way of viewing the innovation journey. The parallel but separate chaotic branching that was found in action and outcome events during the initial period of innovation development creates a variety of experiences with alternative courses of action and a variety of enactments (or thought trials) of performance goals or possibilities. Building such repertoires of action experiences, outcome preferences, and contextual practices increases the likelihood of making creative connections between means and ends when actions and outcomes are related ... By uncoupling actions and outcomes, a chaotic process facilitates the construction of repertoires of action experiences, outcome beliefs and contextual practices. These repertoires increase an organisation's capacity for creative learning. The coupling of actions and outcomes narrows the repertoires to those that satisfy the linear combination of feasible actions and desired outcomes. ... This narrowing process signals the transition from chaotic to orderly development.

Whether or not one agrees with the reference to chaos, this third approach to the innovation journey, puts the capacity to manage the period of "ambiguity", that is the period when traditional mechanisms of accumulation do not apply, at the core of the unfolding process. They suggest that **exploration** is at the heart of the initial phases of breakthrough projects. Our own case studies (under the PROTEE project) demonstrated that the result of this exploration is to learn whether or not there is a possible project and if so, which one it might be. It is only then that the narrowing process, usually involving sequences of trial and

⁶ Exploration (in organizational learning) includes behavior reflecting the search, discovery, experimentation and play of new courses of action, while exploitation includes the choice, refinement, implementation and execution of a particular course of action (March, 1991).

error, can take place and only then that the traditional management tools apply (not forgetting lessons embedded in the chain-linked model and the notions of lead-users and co-conception or co-design).

However the issue remains: how best to follow the positive deployment of such projects in their exploration phase. In addressing this question we extract four complementary resources from the sociology of innovation.

(i) Rather than anticipating external events, as proposed in scenario making, the central anticipatory task is that of rendering visible the **script** of the future world already embedded in the positioning of the project, and already implied in choices made by the project manager.

(ii) The process of project development is no longer explained in terms of a sequence of states (eg. concept, pilot, prototype, industrial development) which projects are expected to go through (however many times and in whatever order) but, rather, in terms of the **trail of trials** which projects subject themselves to in the course of progressively testing the relevance of hypothesised configurations of human and non human actors (this is what organizational colleagues refer to as the action-outcome relationship). Put briefly, what Van de Ven et al. term prerequisite knowledge is the outcome of what the sociology of innovation labels a trail of trials the role of which is to discover whether actors (human and non human) can be enrolled and how they can be articulated together.

(iii) The question of how one might know that actors are enrolled and that uncertainties are indeed clarified becomes a central issue. There are two aspects to this. The first lies in what the sociology of science calls the **robustness** of propositions. Propositions can be said to be robust when the assumptions on which they depend are no longer challenged. To grasp the extent of robustness - that is to determine the range of situations across which assumptions are no longer challenged - it is important to characterize the **fora** or arenas in which they have been debated, accepted, and come to be taken for granted (naturalised following Latour).

(iv) The second aspect of monitoring enrolment has to do with following the **techno-economic network** that supports the project. The key move here is to equate the state of a project to the network that supports it. Having taken this step it is possible to progressively map the results and consequences of each exploration by recording and characterizing the consequent transformation of the network.

This section briefly presents (even if the length measured in lines is quite significant) those results and concepts we consider central to the construction of our proposed methodology. It also draws on other work, especially with respect to questions of uncertainty.

7.1- FROM EXOGENOUS TO ENDOGENOUS SCENARIOS

In all approaches proposed, peoples anticipations and expectations are central to the dynamics and positioning of projects. It is, it seems, necessary to build and work with images of a future world in which proposed innovations not only turn out to be successful but to change the world of which they are a part. This conventionally involves the construction of future scenarios. However, and as in the above-mentioned methodologies, scenarios are typically based on a normative and exogenous description. The method is thus to determine a set of criteria against which projects are systematically reviewed (see box on factors selected by different authors looking at the development of high-tech products and breakthrough innovations).

Factors influencing the diffusion of high-tech products to be integrated into the construction of scenarios

* Factors proposed by Easingwood and Lunn (1992): firm s environment (regulation, macro trends), target group (consumer/industrial, niche/mass), company barriers (resources, specialisation), product characteristics (relative advantage, compatibility, complexity, triability and observability/communicability) and perceived risk of adoption (performance/financial, professional/social)

* Factors proposed by Wilkinson (1996): social (demographics, values, lifestyles), economic (macro; micro, company-specific), political (electoral, legislative, regulatory) or technological (direct, indirect enabling)

* Factors proposed by Cooper (2000): political, behavioral, economic, sociological and technological, to be analysed at three complementary levels: the firm, the business ecosystem and the infrastructure.

* Criteria selected by Noori in their analysis of the Electric Vehicle project

Criteria are organised into two broad categories: micro and macro operating environment .

- Main micro criteria are: key players (focused on their role in the EV market), regulation/legislation, technology (differentiating between the core technology —batteries —and other complementary technologies), competition (who are the other firms and organisations with EV projects, and what are the characteristics of their proposed product: battery, autonomy, charge time, maximum speed, acceleration, number of passengers), product features (especially regarding environment), customer voice (organised groups addressing the subject and their position).

- The macro operating environment is organised in four clusters: social factors, economic factors, political factors (including present political situation, positions taken by different political parties, etc), technological factors.

The purpose of making judgements against such external criteria is to help to evaluate the risks taken and the actions proposed. This drives authors like Cooper to look for proxi-quantitative methods (in his case, Bayesian networks). Such systematic screening, which requires heavy investment (as is witnessed in the cases described both by Cooper and Noori) has one major limitation: how should managers prioritise the multiple unknown issues to be addressed. In addition, this externally oriented approach encourages authors to focus less on internal capabilities (and the corresponding research projects that could help addressing these issues) than on the flexibility and reactivity of the firm and its ability to adapt as an externally determined future unfolds. This might be a realistic model in particular situations, for example, when a certain level of stabilization has occurred, but it contradicts the results of Van de Ven and his colleagues who highlight the chaotic nature of initial phases, when learning is focused

on identifying the universe of possible courses of action, when the relation between actions and outcomes is unclear, and where true ambiguity prevails.

When studying Strategic management under uncertainty , Courtney, Kirkland and Viguerie (1997) propose a four level taxonomy of uncertainty, level 4 being true ambiguity . These authors (who make their own set of general recommendations⁷) conclude that company intervention should be aimed at shaping the market: the shaper s role is to provide a vision of an industry structure and standards that will coordinate the strategies of other players and drive the market toward a more stable and favorable outcome . They thus insist not on reactivity (they even suggest that strategies which reserve the right to play are most of the time a poor bet), but on market shaping. They consider this to be the central activity and make the point that actors seeking to play this role must acquire the credibility required to coordinate action.

Levels of Uncertainty, following Courtney; Kirkland and Viguerie (1997).

The authors use this typology to classify issues facing those involved in making strategy under uncertainty , the title of their article.

At level 1 a clear enough future : managers can develop a single forecast of the future and traditional strategy toolkit can be used.

At level 2 the future can be described as one of a few alternate outcomes or discrete scenarios : Cooper considers that traditional scenario planning works well under these conditions, and the authors mention decision analysis, option valuation models and game theory.

At level 3 a range of potential futures can be identified. This range is defined by a limited number of key variables there are no natural discrete scenarios : Following Cooper, scenario analysis (as proposed by Shoemaker 1995 and Schwartz 1996) begin to wane in value .

At level 4 —true ambiguity —multiple dimensions of uncertainty interact to create an environment that is virtually impossible to predict .

This ties in well with the results of the sociology of innovation and with the reverse approach to building future worlds. Rather than assessing the implications of the external environment, the method is to start by articulating the internal vision inscribed in the project and then unfold the societal content embedded within that vision. Innovation studies highlight the simultaneous technical and social shaping of innovation (the classical wording is socio-technical). This means that in any research project (however scientific and technical its formulation may be), there is a simultaneous set of assumptions about the future working world , and about the prevailing norms and rules which characterise that world. Projects thus contain and embed a script of the future which it is important to de-script (Akrich, 1992 and de Laat, 1996). To put it briefly (we shall discuss this point in greater depth when describing our approach), these assumptions concern the technological characteristics of the

⁷ In such situations, it is critical to avoid the urge to throw one s hand up and act purely on gut instinct . They propose to managers the following directions: catalog systematically what they know and what is possible to know , identify ... a subset of the variables that will determine how the market will evolve over time ... and favorable or unfavorable indicators of these variables , finally identify what information they would have to believe about the future to justify the investment .

innovation and the way they are valued, the future organisation of the market (regulations and norms including the way that competition is organised between producers), and the relation with future customers (in particular how consumers are categorised, what competences they are expected to have and what form user-producer relations are expected to take).

In other words, actors and their projects de facto build endogenous scenarios about the future world which will be receptive to their innovation and make it successful. These de facto scenarios revolve around a selection of factors that are believed to count, factors which in turn point to relevant transformations which must be realised or at least monitored. If project managers unfold and articulate these de facto scenarios (these are usually tacit and only rarely formalised), they will be in a position to identify the key changes required (what has been often termed by sociologists of innovation as obligatory passage points), they will have a position from which to start, and a sense of the route to follow.

7.2 — THE DYNAMICS OF PROJECT EXPLORATION: A TRAIL OF TRIALS

The second feature of the strategy proposed here has to do with exploring and unveiling uncertainties. We have seen that the methods developed so far offered no other solution than that of relying upon the personal opinions of selected individuals gathered in ad hoc committees. We consider that innovation studies offer complementary possibilities which we now present. One central feature of work on the dynamics of innovations concerns the process of enrolment. To establish the feasibility and to determine the potential realm of a want-to-be innovation, there is no option but to interest actors and persuade or make them share the objectives pursued (that is to get them to accept both the vision of the future world and the path to be followed). Translation (Callon, 1986) is thus at the core of innovation processes; this is, to follow Callon's example, what makes fishermen from the Bay of St Briec, consider that the future of their activity is linked to the genetics of scallops. This example (and the related simple sentence) highlights key dimensions of the innovation process. The dynamics of the want-to-be innovation is linked to its capacity to progressively attract and enrol the adequate set of actors. In the sketchy example above, the phrase (what makes) embodies a whole process: in his discussion Callon details the very different sequences gone through before arriving at this step, a step which is, furthermore, not considered to be the last one by the mobilised actors. There are two intermingled aspects to this assertion.

First, there is the capacity to mobilize new actors. Rip (1987) has shown the importance of the promise-requirement circle as a mechanism of continuous mobilisation. In this analysis, the **trials** made are at the core of the process. To explain, the initial promise that attracts new partners is consolidated through the trials made and the results achieved. Whatever their relation to the initial promise, the results help in closing one loop and therefore help in reassessing the relevance of the trajectory as initially defined. Latour (1987, 1992) suggests that what characterises the exploration phase is the inability to both attract those new actors

considered necessary for the future whilst also keeping on board those already present. In any event, the process of making trials and learning from the results is a process in which the project is continually reconfigured, as are definitions of the relevant knowledge needed and the actors required to embody it. This changing actor configuration represents another dimension, or more accurately, another manifestation of the construction of Van de Ven's prerequisite knowledge and the progressive specification of a repertoire of adequate actions, outcomes and contexts for the want-to-be innovation. The progressive **stabilisation** of the assembly of actors (that is when adding new actors no longer requires dis-interested others already present) also provides an indication (and hence a means of monitoring) of the narrowing process mentioned by Van de Ven⁸.

A second aspect concerns the sequences through which an innovation goes. Looked at ex-post, it is clear, at least in radical/architectural innovations, that the final product will have gone through the well known states of basic knowledge, concept shaping, pilot, prototype, final design and industrial development. However, when looking at the actual narratives of numerous innovations, one result is also clear: this linear sequence of events is rarely encountered. Most innovations studied by innovation analysts have gone through such states, often more than once, and always in ad-hoc orders. Would it help to replace these old **states** by others better able to characterise the status of a project. Not really for the "old" classification of states provides a still useful repertoire with which to describe the present technical status of a project. However there is a second societal dimension which relates to the space in which this status has been arrived at. The spatial aspect describes the scope, reach, and more or less collective nature of the **trials** or experiments made to date. For example, pilot studies devised within one company laboratory do not have the same meaning as those developed by a consortium including multiple companies, some interested users and a championing public authority. Looking at different breakthrough innovations in energy and in biotechnology, Rip and Schot (1999) emphasize the importance in the innovation process of **strategic niche management**, that is the construction for a given period of time of an institutionally and socially protected space within which further elaboration can be undertaken. Similarly, looking at innovations in transport, Latour emphasises the role of **collective experiments** or socio-technical demonstrations the purpose of which is to test some of the heterogenous hypotheses made about the technical, social, political and economic configuration envisaged by the want-to-be innovation.

⁸ This enables to rephrase the notion of **path dependency** which is central both to evolutionary economists (Nelson and Winter, 1982) and to analysts of breakthrough innovations (see section 3). For Callon, it forbids to limit path dependency to the mere rigidification of the initial game rules. It should be taken as deploying and unfolding heterogenous arrangements where one finds knit together not only technology but also forms of organisation and governance, relations between firms and public authorities, both local and national, associations and clubs, research centres, bribes, accommodating journalists and so on (Callon, 1998).

This spatial reference offers us a still quite open vocabulary with which to capture the societal dimension of the trials made⁹. What better protected space and niche is there than one closed laboratory? On the contrary a first real size demonstration of a new process or service (like the automatic handling of containers studied in PROTEE) immediately exposes the project to many dimensions of its future world. Thus we need to complement the old terminology of project technical states by another one relating to the spatial extent of the trials undertaken.

7.3 — CONTROVERSIES AND THE ROBUSTNESS OF TRIALS MADE

The trials are there to test the validity of hypotheses made by the innovation-in-waiting. However, one further problem, when faced with breakthrough innovation projects, is that of assessing the extent to which uncertainty has in fact been clarified. In the previous step, we equated the success of the test to the ability to enrol relevant actors and/or to maintain them within the project network when re-directing takes place. We thus associated success with the construction of an enduring configuration of actors, and with stabilising rules which help in shaping both the project and the calculated returns that can be expected from it. But how can we know that this configuration is relevant, or that the actors involved are adequate representatives? What is at stake is not some form of elective representation, but rather a question about the extent to which those involved provide access to relevant dimensions and features given the project's targets and ambitions. Von Hippel proposed the notion of lead users to define those participating in the definition of needs, in the shaping of the functionalities of products, in the understanding of the required user knowledge base, etc. More widely, authors have since proposed the term spoke persons to describe those who, within networks, speak in the name of others. The issue is then to assess their representativeness¹⁰, or, to use Courtney's phrasing, to take the measure of their market shaping capability. Courtney speaks of credibility, a notion which has been extensively used in science studies to discuss the conditions under which researchers and their proposals gain recognition. In addressing the issue of expertise and technology assessment, Rip and Callon (Rip 1986, Callon and Rip, 1992), have extended this approach, highlighting the role of controversies and of the hybrid forums in which they take place. To paraphrase the insights that Rip derives from his analysis of cigarette smoking and cancer in his 1986 seminal article on controversies, A new knowledge has no impact by itself, but only when taken up by

⁹ The experiments made during the SOCROBUST project on wind energy based in part upon the work by Karnoe, tell us that there could be another category of emerging markets, where rules are only locally stabilised, opening for niche markets (in the traditional marketing meaning of the term). We however have chosen here to consider this situation as a type of strategic niche management, highlighting once more the whirling nature of the innovation process.

¹⁰ Not in general, but specifically for the project and the actors targeted.

forceful actors ; facing uncertainties, the sole repertoire of cognitive aspects will not prove useful; when a controversy is resolved, a certain view of the issue has become dominant and widely available . This means that opponents (like the US Tobacco institute in his example) have stopped presenting a dissenting view: they are running up against arguments, evidence, social alignments, interests, and cultural values, many of them interrelated and therefore lending support to the dominant view .

In such debates, not truth, but impact is what counts , not substance, but sociocognitive strategies and their outcomes should be the focus of trials made. And their successful ending lies in the **robustness** of outcomes: Robust is whatever holds on its own . Rip takes the image of mathematical models, where robustness as a property means that the outcomes of model runs should not change dramatically if a parameter is changed only slightly , or said otherwise a little effort cannot disturb the outcome . One important property of robustness is articulation, that is the web of heterogenous linkages, scientific, social, economic, political and cultural, which materialise and stabilise the outcomes of controversy.

In a later article, analysing the role of expertise, Callon and Rip, underlined another important characteristic of robustness. The space, which they call a forum, in which the outcome of controversy was arrived at, and within which controversial assertions are no longer challenged, is of utmost importance. They link the degree of robustness not just to the spatial extent but also to the hybridity of the forum in which the controversy and its related debates took place, that is they take account of the types of actors involved, the types of arguments exchanged, and the types of modalities for voicing and reaching closure.

These results are central for breakthrough innovations. The new articulations (or webs of scientific, social, economic, political and cultural linkages) they require have to be visible and discussed if they are to gain recognition and support. The new valuations they suppose and, as mentioned by Noori, the new infrastructures they require have no other way to be embedded in society than by being shown to be superior as compared to present practices. And, in a way, the degree of robustness arrived at will determine the type of market entry, and the size of the initial niche, which the want-to-be breakthrough innovation might reasonably aim at.

7.4 — THE PROJECT TECHNO-ECONOMIC NETWORK AS A MARKER OF ITS DEVELOPMENT/PROGRESS/STATUS

Robustness is one characteristic of the assessment of uncertainty solving and of the involvement of relevant actors. However, it does not tell us about the development of the project as a whole. The notion of techno-economic network helps to address this issue.

The results of the trials made can be analysed both as states arrived at (we now have a prototype that works under such and such conditions) and as the capacity to interest and enrol actors judged critical to the success of the want-to-be innovation. In Callon s example,

there are first those explicitly mentioned, the fishermen, the future users of the innovation. This dimension has been emphasized again and again in the literature to the point that we tend to forget other dimensions in innovation processes and make of the presence of users the main if not sole factor of success¹¹. Told in detail the story features many other actors —industrial and service ones (which transform and distribute the scallops), local authorities, public research policy (through a government lab dedicated to fisheries) — which are mobilized by the project, share (at least temporarily) its objectives and are involved (one way or another) in its activities. We thus face a coordinated set of heterogeneous actors —laboratories, technical research centers, financial organizations, users ... and public authorities —which participate collectively in the development and diffusion of innovations, and which organize, via numerous interactions, the relationships between research and the market place . We have proposed to name the network so gathered: **techno-economic network** (TEN, Callon, 1991, Callon et al., 1992, Lar do et Mustar, 1996).

This terminology is used for two reasons. First to remind us that we should not too easily assimilate actors with social actors: technical devices are also often as important to consider. Secondly that one central feature of such networks lies in their coordination and the intermediaries that support it.

Actors are not only human, they are also non humans : in Callon s example, the scallops did not behave as expected and thus called in question the articulations hypothesized. There are numerous examples of technical devices that either do not produce/deliver what was expected or that are incorporated because they are taken for granted when doing a given job - for instance the normalised standard person (MTM) is used to represent all users entering the Paris underground and thus used in calibrating the dimensions of the turnstiles (portillons) (Akrich, 1992). Technical devices, as incorporated, produced and/or circulated, are important markers not only of technical choices, but also of societal ones (such as in the above mentioned case, the normalised standard person takes not account of children, just as it takes for granted the fact that users will naturally learn how to go through the portillon). This links with the above-mentioned argument about the endogenous scenarios.

Their presence also acts to coordinate sets of actions: it is because of MTM that different engineers can integrate their activities and respective outputs into one single portillon. Technical devices are thus one coordination mechanism (Mangematin, 1996), whether these be support materials (samples, reagents or reference materials...), technical artifacts (softwares,

¹¹ An important feature is that those interested, fishermen, are not theoretical, they are present, at least some of them are present and are empowered (at least by the project promoters) of the representation of all others. The lead users (Von Hippel, 1988), a central feature of innovation analyses, are not only those volunteering to participate into the project, but even more they are supposed to prefigure the requirements of future users and thus help in shaping the functionalities of the new product, process or service. They are spoke persons for the future users, and a central question lies in the adequacy of this representation (in its dual meaning: capacity to represent the supposedly targeted audience, capacity to act as shapers).

prototypes, machines...), etc. . The sociology of science has also shown the existence of two other co-ordination mechanisms: inscriptions (such as articles, reports, experimental data, patents, graphs, designs, etc.) and embodied knowledge (researchers changing laboratory, engineers moving between companies...). These add up to the well known and well studied dimensions of hierarchy (or more widely interpreted, organisational aspects), market (materialised by contracts for cooperation, subsidies and grants, financial loans, initial purchase by a client...) and trust¹².

This is to underline the point that a network is not just defined by the actors that make it up. A whole set of intermediaries circulates between them which give material contents to the links uniting the actors . Thus, when we speak of techno-economic network, it is, on one hand, to underline the heterogeneity of actors and activities, the flexibility of arrangements and the diversity of coordination mechanisms; but it is also to point to the existence of a new actor capable of a collective attitude and strategy and able to build a clear differentiation (even if it changes over time) between itself and the outside world (Lar do and Mustar, 1996).

Following the dynamics of a project, that is the results of the trials undertaken, is thus an exercise in following the unfolding of the network in its three dimensions, the actors that make it up, the intermediaries that circulate between them, and its capacity to position itself as a collective actor vis- -vis the external world. All of this means that questions about the project can be examined by analysing the present state of the network: issues about competences relate to the shape or completedness of the network (who is involved, who is considered necessary); issues about learning relate both to the convergence of the network (how aligned are the actors, what coordination mechanisms ensure it), and to its durability (how reversible are the engagements).

One practical way of tracking these features is to formalise the state of TENs by considering the different poles around which projects organise themselves. Callon et al. (1992) have proposed a simplified version, called the STM network (standing for Science, Technics and Markets, cf. box). This helps to reveal the transformation of the network over time by simultaneously following the actors involved, the activities undertaken and the forms of coordination (via intermediaries circulated). There have been numerous enrichments since, two of which are of particular relevance here. De Laat (1996), following the actors he was studying (The French agency for environmental technologies) added a fourth pole, Regulation, to take into account the major role of public authorities. Rip and Schot (1999) have proposed a concentric TEN approach to map the innovation journey in context, taking into account the macro positioning of the project within its product class (to use Tushman and Anderson s

¹² cf. among others the work by Zucker (1986) about the three forms of trust (characteristic based, process based and institutional based) and the work by Lane et al. (1995) about the role of generative relationships in innovation processes.

terminology) or technological paradigm (Dosi, 1982). This is particularly relevant, again using Tushman and Anderson (see introduction) when facing a period of technological ferment, with a substantial rate of product variation as is the case with breakthrough innovations and before a dominant design structures the product class/industry.

A simplified version of TEN (Callon et al., 1992)

We have proposed the idea that a TEN is built around five major poles out of which three are the supporting pillars. The scientific pole (S) is characterized by the production of certified knowledge (most of the time through articles in refereed journals). The technical pole (T) corresponds to the conception, elaboration and transformation of material objects that have their own coherence (assuring them durability and reliability) and capable of rendering services (that is to say of contributing to the realization of certain programmes of action). The Market Pole (M) corresponds to the universe of users; it is not the market as defined in the economic theory as the place where supply meets demand but this terminology heavily draws on the practitioners' definition of the market : identity of users, nature of their "needs", information on their expectations, hierarchy of preferences, forms of organization...

There is no a priori equation between those pillars and their output, for instance between certified knowledge and a technical object. Coherence between the two is progressively constructed, step by step, by trial and error. If it turns out that the results obtained by a given laboratory are transformed into innovations, this is not the fruit of some miraculous happenstance. There has been a deliberate process of engendering and nurturing of these different activities, and by successive iterations this has permitted a progressive co-adaptation and complementarity between the one and the other. If one wants to describe the network as a whole, then two further mediating poles need to be added. What we call the development - commercialization pole consists of production and distribution activities that mobilize technology to create/satisfy needs (TM). The Transfer pole (ST) specializes in connecting science and technology.

7.5 — WHERE DO WE STAND

The three previous sections have tried to show how results from the sociology of innovation complement the conclusions of other disciplines and can together inform strategies for monitoring breakthrough innovation projects which are still in the exploration phase.

(i) There are not, out there away from the project, scenarios of the future world to which the project should conform and whose realisation it will witness. There is a future world inscribed in the project, implying one or sometimes more endogenous scenarios . There is thus no need for a systematic external check of predefined political, behavioral, economic, sociological and technological aspects. The project itself makes assumptions about the future world, which it is important to de-script . This enables us to identify, compared to the present situation, the key changes that should occur and to define the areas in which the project could consider adopting a pro-active approach to the re-shaping of its own environment.

(ii) The actions undertaken should be considered as trials the role of which is to test the relevance of the hypotheses made, that is the definition of both adequate actions, outcomes and contexts, and of their articulation. Said otherwise, under conditions of uncertainty, each action is a test of the feasibility of the future world envisaged and of the adequacy of the path envisaged: it is NOT a milestone on a given trajectory defined ex-ante and once for all. The understanding of the innovation process as a trail of trials is a central notion which translates the importance which analysts have given to the initiation of the process, to path

dependence and to the successive redefinitions which any breakthrough innovation project faces.

(iii) The results of the work referred to above point to possible markers with which to follow the exploratory process, this being an aspect yet to be addressed by the different management methods already proposed. One set of markers deal with the robustness of the articulation made between given actions, outcomes and their context. Another set tracks the progressive transformation of the techno-economic network supporting the project. This analysis helps to determine and understanding the areas to be targeted, and to assess the efforts made and the results achieved.

Such are the main inputs that have been used in the development of the two methods described below.

8- EQUIPING THE EVALUATOR: THE PROTEE QUESTIONING FRAME

The first methodology addresses decision-makers faced with choices about given projects (these may be people responsible for making funding decisions within firms or within funding/supporting bodies, and especially public research funding organisations for which the framework proposed was first developed).

How to rephrase the problems decision-makers are faced when handling breakthrough innovation projects? Or, taking the conclusions of section 6 on board, how to facilitate and monitor the performance of the proposed learning pact?

To grasp how the evaluative interaction can be productive, one has to accept two preliminary assumptions: (a) the funding authority recognises, as we have mentioned, that there are certain situations in which traditional calculation practices are inappropriate and that an alternative decision-making track is required; (b) we are in an evaluation situation where the evaluator knows little about the project, but has a lot of experience about critical issues and sources of failures, and where the evaluatee (the project manager) knows many things about his project, especially about painting it in beautiful attractive colours, and about how to skip over its more slippery features¹³.

¹³ In the PROTEE project when we discussed our approach with project managers, most were very reluctant to adopt it considering that this was not their role but required the company to first change its approach to project funding and control. In the sole on-going experiment we made, the critical issue was to convince the financial and commercial responsables about the usefulness of sharing debate about the risks taken. We were also told that such a change had to challenge accepted characteristics of good project management: a good manager is not only one who manages successful innovation projects, but one who is able to propose stopping a project early enough when judging it to be no longer in a position to remain as a project. In our on-going case, this was de facto recognised since, one year later, the project manager proposed to stop the project ... and was very soon after promoted to a more senior position.

How can the evaluator make sure that critical issues linked to the identification and characterization of uncertainties have been addressed, and that he/she is faced with a relevant description of the project on which he/she can make or propose decisions about its future? In one word how to ensure the relevant descriptibility of proposed breakthrough innovations? Of course, his/her knowledge is based upon his/her own previous experience (as project manager and as project evaluator). The issue is however to avoid a situation in which the evaluator wants to impose his/her views derived from previous experience or to put it crudely to simply apply the recipes, may they be his/her own experience or from so called best practice. When dealing with breakthrough innovations, one lesson not to forget is that best practices are unlikely to apply since the well defined situations and stabilised settings which such strategies propose are themselves being questioned. This explains the need for equipping the evaluator with a specific questioning frame on the one hand, and a guide for the assessment, on the other. Both must be thought of as being inscribed in the learning pact and in the formulation of joint agreement about the project's present state and future.

The objective of the questioning frame is to help articulate both the project and the issues which it faces. Latour has identified from the numerous studies of failed projects three main pathologies which projects generally face and which must be guarded against¹⁴. These are, following Latour's denomination, lack of realism, lack of strategy; lack of falsifiability. A set of descriptors¹⁵ has been built to address these three issues and the prototype of a manual for handling the successive interactions developed (Bijker et al., 1999). Let us recall them briefly.

The first pathology is linked to the supposed superiority of the solution proposed: it is so good that users will adopt it as soon as they see/test it. This means that project promoters are certain that there is no other competing solution, and no other path to follow for solving the problem addressed. In one word the danger is in developing ballistic and consequently unrealistic projects. To be sure that the project is not facing one or the other risk, the PROTEE methodology suggests that descriptors are based upon analysis of the project script, that is of its future world. They are designed to check the richness and the heterogeneity of the project¹⁶, to identify the nature of uncertainties faced (referring for instance to Courtney's

¹⁴ For a full review of this, see the theoretical part of PROTEE final report, written by Latour (2000), and seminal works, especially the collection edited by Bijker and Law (1992), the book by Latour on Aramis (1992, 1996) and the work by Akrich on new energy producing devices or systems (1993).

¹⁵ We prefer the term of descriptors to this of indicator (which was used in PROTEE final report) for one main reason. In science and technology, indicators are used to label all data that has been gathered but which is not answering complete statistical requirements (e.g. the US science and engineering indicators). There is thus a danger to try and find quantitative methods translating the description arrived at (such as those issued from Bayesian network analysis) and avoiding the evaluator to share risks taken, that is to enter into a learning pact.

¹⁶ Latour notes that each story or script should contain entities undergoing actions of transformation, obstacles that may be encountered, borders (that is other preoccupations that are known to exist but left outside for now), and boundary objects (that is elements that require the collaboration of others).

classification)¹⁷ and to assess the degree of flexibility of the project: what are the possibilities of one or another outcome for a given uncertainty, what aspects must remain for the project to survive? (what is called irreversibilities by economists and obligatory passage points by sociologists).

The second pathology deals with the very frequent problem of paranoia, that is the inability of the project to absorb opposition other than by saying that the opponents are irrational, and thus to remain in ignorance of all the good reasons opponents might have for not co-operating. The descriptors are there to insure that project acquires knowledge of relevant anti-programmes (that is not only opposition to, but other proposals to address the same issue and other articulations than the one which the project represents) and is in a position to develop a coherent view of such opposition. Case studies have also shown that swallowing opposition often requires a measure of substitution and perhaps some transformation of the project itself. It is thus important, having described anti-programmes, to assess the negotiability of the project, that is its degree of modularity or to use an economic image, its absorption capacity. Analysing the transformations that can and can not be introduced (perhaps as a means of enrolling opponents) obliges project managers to determine the essential ingredients of the project core, i.e. those aspects that cannot be transformed without endangering the coherence, identity and integrity of the project as a whole.

The third pathology deals with closeness. Another important lesson derived from case studies is that innovators tend to remain in their technical world and only consider other types of trials once all technical issues will have been solved. How can the evaluator be sure that the trials proposed are relevant, that they will test critical dimensions of the project and that they will identify new allies to be enrolled (and not remain within the sphere of those already convinced)? The questioning frame proposed is designed to: verify the scope of the uncertainties identified; highlight issues raised by anti-programmes; ensure that the expertise mobilised in defining trials is heterogenous (that is comes from different sources not all linked to the project — avoid the lobby effect); and make explicit the translation proposed (that is the articulation made between the issues raised and the expected results from the trial, between the enrolment sought and that which is achieved). Together these descriptors make it possible to assess what Latour has proposed to label the *criticity* of the trials proposed.

These descriptors help to determine the project's ability to guard against the main risks of failure associated with project management. They can be used to organise a questioning canvas (see box) and to keep track of the agreed description. This makes it possible to compare the two descriptions. Evaluation is thus not absolute but relative to the previous description¹⁸.

¹⁷ if there was none, the project should revert to classical evaluation processes.

¹⁸ This does not apply for the first encounter. Our experiment on an on-going project within PROTEE was in a way mimicking a first encounter. Lessons derived tell that elements of judgements have to be passed about the

Such comparison makes it possible to grade or assess the learning curve of the project. This grading constitutes the assessment part of the interaction. This assessment is in four parts. (i) It first considers the capacity of the project to react: if nothing is learnt from the trials made, if nothing is changed in the project's life, it either means that the project environment can be considered stable enough for the project to enter into normal channels of investment appraisal, or that conditions for learning are no longer present and that it is useless to continue the exploration. (ii) When learning occurs, one central question is whether the project is still able to integrate the often contradictory results of the exploration: is there still an object - a project - capable of holding all the recognised tensions together —what is termed in the sociology of science, a hopeful monster? (iii) If this is the case, it is important to assess the capacity of the project to remain flexible: are irreversibilities built so strong as to require unlikely societal changes —what American analysts call white elephants and French engineers refer to as usines gaz? And (iv), if we face a learning project, able to integrate all tensions identified and which is still adaptable enough to cope with dimensions which remain uncertain, the last aspect to consider is the relevance of the next steps proposed: will they help to determine and address the uncertainties identified? In the final encounter both the evaluator and the evaluatee should reach the conclusion that anti-programmes have been incorporated and uncertainties solved to the point that the project is no longer a hopeful monster but a tamed animal that can enter into normal company life and be subject to the usual processes of investment selection.

The dual orientation of the descriptors, partly assessing the health of the project, partly determining the conditions for continuation, gives shape to a procedural approach which does not generate recipes for handling critical issues but which does ensure they are addressed. The experience of testing this method in one real situation with an on-going project, showed that, to prove fruitful, it was also necessary to equip the project manager (the evaluatee) so as to put him/her in a position to address the questions posed. For this purpose a different approach was needed. Developing such an approach is the focus of the SOCROBUST methodology which is sketched below and presented in the following methodological chapter.

richness and heterogeneity of the future world, and about the healthiness of the description made: how are uncertain dimensions described? are there elements of modularity in the project able to address them? is there a notion of possible controversies and has there been a search of anti-programmes? How have the trials proposed been selected, argued and defined? They require a first, quite a-symmetrical decision since the evaluator is all in the hands of the evaluatee, and at the same time having to make a decision along criteria that are often external to the project (like the global portfolio, the type of uncertain dimensions the company is interested into exploring, often for other reasons than the local project under discussion), etc. However this remains an open issue.

The Protee descriptors and the evaluator s questioning

Source: Protee final report and Protee manual

Protee approach is made of three analytical classes (class 1 to 3) and a summing up class for making up decisions about the future of the project

Class 1: Realism or anti-ballistic

The whole class makes sure that innovators have not started with a project and then looked for a world in which to implement it with as little deformation as possible (the ballistic pathology) but are able to describe a future world and only then search out elements that render the innovation more realistic

The four descriptors selected are expressed in the following questions

- a) how rich is the innovator s description of the project?
- b) How diverse, heterogeneous is the range of elements they describe?
- c) To what extent do the innovators distribute levels of uncertainty throughout the project description?
- d) Is the innovator s description of the project contingent and branched or is it inevitable?

Class 2: Strategy or anti-paranoia

This second class makes sure that the project is now thought in strategic terms, that is considers every opposing view as an opportunity to modify the project and entering into a negotiation as to its character, goal and functions.

The four descriptors selected are expressed in the following questions

- a) How much opposition do the innovators take into account?
- b) How coherently do the innovators describe the project from the point of view of the anti-programmes?
- c) Are the project s central and peripheral aspects clearly distinguished?
- d) Can the project sacrifice elements to adapt to criticism by opponents, as part of a negotiation process?

Class 3: Falsifiability or anti-manipulation

The third class of descriptors makes sure that the trials proposed by experts, politicians, technicians, public etc. for assessing various aspects of the future project are themselves relevant, useful and quality controlled. Without this checking of the relevance of their objectives, the trials would be carried out in vain.

The four descriptors selected are expressed in the following questions:

- a) How specific are the trials to test various aspects of the project?
- b) How diverse and independent are the experts and methods to evaluate the project?
- c) How well do the innovators justify decisions about the project with respect to gains and losses in information?
- d) How critical are the trials for the project?

Class 4: Innovativeness or anti-monsters

The fourth class makes sure that the process of exploration itself should not be continued without good reason, either because the project should be discontinued (it is a white elephant) or because, on the contrary, it is a very innovative long term risky project (a hopeful monster) or, finally, because it has matured so that other project management techniques are applicable.

This recapitulative judgement is arrived through the following questions

- a) is the project learning from its environment (retroactivity)?
- b) can the project reconcile its contradictory supports?
- c) Is the project a hopeful monster or a white elephant (risky diagnosis)?
- d) What is the project s degree of innovativeness?

9- EQUIPING THE PROJECT MANAGER: THE SOCROBUST METHODOLOGY

The project undertaken with the support of the EU (1999-2001) sought to test the feasibility of developing a methodology that would allow project managers to prepare a description of their project which would be relevant and useful in the proposed evaluation process.

As mentioned in the conclusion of section 5, relevance is constituted through four main elements of a methodology which seeks to (i) unfold and render visible the future world inscribed in the project, (ii) identify the key changes required (by comparing the future world with the present project network), (iii) assess the robustness of the assumptions made about the key changes, and especially identify competing views of the world or of ways to address these key changes, and (iv) identify/evaluate the project's current margins for manoeuvre.

9.1 SOCROBUST AS A RESEARCH PROJECT

It is important, at this stage, for the reader to appreciate the status of the SOCROBUST methodology presented below. Given the many methods of research evaluation and technology assessment that have been developed during the last 20 years¹⁹, it was initially thought that the central task was to determine which existing tools should be used, when, and how to tailor and integrate them to fit the problem in hand. SOCROBUST was thus only a feasibility study (which nonetheless ran over a two year period and involved 6 academic teams from 5 countries) designed to verify such assertions and develop an adequate architecture or framework with which to monitor the embedment of projects within society, or to use the results presented in section 7, to assess their societal robustness, hence the acronym selected.

An initial literature review revealed an overwhelming number of potentially relevant concepts but at the same time showed that relatively few were either derived from empirical studies (observed reality) or had been tested (meaning translated one way or another and implemented in reality). We thus entered into an unanticipated form of exploration which led us to make two important simplifications.

(a) We limited our selection of concepts to those already used in practice (at least for the analysis of past cases, and at best used in given organisations in a partly routinised way). This selection was tried out and further hardened through an extensive thought experiment based upon one in-depth case study on the deployment of large scale wind mills and on the emergence of the market for wind energy in most European countries. There were, however, a

¹⁹ For a review see among others Callon et al. (1997), Georghiou and Roessner (1999) for programme evaluation, Schot and Rip (1997) for constructive technology assessment, and the works of the ASTPP network for a full state of the art (summed up in the final report, Kuhlmann et al., 1999).

number of aspects not covered by existing tools (especially relating to the assessment per se) and in dealing with these we constructed a handful of new techniques (at present still at the state of laboratory pilots).

(b) We organised our main trial as a form of consultancy interaction between the SOCROBUST team and project managers responsible for five on-going cases²⁰. We had two objectives in mind. One was to test the technical feasibility of the proposed scheme — would it be possible to product an assessment report along the lines we had envisaged? The second was to test the strategic capability of the method: would the SOCROBUST assessment report provide the project manager with a relevant description of his/her project? Did the process and the robustness assessment generate new insights for the project manager and, did it, was the assessment of the robustness proposed bringing new insight to the project manager? Did it change his/her way of thinking about the next steps to take?

The testing process went as follows: for each project a consulting team of two persons was formed. This team was responsible for getting hold of existing literature on the project and for undertaking two interviews designed to sketch out the innovation journey and to unfold critical aspects of the project (future world, present TEN), always remaining within the logic of the project manager. The consulting team was also in charge of making the external check (a web search conducted with the assistance of a specialist team), and of drafting the assessment report. In order to monitor difficulties encountered along the way, for example, in explaining the approach and working with it, and in order to learn from the process of interaction, the two interviews were followed by an observer. A third meeting was held between the project manager and another member of the SOCROBUST team after the assessment report had been completed and sent out. The purpose of this final meeting was to consider the relevance of the method and the process. In practice, most also turned into strategy making discussions involving consideration of the results of the consultation and their meaning for the future course of the project.

The presentation that follows integrates the lessons derived from these case studies which, because they dealt with on-going projects, cannot be disclosed.

²⁰ The projects selected correspond to EU supported projects in three areas: new energy sources, telematics application in health and telematics for public administrations. The selection was arrived at through discussion with EC programme managers (selecting within their portfolio of projects those they consider as breakthrough). 8 projects were identified and gave rise to initial contacts. Because of funding and time constraints, only 5 (as initially planned) were fully developed. This selection has both strengths and limitations. Its strength lies in the importance of socio-political dimensions projects face, thus enabling to test the relevance of the approach for these dimensions. The main weakness no doubt lie in the sometimes fuzzy insertion of projects within their own organisation, limiting the learning made on this critical aspect of the management framework proposed.

9.2 SOCROBUST METHOD: A FOUR STEP PROCESS.

1- As with all the methods proposed this far, the SOCROBUST process begins with the anticipated future world. As mentioned in section 7, the method focuses on the de-scription of the future world embedded in the project, what we call the project's endogenous scenario(s). The method for determining these endogenous scenario(s) reflects the results of previous experiments (among others De Laat, 1996) and the learning derived from both PROTEE and SOCROBUST case studies. On this basis, we have identified four sub-steps, each instrumented with tools (that is visualisations, graphs, charts, tables).

At any moment in time, a project manager is in a position to provide a narrative of his/her project. This encompasses both the past trajectory of the project (with its turning points or critical moments where branching occurred)²¹ and its anticipated future path assuming that all goes as well as expected. In sketching the future, the next step is usually quite precise, though further moves may be more tentative. In addition, more than one future scenario may be envisaged, each of which, though different, might constitute success. Past and future turning points are summed up in the critical moments table.

This storyline²² provides a foundation for further unfolding the project. It has appeared important to start from safe ground, that is from where the project stands now. The second sub-step is thus to describe the present project network, using a simplified TEN approach as a support. We have selected the STUR network based on four poles —science, technology, user and regulation — which has been extensively used by public agencies such as ADEME in France and can thus be considered operational. This scheme is used to produce a map showing where existing actors are positioned, delineating the nature of the relationships between them, and identifying the intermediaries that bind them together. This map provides the raw material from which to construct a first table of critical actors. It was interesting for us to see that project managers had no problem in considering a system, a device or a standard as a project actor. It was also evident that this simple mapping exercise helped to articulate and question the richness and heterogeneity of the network, to reflect on the nature and durability of other actors involvement, and to record the existence of other actors in the different poles pursuing similar goals (with similar views or not, thus being competitors with similar interests in market shaping; or being anti-programmes proposing different alleys and approaches to market shaping).

²¹ When it is a want-to-be project proposed for funding, project managers always root the proposal in previous results which both justify the interest of making a project and provide a basis on which to rely.

²² In our case studies, this was sketched in the first interview by the project manager. The consultants then, after the meeting, wrote a project narrative and criticals moments table. The starting point of the second interview was to check their accuracy (for the project manager).

It also helped to outline blanks or poles sketched in such general terms that no spoke persons of interest to the project could be identified. By extension, this exercise made it easier to go to the next sub-step, that is to specify the composition of the network should the project be successful (using the same network visualisation). This sub-step in turn helped to identify new critical actors who should be enrolled and aligned, to consider relevant spoke persons who might be involved and/or relevant actions which might be undertaken to better identify competing views and approaches. A further sub-step, for which a specific tool has been designed, is to sketch the future working world in order to better assess the extent of anticipated change in the market infrastructure (be it physical or immaterial: new norms, standards, rules, codes of conduct), in the user knowledge base and in producer-user relationships²³.

2- It is then possible to compare the present state of the network to that needed to build a future working world. Going further, the method also identifies key changes - developments which must take place before this future world exists. But identification is not enough. Key changes must be characterised in term of the new practices that will have to be taken for granted, the present practices that will have to be discarded (and the corresponding actors as a source of opposition/compromise), the cast of outside actors sharing similar visions and the specification of fora (if any) in which such changes are already discussed. Key changes have also to be related to the manner in which they might be addressed: can they be brought within the present network (what is at stake is then convergence within an existing network), or is there a need for new enrolment, or for spanning the boundaries of the present network? And what are the project manager's views about all this: can the project be pro-active, that is can it move to enrol spoke-persons and thus shape the issue (or at least participate in its shaping)? Or is it only in a position to monitor or watch developments that happen outside the borders of the network? In which case the challenge is one of remaining flexible, and of adapting, or of being aware in advance in case of negative shaping. Characterising key changes in this manner helps to formulate sets of assumptions, the robustness of which is critical for the project's future. Articulation of these assumptions makes it possible to move on to assessment of the societal robustness of the project.

Let us underline, at this stage, one central feature of the method: these two steps are firmly located within the boundaries of the present project network. In our tests, the sources used to get to this point in the SOCROBUST process were limited to the existing literature and, first and foremost to the knowledge embodied in the project manager. To our point of view this

²³ It takes on board empirical lessons which highlight the growing role of prescribers in the user-producer relationship (thus proposing a triangular relationship). It integrates the results about the construction of markets, which are empirically taken up in many of the normative criteria proposed by the management methods mentioned about shared rules, standards, norms, modes of valuation and codes of conduct which have to become established/dominant for a market to develop (cf. Callon ed., 1998).

represents a decisive advantage: capabilities are not external to the project. It is, in consequence, not necessary to invest in an expert team or to seek resources over and above existing capacities and forms of expertise. Instead, the task is to unlock this expertise so that it can be internalised, by training (whether that be formalised training or, as was partly the case in our tests, by on the job training) and circulated as project managers or project participants involved in such practices move on.

3- Once key changes have been identified and characterized, the methodology then opens out to the wider world with a central question: what can be said about the probability that these key changes will take place? Conventional means of answering this question can then be adopted, these being already well known as technology or market watch and, now with the web, data mining. Such techniques are numerous, but are typically time consuming and expensive (at least the sophisticated ones). However because the purpose is not to check very general developments (say mad cow disease) but to focus on issues which have been quite precisely identified through the analysis of key changes (what animal tracking systems exist which incorporate health issues? what governments have passed relevant legislation, which countries have tracking systems already in place? are there other actors, either at regional, sectoral or functional levels, also interested in animal tracking?). The objective is to know, for each key change, what can be found through a search for other actors having the same approach, for actors proposing other strategies and for studies, debates, and positions taken about the transformations (that is new market infrastructures) required, and hence about the direction to take. While we have labelled this phase an external check , we only focus on the critical assumptions made by the project.

For our 5 cases, we made the following assumption: any antiprogramme that has taken shape, any competitor that follows similar goals, any organised group that positions itself with respect to one of the key changes (and uncertainties) will by now be visible on the worldwide web. We therefore limited our external checks to internet searches. Even then, we had only limited capability to undertake such searches (on average between 3 and 5 persons days) meaning that sophisticated approaches were not used and that we used standard search tools and procedures. This was, however, enough to reveal an extensive body of material much of which helped in at least partly reshaping the project manager's approach to and view of the key changes required (e.g. sectorally dedicated systems for animal tracking might turn out to be a significant market, other manufacturers with similar goals were discovered, security issues had been overlooked and were the object of important certification debates, etc.). Both for the consultants and, in 3 cases out of 5, for project managers, this external check brought new elements to the fore, often highlighting the existence of project diseases recognised and addressed in the PROTEE questioning frame (e.g. over looking competition, rarely considering

dimensions other than the technical, or interacting only with the operators of the future system).

The external check, by assessing project's key assumptions, contributes to the central tool of the assessment, which we have labelled the project positioning table . Up to this stage, all elements mobilised in the method had been developed and used in practice (even if in other contexts and even if not labelled as such). We are now entering the part of the process for which we found no relevant approach, even though the problems and concepts at stake are quite well established.

The positioning table sums up where the project stands. In one chart it shows whether there are other approaches to the handling of key changes, how the project stands with respect to these alternatives, who potential allies and opponents might be (and how much have they expressed and/or organised themselves), - all of which provides an overall assessment of the project positioning vis vis the key change in question. We have tested two approaches to the handling of the positioning table: one is to simply analyse the project's position with respect to each key change identified, the second, developed on the basis of our experience with this first strategy involves grouping key changes along three dimensions so as to better capture the nature of changes required. Drawing upon the work of those who have analysed breakthrough innovations, we grouped key changes as follows:

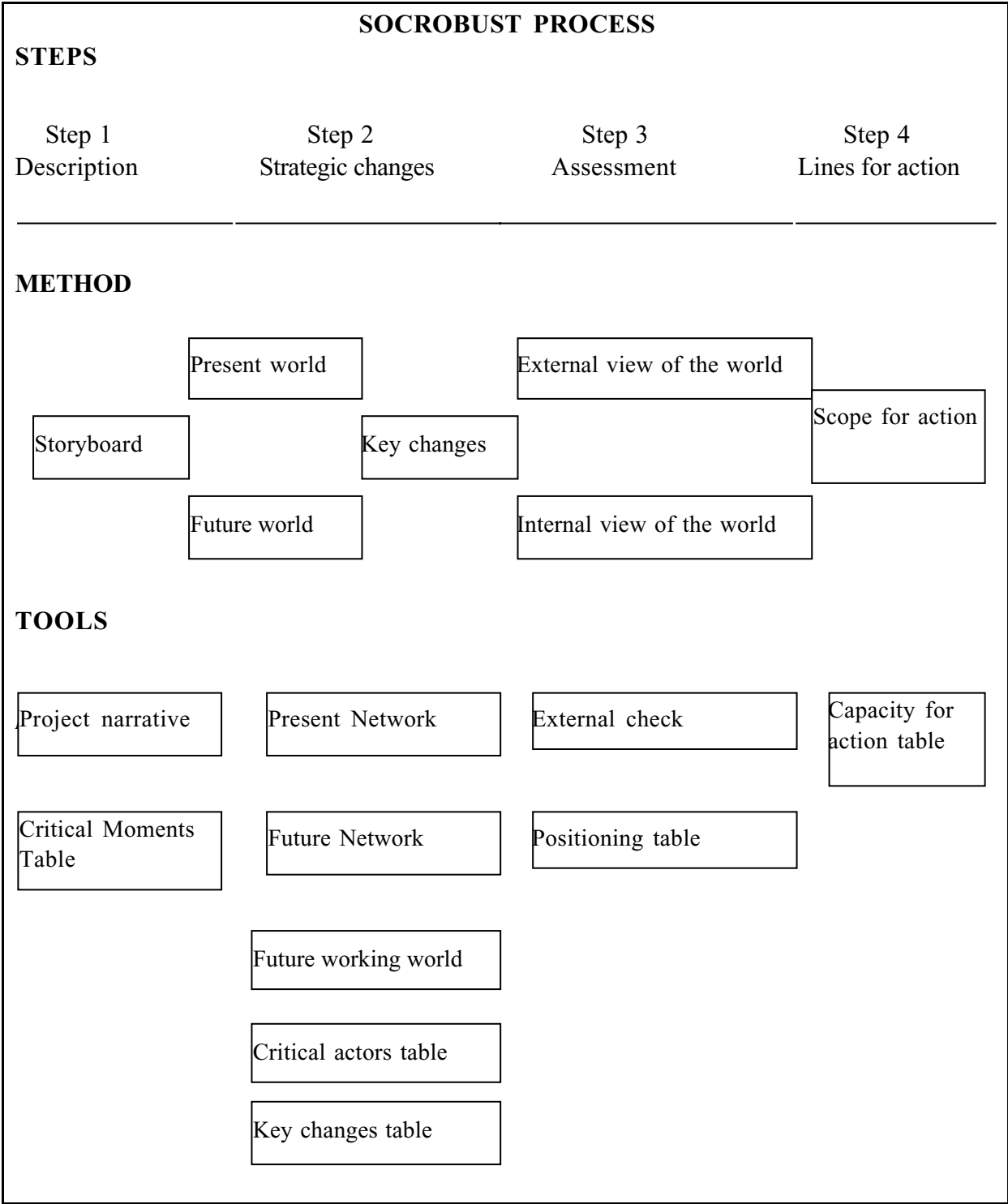
- changes in the technological landscape (for breakthrough innovations these are often associated with new paradigms or new dominant designs, in other words, they require new shared knowledge about what the technology can do and how to do it),
- changes in user-producer relationships (this includes all aspects of customer preferences, market segmentation, new knowledge which customers will require to value the qualities of the new products proposed and to be in a position to use them —We were also struck by the importance of new activities required to service the new products and by the importance given to intermediate bodies and prescribers in most of our case studies),
- changes in the legal, administrative and regulatory environment. This includes all well-known issues about norms and standards, but also ethical issues, issues about the environment, and about quality and consumer safety. We were struck, in quite a number of the case studies, by the importance given to the effective structuring of markets by public intervention such as pricing issues for wind energy, priority setting in health which in turn has important economic effects, etc.

Project positioning tables were an important focus for discussion in the third meeting with project managers. This was because they went beyond the confines of the project's present boundaries and discussed its standing in the wider world. In this the table relates to a crucial dimension of the PROTEE questioning frame by providing a quasi-benchmark with which to evaluate the extent to which the project is open to the external world: how far is it aware of

other actors pursuing similar aims and how much does it know of actual and potential anti-programmes?

4- The final step of the methodology considers the margins for manoeuvre, that is the scope which the project (and project manager) has for action. Within the three main dimensions and for each key change what is the capacity for action? This is where we mobilize the results presented in section 7 about the robustness of constructions made or envisaged. The probability that a key change will unfold as expected is linked to the robustness of the collective agreement arrived at within the communities involved. This requires first that there is a space for debate, a forum, where the required reshaping is discussed. The actors that make up the forum (thus its hybridity and representativeness), the arguments exchanged, the solutions sketched and the actions / directions defined, all influence the potential robustness of the outcome. A further element of assessment concerns the centrality of the project within the forum, that is its capacity to enlist key actors in the forum, to ensure that the project's position is not marginalised and that its goals are internalised by relevant groups in the forum. Such considerations inform the completion of the capacity for action table from which potential actions which promise to foster the societal embedment or societal robustness of the project are derived.

These conclusions are of course focused on the next step since this is the central issue of the learning pact. The action vocabulary is clear: the emphasis is on next steps which build, test, or demonstrate. Recommendations also encompass precautionary measures: which critical issues that remain beyond the scope of the next step should be looked for; what should be done to watch for dangers. Here the watching might remain traditional, that is passive. But it might also be much more pro-active, for example, monitoring specific developments (including participation in existing fora to make sure that events flow in the preferred direction), reflecting upon routes not taken (and the potential weaknesses that may result from others having selected these routes) or specifying alternative definitions of the project (depending on its flexibility), organising internal debate about the positioning of the project (in one case, this highlighted what might be gained by incremental adjustments in the project).



The SOCROBUST methodology, as just sketched, differs from the PROTEE questioning frame. In the latter, the issue is to foster a risky description of the project and to insure a relevant selection of trials proposed. The description is risky in that it highlights all the uncertain aspects and all the potential anti-programmes that endanger the project. The selection of trials is relevant because it focuses on the articulation between the objectives

aimed for and the trial made, that is on the coherence between the actions proposed and the information sought from them.. The object of the SOCROBUST methodology is not only to help in addressing these issues (uncertainties have been identified, anti-programmes are known and have been taken care of, expertise mobilised within the project is heterogenous enough to ensure the relevance of trials, their construction is coherent enough to ensure their performance), it is also to prepare the project to account for the steps that have already been taken, and to demonstrate the validity of the exploration proposed. In one word, the methodology is there to support project management. This difference of focus means that SOCROBUST is a normative methodology which, instead of identifying failures to avoid, focuses on conditions for success.

10 — TO RECAPITULATE

In this first positioning chapter we have tried to establish the role played by breakthrough innovations in the long term dynamics of firms and industries. We have also seen that management and organizational sciences agree on the need for a specific management approach with which to handle such ventures. Colleagues who have addressed this issue suggest the adoption of a management framework based upon three core principles: the need for anticipating the future world, the need for consistency with present situation in order to define a pathway of future development and the requirement of dynamic adaptation. These suggestions provide a place to start, a direction for improvement and a way to update continually a dynamic planning document (Cooper, 2000).

The issue is then to translate these principles into operational management, or at least into tools and approaches that managers can use in practice. This positioning paper has shown the limitations of the operational proposals made to date and has identified the complementary resources available from innovation studies. These resources are linked to three distinctive arguments all of which render the management of radical innovations more operational than has hitherto been the case, and which therefore make it possible to go beyond ad-hoc reliance upon the views of external experts.

The first and foremost change comes from a reversal of approach: periodic pro-active evaluation of the explorations made to date lies at the core managing of ventures which face uncertainty. This argues for another decision-making track (parallel to the usual investment calculation tools) based upon what we call a learning pact . This track differs from usual investment procedures on two counts (i) it does not only allocate means, it also helps to determine the direction to be followed, and (ii) it does not commit parties through to the end of the process (modulo periodic control) but only until the end of the next step of the exploration (at which point a new evaluation will determine the next course of action).

Like other methods, the learning pact begins with anticipations made about the future world. Here again we propose a shift from external to endogenous scenarios based upon the fact that

any project entails a script of the future world, and that de-scripting this future world provides all the scenarios that need to be tested, without having to a priori mobilize external competences.

In following the unfolding of an innovation and the dynamics of the explorations associated with it, and in tracking the development of the techno-economic network that supports it, we offer a practical way of handling one of the aspects yet to be dealt with by existing methods, that is how to appreciate and evaluate progress during the exploration phase. Comparison between present and future networks provides a means of answering the question of how to select a path of future development which is consistent with present capabilities and with competences already acquired.

In this positioning paper we have tried to go one step further, edging beyond the principles already presented. We have set out two methodologies developed for the purpose of rendering this learning pact operational. The PROTEE questioning frame helps in defining the terms of this new style of procedural management for the evaluator, in charge of making decisions about whether and how to proceed.. The SOCROBUST methodology equips the project manager: by assessing the societal robustness of his/her project, he/she has the capacity and the project-related intelligence with which to enter into and engage with the learning pact.

Together, these three elements, —the learning pact, the PROTEE questioning frame and the SOCROBUST methodology — constitute a full management framework .

CHAPTER 2 — THE SOCROBUST METHODOLOGY, A DESCRIPTION

1- INTRODUCTION

This second part of the report presents the SOCROBUST methodology. The methodology presented here is conceived of as a procedure with which to support managers in assessing the robustness of the societal dimensions of their projects. It has been developed as a stand-alone methodology but, following the wider management framework proposed in the position paper, it allows managers wanting to enter the proposed PROTEE evaluation process to produce a relevant description of their project.

The present chapter is organised in four sections. Section 2 recalls the principles on which the method is based, section 3 presents the process as it now stands, and section 4 presents the different tools taking into account the lessons learnt through the two phases of the SOCROBUST project, and especially through consultancy interaction with five on-going or very recently finished case studies.

It is important, in this introduction, to underline two dimensions: one linked to the choices made in organising this report, the other linked to the very focus of the project, that is its methodological dimension.

We have decided to introduce the reader, directly, to the methodology as it now stands. The reader should, however, know that we started with very different ideas about our approach and purpose. Thus SOCROBUST should itself be taken as an exploration of an uncertain world. This kind of exploration, recognised as important for management as early as 1985 (cf. Abernathy's conclusion in his last published article) has not, as mentioned in Chapter 1, given rise to many works. Those which are closest to the approach developed here were published during the life of the project (Noori et al, 1999, Cooper, 2000, Collarelli O Connor and Rice, 2001). Our own exploration was far from linear, it crossed borders looking not only at management literature but also at the wealth of concepts produced within sociology, organisational sciences and evolutionary economics. Chapter 3 will recall the different steps of the project since the participants of the SOCROBUST project agree that the experience of this experimentation should not be lost and because it is, in any event, necessary to understand the simplifications we made, and the new strategies and approaches we developed. However, this only makes sense when seen in the light of the results we arrived at. It is for this reason that we choose to begin with a discussion of the SOCROBUST method.

Practical methodology is at the heart of our experience. It is practical since our ambition is to provide managers with an operational solution to a particular problem. Our work is consequently designed to span the boundary between recent scientific advances and the immediate needs of project managers. Taking this practical orientation seriously had important implications for the design and development of the project. One was that we had to ground any new development in the context of existing practices. The SOCROBUST project therefore began by studying what had been done before. Second, this driving force provided us with a

strong, simple criterion, for evaluating existing concepts: namely, that of applicability. Third it required that, before drawing any methodological conclusions, propositions should be tested under real conditions and in real life. This explains the time we spent developing effective tests in the real world of project management. Chapter III describes the experimental design tested on the 5 on-going projects.

SOCROBUST is a first attempt at designing a management methodology and management tools with which to handle architectural innovations. It supports managers:

- in identifying and describing the societal dimension of their projects,
- in uncovering/eliciting the key societal changes they are aiming for,
- in defining the limits of the strategic steps/actions they can take to trigger these changes,
- and in assessing the associated risk/likelihood of achieving such changes.

2- THE PRINCIPLES UNDERLYING THE PROPOSED METHODOLOGY

2.1- RECALLING THE CHALLENGE FACED

Most of the literature on innovation, and most managers with whom we have been talking, recognise the existence of two kinds of innovation: incremental and radical. Literature reviews and interviews with managers further confirmed the view that a number of management tools covering a wide array of activities (strategic planning, project management, finance, marketing) have already been developed to tackle incremental innovations. Such was not the case for the management of radical innovation. One plausible reason for this lies in the nature of uncertainty with which radical innovators are confronted: if risks can be calculated for incremental innovation, *ceteris paribus*, they cannot be for radical innovation.

To understand the grounds for such a differentiation, we need go back to the definition of radical innovation. This brings us to a first observation: the definition is polysemic, radical innovation is used in very different ways, and most of these are fuzzy. One key insight has been provided by researchers at the Harvard Business School: they have shown that radical innovation does not simply (or predominantly) refer to radical breakthrough in technology — although this is not exclusive — but to a radical change in society (or to put it briefly, in the market in its widest definition). They characterised such innovations as **architectural** and so do we, in reference to their path-breaking work. For us, the important lesson derived from Abernathy and colleagues of the HBS is that the management of incremental innovations takes place on two dimensions (technology and economic) while the management of architectural innovation takes place on three (technology, economic and societal or socio-political). One consequence is, as already noted, the absence of relevant calculation models for architectural innovations. Calculation models exist for technology and for economic aspects, but not for the societal dimension. The exploration made in SOCROBUST thus consisted of: a) locating every effort made to deal with this issue, b) determining whether management tools and reference guides could be provided for managers dealing with architectural innovations, and c) having a first try at designing and implementing such tools.

2.2- THE NATURE OF THE CHALLENGE WE FACED

Most tools designed to facilitate the management of incremental innovation have to do with the relationship between two classes of actors these being, on the one hand, principals/sponsors, and on the other, project managers/promoters. The fine art of innovation management concerns the relation between these two. It is this which provides the framework and the niche in which innovations first mature and grow.

Main orientations of existing innovation management tools

A simple agreement provides the starting point from which such a framework is built. This agreement has to do with the specification of a shared interest and a converging vision of the future. In the case of incremental innovations, established methods of calculation provide a common language which is shared by both categories of actors and which defines the terms in which decisions are made and rates of return estimated. A contract stipulates the details of this joint commitment. This usually consists of a set of milestones and the definition of periodic proofs linked to deliverables, all marking progress towards the shared final goal. The process is generally straightforward enough to be planned: progress is measured by the degree of materialisation of the innovation and its degree of contextualisation (as proven by its capacity to function in conditions which increasingly resemble those of the real market). A classical way to represent this process is through the following sequence of steps: design/specification, prototyping, demonstrating, and market introduction. This pattern of innovation management is de facto one of organising the future: it represents a bet about the future, which thanks to its incremental and calculable nature, can be made relatively safely. The more calculable the trajectory appears to be the fewer the milestones and the fewer the moments of periodic proof that are required. Formally, of course, a project promoter needs to convince his or her sponsors of the project's potential viability in order to get the resources necessary to build and carry out the proposed scheme. Principals usually grant support on a provisional basis, always contingent on promising calculations of expected return, complemented by periodic assessment and the delivery of evidence demonstrating the project's progress in terms of the planned agenda. This plan is a de facto learning path. It identifies key obligatory passage points —and by implication details what needs to be searched for, tested, and learned about, in order that the proposed innovation becomes reality. The plan and the periodic deliverables specified in it constitute a roadmap and a point of reference for the project team: it is around this that efforts are focused in order to ensure success.

Specific problems associated with the management of architectural innovations

In cases of architectural innovations, the results of the exploration cannot be guessed at in advance. Because learning occurs step by step, the project can only advance one move at a time. In these situations, efforts to impose some overall method of project planning are to a large extent counterproductive and may even lead to the death of projects which have a potentially promising future. This is because learning cannot be planned in advance, but can only be evaluated ex post, once it occurred. Not only that, the innovation process tends to follow a whirling rather than a straightforward trajectory. In cases like these, the

principal/sponsor is not only a provider of funds and means, but also and perhaps more importantly, a key resource for project promoters in seeking to build the robustness of their project. One consequence is that the agreement between these two parties cannot encompass the whole project trajectory in advance. It can only sensibly focus on the next step to be taken, on the terms in which that step should be evaluated, and on the further evidence required to shape the project's future. This step by step approach means that the process is as important as its end result. Learning can only occur one move at a time. This does not mean that planning disappears, but that it is viewed, ex post, as the aggregation of multiple step-by-step plans. Evaluation of project planning is an evaluation of the relation between promoter/sponsor and project manager, as well as of the results achieved each step of the way (see the notion of double loop learning by Argyris & Schon). This kind of learning is closer to an academic rather than an industrial model since it requires autonomy and since it implies the co-shaping of problems and solutions. On both counts it differs from a more hierarchical and control based approach. Since the learning path is invented along the way, we suggest that strategic interaction (between promoter/sponsor and project manager) be seen in terms of a learning pact. The actions undertaken within this learning pact might, for instance, be organised around a number of periodic interactions during which project managers describe the progress made to date, and in which the promoters/sponsors evaluate the knowledge that has been generated as a result, and specify the extent and character of the further progress required.

The very idea of the learning pact means that both the principal and the project manager should be equipped with methods and tools which allow them to contend with the specific properties of architectural innovation. The two sides of this relationship have been considered by two different EU projects. The PROTEE project's objective was to equip promoters/sponsors with techniques and criteria designed to help them distinguish between hopeful monsters (i.e. projects which should be continued) and white elephants (which should be terminated). By contrast, SOCROBUST is designed to equip project managers with the tools they need to assess the societal robustness of their project, to thereby increase the chances that their project will in fact succeed, and to provide a relevant and realistic basis for discussion with their promoters and/or sponsors.

Given the points made above, it is the management of the societal dimension which requires special attention in the case of architectural innovation. Key elements to consider here include project descriptibility, embedment and societal robustness (see the positioning paper, chapter I, for more details.).

2.3 - THE PRINCIPLES OF THE SOCROBUST PROCESS

The SOCROBUST process involves two distinct phases, one of de-scription and one of assessment. As was mentioned in the positioning paper, the strategy adopted is the reverse of that which underpins more conventional methods of scenario building. Before exploring or even considering the external world, SOCROBUST seeks to unfold and reveal the future

world already embedded in the project, and in the implicit assumptions about users, values, rules and infrastructures that it already embodies.

The first task is thus one of helping project managers better describe their own project, better unfold its different dimensions (technical, economic and societal) and better identify and characterise the key changes that are required, as compared to the present situation, if the project is to succeed. The first principle is to develop and articulate aspects and dimensions of the existing project which are central to its future but which are rarely made explicit. The result is an extensive picture of the project generated through a process of what we call description: an articulation of the different dimensions inscribed in the project including uncertainties, irreversibilities, and assumptions about the future social world, and a careful record of its whirling path and trajectory to date - again features which are not usually discussed.

The second task and the second principle is to assess the character and nature of prevailing uncertainty (the existence of which makes it pointless to try to evaluate project progress in terms of the final goal). This means focusing on the next steps and trials that will help stabilise aspects identified as being both relevant and uncertain. It is only then that it will be possible to make calculations and decisions about the risk and potential value of pushing the project on towards the market. As with conventional scenario making, reference to the external world (that is the world outside the project) is an integral part of the method. For SOCROBUST, the difference is that the external check is both focused and directed. Its purpose is to assess the feasibility of realising key changes necessary to the project's success and - as part of this - to identify elements, groups and projects which either share the same views (and thus enhance the robustness of the project) or on the contrary develop alternative views of the world (what sociologists call anti-programmes). Only then can an analysis of the positioning of the project and of its margins for manoeuvre be made, and only then can judgements be passed and decisions taken (within the project or between project managers and principals) about the next round of actions.

The two principles inform the design of four steps, the main objectives of which are presented below.

Preparing project managers to describe their project

Financial figures and models are handy tools with which to overcome information asymmetries between promoters/sponsors and project managers. They provide a common language and help to simplify the terms of debate. When conventional calculations are not possible, project managers have no option but to describe their project to the relevant promoters/sponsors and hope that this description will provide a sufficient basis for dialogue and exchange. In producing a good description (i.e. one which is fit for this purpose), project managers should be able to offer a clear account of

- their project's rationale (main goal and origin, global strategy),
- their project's trajectory (main critical moments or turning points, main alternatives faced and choices made, reasons for such choices, related zones of uncertainty and instability),
- their project's societal dimensions (networks of actors mobilised, level of commitment of actors, competing views and antiprogrammes),

- the future world as it will look if they are successful (embedded networks of actors routinely producing, improving and consuming the new product/service, necessary infrastructure).

Preparing project managers to identify key changes required for success

Once agreement is reached on what the project is about, who and what is (or should be) involved and which future world the project is trying to build, the next step is to identify the key changes which must be made in order to close the gap between the present state of affairs and the desired future world. What are the key ingredients needed before the anticipated future world becomes a working reality? In tackling this question, project managers need to

- articulate the future world inscribed in their projects,
- articulate the assumptions they are making about the evolution of the societal context (technology, regulation, market) and how it might be in the future,
- make clear what role they intend to play in this evolution and the assumptions they make about their own capacity to affect the world of their project,
- backcast scenarios to identify the steps to be taken if the project is to move to a new stage,
- reflect on the coherence of the desired future world and the assumptions they are making about the evolution of the world.

Preparing project managers to reflect on the strength and weaknesses of their project

It is not enough to imagine a future to make it come true. Major threats include those posed by alternative images and visions of the future backed by strong, diversified, or powerful networks of actors (one classical example is given by competing technologies VHS vs BETACAM), and by the alternative scripts incorporated in existing artefacts (scallops may not like to reproduce in certain places, blast furnaces may refuse to consume certain categories of coal). In other words, the convergence (or difference) between the project manager's vision of the future and the visions circulating in the wider world or espoused by other actors interested in similar questions, requires clarification. Convergence is certainly not a definite measure of success (architectural innovations are by definition going to change the world) but it is a good approximation of the effort which a project (and/or project manager) will have to invest in order to bring about such change and to build the necessary networks of relevant allies. In the societal arena, it makes no sense to talk of true or false. Instead, there are shared and dominant views that become embedded in society and others which remain marginalised. Ex-post, the dominant view is always the right one. Innovation studies often refer to this dominant view as a black box. Blackboxes are items, conventions, and assumptions that can be reliably reproduced, calculated and anticipated: they dominate and they are taken-for-granted. Tools for managing incremental innovation reduce uncertainty by blackboxing the project environment, particularly its societal dimension. Calculation therefore proceeds as if the market will behave in accordance with an existing market that is known already. Such is not the case for architectural innovation, the aim of which is, on the contrary, one re-opening existing blackboxes and proposing other architectures, conventions, and ways of doing things. Hence the importance of blackboxes. Major areas of uncertainty and collective questioning give rise to alternative views at a certain point in time. Controversies in turn call for closure. The conclusion of controversy tends to result in the naturalisation of one dominant view as *the*

answer, positioning it as the only solution in a move which again represents a form of blackboxing. The quality of this blackboxing process needs to be carefully monitored. At any point it should be possible to answer questions like these: what is it reasonable to blackbox, and at which stage (and what is not), what can be reasonably anticipated (and what cannot), what can be reasonably achieved by the project and what is beyond its scope for action. The external check thus focuses on the key changes required for the realisation of the project in question, and on the blackboxing processes this gives rise to, or demands.

Instead of scanning the world at large, the SOCROBUST method involves testing the main assumptions underlying the project's vision of the future world. What are the main areas of uncertainty? What are the main alternative views and controversies about these points? Where are those expressed and debated (in what we call a forum)? How developed are the networks and fora where these questions are discussed and investigated? How well established is the project's position within and across these related fora? Who are the project's potential allies and who are its potential opponents? At this stage, there is no need for complicated and costly calculation, all that is needed is a better appraisal of the chances of effectively blackboxing those elements which must become taken-for-granted if the project is to succeed.

Helping project managers identify their scope for action

Identification of the project's strengths and weaknesses constitutes a necessary basis for discussion between promoters/sponsors and project managers. This discussion focuses on the strategic question of what can be done next either to adapt the innovation to the societal world in which it must exist or to adapt the social world to suit the innovation. The fourth step helps managers

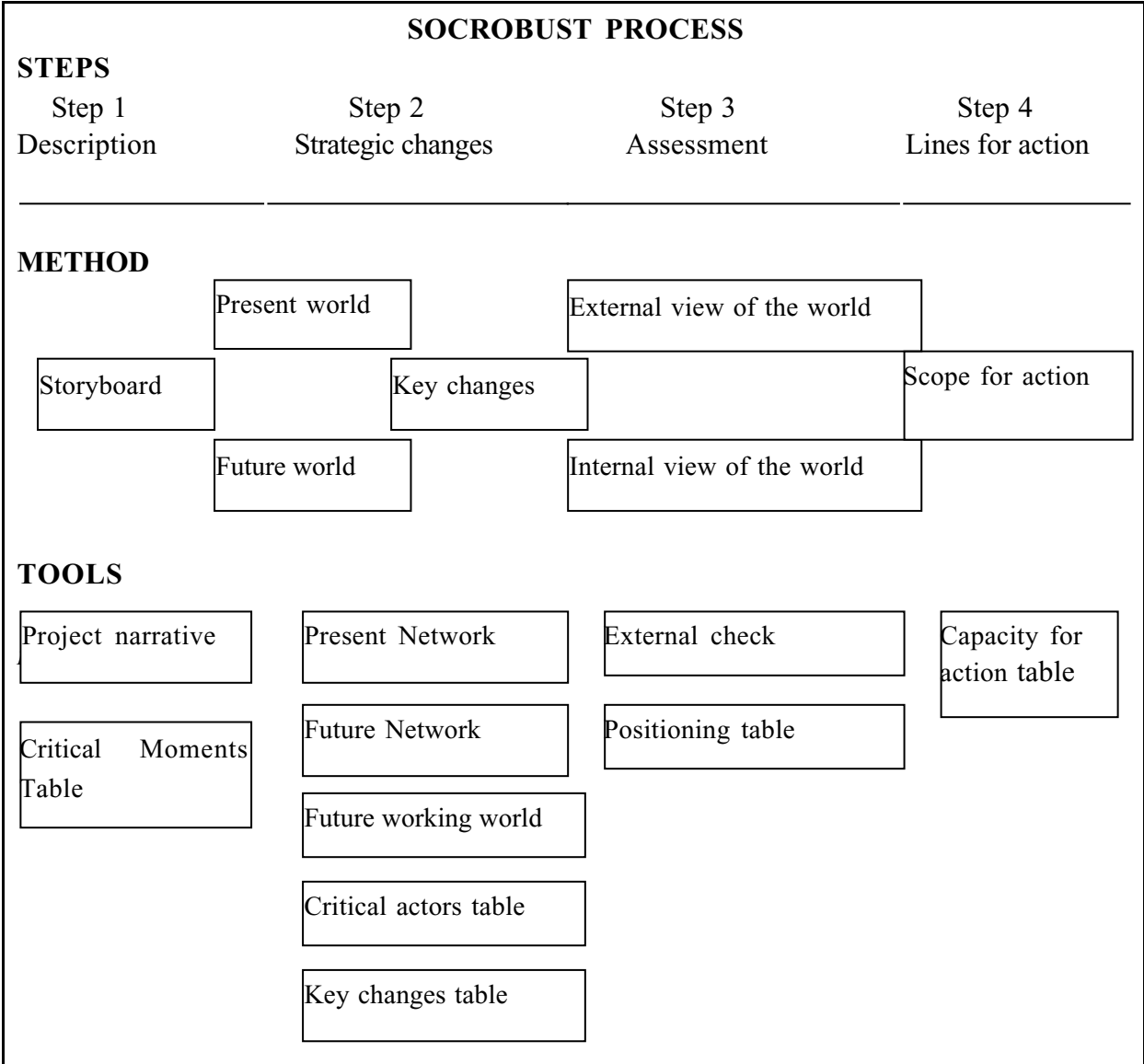
- identify desirable changes in order to increase the chances of success,
- recognise key actors and locations from which to trigger these changes,
- recognise what is within and what is beyond their scope for action,
- identify alternative modes of actions (entering the debate, constructing the forum, enrolling one key player in the controversy, changing the innovation specifications...).

It is only then that decisions can be taken, rendered explicit and shared between project managers and project promoters/funders.

3- THE SOCROBUST PROCESS: 4 STEPS AND 10 TOOLS

We now present the SOCROBUST process as it stands today, taking into account not only the lessons of the retrospective case studies done (which helped establish a first process) but also the results of the testing it on 5 on-going cases. What follows is thus the result of a first demonstration , a first trial in the real world.

The basics of SOCROBUST can be explained relatively simply. It is a four-step process backed by the use of 10 tools. The 10 tools each contain some kind of image or visualisation like a map, a table or a graph. These are deployed in a pre-determined order in which the results of one tool are taken up by the next. The sequence corresponds to the principles mentioned above, and the tools together help build the four main steps of the protocol: description, key changes, assessment, capacity for action.



Step 1 - Description

At any moment in time, a project manager is in a position to provide a narrative account of his/her project. This enables him/her to trace both the past trajectory of the project (with its turning points or critical moments where branching occurred) and to consider its future path, the next step being quite precisely specified, later ones being more tentative, assuming all goes as hoped/expected (sometimes the project manager may envisage several possible futures, any and all of which would constitute success). Two tools support this preliminary effort: the **project narrative (tool 1)** and the **critical moments table (tool 2)**.

The project narrative is the starting point for unfolding the project. In developing the method we felt it was important to start from safe ground, that is from where the project stands now. The first unfolding action is thus to review the present project network, using a simplified TEN approach for this purpose. We have selected the STUR network based on four poles —science, technology, user and regulation—which has been extensively used by public agencies such as ADEME in France and can thus be considered operational. This exercise results in a map showing which actors are involved, where they are positioned how they relate to each other and which intermediaries bind them together. This map provides a first **visualisation of the present network (tool 3)** and the raw material for a first **table of critical actors (tool 4)**.

This first mapping helps in questioning the richness and heterogeneity of the network and the nature and durability of the actors' involvement. It also reveals the existence of other actors located at the different poles and pursuing similar goals (either as competitors with similar interests in market shaping; or representing anti-programmes proposing different avenues and approaches to market shaping). In addition, it helps identify blanks or poles so weakly or so generically developed that no spoke persons of interest for the project can be identified.

The next action uses the same network visualisation and the same mapping method to describe the composition of **the future network (tool 5)**: that is the future network as it would be should the project have succeeded. This future oriented exercise helps to identify new critical actors who should be enrolled and aligned, and it provides a point of reference for further discussion of relevant spoke persons and/or relevant actions which might be undertaken to better identify competing views and approaches (in which these actors are often already involved). Developing these issues further, this exercise also provides a basis from which to sketch **the future working world (tool 6)** in order to better assess the extent of necessary or assumed changes in the market infrastructure (be that the physical infrastructure, or the infrastructure of norms, standards, rules, codes of conduct), in the user knowledge base and in producer-user relationships.

Step 2 - Strategic changes

As a result of step 1 it is possible to compare the present state of the network and the hoped for future working world. This in turn makes it possible to identify the key changes that will have to take place before this future working world exists. Identification is not enough. Key changes have to be characterised more precisely, for example through specifying new practices that will have to become taken for granted and present practices that will have to be

discarded (with implications for actors likely to represent either a source of opposition/compromise). It will also be necessary to specify actors outside the project who share similar visions and (if any) and to look for and detail fora in which such changes are already discussed. Key changes have also to be considered in terms of how they might be addressed: can they be addressed within the present network (what is at stake is then convergence within an existing network), or is there a need to enrol new actors, that is for extending the boundaries of the present network? And what are the project manager's views of these options: can the project be pro-active, that is can it actively enrol adequate spokes-persons and thus shape the issue (or at least participate in its shaping)? Or is it only in a position to monitor / watch developments made elsewhere, and outside the borders of the project network? In which case, the challenge is to remain flexible and adaptable and to have early warning especially of negative shaping. The key changes so characterised are encapsulated in the **key changes table (tool 7)**. Specification of these changes helps in articulating the project's core assumptions, the robustness of which is critical for its future development. The careful detailing of key changes is thus a precondition for embarking on an assessment of the project's societal robustness.

Step 3 - Assessment

Once key changes have been identified and characterised, the methodology then opens up to take account of the wider world in which the project is located. It does so not in general terms but with reference to a central question: what can be said about the probability the key changes (specified above) will come about? It is not a general check (for example, on the implications of mad cow disease) but a check which focuses on issues which have been quite precisely identified through the analysis of key changes (what animal tracking systems exist which incorporate health issues? what governments have passed relevant legislation, which countries have tracking systems already in place? are there other actors, either at regional, sectoral or functional levels, also interested in animal tracking?). The objective is to know, for each key change, what can be found through a search for other actors having the same approach, for actors proposing other strategies and for studies, debates, and positions taken about the transformations (that is new market infrastructures) required, and hence about the direction to take. While we have labelled this phase an **external check (tool 8)**, we only focus on the critical assumptions made by the project.

In checking these assumptions, the method makes the following supposition: any antiprogramme that has taken shape, any competitor that follows similar goals, any organised group that positions itself with respect to one of the key changes (and uncertainties) will by now be visible on the worldwide web. The external check is thus focused on internet searching. Devoting even limited resources to such searches (on average between 3 and 5 person days) and using only standard search tools and procedures were however sufficient, in the 5 case studies made, to bring to the fore a extensive body of material much of which helped to reshape the project manager's approach to, and view of, the key changes required.

By assessing the grounding of the project's key assumptions, the external check helps in constructing the central tool of the assessment, which we have labelled the **project positioning table (tool 9)**. Up to this stage, all elements mobilised in the SOCROBUST method have been developed and used before (even if in other contexts and even if not labelled as such). We are now entering the part of the process for which we found no relevant approach, even though the concepts involved are quite well established. The positioning table sums up where the project stands. It shows whether (or not) there are other approaches to handling the necessary key changes, it shows how the project stands with respect to these alternatives, and as well as identifying potential allies and opponents, it shows the extent to which they have expressed their views and/or organised themselves. This provides an overall assessment of the project positioning vis-à-vis the related key changes. The table shows how the project is positioned with respect to key changes relating to the following dimensions:

- changes in the technological landscape (for breakthrough innovations these are often associated with new paradigms or new dominant designs, in other words, to the development of new shared knowledge about what the technology can do and how to do it);
- changes in user-producer relationships (this includes all aspects of customer preferences, market segmentation, new knowledge which customers will require to value the qualities of the new products proposed and to be in a position to use them —We were struck by the importance of new activities required to service the new products and by the importance given to intermediate bodies and prescribers in most of our case studies);
- changes in the legal, administrative and regulatory environment (this includes all well-known issues about norms and standards, but also ethical issues, issues about the environment, and about quality and consumer safety. We were also struck, in quite a number of the case studies, by the importance given to the effective structuring of markets by public intervention such as pricing issues for wind energy, priority setting in health which in turn has important economic effects, etc.).

Step 4 - Lines of actions

The final step of the methodology tries to assess the margins for manoeuvre, that is the room for action within, and for the project. What is the project's capacity for action with respect to each key change? This is where we mobilise the results of the external check regarding the robustness of the constructions made or envisaged. The likelihood that a key change will come about as expected relates to the nature and scope of collective agreement. Amongst other things, this depends upon the existence of a space for debate, a forum, where the required reshaping is discussed. The actors that make up the forum (thus its hybridity and representativeness), the arguments exchanged, the solutions sketched and the actions / directions defined, are all ingredients of the potential robustness of the outcome arrived at. A further element concerns the centrality of the project within the forum, that is its capacity to enlist key actors in the forum, to ensure that the project's position is not marginalised and that its goals are internalised by relevant groups in the forum. These features are represented in the **capacity for action table (tool 10)** which helps specify practical next steps for fostering the societal embedment of the project and enhancing its societal robustness.

These conclusions are of course focused on the next step since this is the central issue of the learning pact. In some cases the recommendations are active: to build, test, demonstrate etc. Yet they may include precautionary measures especially regarding features which remain beyond the scope of direct influence. In these cases, the watching might remain traditional, that is passive. But it might also be much more pro-active, for example, monitoring specific developments (including participation in existing fora to make sure that events flow in the preferred direction), reflecting upon routes not taken (and the potential weaknesses that may result from others having selected these routes) or specifying alternative definitions of the project (depending on its flexibility), organising internal debate about the positioning of the project (in one case, this highlighted what might be gained by incremental adjustments in the project).

4 — A TOUR OF THE SOCROBUST TOOLS

This fourth section is designed as a prototype user guide. This is somewhat premature since we anticipate undertaking further development work which has still to be tested. As chapter 3 explains, the method has so far only been tested through consultancy interaction with on-going cases and further work is required to develop SOCROBUST as a stand-alone process which project managers might undertake on their own. We have however considered it important to anticipate and present our present hypotheses about each of the tools, as we would like to further test them (see our proposals at the end of chapter 3).

In the following presentation, we have thus envisaged two main situations in which the method might be used: (a) in the first situation, the project manager is working alone to review and describe his/her project in preparation for a forthcoming interaction with his/her promoters/sponsors; (b) in the second situation, that of a so called consulting interaction, consultants are using the SOCROBUST method as a service to the project manager. The reader will notice that only the second position is addressed when dealing with the steps 3 and 4 of the process.

Each of the 10 SOCROBUST tools will be presented in turn following the sequence of deployment proposed in section 3. Each presentation will include a description of the tool, of how it is to be used, and of the material required. Then, when possible, specific aspects of each of the above mentioned situations of use —self administration or consulting interaction — will be addressed. All visualisations are set in a second volume, so that they can be referred to while reading the text presented both in this chapter and in chapter 3.

The consulting interaction which we organised with the 5 case studies concluded with a report and a final strategic interaction between the consulting team and the project manager (see chapter 3). The content and shaping of the report will be discussed in chapter 3. Being developed as part of a consulting interaction, these reports had a concluding section highlighting recommendations for future action. The last section of this second chapter will review the issues raised and the lessons learnt about making and presenting recommendations.

4.1- TOOL 1 — PROJECT NARRATIVE

The first tool is a narrative. The project manager tells the project story in his own words from which a written synthesis is produced. The idea is to summarise the main elements of the project in a two page format and in terms simple enough that any outsider can understand it. On the face of it, this is a straightforward exercise. In practice, the experience proved that the creation of a good narrative, clear enough to be inviting and rich enough to isolate key issues for discussion requires rigor and method.

This first description might include references to:

- the origin of the project,
- the very idea and need it is addressing,
- the main lines of choices and difficulties/uncertainty experienced,
- the artefact designed and its basic principles,
- the expected future(s) of the project.

MODE ONE: SELF-ADMINISTRATION

Description

The objective of this step is to produce the narrative of the project. Written documents and conversation are the simplest and most widespread tools used by professionals to communicate with others. In SOCROBUST, a written narrative is used as **the basic reference** that ensures that both principals and managers, and any other actor involved in the interaction, are talking about the same thing. This is a text to which each can return at any time. Project managers are often required to deliver, read and discuss all kinds of presentations of their project. While existing documents will be used as sources (see sources), most routinely delivered documents are esoteric, difficult to read and seldom provide a sense of the overall trajectory of the project. A good reference document is of tremendous importance to project sponsors/promoters but to be good it needs to be simple, short and rich. The project narrative helps managers produce such a basic reference.

Process

Our experience has shown that, contrary to what we first thought, the delivery of a good narrative is not an easy task. This job is made easier (at least for the project manager) if an external writer is used and if the SOCROBUST protocol (sub-step 1) is followed, as described below.

To create an efficient narrative of the project the writer should be naive and new to the project in the sense that he/she should not be acquainted with its technical specificities. He/she should have a certain acquaintance with innovation management and be experienced in understanding (non- normative) interactions. The presence of an external non specialist writer brings the naive reader's view into the process and obliges the manager to rephrase his project in terms which can be understood by non-specialists.

The external writer will proceed to an interview (interview n_i1) with the project manager. The interview should be carefully prepared by the external writer through consulting existing and available literature on the project (*see sources*). The result of this preparation is to give the writer a first general idea about the project story (to be tested during the interview) and a set of questions to be clarified by the project manager.

Later reversing these roles, the external writer will present his/her tentative first draft of the project narrative to the project manager for agreement and validation during the second interview session (interview n_i2) during which time, if he/she is in a consulting interaction, the next step is being prepared (see critical moments table). The external writer will then prepare a revised version of the project narrative.

Sources

A documentation file should be created. It should contain existing project documentation, reports, presentations, websites. Another objective of the interview session is to identify relevant complementary sources, and to find out how they might be acquired. This documentation file will accompany the whole SOCROBUST process.

Output:

A validated two page narrative of the project (centred on the project vision). This ideal situation was never achieved in the 5 case studies undertaken, the average length being over 3 pages.

Visual: No visualisation available for this particular tool.

MODE TWO: CONSULTING INTERACTION

The main operational lessons derived from the SOCROBUST experiment in terms of consulting interaction are four fold. Before listing them, it is important to note that the first interview cannot be separated from tool 2, that is the identification and characterisation of critical moments.

(i) We suggest that all interviews are made by two persons. One person can thus conduct the interview while the other keeps track of the interview by making detailed notes (roles can be periodically reversed during the interview).

(ii) Time allowed for the interview should be between one and a half and three hours.

(iii) In case of two interviewers, a one hour meeting to prepare prior to the interview session seems a minimum (in order to exchange ideas, understandings and questions, and to prepare the interview and allocation of tasks during the session).

(iv) Immediate joint debriefing just after the meeting also proves very efficient for defining the set of critical events and for sketching a first TEN map and critical moments table.

4.2- TOOL 2-CRITICAL MOMENTS TABLE

The second tool, the Critical Moments table, complements the narrative. To produce this table, the project manager looks back at the turning points of his/her project and analyses them. By filling in the critical moments table, he/she acquires a birds-eye view of the evolution of the project over time. This view increases his/her ability to describe the project's trajectory to date, and the main factors affecting it. This representation of the innovation journey provides a powerful means of reviewing the heterogeneity of trials and tests needed to make a successful innovation.

Each critical moment is characterised in the following terms:

- date of event,
- description of event (key words),
- source of event (proactive or reactive),
- critical choice made by the project,
- solution/ outcome envisaged,
- nature of the alteration introduced in the project,
- degree of irreversibility of the change,
- state reached by the project in the innovation journey.

MODE ONE: SELF-ADMINISTRATION

Description

The objective of this step is to foster a strategic reading of the project narrative. Innovation progresses by gradually blackboxing choices that are then used as building blocks and foundations for the next steps. Project dynamics are therefore conditioned by the proactive or reactive choices of the project team. On whatever grounds they have been based, certain choices, once taken may prove difficult to displace or reopen. Re-tracing the innovation journey to date makes it possible to identify the web of constraints which channel the avenues now open to the project team. It is important that promoters/sponsors are aware of these dynamics if they are to discuss current and future options and the prevailing state of uncertainty. It is equally important for project managers to identify the key decisions taken in the past and the key choices still open for the future, as a basis for discussion with the promoters/sponsors. Project managers are generally preoccupied with the day to day aspects of management, and rarely have the chance to talk openly about the strategic aspects of their projects and even less to think back over the project's trajectory.

Process

In our experience, project managers are keen to seize this opportunity to reflect on the dynamics of their project dynamics and have no trouble doing so when provided with the proper tools and associated questions. Identifying and analysing the main events that have affected the project trajectory requires nonetheless a switch of perspective. Going through the

SOCROBUST protocol helps achieve this switch (sub-step 2). The creation of the project Critical Moments Table provides a smooth and practical introduction to a more strategic reading of the project story.

As with the project narrative, this process is facilitated by the presence of an external writer. The writer should be acquainted with innovation management, with the notion of the innovation journey and with the different possible states including research, design, pilot, prototype, demonstration, development, industrialisation, first introduction. This is important in order to move from the project narrative to its analysis in terms of more these more generic categories.

The first task of the writer is to prepare a second interview with the project manager. Following the first interview (see project narrative) and while preparing a first draft of the narrative, the writer will prepare a list of the project's key events and critical moments. He/she will fill a table form in accordance with the information provided to him/her so far.

The external writer will then proceed to a further interview (interview n_i2) with the project manager. At this meeting, the table will be briefly introduced. The list of events will be discussed with the project manager, for validation. The table will then be developed together, the project manager agreeing, commenting, amending and complementing the first draft as required (see criteria above and in the visual). A revised version of the Critical Moments Table will then be produced by the writer after the second interview.

Sources

- Documentation file
- project narrative and associated interview notes

Output: a critical moments table.

Visual: see table 3 below.

MODE TWO: CONSULTING INTERACTION

The SOCROBUST experiment led us to identify a number of tips in the case of a consulting interaction

(i) Do not start the session before making sure that the manager understands the categories of the table and associated questions. It takes 5 minutes to explain them. In our experience, the notion of irreversibility nearly always required extensive explanation.

(ii) Provide the project manager with a printed copy of the tentative table at the beginning of interview session n_i2 so he/she can comment and correct directly.

(iii) Use this copy for joint discussion and elaboration of the critical moments table. This has proved to be a very efficient way of working which puts the project manager in a proactive, leading position. The external writer's role is to help the manager think these issues through in his/her own mind, not to impose the writer's own views!

(iii) Wording is essential. Take notes of every single rephrasing or correction that the manager makes while commenting on the table. Use his/her wording throughout (especially for the

event side of the table). Prompt him/her to provide specific details (specific names, dates, items, companies) rather offer a generalised account. Suggest that he/she reinterprets the question or finds alternatives only when his/her proposal is at odds with the framework proposed (especially for innovation journey side of the table).

(iv) The lexicon of the innovation journey is another important issue. In the tests we made, we decided to work, as far as possible, with a traditional terminology for describing the R and D process. However, we introduced a few twists to the language: research, pilot, demonstrator*, prototype, demonstration* or collective experiment, first introduction.

* Actors use the term demonstrator to refer to a prototype materialisation or artefact that helps to show what can be done. By contrast, a demonstration is a first implementation of the system with lead users.

4.3- TOOL 3 — PRESENT NETWORK

The first two tools help managers represent and tell the project story. Tools 3, 4 and 5 have the aim of unfolding the project. By following these sub-steps, the project manager will find him/herself in a position to switch from a technical to a societal description of his/her innovation.

The third tool is a map. A societal map. This visualises the current societal situation of the project. To produce it, the project manager is asked to list and graphically represent the elements populating his/her innovation world. By mapping his/her innovation world according to the SOCROBUST protocol, the manager is in a position to identify, represent, and discuss the networks of people and things that are relevant for his/her innovation. SOCROBUST helps managers visualise this world in a map which is easy to comprehend and discuss with promoters/sponsors.

The map we use, called TEN (Techno Economic Network), is made of 4 poles around which we plot the social geography of the innovation project: the poles include the Science Pole, Technology Pole, Users Pole and Regulation Pole.

MODE ONE: SELF-ADMINISTRATION

Description

The objective of this sub-step (sub-step 3) is to provide the project manager with a visualisation of the innovation in terms of the heterogeneous web of linkages (between a variety of things and people) which construct and surround it. Managers are directly involved in this heterogeneous web, which forms the world of their project. Traces of this world will have already surfaced in the project narrative. Preoccupied by discussing marketing with marketing people, technology with production people, and finance and economy with their promoters and sponsors, they do not have much opportunity to picture all the dimensions of the project at once. In representing this complete picture, the map provides its readers with an immediate overview of the key items and relations to be considered. It also plots the different

spoke-persons which the project manager identifies anchored around each of the different poles. Equipped with a TEN map, the manager will find him/herself in a position to describe the current state of the societal situation regarding their innovation. The TEN map also proves to be a very useful tool for team co-ordination bringing together, on the same ground, representatives of different specialities.

Process

Equipped with the TEN tool, managers (in our case studies) were at ease and coped very well with the heterogeneous mapping of the present network of their innovation project. They are routinely familiar with this heterogeneous reality - it is part of their everyday practice - and are therefore keen to represent this world without having to slice it into multiple specialities. An introduction to the TEN technique was however a necessary precondition and some assistance on this score proved to be essential.

TEN stands for techno-economic network and is a technique developed to represent heterogeneous networks of people and things, and the relations between them, in the form of a very simple and straightforward one page diagram. The principles of the TEN have been summarised in Chapter 1 and are based on published research results (see Callon, Laredo et al. 1992). Managers are briefly introduced to these and to the main elements of the TEN instruments: that is to the concepts of actor, intermediary, and network.

The manager is then with provided the basic materials —that is a blank scheme containing the cardinal poles —with which to map the network of his/her innovation. He/she draws his/her map of the project and its alliances and comments upon this in the process of drawing it up. The interviewer's role is to help the manager complete the map and characterise the items and relations of which the network is composed. The assistance of an interviewer helps enormously in questioning and commenting upon the map: Actors involved as well as things circulating amongst them need to be carefully identified and detailed so that interactions between the various elements are sufficiently precise. The production of the map itself fine tunes this analysis, icons of different shape, shade and size being used to indicate the nature and strength of the relationships involved and to give some sense of the importance, or otherwise, of linkages between the different parts of the project network. With luck, the end result will be computerised by an assistant!

Sources

- documentation file
- project narrative

Output: TEN map.

Visual: see table 4 below.

MODE TWO: CONSULTING INTERACTION

A number of lessons have been derived from our operational experience with SOCROBUST as regards the consulting interaction. Before listing tips for improving the interaction, we draw

one clear conclusion: the project managers were actively and constructively involved in this exercise and were keen to participate, and keen to get it right .

- Time required: around 30 minutes.
- Material - provide coloured pen and a scheme on which he/she can draw.
- Training - explain the poles.
- Training (2) - show an example of mapping.
- Mapping - Encourage pole switching and renaming.
- Questions should encourage the manager to be as specific as possible in names, things and so on.
- Inter-twine technical and social dimension of the innovation: do not reintroduce specialities, treat everything the same way whether technical, or organisational.
- Take notes about the comments and enrich the documentation file with it.
- Take a copy of the map at the end of the session (the project manager should keep the original).
- Computerise-copy the map later with the help of the notes but do not change the positioning, naming, sizes, or colour of the elements involved.
- De-scription and representation - rules of thumb:
 - Identify actors and position them in relation to one another in the space of the map;
 - The centre of the map indicates the most central element (polar), the margins contain elements most marginal to the innovation;
 - Qualify links by arrows (use double or single arrow for direction, thickness to indicate irreversibility).
- TEN was conceived of as an evaluation tool and although it could have an ex-post use in feeding the assessment stage (see Callon et al. 1992 for guidelines), we restrict ourselves here to its role as a de-scription tool as part of the first Step. The main criteria for assessing the map as a whole are:
 - Length — connection to poles/ are all the poles required involved?
 - Completedness — poles internal diversity/ are all the competences needed gathered together?
 - Alignment — are the different actors willing to work in one direction?
 - Polarisation — does the project manager have enough co-ordination power?

4.4 - TOOL 4 — FUTURE NETWORK

The fourth tool is formally the same as the third in that it too involves the application of the TEN mapping techniques. Its content is however very different. Project managers are invited to list and graphically represent elements (actors and artefacts) populating the world of the innovation once it has become normal and once it is diffused. The map of the future network goes further in helping managers unfold their project, and in this it helps them articulate their own vision of the future and answer a series of questions including the following: how will the innovation look when its goals have been realised? What network of things and actors will it link together? Who will be using it and how? In short this exercise will put them in a better position to visualise, expose and discuss their vision with others.

As in the case of present network, the mapping is organised around 4 main poles: the Science Pole, Technology Pole, Users Pole and Regulation Pole.

MODE ONE: SELF-ADMINISTRATION

Description

All projects embed a script for the future (see positioning paper), that is they are based on a bet about the occurrence of a certain future, and the chances of realising a preferred scenario (fictive script). For most of the time, the scenario and the bet are not clearly formulated. This is partly because standard methods of project evaluation and control encourage project managers to minimise uncertainty and ambiguity. For whatever reason, our experience suggests that these aspects are not usually made transparent, not even to the project managers themselves.

The objective of this sub-step is to provide the project manager with a visualisation of the future as he or she pictures it. The TEN map of the future world elicits the ideal situation for the proposed innovation. Other readers will see in the same map a simple and synthetic overview of the manager's ambitions for the future. Such an overview will facilitate discussion of the bets, the scenario, the uncertain zones and the future because it highlights key but currently fragile elements on which success depends. The use of the same format for mapping and representing both the Present and the Future network in itself encourages comparison and analysis of the changes involved.

Process

Our experience with managers reveals two things. First, project managers are not usually in a position to spontaneously elicit the script for the future at which they aim. On the other hand, once equipped with the right tools, and with the assistance of a skilled interviewer, project managers were very keen to describe their vision of the future.

There is no need to introduce managers to the TEN, since that was already done in sub-step 3 the present network. A skilled interviewer is nevertheless highly recommended since the interviewer's skills include those of understanding the process of developing the project's vision, and the capacity to imagine and question the virtual world which is in the project

manager's head, in a detailed, constructive and practical manner. During the interview, the main line of questioning will have to do with the general economy of the future network of people and things amongst which the innovation will circulate and within which it makes sense with reference to the four poles of science, technology, regulation and uses.

The map is again organised around the same four poles. Again the map describes the people and things at stake and the linkages between them. If we take the user pole as an example, what might the main categories of users be? Will they be organised? Are they separated or linked with one another? How are they related to the artefact? What will be the main artefacts? What will circulate between them and the rest of the network (money, software, PCs, datasheet)?

Source Documents required

Existing documents. These should help identify relevant categories and central features of the future world.

Output

The future world map (one page representing the web of actors and links around which the project has been built).

Visual: see table 5 below.

MODE TWO: CONSULTING INTERACTION

The main experimental lessons derived from Socrobust in terms of consulting interaction are quite similar to those mentioned for the present TEN: the process requires extensive involvement on the part of the project manager, and requires a similar duration (around 30 minutes), similar material (an empty scheme and coloured pens with which to construct the map), it promotes a similarly pro-active attitude towards the scheme (favouring pole switching and renaming).

There are however important differences.

- The phrasing of what is expected is important. This exercise requires a short introduction like: now imagine a world in which XTX is successful and diffused. What would this world look like? Within what web of interactions would the innovation move?
- Let the manager draw a first general map (what are the main people and things, and the main linkages involved).
- Once the general picture is in place, encourage the manager to specify and develop what he/she has drawn in further detail. This is critical for the process since managers will most often remain at a rather general level and disclose generic categories of actors and things (users) rather than specific names, dates, places, and details. Then question him/her about the links and interactions between the different items represented.

4.5 - TOOL 5 — CRITICAL ACTORS TABLE

The fifth tool could have been an annex to the third and fourth given how closely they are linked. For the sake of clarity we have chosen to distinguish between them despite the fact that they are produced through the same process. The Critical Actors Table is both a complement to and a product of the TEN maps. It summarises, but in a different form (this time a table) further details about key items represented in the maps: in effect the Critical Actors Table works as an hypertext of the maps. It was designed to fulfil the function of a double-click-box: select one actor on the map, double click on the actor-icon and get further details and comments regarding this actor's strategy, alliances, involvement and importance to the project. Since there is as yet no software version of SOCROBUST, separate maps and tables are used.

Actors are characterised in terms of their importance to and involvement in the project.

Importance is characterised by:

- actor's centrality within the pole,
- actor's specificity/substitutability,
- actor's centrality within the network.

Involvement is characterised by:

- actor's motivation to join the project,
- actor's objective in contributing to the project,
- importance of objective relative to the global strategy of the actor's organisation,
- strength/irreversibility of actor's commitment,
- alignment towards/agreement with the project manager's objectives.

MODE ONE: SELF-ADMINISTRATION

Description

Maps and graphs help picture the state of the innovation network at a given point in time. This is a necessary step to identify all the components of the network that support the innovation project. However there is a need to know more about each component. Here we focus on social actors only. Such expertise, which managers deploy intuitively, is seldom articulated in a systematic manner. This is the role of the Critical Actors Table. It prepares managers to describe, and answer detailed questions about the components necessary for the project's future. It allows them to systematically review key actors' positions regarding the project, paving the way for a strategic analysis of further actions required to enrol/align elements that are only loosely connected but which are important for the success of the innovation (see assessment step).

Process

The deployment of the critical actors table follows logically from the project manager's description of the present and future networks of actors that count and will count in their innovation future. Our experience demonstrates that the assistance of an external interviewer is

important to review in detail the participating actors and the nature of their involvement. Listing and positioning items (that is both actors and material artefacts, including those that are being developed and those which support the interactions between actors, and which we call intermediaries) is a relatively straightforward exercise for most project managers. So is the qualification of their relative importance for the project. Analysing the degree of commitment/ reliability of these actors for and to the project, understanding the web of alliances from the actor's viewpoint rather than from the project/manager's perspective, identifying the circulation of intermediaries and things materialising relations within the network is another matter. For unpacking this level of the de-scription, the presence of an external interviewer appears once more to be an important resource.

The interviewer needs to be trained in the TEN principles and practices. He/she should be aware of three crucial points for de-scription:

- Actors' accounts have to be handled carefully. In ordinary conversation, the involvement of an individual is often conflated such that the interest of one person or a particular team is mistaken for interest on the part of the entire firm/organisation to which they belong. The specification of interest is a key variable in the analysis and assessment and should not be taken for granted. The interviewer needs to ensure that the representativeness of spokespersons is properly analysed, i.e. what is the capacity of the representative, that is of the actor involved (this can be a non human actor such as a market study), to reflect/convince/act on behalf of the organisations they are taken to represent.

- Actors' importance is an evaluation of the degree to which they are substitutable by others offering similar competences in the outside world, it is an evaluation of their credibility/legitimacy in the outside world (i.e. is the network facing a monopoly position?).

- Actors' position and involvement in the project is another key dimension which requires careful clarification. The first line of questioning concerns actors' strategies and the extent of their convergence/alignment with the global goals of the project. The second line of questioning concerns the extent of their attachment to the project. Intermediaries that circulate within the project network are good indicators of the strength/ irreversibility of attachment to the innovation. These markers consist of the intermediaries exchanged (*modes of co-ordination*), the strength of the relations in which they are involved within the network (i.e. *frequency* + presence of *infrastructure and rules* for exchange) and the investment they have made in the project so far.

The external interviewer will use the second interview (interview n_j 2) with the project manager to pursue the lines of questioning mentioned above. A list of key actors will be defined in conversation with the project manager and entered into the critical actor table. Criticality will be defined as a function of actor's capacity to influence the definition of the innovation. The categories on which the table is based will be introduced to the project manager. The table will be filled line by line, and actor by actor, by the project manager and the interviewer, working together.

Sources

- Documentation file
- Present Network

Future Network

Output: A Critical Actors table.

Visualisation: see table 6 below.

MODE TWO: CONSULTING INTERACTION

The SOCROBUST experiment leads us to offer the following tips:

(i) Do not start the session before making sure the manager understands the categories of the table or before any associated questions have been answered. It takes 5 minutes to explain the table. Differences between an individual actor's goal in the project and his/her organisation's global strategy need to be clearly identified. The attraction which the network exerts on actors (modes of co-ordination/ strength) requires explanation.

(ii) Provide the manager with a printed copy of an empty table at the beginning of the interview so he/she can fill it in.

(iii) Use this copy for purposes of joint elaboration.

(iv) Wording is crucial. Take notes of the manager's comments and words. Use his/her wording in constructing the table. Only suggest rephrasing when his/her proposed terminology does not match the criteria.

(v) The identification of critical actors is necessary but it is not sufficient. It is the specific context of actors' involvement which needs to be understood. One key element for analysis concerns the nature of the intermediaries which are exchanged with others. It is important to know the conditions under which intermediaries circulate (are there official rules, does this circulation require a specific infrastructure or logistics), their space of circulation (is it restricted to network members or to a subset of members, and if not, who is involved outside of the network), and their relative importance in shaping relations (frequency of exchanges, mixes of intermediaries that link members or given subsets of the network).

(vi) Intermediaries and their circulation can be characterised in terms of 6 modes of co-ordination, according to Callon, these include: Hierarchy, Market, Trust (see institutional economics), Text and documents (that is codified knowledge), the mobility of People (that is embodied knowledge), and Material artefacts or technical devices (see science studies). It is rare that relations are based on only one mode of co-ordination. It is the mix of modes which counts. It is also rare that the materialisation of relations merely requires the existence of a generic infrastructure. It is therefore important to track the specific arrangements made which allow circulation between actors (e.g. the logistical arrangements needed to make samples usable, or the property rules governing their use).

(vii) Estimates about the flexibility and reversibility of involvement can be made. It is very likely that this will not be visible in ordinary forms of project documentation. Nonetheless, an evaluation of the nature of linkages built to date constitutes an important dimension of the consulting interaction. For example there is a world of difference between having one actor entirely depend upon another for all the blood sample he/she needs and a situation in which an

actor is able to make use of samples provided by the project network, this being one amongst other possible sources.

4.6 - TOOL 6 — FUTURE WORKING WORLD

The sixth tool, the visualisation of the future working world, goes hand in hand with the fourth one, that is the visualisation of the future network. It is conceived of as an extension of the future network, which focuses on anticipated market institutions rather than on the implied future network in general. While the future network exercise was designed to produce a map describing the main actors, intermediaries and relations comprising the project's future script, the *future working world* is a tool designed to reveal the infrastructure necessary for the emergence of a market for the new product/service in question and to articulate the contexts in which the necessary transactions become possible. Building on differences between visions first of the present and the of the future network, the map of the future working world reveals two classes of necessary infrastructure: those which already exist and those which have yet to be built.

Criteria and indicators used are as follows: the existence (or otherwise) of

- markets with clear competition rules,
- lasting policy regulations,
- stabilised technological competition,
- customers that can be segmented and become the object of classical marketing studies,
- prescribers that discriminate between different alternative products.

Description

Bringing a very innovative service or product into economic life is a remarkable achievement in its own right. Developing a market that is capable of extracting value out of this innovation is a second essential requirement. The map of the future network deals with the first issue, that is with constructing a world of people, institutions and things and of carving out channels through which an innovation can circulate. The objective of this sub-step is to prepare managers to content with the second issue: that is of building a durable market infrastructure encompassing institutions, organisations, stabilised links and centres of calculation within which the value of the innovation can be meaningfully assessed and within which relevant exchanges can occur. All this is required to describe the future stabilised world. In other words, project managers are invited to identify what part of the necessary infrastructure is already in place, what needs to be modified and what needs to be created. The protocol for constructing a future working world directs their attention to three key features, namely the role of users, producers and prescribers. This de-scription helps to explore / render explicit changes other than those which have already been taken account of in the project but which are nonetheless necessary if the innovation is to become firmly rooted in society.

Process

This tool has a specific story. It has been developed in the process of the implementing of SOCROBUST, that is of learning by doing. While working with managers trying to articulate their visions of the future, we realised that it was not easy for them to visualise a future market infrastructure by simply looking at a classic TEN map of the future network. We therefore created a specific tool designed to represent the market infrastructure and its institutional dimensions. Our experience with this tool is consequently limited and experimental. Effective implementation would probably require further development.

We propose to focus on an analysis of the future object/service (i.e. the innovation in practice) under circumstances of routine application, starting from the micro level of the delivery of the product/service in question and working out to consider the relevant categories and practices around which this new world is built. To do this we use a simple triangle, based on four main categories: a) the users and b) producers, as usual, but also including, c) the prescribers (i.e. actors who channel final users toward the product or the service, for example, general practitioners in health, consultants in business, other experts, including advertising and distribution channels for manufacturing products) and d) institutions / infrastructures which facilitate relevant exchanges taking place over time in a satisfactory manner (standards being a well established and well documented example of such an infrastructure).

The set of questions to tackle include the following:

- What general infrastructure is presupposed in order that the new product or service might shape its own market?
- Does it require new regulations (such as those for wind energy), new standards (like safety rules for electrical devices), new labels (like GMO free products), and the like?
- What changes in the physical infrastructure are required (like a new conception of the grid for decentralised energy production)?

Output: A chart of the Future working world which describes organisational/ institutional aspects of the expected market

Visual: see table 7 below.

4.7 - TOOL 7 — KEY CHANGES TABLE

The seventh tool is based on a comparative reading of the maps produced by tools 3, 5 and 6. By comparing the future world to the present network, the manager can identify the main changes required in terms of material infrastructure, practices and rules of the game in order that the anticipated future world becomes a reality. The idea is to identify and characterise the four to five crucial changes necessary for the innovation to work and be adopted in practice.

Each key change will be described in terms of the following characteristics:

Characterisation

- what is the aim of the change (i.e. what is the blackbox aimed at),
- what other practices, rules, artefacts will be displaced by the change,
- which actors are affected by it,
- what is the extent of the change,
- what is the rate of change.

Levers

- what are the critical factors for implementation
- what features should be prioritised,
- what are the most appropriate points of entry, i.e. points from which to initiate change
- what opposition is expected.

Description

The objective of this step is to focus attention on the few crucial assumptions which the project makes about its present situation and about the future.

Process

In our experience, properly equipped managers were quite at ease with the exercise of simply mapping present and future networks. However, they found it more difficult to isolate and articulate the changes implied by their vision of the future working world. This is the reason why we consider that the process, in its present state of development, benefits from the presence of an interviewer who can highlight questions and focus discussion so as to help managers pinpoint the main changes required.

Comparison between the present and future networks and the chart of the future working world chart provides a useful starting point. The set of questions to then ask/answer about the new product/service can be summed up as follows:

* What will it do and how different is this from today? Whom does it address? Whom/What does it replace? All these give important clues about potential sources and forms of opposition.

* How does it work? What is inscribed in the product/service (prescriptions, interdictions, options for use, etc)? What new competences are required and how far do they differ from those which users have today. This second set of questions seeks to clarify two complementary dimensions: first, what past irreversibilities have to be destroyed and

reshaped into new ones consistent with the product/service in question; second, how important is the product or the technical devices linked to the service in question in shaping relations and markets.

The key changes table lists the changes foreseen. This is solely a descriptive table with an entry per key change identified. The idea is to have a list of changes which evolves over time and which therefore records, at different points in time, what has already been integrated into the project, in other words what has been internalised in the project network, and naturalised by all the project's stakeholders. This continually updated list will give a sense of what has been learned about the societal transformations required.

Key changes are likely to concern different infrastructural aspects of the innovation, for example

- in the rules of and for competition,
- in forms of representation, in representatives and/or spokespersons,
- in values, norms or standards.

The description of key changes should say something about their scope (for example, which category of our template do they concern?), extent (how radical is the anticipated change? how rigid are aspects of the present situation which have to be overcome?), and likely duration.

Changes have also to be described in terms of the new factors involved (e.g. do users have to separate their waste in new ways?), ways of influencing these factors (e.g. through the provision of ad-hoc training for each household), and appropriate points of entry (e.g. through working with children in schools, or via caretakers or housing managers). It is also important to record established or potential opposition to the proposed change (opposing points of view should be described in a few key words).

Output: key changes table

Visual: see table 8 below

4.8- TOOL 8 — EXTERNAL CHECK

The assessment step differs from the preceding steps in that it has been conceived of and tested as a form of consultancy, not requiring the direct involvement of project managers. As a result, there is nothing to say about how this step might be self administered. We therefore continue with this presentation assuming that managers interested in the societal robustness of their project have hired a consultant. In practice, we do not think there would be any problem adapting the approach so that trained managers could do it for themselves, (but this remains an hypothesis to test). Another development of SOCROBUST would be to design and test a self-evaluation tool to be incorporated in the project management package.

The assessment step involves standing back from the project and testing the societal robustness of its main assumptions. This requires two sub steps: the external check - in which information is gathered about the state of art and of knowledge relating to each key change identified (see key changes table), and the positioning table which assesses the project s robustness with respect to each key change. The two sub steps have been kept simple, cheap, and easy to run.

The eighth tool is a web search. The key changes table identified the main bets which the project makes about the future. These key changes relate to the project manager s core assumptions about the future of the innovation. The web search transforms these bets and assumptions into a set of questions which require clarification, and identifies the principal positions taken on these questions in the world beyond the project itself. The result is a table which summarises these positions along with their most significant arguments and which details the experiments and tests undertaken to date regarding each key change. Our experience showed that managers valued this output which, in three of the five case studies undertaken, led them to modify their approach to at least some of the problems facing the project.

Two aspects were considered for each key change: the first concerns relevant positions taken by others in the outside world. The second has to do with the artefacts per se.

Position

- general statement about the intensity, the variety, and the nature of the positions taken and the stage reached by the debate,
- list of arguments developed for each position,
- list of proofs, experiments, theories, authorities mobilised,
- who is talking (what organisations and who in the organisation, and with what authority),
- who is reading (not always easy to determine on the web, but debate and references are indicators).

Artefacts

- general statement about availability, diversity, and nature of the available artefacts and the state of competition,
- list of alternatives and their characteristics,
- stage of development and horizon for maturity,
- who is producing (what organisation, what core business, capacity to push it),

- general statement about how the artefacts might be used.

Description

The objective of this step is to put the project's assumptions about the future world into perspective and to specify alternative views and scripts of the future shared by the other actors concerned. More and more companies and organisations use economic intelligence, technology and competition watch to inform their innovative projects. Managers are used to appreciating the diversity of alternatives and the uncertainty that characterises innovative projects. The first distinctive feature of this approach, as compared with conventional methods of technology watch or benchmarking, lies in its close relation to the analysis and identification of the project's founding assumptions about the future: what is tested is very specific to the project and concentrates on just these zones of uncertainty and the debates associated with them.

The second distinctive feature relates to the dimensions considered for analysis and test: three main dimensions are investigated, namely, the technological landscape; the legal, administrative and regulatory environment; and the future market.

The resulting document provides material that project managers can use to learn more about the other actors involved in connected projects and about a range alternative strategies they might adopt.

Process

We were impressed by the amount learned from very simple, although methodologically precise, web searches taking no more than one or two days. These searches consistently revealed as yet unexplored data relevant to those managing innovative projects. Paradoxically, it took longer to summarise and represent this material in a convincing manner than to search for it.

The External check is a simple and rapid method based on lessons from the sociology of knowledge. It makes two main assumptions:

- knowledge is always debated before becoming entrenched. It is therefore possible to follow knowledge dynamics by tracing arguments and controversies.
- If an idea or a debate emerges, there will be publicly available traces of it: the web appears thus as a clear resource.

What is looked for

The External check has to do with cyber-geography(*) i.e. mapping the different positions adopted on the web on one question. The information gathering process is one of tracing:

- debates (positions, arguments, figures and calculation, proofs and experimentations),
- fora and actors concerned and implied - as related to relevant aspects of the key changes (where are debates located and where are positions are expressed, who are the actors involved, how are they linked together/affiliated).

* Cyber-geographers are specialists in mapping the different communities living on the web.

Where to search

External checking relating to key questions will focus on three main areas depending on their nature:

- technological landscape (scientific and specialist reviews sites),
- legal and regulatory authorities (sites for governmental, ministerial, and public authorities),
- future market (sites for consumers and users representatives, industry and trade associations). This can be done by consulting specific parts of the web and associated databases (for example, using the ministry of health search engine to identify specific rules regarding the reimbursement of costs for diabetic care) or/and through generic search engines using terms from the key questions and translating these into key words (For example, in Google: diabetes care reimbursement then diabetes care reimbursement + policy + patients + device).

How the search is done

First, key questions are translated into a list of key words. Wording is crucial here and should be prepared with care by the consultant. Key words fulfil two functions: to *specify* the originality and uniqueness of the innovation, and to *situate* the innovation in the wider world. Key words should correspond closely to the specific features of the project as described by the project manager, pinning down original features and details and identifying more generic categories within which these specific features and assumptions are embedded. It is important to refer to the project manager's specialist vocabulary and at the same time locate the families/communities within which these terms are recognised.

Second, key words will lead the external checker to a number of sites displaying documents of interest regarding the quest. For each hit, the document and its arguments will be contextualised, that is to say the context of their production will be noted (who is writing, who is editing, who is publishing, when was it published, how did it evolve over time, what are the references and sources...). In this way, the arguments are identified as are the contexts in which they are mobilised, this being used as a measure of their social significance and weight. Just as previous steps have served to contextualise actors' social position, so the social authority of competing claims can be clarified (in which organisation they are, how legitimate they are, what alliances and oppositions they are facing).

The final step in the external check is for the consultant to write a synthesis of the main positions identified, of the arguments mobilised, and of the most interesting material revealed by the search relating to each key change.

Sources

The project documents and interview sessions

The web

Output

A document synthesising the project's key assumptions for the future (this is, de facto, a significant document, since it specifies why it is necessary to question the project's assumptions regarding selected key changes).

4.9 - TOOL 9 — POSITIONING TABLE

Following the external check, the ninth tool is an assessment of the project's societal robustness. The external check involved an exploration of the outside world, documenting alternative positions being taken with respect to the key changes on which the project depends. The positioning table formalises these insights to produce a diagnosis of the project's robustness. This diagnosis identifies the project's relative strengths and weaknesses and identifies key obstacles it is likely to confront in the future. By so doing, the positioning table provides an evaluation of the project's vulnerability, as it is presently configured.

A radical innovation's robustness is defined in terms of the quality of its anchorage in three public spaces: the technological community; the legal, administrative and regulatory environment, and the world of design, uses and markets. In each of the three spaces, the quality of the embedment/ anchorage of the innovation is evaluated according to the cross cutting analysis of 4 main criteria:

- Project focus/position;
- Potential allies and existing alignments;
- Potential opponents and existing alignments;
- Main challenging alternatives/positions.

Description

The success of radical innovation projects depends on the project team's ability to offer a sound technical solution (design) for an emerging market. As economists know well, an established market is built on 3 pillars:

- shared technological knowledge,
 - shared rules and infrastructures of competition,
 - agreement about product/service qualities,
- so that the only uncertainty left is that of pricing.

The literature reviews we undertook showed that successful radical innovations always involve significant disruption in at least one of these three dimensions —technology, regulation, and/or design-uses: it is precisely because their success involves the radical transformation of one or another of these three market pillars that they qualify as architectural/radical innovations.

Achieving radical market transformation is never straightforward. Innovation studies are full of beautifully innovative ideas that crashed spectacularly and failed to transform the market in the desired way. One condition for success is the management of the societal dimension: the

innovation needs to be shared and accepted among certain key communities, institutions and organisations. For instance, if the project is to move a technological frontier, its potential contribution must be acknowledged by recognised experts and interested technologists: in short, it needs to be accepted as such by them if it is to become robust. Societal robustness is unlikely to be achieved without the active involvement of the project team, even if the necessary changes and developments have to do with events and actors beyond the team itself.

Science and technology studies (and especially those focused on technology assessment and the acceptability of new techniques) show that such processes of social construction (which is assimilated to a blackboxing process, cf. principles) typically involve three phases: one in which a problem or issue is recognised, one in which it is debated, and one in which the debate is closed.

- The opening phase corresponds to the designation or definition of recognised places in which people talk or write about the issue in question. Different terms have been used to describe such arenas. We prefer, following Callon and Rip, the word Forum.

- The forum is the place where different views can be formulated and where controversies can develop.

- Closure requires a process of collective resolution/ codification of debate (and often of valuing different aspects of the issue so that comparisons can be between alternative proposals). Closure happens when opponents stop presenting dissenting view because they are running up against arguments, evidence, social alignments, interests and cultural values, many of them interrelated and therefore lending support to the dominant view (Rip, 1986).

During the process of social construction, and until one solution becomes entrenched, uncertainty is high, since it is usually difficult to predict which alternative will finally be selected as the solution. This has two major implications for project management. First, the level of uncertainty about the future outcome is an indicator of the risk taken by the project. Second, the relative influence of alternative approaches and solutions is a function of the network of alliances built and of the authority granted to one or another network in the shaping of recognised, accepted or best practices.

The project positioning table summarises our evaluation of the project's societal robustness along the three dimensions of the future market. The resulting positioning table describes the state of the current project in terms of two criteria: (a) prevailing uncertainty and (b) the relative strength of the project's position (compared to alternatives).

Process

In our experience, the construction of the positioning table was relatively straightforward once a quality web search and external check had been performed. In our five case studies, the evaluation sessions (after the report had been delivered) showed that project managers had to anticipate the future characteristics of the market and assess the extent to which their project complied, if they were to make sense of the positioning table. All those encountered in the course of SOCROBUST were used to envisioning the future and anticipating future markets. However, this tended to be an intuitive rather than a systematic enterprise. The

positioning table helped in formalising an analysis of the project's present strengths and weaknesses regarding its future embedding in society. The tool helped managers test their visions of the future in a systematic manner and to thereby identify zones of uncertainty and potential obstacles to their project development.

Gathering material

The basic materials with which to conduct an assessment include the key changes and the results of the external check. In our case studies, it helped that the same consultant performed both the external check (or at least part of it) and the assessment. The reason for this is that exploring the web is itself a learning process. Because only the most significant information is represented in the synthesis of results, the web searcher him or herself knows much more than is written down.

Material reorganisation

Collecting material does however do the trick alone. The assessment process also involves a reading and an organisation of the key changes and the results of the external check with reference to the concepts and criteria of robustness for each market pillar. Assessment criteria are then applied in order to identify and characterise present uncertainty and to take stock of the project's societal robustness in each of the future market's three dimensions.

Criteria used for assessment

Uncertainty is used here as a measure of the ease and confidence with which a final selection can be made from the range of alternatives.

The main questions are:

What is the likelihood that the project's bets prove correct?

What is the likelihood that a competitive project wins the game?

- number of unaligned approaches
- respective strength of alternative approaches

How well is the project prepared to lose or to cope with and respond to unexpected events and turns?

- how important is the position tested to the project's future success?
- how well is the project prepared for alternative scenarios?

Societal robustness relates to the extent to which the project's position converges with those adopted in the wider world, as revealed by the external check.

How well does the project link up to emerging/booming trends in society?

Where does the project stand with respect to the most widely accepted beliefs and views within the community?

How well equipped is the project: what resources does it have with which to enforce its position:

- presence /absence of project representatives, views, position in the relevant forum,
- authority/ legitimacy of the project representatives/ views in the forum,
- level of organisation and interconnection of the allies/spokespersons,

- level of development and organisation of potential opponents and counter-programmes. How well prepared is the project team should the anticipated future come about?

The table is a scheme facilitating both a synthetic presentation of relevant information revealed through the web search, and an assessment of the project's position. It is used to support dialogue between the consultant and the manager (interview n;3). The dimensions of the table need to be explained to the project manager before each is reviewed, commented upon and discussed. At the same time, discussion of the table provides an opportunity for the project manager to say more about his/her own position and produce further arguments with which to defend the project's position.

Output: A three page table assessing the project's assumptions and bets regarding the technological, regulation, and market future of the innovation.

Visual: see table 9 below.

4.10 - TOOL 10 — CAPACITY FOR ACTION TABLE

The 9th sub step of the Socrobust project provides an evaluation of the project's robustness. It identifies the strengths and weaknesses of the project as it stands at the time of the analysis. This view remains static in that it takes the current project position as given and immutable. However, project managers do have room for action and transformation either by better adapting their projects to an expected future world, or by acting to shape the future world so that it is more in accordance with their innovation. It is nonetheless important to recognise the limits of their action: project promoters are not always in a position to change or influence the world. The last step of the SOCROBUST process seeks to identify the project managers margins for manoeuvre and his/her capacity to position the project so as to enhance its chances of success. The idea is to pin point, in a one page table, alternative courses of future action. This table is the logical outcome of the previous sub-steps and provides the project manager with a clear document outlining his/her main options for action.

The project manager's capacity for action is considered with respect to each of the three public spaces that build the future market: the technological community; the legal, administrative and regulatory environment, and design, uses and markets.

Criteria for identifying capacity for action are:

- project goal/ zones of uncertainty/ main weakness,
- extent of the change required,
- room to amend/redefine the project,
- existence of a debate, forum, technological community,
- project team's ability to influence the debate, forum,

- project manager's resources, alliances, means to contribute to the debate, participate in the forum.

Description

The positioning table acknowledged the weaknesses and obstacles that could hamper the development of the future market for the innovation. The objective of this sub-step is to then identify the project team's capacity to act and react so as to minimise these risks and improve the management of the project's societal dimensions.

Each of the three future market dimensions is studied in a distinctive way as regards the robustness assessment and the capacity for action. For example, the challenge of promoting technological devices for matching organ donors with organ recipients requires types of action and forms of networking quite unlike those which would be needed to influence national policy on the ethics of allocating donated organs.

As we have seen, the basic mechanisms of social construction are, however, the same for all dimensions of the future market. All have to do with building the project's societal robustness by identifying the relevant forum, by participating/shaping controversies and debates, by finding adequate project representation, or by promoting a converging position /codification that would be favourable to the innovation.

Establishing a project team's capacity for action requires two sorts of investigation. First, identify the project's weaknesses and recognise the kind of action needed. Second, evaluate the project team's ability to implement relevant actions in the desired direction.

The objective of the capacity for action table is then to make a statement about both desired actions in each of the three main market dimensions, and to describe the project team's possibilities for effective action. This tool complements the previous one by identifying plausible courses of action and practical options for improvement.

Process

In our experience, managers' first question, following discussion of the threats their project faces, is about the specific actions they might take in response. This is precisely the question which the capacity for action table addresses, that is, identifying potential courses of action that would increase the project's societal robustness, and determining how well prepared the project team is, or could be, to carry out these actions.

Although a different exercise, the process of determining the capacity for action complements the robustness assessment. The same practical protocol is used in the two cases: a consultant is in charge of organising and first interpreting the material gathered (key changes, external check and positioning table) and of discussing this interpretation with the project manager. This is done for each of the three market dimensions in turn, although certain weaknesses may have implications across more than one dimension.

Recognise the kind of action needed

This analysis focuses on sources of uncertainty and potential threats to the project. Each weakness needs to be translated into a specified target for action. Building on the results of the positioning table, already identified threats are used as key entries in the table. The central challenge here is to translate generalised threats into a series of relevant and viable steps for preventative or promotional activity. Detailed specification is crucial. For example, the project manager will not be in a position to promote new software for matching organ donors and organ recipients which will replace the existing Microsoft medical platform, but might realistically look for ways of developing software for matching organs which might become a widely used plug-in which exploits the Microsoft Platform. In other words, weaknesses should be translated into targets for actions with as much precision and realism as possible. The more generic the transformation required, the greater the strength and investment needed to bring it about. One question here is then to realise when action is needed (by the project team) and when necessary changes are likely to occur on their own.

Specifying possible actions

Targeting actions and identifying practical goals is one step. The next one is to clarify mechanisms that could lead to the desired changes. As we have mentioned, societal change is not straightforward and always implies a collective dimension that usually lies beyond the scope of the project team's influence. One common feature in the dynamics of the three public spaces considered is the existence of controversies, of forums where they develop and of processes of alignment through which debates are closed. A sound strategy therefore consists of:

- (i) identifying places and actors relevant to each specified change
 - who are the actors that will have the authority to judge?
 - where do they meet?
- (ii) analysing the stage which the collective dynamics of change has reached
 - is there an established audience?
 - is there a collective competence?
 - is there an established forum?
 - is there an established institutional framework for this forum (is it ad hoc existing for other purposes)?
- (iii) determining the most efficient strategy for interaction
 - how developed is the field?
 - how strongly established are organisations already in the field?
 - how concentrated is their authority in the field?

Modes of actions must take account of the stage reached in the dynamics of change and the structure and rules of the game in each case. Much depends upon the reach and scope of the public space in question. Is the challenge one of making all relevant participants (to the forum) converge on a favourable view (for instance agree that there should be one common tariff for micro combined heat and power systems), or is the challenge one of forging alliances with the main manufacturers of micro-combined heat and power systems and of offering them incentives to adopt the desired tariffs?

Evaluating margins for manoeuvre

The consultant finally evaluates the project manager's ability/ capacity to undertake the types of action proposed. Three dimensions are taken into account:

(i) the legitimacy and/or credibility of the project team as measured by past actions of a similar kind and their impact on the relevant forum. This has to do with questions of trust and reputation in the field;

(ii) the project team's resources and the potential allies/ spokespersons that can be enlisted to influence scientific debates, rules of the games and infrastructures, and/or users' behaviour.

(iii) the flexibility/ adaptability of the project definition with regard to the aspects under focus.

Does the project depend upon a favourable outcome: can it survive if things turn out differently, can it adapt to at least some of the alternatives and variants under discussion. When the existing environment is well established and/or unlikely to change, and when this prevents effective realisation of the proposed innovation, one obvious response is to adapt the characteristics of the innovation to better fit the existing situation.

The capacity for action table provides a synthesis of this analysis. Equipped with this material, the consultant proceeds to an interview with the manager (interview n₃). Points for discussion concern recognised threats and their translation into targets and desired lines of action. Following this discussion, the manager will be well placed to a) reconsider his/her position and some of the characteristics of the innovation in question and/or b) develop a proactive strategy to optimise the societal context for the future diffusion of the innovation.

Sources: External check and positioning table.

Output: One page capacity for action table highlighting possible courses of action and the resources available for them.

Visual: see table 10 below.

4.11- FORMATTING RECOMMENDATIONS

The purpose of the capacity for action table is to establish the margins for manoeuvre within the project. There are strong relations between a given positioning (as represented in the positioning table) and the types of actions that can be thought of, e.g. the non existence of a relevant forum calls for either the redefinition of the project (such that this no longer constitutes a problem), or for steps to be taken to create such a forum. Recognition that the project (and/or project team) occupies a marginal position in a given forum can have a number of practical implications. It may mean that the project should retain the capacity to react (to agreements reached by others) and remain flexible (to avoid or side-step actions which lock-in or fossilise aspects that are under debate elsewhere); or that it should take steps to become

more involved and to invest more heavily in shaping debate and facilitating agreement around a favourable conclusion - again this may involve using resources (of time, money, energy etc.) that could be directly invested in project development).

In the 5 case studies we undertook, our recommendations revolved around actions which reflected the project's present position within the space for debate. The following box lists the action-oriented vocabulary we used for this purpose. An average report used 5 such terms, thus proposing that a combination of actions be undertaken. This suggests that the task of enhancing societal robustness does not resolve into a single package of work (or workpackage to use EC jargon). In most cases, each of the three dimensions (technological, institutional and market related) required ad-hoc responses, and case-specific actions and strategies.

The action vocabulary used for recommendations made

Source: the 5 socrobust reports made.

Monitor (a given controversy, the emergence of organised groups, the legal environment and the debates about possible change...)

Reflect upon (the routes not taken)

Think about, Explore (possible other routes, options)

Build, prepare, establish, or contribute to/ encourage such actions (a forum, a community, the naturalisation of the project within an identified forum)

Discuss (the model underlying the project with other actors in the project)

Strengthen (the links between actors in the project)

Take care of (the involvement of adequate actors and their participation in the experiment)

Exploit (the potential included in the present project avoiding too early choice)

Extend, enrol (other actors)

Develop (demonstrations, given attributes...)

Abandon (a given route or given ambitions).

There were four further lessons to be drawn from our experience.

(i) in all projects there are dimensions which lie beyond the project's margins and outside the project team's room for manoeuvre but which appear central to the project's future success. These have to be passively monitored on a on-going basis, so that actions can be taken, as soon as events unfold. Monitor is the relevant action verb in these instances.

(ii) Most projects can however be pro-active and actively shape their markets (cf. Courtney), for example by actively creating, building, or establishing an adequate space for debate, or at least contributing to and encouraging its emergence. They can also be more active within existing spaces, for example, in pushing forward their views, and in fostering their take-up by other relevant groups.

(iii) The innovation journey had typically generated irreversibilities in the project trajectory. However these irreversibilities were quickly forgotten, especially after some time. In practice, most of the projects we reviewed had had a de facto life of over than 5 years. In some cases, other competing projects had made different choices and kept open routes abandoned by the project in question. The result is that the projects studied had difficulty in understanding the terms of competition with the other identified projects. Were they, or were they not, in the

same game? This led us to propose action verbs such as reflect upon (routes not taken), and/or think about , explore (possible other routes) and in one case, abandon .

(iv) Many action verbs address the present network or the one that should exist following the actions on-going or under consideration. Many relate to actions to be undertaken and compromises to be made, for example, to ensure adequate and more durable involvement from critical actors. In many of the projects we considered, the importance of these kinds of action was seriously underestimated. As a result, the present network and the durability of the results achieved to date were fragile, being built, as they were, on a raft of ad-hoc judgements and intuitive responses. This explains our use of action verbs like extend , enrol , exploit , take care , strengthen , discuss , and above all, reflect upon these types of issues.

A final comment concerns the distinction between the capacity for action table - which forms part of our assessment, and the list of recommendations which represent our translation of the assessment and our interpretation of what it means in practice - was central to the perceived relevance of approach. Project managers could, for instance, agree with the assessment part but come up with their own recommendations or ideas about routes which might be taken to address the problems identified. In these cases, as with those where project managers simply agreed with the next steps proposed, the method proved useful partly because of the project manager s involvement and because he or she was free to follow the recommendations made, or to come up with other solutions of his/her own.

CHAPTER 3: THE SOCROBUST PROJECT PROCESS, DYNAMICS AND PROPOSED NEXT STEPS

1- A SUMMARY OF EXPECTED VS ACHIEVED RESULTS

The project objectives, as expressed in the technical annex, articulated three notions together: architectural innovations, societal robustness and management framework. These notions are made explicit in the first three assumptions around which the project is organised (see box 1).

Box 1 - The argumentation of the SOCROBUST project (1)

Source: Technical annex.

First, the project only focuses on a limited subset of innovation projects, those which entail a radical transformation in the way users needs are satisfied or/and in the social structures in which they are embedded. We have called these innovations, following the work by Abernathy, "architectural" innovations.

Second, taking on board the major lessons from innovations studies, the project recognizes that every technological choice is simultaneously of social choice, through the "script" of the future world it includes. Thus "embedment in society" is not an "end of pipe" issue, a question of acceptability, but is created in the same movement as the objects, processes or services are shaped. In one word, the capacity of the innovation to find its way in society is "co-constructed" during the project through the tests and trials the potential innovation undergoes. Many instruments have been developed to follow the technological aspects of these choices. The project addresses their social dimensions. For doing so, the project takes hold of work done on constructive technology assessment which stresses the role of hybrid forums where stakeholders and interested parties in a given project, through controversies and compromises, alliances and alignments, progressively establish the conditions under which the project can develop. Societal robustness is then not given ex-ante, nor a set of criteria along which to measure projects, it identifies the agreements arrived at and the corresponding embedment in society promoted.

Third, this is not done once for all, as we know that the innovation process is not linear but whirling, that multiple trials and loops are necessary to progressively shape the technical, market and the social characteristics of the potential innovation. This journey is marked by "irreversibilities" i.e. by choices which, once made, will no longer be questioned or very difficult to override. Thus societal robustness is not only an ex-ante or an ex-post issue but a on-going one, which requires to be monitored periodically, at each step of the project. It acts as a feedback mechanism.

These dimensions have been confirmed and further developed by the project (see position paper, chapter ...). This development was made possible through extensive literature reviews, nurtured by the questions raised through the cases explored. The literature reviews confirmed the dominant focus on incremental innovations, and the very limited work done on radical, breakthrough or architectural innovations. The closing sentence of the last article written by Abernathy in 1985 remains valid, even when taking into account the work done since, work which the position paper reviews. At the same time, we shall see that the case studies undertaken have been instrumental in helping us assess the relevance (for our objectives) of existing concepts. This to-ing and fro-ing was only closed at the end of the project, meaning that, depending on results arrived at, we spent our time reopening the box of the literature review.

The project objective was to create a laboratory pilot based upon test cases of selected European projects. In doing so it made three assumptions, all of which were at least partly invalidated by the work done, a feature which explains the delay encountered in the development of the project (see box 2).

(i) It first assumed that numerous tools existed and that the issue was their integration, their articulation into a global management framework. The experience of reviewing the literature demonstrated that numerous concepts existed, many of them having been only born of theoretical consideration and thus never tested (even implicitly) in actual life. It took us one year to review and test these concepts (we did not want to throw away an intellectually interesting concept without making sure for ourselves —at least through a thought experiment — that it was not possible to turn it into an instrument within the timeframe available) so as to identify a workable selection, meaning a mix of both validated tools and prototype ones (often directly developed by us).

(ii) The project also supposed that we could easily develop thought experiments from ex-post case studies as a means of shaping the management framework. In fact, it is well known that ex-post case studies require heavy investment in gathering relevant empirical data, with iterative returns required when conducting the thought experiment, that is a reconstruction based on what if analyses. We undertook such a retrospective thought experiment on the EU wind energy programme. This programme, which started in the mid-1980s and lasted over one decade, focused on multi-megawatt wind mills. The material was rich enough for us to put a number of potential tools to the test and the case was very instrumental in shaping our views about the pilot to test. It also told us that there was no sense in multiplying retrospective case studies. We therefore decided to change the balance of the project, and focus our second year's efforts on on-going cases: 8 were selected, and for different reasons (but mainly issues related to time), 5 were completed within the framework of the project. They have been instrumental in shaping the proposed method (see methodological paper, chapter).

(iii) The third assumption related to the selection of case studies. What was seen as a light and brief task, turned into a major one year activity, not because we had to convince EC programme managers from Info Soc DG and the ex-Telematics Application Programme (they were on the contrary very interested, and active, indeed pro-active), but because of the process involved in selecting adequate projects and ensuring their involvement in the experiment.

Box 2 - The argumentation of the SOCROBUST project (2)

Source: Technical annex.

Fourth, this issue is not new for innovation analysts. Numerous partial instruments have been tested. Apart from being often only at the pilot or prototype stage, they face one major limitation: they tend to address only one stage in the process (mostly for initiating projects or at later stages, when economic calculations can start to be made). The project wants to build on them, assuming that little development of individual tools will be necessary. What is at stake is their articulation, i.e. the mix of relevant tools to monitor a given situation (e.g. after a test has been made with a first lead user), and the extend to which a given tool (e.g. techno-economic network analysis) has to be deployed. These issues are central since cost issues are central to any management process. The final objective is thus to develop a "management framework".

Fifth, for doing this, the consortium has chosen a "step by step" approach. The project thus only aims at a first "articulation" and a first "trial".

The first articulation will be made through a literature review and three "retrospective" case studies (i.e. on EU supported projects with a long history and considered by EC managers as well advanced). The first trial will consist of the application of this management framework to three "on going projects", the interaction with these lead users (EC programme managers, project managers and participants) helping in a first stabilisation.

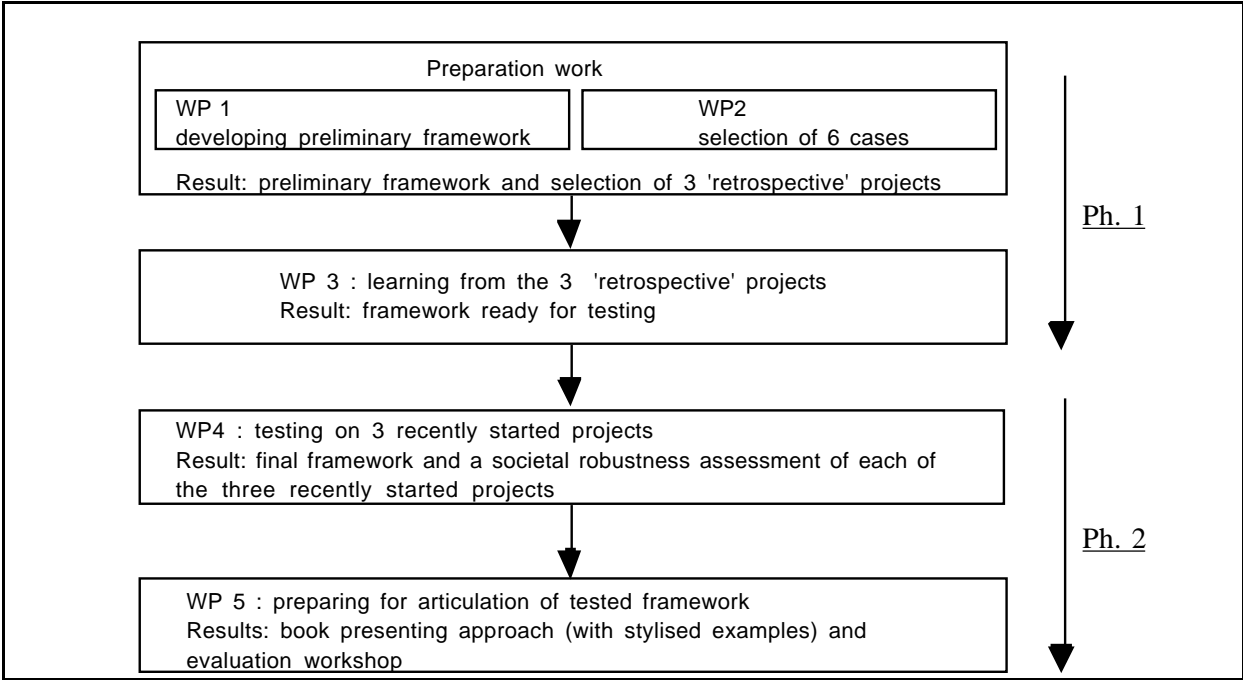
The end result corresponds to what we expected, a laboratory pilot which engages with the following points: (i) what management problems does the pilot address, and how does this relate to existing tools/procedures/methods? Answering this question is the role of what we have called the position paper (Chapter 1). (ii) what is the pilot about and what does it do? The methodological chapter answers these questions, using illustrations from the cases made. (iii) How do we intend to go from this preliminary state and take the pilot out of the laboratory and into real life? This paper on the process of the SOCROBUST project will dedicate its last part to this third question —and the related developments already undertaken to prepare for the next steps. In a way these sections deal with the issue of future exploitation though at this stage it would be unrealistic to expect that a feasibility study should conclude with a technology implementation plan. These developments and results differ markedly from those we expected (in the project we spoke of a prepared book and of an evaluation workshop).

The chapter is organised as follows. After recalling the expected project life (and its organisation), five points will be dealt with: (a) the selection of cases —and where we stand in relation to the cases selected; (b) the construction and test of the preliminary management framework, and the lessons derived (this covers WP2 and part of WP3), (c) the protocol for interaction with project managers devised for on-going cases (second part of WP3), (d) the tests made on five cases, the lessons derived and the revised methodology (WP4), and (e) the positioning of Socrobust as a method in a wider management framework in view of the preparation of next steps (WP5).

2- THE PROJECT LIFE AT A GLANCE

The project was classically organised in 5 workpackages. The first 2 workpackages were to run in parallel and were dedicated to the selection of case studies (WP2) and to the elaboration of the first management framework (WP1). Then was the time for work on retrospective case studies, first gathering material and then running the thought experiments (WP3). This was supposed to run on 3 projects with the aim of developing a revised management framework to test, through a consulting interaction (with a strict protocol) on 3 recently started and on-going projects (WP4). These tests should make it possible to devise a first methodology (or at least its principles, this was left open in the proposal) to be presented in a potential book and discussed in an evaluation workshop (WP5).

Box 3: Initial working plan
Source: Socrobust technical annex



What was done? All the work packages have been fulfilled but both their duration and the activity required have been subject to extensive reconsideration. The three tables below describes the effective activity of the project. Project meetings and work sessions show how interactive the work has been between teams¹. This is clearly demonstrated in the table

¹ Two elements must however be mentioned: due to illness, the team from the University Carlos III could only join in January 2000 (CSI thus recruited earlier than expected an economist to undertake their share of the workload during 1999). The recruitment to a permanent position of the post-doc making the core of the

describing how the workload has been shared on the different cases undertaken. The table describing the project dynamics highlights four major phenomena which we shall now focus upon.

(a) Selection took far more time than expected.

(b) The first retrospective case study undertaken demonstrated that most concepts thought of were not yet operational and that a full revision of the management framework was needed.

(c) The finalisation of the full consulting interaction could only be made while doing cases and thus entailed delays rather than changes. The most significant development has been a reconsideration of the evaluation session, which turned into a strategic interaction. Lessons derived from the cases also led us to propose modifications to the final method adopted for further tests.

(d) Our views upon the next steps for the development of the method have completely changed as compared to the rather stereotyped proposal we initially made.

These four points are now addressed in more detail, trying to apply to Socrobust what we do for other projects, that is, reconstructing the innovation journey, identifying critical moments and unfolding them as far as possible.

Box 4 -The project dynamics (as compared with the initial expectations)

WP2 criteria for identifying architectural innovation and selection of cases

Initial duration: 4 months. Effective duration: 12 months.

Objective: Selection of 6 cases. Retrospective case (Wind energy) selected in September 1999. On-going cases selected between January and May 2000.

WP1 development of a preliminary framework.

Initial duration: 4 months.

Process: literature reviews

Objective: canvas to follow for studying retrospective cases.

All this was discussed and the MF adopted in September 1999. However, literature review was expanded. It was updated and discussed in January 2000. A full addition on knowledge management was then decided, discussed and incorporated in July 2000. A selection and further revision was made in 2001 for establishing the position paper.

WP3 learning from retrospective cases

Initial duration: 9 months.

Process: use of 3 cases and of thought experiment (reconstruction of choices at turning points/critical moments in the life of projects).

Objective: revised canvas to apply on on-going cases.

Effective activity: from October 1999 to June 2000. The first thought experiment done on Wind energy drove to a full reconsideration of the approach. No other retrospective case was initiated and a completely revised method was discussed through one project meeting, two working sessions and one experiment on the future of wind energy. A full methodological note was issued in June 2000, tested on the first on-going case study (EUROVET) and adopted in July 2000 (project meeting) for all other cases.

WP4 test on recently started cases of the revised management framework

Initial duration: 6 months.

Process: use of the method as a consulting interaction.

End result: a consultation for each project (with an assessment report) and a revised final management framework.

The method required two successive interviews with the project manager, one external check, the writing of an assessment report and an evaluation session with the project manager to discuss the report, its usefulness and

involvement of Twente University also drove to reconsideration of the activities in WP5, and of increasing again the role of CSI in the writing of the final report.

limits. The first meetings started in June 2000 (Eurovet) and were only closed in January 2001 (Eusland). The first reports were delivered in November 2000 and by January 10, 3 evaluation sessions had taken place. Two other reports were finished between March and April 2001 and evaluation sessions took place in May 2001. It was then decided to stop the work on the remaining projects.

WP5 final report and preparation of next steps

Initial duration: 6 months

Process: the preparation of a book, an evaluation workshop

The Lancaster meeting (January 2001) decided of a full reshuffle of the approach. It considered evaluation done through the evaluation meetings undertaken. It was decided to organise the report and action around 4 elements: (i) a more academic paper positioning the issue and the approach developed (the present positioning paper), (ii) an operational description of the present method with the project appreciation of its present status of validation (the present methodological note), (iii) the definition of functional characteristics for a dedicated website that would introduce SOCROBUST to non specialists faced with the problem of managing risky innovation projects, and (iv) search for lead users ready to enter into a larger scale experiment, linking both SOCROBUST and PROTEE, while considering the need for protection of the approach.

Box 5 - Project meetings and work sessions

- Brussels, May 3-4, 1999. Kick-off meeting (organisation of activities)
- Toulouse, September 27-28, 1999. 2nd project meeting (literature review, selection of retrospective case, adoption of preliminary framework)
- Petten, December 21-22, 1999, thought experiment on wind energy (ECN, Lancaster, CSI).
- Paris, January 18, 2000. Working session (CSI, Toulouse, Technopolis). Review of results from Petten experiment and preparation of Twente meeting.
- Paris workshop, March 24, 2000, Embedment of wind energy in Europe (ECN, ISRDS, CSI, Technopolis + Copenhagen Business school and ADEME).
- Twente, January 31-February 1, 2000. 3rd project meeting. Review of results from Petten experiment, principles for the revision of the management framework. Selection of first on-going case studies.
- Paris, May 18-19 2000. Working session (Lancaster, Twente, Technopolis, CSI). Adoption of the consultation process and methodology for the tests to undertake.
- Paris, July 12-13, 2000. 4th project meeting. Review of first on-going test case (EUROVET), final adoption of methodology, final selection of cases and allocation of work.
- Roma, September, 2000. 5th project meeting. Review of test cases. Adoption of framework for assessment reports (based upon the experiment on EUROVET).
- Amsterdam, October 23, 2000, work session about the shaping of assessment reports and about the last phase (Twente, Lancaster, CSI).
- Lancaster, January, 11-12, 2001, 6th and last project meeting. Review of test cases. Lessons derived from first evaluation meetings made. Adoption of final work programme, including reorientation of final report and of exploitation tasks.
- Paris, February 9, 2001. workshop on the functional definition for a introductory web site (Lancaster, Technopolis, CSI).

Box 6 - The experiment on on-going cases

Notes: places not filled correspond either to the fact the corresponding function was not fulfilled for the case (e.g. observer), or that the case did not go to this stage

Case	Eurovet	Fasme	Tappe	Eusland	Retransplant	M2DM	Tesemed	DEO
Consultants	Lancaster Armines	Madrid Toulouse	Lancaster	Armines	Toulouse Armines	ISRDS Armines	Madrid Armines	ECN Lancaster
Observer			Armines		ISRDS	Lancaster	Toulouse	Armines
Web Searcher	Toulouse	Madrid	Toulouse Armines		Toulouse Armines	Toulouse Armines	Madrid	Toulouse Armines
Reviewers	Armines Twente		Armines Twente		Armines Twente	Armines Twente		Armines Twente
Evaluator	Armines		Armines		Armines	Armines		Armines

3- SELECTING EC PROJECTS AS CASE STUDIES: A TWO-STEP PROCESS

Though the project started in May 1999, and so did interactions with the different DGs the full selection process de facto took exactly one year. Why was it so?

Time being short, we needed to select the retrospective case studies very fast. We chose to proceed in two stages, to identify one case very quickly, and to leave the selection of the 2 other cases to our interactions with EC programme managers.

The first case chosen was large wind turbines. This choice was made for two reasons: (i) we had preliminary knowledge of the case (thanks to two successive evaluations of the non nuclear energy and Joule programmes); and (ii) the project had been developed with energy as a major target, hence the participation of the Dutch team from ECN, the largest energy research institution in the Netherlands. The case was interesting because of long EC involvement; long standing differences between the dynamics of localised, incremental development, and the efforts of large firms pursuing major breakthroughs in design and approach; and a progressive closing-up of the gap recently enabling the emergence of a megawatt (and even multi-megawatt) market based upon a radical redefinition of public energy policies and thus competition rules. The architectural change thus concerned simultaneously in the technology and in the shaping of markets.

Secondly we decided to concentrate on the rapid changes observed through the web and the information society, focusing on the emergence of new approaches to the management of public services. Links with the then DG XIII were rapidly established, a process facilitated by the fact that some members had participated in the evaluation panel of the TAP programme and were involved in monitoring the new FP5 programme. The choice was made to focus on health and administration (both present in FP4 and reinforced in FP5 — key action 1).

Interacting with programme managers and defining a procedure for selecting projects, informing project managers, and verifying that they were willing to participate in the experiment, took far more time than expected. Some projects were identified quite soon (but in any case not before December 1999, i.e. already 8 months from the start as opposed to the planned 4 months) while the last round of projects was only identified in May 2000.

Programme managers rapidly translated the notion of architectural innovation projects to mean projects with sufficiently large ambitions that they were likely to be faced with socio-political issues. The issue was then to review such projects, to select those which were relevant and to then to introduce the relevant project managers to the experiment so that they could decide whether or not to be involved. This required us to make a clear presentation of our approach, and to define both the involvement we sought from project managers, and the output they would get in return. This meant we had to have defined and tested our preliminary framework, and thus be quite advanced in WP3. It was no surprise that this elaboration was not finished until the beginning of 2000. The presentation leaflets were distributed in March 2000 and the final cases selected in June 2000.

The time delay was such that the selection of cases was solely focused on on-going cases, meaning cases that were still supported by EC funding or only recently finished. The idea was

to select more than were strictly required. This provided some security in case unanticipated difficulties arose, and that, if everything worked well, we could finalise more than the 5 cases initially expected.

Although the selected cases were expected to face socio-political difficulties, not all projects were intended to generate breakthrough technology. Even so, the activities and ambitions of these projects were designed to help promote new public-private, producer-customer relationships and in quite a few cases the central issue was about shifting competences, discarding existing activities and creating new services. The final sample was thus rich in situations of potential relevance for societal embedment. Furthermore, the sample included managers who were well aware of such issues, having already confronted and responded to these kinds of challenges. In choosing to work with this population we put the capacity, usefulness, and relevance of our approach to a harder, more challenging and consequently more revealing test than if we had, for instance, interacted with engineers who focussed on technology alone. In a word, the experimental conditions were diversified enough and hard enough to demonstrate the potential value of, and interest in, such an approach.

Apart from wind energy, 8 cases were selected for the second phase and the on-going test. Box 6 lists cases and the allocation of tasks between project members while table 23 (later) shows where we stand in relation to them. This table is only present in the confidential report handed out to the Commission since we have guaranteed full anonymity to project managers. The examples proposed in the methodological paper come from various cases, names having been changed and data sometimes mixed from more than one case.

4- ESTABLISHING THE MANAGEMENT FRAMEWORK OR THE PAINFUL LEARNING ABOUT THE MANAGERIAL UPTAKE OF LITERATURE BASED CONCEPTS

The project did not start from scratch. Participating teams had been heavily involved in the preceding years in developing approaches and tools which addressed the needs of large organisations and public policies. The University of Twente had been active in developing constructive technology assessment dealing with the public intervention in the shaping of new technologies (at their development stage, and no longer only at their introduction or dissemination stage) and was then focusing on strategic niche management. This followed long standing work in connection with CSI on science and technology controversies and the need for hybrid forums. The University of Lancaster had further enlarged this approach working on environmental controversies and on sustainable mobility and building. ISRDS (from CNR) was involved in OECD work on distributed systems of knowledge using a cluster approach; it also had done work on organisational learning based upon the Nonaka framework and the more recent technology cycle proposed by Noteboom. CSI had long been involved in developing tools and approaches for the management of research activities by public agencies (around the notion of techno-economic networks) and was participating in an on-going project designed to equip public agencies to monitor their involvement in breakthrough projects (the PROTEE project). Finally both the Universities of Toulouse and Carlos III were involved in

the development and assessment of tools for technology management, with a specific focus on knowledge management and resource based theories.

This explains why the group did not consider it to be essential to start with a literature review, though this was an explicit requirement linked to the EC support. IT was instead decided to work on two parallel tracks, to undertake a focused literature review and to construct a first version of the management framework to be applied on the retrospective cases.

The literature review initially confirmed our expectations. Little had been said about architectural innovations in the management literature, and the few exceptions to this were readily identified (especially the work just published by Noori et al.). These confirmed the relevance of our approach.

We were, however, overwhelmed by the number of potentially useful concepts already developed mainly in economics and sociology. Thus the first management framework adopted (September 1999, Toulouse meeting) we devised and tested on the selected retrospective case, was more an organised catalogue of concepts than a framework per se. The test was therefore critical as a means of assessing this catalogue of concepts and determining whether and how they might be used in practical situations. As our management colleagues had told us during the kick-off meeting, management issue is not only a problem of identifying the relevant literature, but also an issue of uptake. The thought experiment (Petten workshop, December 1999) was therefore focused on our ability to master these concepts and put them to use then in reality, that is, in assessing situations and shaping decisions.

The test was radical, meaning that it led us to eliminate most of the concepts we tested. As a result we were no longer faced with an extensive catalogue but with a very limited number of tools, and with the need to define one framework, or more precisely, one method which we could apply to on-going cases.

The following box describes this process which took one year (as was initially planned) though (i) internal tasks (WP1 to 3) were completely redesigned, and (ii) only one retrospective case study was fully undertaken. We shall however see that this case also turned into a prospective one (Paris workshop, march 2000). Furthermore, two other cases were mobilised to check the relevance of the new framework that we devised as a result (work on the Imagine Project and with a wind turbine producer, however without producing any specific document).

In the following sections we describe: (i) the use of literature reviews within the project, (ii) the initial framework, (iii) the thought experiment (principles and operation), (iv) the main lessons derived and the principles adopted for a consultancy based protocol (seen as a simple and common method to apply to a variety of cases, associated with rapid feedback loops to evaluate and learn about its impact, cf. progress report 2, December 2000).

Box 8 - Activities undertaken — June 1999/ July 2000

- September 1999: Toulouse workshop. First discussion of disciplinary based literature reviews, adoption of preliminary framework to test on one retrospective case. Selection of the first case: wind energy.
- December 1999: Petten thought experiment on Wind case based upon case material gathered (documents + interviews both at EC level and in different countries with main stakeholders). Test of the different tools of the management framework.

- January 2000: Twente workshop. Lessons from Wind case point to the need for a revised architecture of the management framework and a rigorous selection of tools. New emphasis on knowledge management and on boundary spanning in the literature review.

- March 2000: Paris workshop on the emergence of Wind energy markets (with guests from the French energy agency and scholars from Denmark). Demonstrated the interest and feasibility of the approach through the collective identification of one societal issue critical to the embedment of wind energy and not addressed as such in research programmes.

- May 2000: Paris meeting. Definition of the test protocol for the consulting interaction (so called 6 steps, 4 tasks procedure).

- June 2000: Methodological note on test case studies.

- July 2000: Paris meeting. Reviewed the internal test done by ECN with one wind energy company (validated the process) and considered issues raised by the first case study undertaken (EUROVET, serves as a learning platform for other case studies). Revised methodological notes issued afterwards. Organisation of External check established and principles for assessment discussed. Agreement about the on-going revision of the literature review as a permanent support to project elaboration. Final allocation of responsibilities for WP4.

4.1- Literature review: an on-going (rather than a one-off) activity

Main lesson: The literature review was not a one-off initial event. It began as an obligation from which we expected to derive little added value (as compared to the knowledge present within the network) but turned into an on-going search involving ad-hoc re-reading of given subsets of literature combined with specifically targeted scanning, both of which profoundly transformed the final knowledge base on which this project relies.

The starting point for the literature search was rather conventional, and largely linked to the competences gathered within the consortium.

Teams linked to management (from the University of Toulouse and Madrid) studied the management literature focusing on project management and enlarging it to include knowledge management. CSSTS provided an STS survey of innovation, and of science and technology studies focusing on project dynamics and societal embedment (with special references to actor-network theory and constructive technology assessment). Economists participating in the project (from CNR /ISRDS and CSI) focused on industrial/organisational learning, with specific reference to dominant designs, technological paradigms and cycles, and path dependency².

Reviews were not intended to be comprehensive, but to focus on innovation related concepts and tools relating to the issue of societal embedment and/or market shaping/construction.

We shall not sum up the results which this process generated since the position paper does the job of highlighting conclusions we consider relevant for our purpose. The table below is however useful since it highlights the conceptual richness we were faced with, and since it shows that most of the developments mentioned were inspired by other, often broader, ambitions.

In this final report, what we would like to stress is the learning process we went through. Most of the literature we end up with is of an interdisciplinary nature, mixing elements from management with economic theory, or elements of management with sociology, or with more

² All these reviews are available as separate deliverables.

classical socio-economic developments. A standard review of project management or of more recently developed work on knowledge management appears quite disappointing, the main lesson being that it does not consider situations which break with accumulated knowledge and practices. Disruptive dynamics have not been high on the agenda during the mid-1980s —mid-1990s. Thus sources are either quite old (typically end of 1970s and beginning of 1980s) or very recent (3 of the major sources we use to position our approach have been published within the last 2 years, i.e. after the project started). They all share one characteristic, that is they are published in a quite diverse set of journals, always representing a minor line of publication, if not a one-off event for these journals. It was no surprise then that the literature review (as a compulsory initial exercise asked for to all projects funded under the TSER programme) did not produce significant results. However, and this is crucial for the dynamics of our project, it proved to be an important resource when we were later faced with specific issues, or when we were confronted with practical problems when trying to implement intellectually attractive concepts/theories. The initial literature review on management identified marketing (more specifically work dedicated to high tech products) as a potential source, and scanning helped to locate the only article on the subject published in THE main academic journal on marketing in more than five years (Cooper 2000). Similarly work on risk assessment revealed convergence among the done by economists and sociologists on uncertainty, and pointed to the typology proposed by Courtney et al. (1997) in the HBR. The innovation journey, a concept central in constructive technology assessment, pointed to the organisational work of Van de Ven and his colleagues, one of the few in management to have crossed the decade focusing on breakthrough innovations. The articulation with evolutionary economics, path dependency, technological irreversibilities, lock-in situations, technological paradigms and cycles as well as dominant designs, was an important starting point for all members of the consortium. We were however faced numerous problems when looking at possible implementations, and had to return to the source in order to look again for concepts that were capable of being operationalised: these were mostly found at interfaces with STS approaches, as explained in the position paper.

Box 9 - List of the main concepts and tools retained from the literature reviews
 Source: Progress report 1, March 2000.

Literature domain	Main concepts identified	Main corresponding tools	Main references
Science&Technology Review	Scripts Trial & errors Alignment Enrolment States & stages Innovation journey Obligatory passage point Stakeholders and Controversies	Narratives Fictive Scripts Stages of innovation Strategic Niche Management TEN Stability indicators Hybrid forums	Akrich (1989) Bijker & Law (1992) De Laat (1996) Callon (1986, 1991, 1992) Van de Ven (1991, 1996) Garud (1994) Rip 1986, 1992 Rip & Kemp (1998) Rip & Shot (1999) Shaeffer (1998) Latour (1987, 1992, 2000)
Management Review	Risk Organisational learning Resource based theories Project management	SWAPS, IRR Logic of integration Concurrent engineering, TQM, CI	Lam (1999) Argyris & Sch n (1978) Nonaka (1994) Grant (1991)

	Competence Uncertainty New generation scenario	Scenario	Bower and Christensen (1995) Courtney et al (1997) Noori et al (1999) Collarelli O Connor (1998 et 2001) Cooper (2000)
Industrial Learning	Path dependence/creation Paradigm, technological regimes & trajectories Technological communities Irreversibilities Variety, Competition & selection Dominant designs Focusing devices	Design hierarchies Technological space Diffusion curves Stability indicators Bottlenecks	Abernathy (1978) Clark (1985) David (1985) Schaeffer (1998), Jolivet (1999). Nelson & Winter (1982) Dosi (1982) Rosenberg (1976) Sahal (1985) Callon (1992) Tushman and Anderson (1986) Noteboom (1999)

4.2- The initial framework or dealing with the multiplication of concepts addressing technological change

The driving force behind the project was a recognition of the need to anticipate societal embedding during the life of RTD projects. In doing so, we extend the idea of concurrent (or simultaneous) engineering to include embedment in society as something which has to be taken into account alongside R&D, production, marketing, etc. (Management framework, from now on MF, preliminary version, 21/9/1999).

The way societal robustness is arrived at is path dependant, linked to the successive trials made. This entails that there is no linear sequence, but iterative and looping processes, loops being defined as the works, tests and trials conducted between two positioning exercises, i.e. between two evaluations (kick-off meeting, conclusions). The role of the MF is to enable actors to perform these evaluations. Who and how were heavily debated in the kick-off and Toulouse meeting.

The focus on the operational level of projects and their managers

Who is our audience? Who are the actors who should perform the above-mentioned evaluations? And what are we evaluating? An answer was found through reference to the idea of a management framework, a notion which puts the focus on implementation. Another question was immediately raised: Does it mean that we only address firms? Or more broadly all stakeholders involved in a project, or only those interested in diagnosing the project's present position from their own perspective, or are we concentrating, in particular, on EC programme managers? A pragmatic answer was given: for this feasibility study, we focus on the operational level of the project manager regardless of the structure to which they belong (firms, research institutions, universities). In a word we focus on approaches and tools that project managers can use for self-assessing the societal robustness of their projects.

This focus, which has not changed over the life of the SOCROBUST project; had two implications.

(i) It meant that we had to pay special attention to project managers understanding of the approach and to their ability to master and internalise it. This was of paramount importance and proved central in the progressive simplification and transformation of the MF.

(ii) The notion of the project became critical. We all know the project fallacy . The debates in Toulouse (September 1999) and the second version of the MF (October 1999) introduced the notion of the project PLUS : The RTD project that is focused on is really an entrance point into a larger, often distributed whole, the project PLUS, which carries the interesting dynamics. Because of its distributed character, managers cannot always capture the full scope of project PLUS, and may resist proposals to take project PLUS as the unit, rather than their own project .

The numerous issues raised by this central question were de facto solved by the fact that actors themselves never considered our entry points (EC supported projects) to be discrete, bounded, and isolated events (the project), but always saw them as elements of a wider project which had started before and was likely to continue after the end of EC funding, and which was sometimes (but not always) of much wider scope than the package of work included in the EC funded project. The definition of the boundaries of the project were thus of central concern to the actors and again recognition of this point had important implications for the shaping and progressive evolution of the MF.

The conclusion was that tools and the MF should be strategic but at the operational level of Project plus (Toulouse meeting, conclusions).

The management framework: principles and implications

How to perform a self-assessment of societal robustness? The central assumptions in the proposal (see box), which were reinforced in the initial MF were that: (i) numerous tools are available for assessing embedment, (ii) more than one tool, but not all, will be needed for any one assessment, and (iii) the deployment of individual tools also depends upon the degree of development, or the materialisation of the project. These three assumptions explain our adoption of the notion of a management framework .

Box 10 - Initial view of the management framework

Source: Technical annex

Our assumptions can be summarised as follows.

In the whirling model of innovation, a project is made of a series of loops which, through trials and errors, foster learning and simultaneous shaping of the product and its market (user community). It thus undergoes phases , each being clearly identified by an initial state of the project and a hoped transformed state at the end of the phase. At any time a project can thus be described by the set of phases its envisages for attaining its objective. We also assume that, most of the time, actors only commit themselves to a project for the next phase, their later involvement being conditional to a re-examination of the state of the project at the end of the given phase. The management framework is devoted to this re-examination.

Even though many tools have been developed, no single existing tool is relevant to all states of projects. To appreciate the societal robustness of a project in a given state requires thus an ad-hoc mix of tools. Furthermore, for a given tool, different states may require different levels of deployment. The framework is aimed at helping actors in selecting for a given state of affairs, the adequate set of tools and their adequate level of deployment.

It will do so through three ways which will organise the literature review made and the proposed integration: (i) by providing a referential of cases, or more precisely of states within given cases, (ii) by identifying issues (check lists) that are common to all (or to numerous) states , by characterising certain states that are often encountered (which can be considered as typical configurations).

This meant that the management framework had three functions (MF, preliminary version, 21/9/1999): (i) suggest the mix of relevant tools to be deployed in state X, and the extent to

which each of them has to be deployed; (ii) be a monitoring and diagnosing framework to characterise the situation of the RTD project as to its state, and (iii) define tools that map and monitor anticipatorily society and possible embedment .

This first definition prompted the group (Kick-off and Toulouse meetings) to discuss the implications of these features. Two points were very strongly emphasised.

- To propose the selection and level of deployment of relevant tools, the MF supposes an image of successful innovation (MF, preliminary version, 21/9/1999). In the discussion we wondered whether or not we were creating a new linear model . The answer was, of course, no. Our image of successful innovations requires however that obligatory points of passage on a successful innovation journey should be identified. Two joint discussions took place. We first discussed the relevance of using terminologies such as states, stages, steps, phases or cycles to describe these typical situations or moments a project should go through. We also discussed the issue of their labelling: since positioning is both technical and social, should the traditional technical language linked to the degree of materialisation of objects/systems (such as pilot, prototype, development) be used? Or should we define another terminology such as exploration, articulation (of protected spaces) and collective experiments? Did this mean we should revisit the literature review with the aim of highlighting the passage from old to new states and stages ? Another possibility was to be more processual, that is interpreting success in terms of improving the process so that the chances of success (phrased in the managers own terms) are improved?

- This encouraged us to explore work on the innovation journey (cf. Rip and Schot, 1999). As a result of this debate we highlighted the importance of three dimensions: actor involvement (cf. TEN), degree of materialisation (related to traditional and/or renewed typologies) and time dependence (path dependency, irreversibilisations and anticipated future). The implications of this for the emerging principles of the MF were to: describe the grid in a given situation (such description depending upon the situation), look at path dependency (what has been irreversibilised before), and address the anticipated future.

Existing concepts and tools in context

The proposal offered a preliminary review of management tools which promised to be of value in assessing and preparing for societal robustness (cf. box 11). It concluded that, individually, each tool addressed only a limited aspect (or set of aspects) of societal robustness. Tool 3 for instance, looks at whether the project can be embedded in current industrial sectors and technical regimes. Tool 5 (fictive scripts) investigates the expectations that research actors implicitly have on the future. And tool 7, on boundary objects, concentrates on the common focus defined by the actors within the project for developing their research. The tools described are thus complementary, in the sense that they address different moments in a project's life and depend on the specific setting associated with the project.

Box 11 - Initial review of management concepts and tools for societal robustness

source: project proposal, 1998.

Group 1: tools focusing on current embedding

1. promise/requirement cycle analysis
 2. anticipatory societal embedment analysis and 'first users'
 3. analysis of technical regimes and of structures in relevant sectors
- Group 2: tools for the analysis of (anticipated) socio-technical relationships
4. techno-economic network analysis
 5. socio-technical scripts and *de facto* scenarios: anticipated future worlds
 6. shifts / lock-ins / path-dependencies / irreversibilities in the innovation journey
- Group 3: tools for technology management
7. analysis of obligatory passage points and boundary objects
 8. tools specifically geared toward firm's technology management

The preliminary MF (September 1999) recognised that, for each purpose of the project (see the above-mentioned three functions), there was not one tool or concept but a cluster of them, which had to be reviewed. The objective of the work on retrospective case-studies was to undertake this review and to thereby learn about the performance of different tools and groups of tools in given situations. We defined four clusters of tools and concepts each cluster relating to a different activity or purpose. The four clusters were:

- Cluster 1 — tools to map and diagnose the project PLUS
- Cluster 2 — tools to trace internal-external consistency now (emerging alignment).
- Cluster 3 — tools to Anticipate on embedment
- Cluster 4 — Meta- tools help managers to navigate within the tools

We shall review them in turn to give the reader a clear sense of the difficulty we were faced with. Given the initial list of concepts presented in Toulouse, we stated that a distinction had to be made between concepts to be incorporated in some specific instruments, and the instruments or tools themselves. The latter are procedures that can be implemented to check one dimension of a project while the former are elements which help to produce better project descriptions. The responsibility for making this classification fell, in practice, to those involved in the "thought experiments" we were about to undertake (cf. below).

The diagnostic exercise requires a reconstruction of the key states and stages in the project, and a map of the evolution of its journey. The purpose of Cluster 1 is to produce a re-description of the journey ... in such a way that fluidity remains visible, as well as the project's linkages with the wider world, and the gradual materialisation of its expectations. One objective is to do justice to the richness of the journey. However, a full reconstruction may not be necessary for management purposes... Which aspects are to be taken up in detail cannot be specified beforehand; a two-step approach appears useful. This consists of a global mapping and diagnosis, as a first step, followed by a closer look at particular aspects in the second step. Thus the MF introduced, right from the start, a two-step approach to the description of projects. This turned out to be a central feature of the method we finally proposed. The list of tools/concepts that were subjected to testing is presented in box 12.

As RTD projects are generally attempting to create novel options, the consistency within and between the project and its environment must be understood in dynamic terms. Cluster 2 addresses the alignment of interests and material forces that emerges in the cases of successful innovation. This alignment typically results from a process of conflict and from challenges which must be overcome through the construction of consistent networks. We

selected tools from organisational learning and the 'logic of integration' as means with which to analyse consistency within the project. For examining the emerging alignment between the project and its environment, network analysis and stability indicators may be used (see Table 13).

Since RTD projects attempt to transform certain social practices through their proposed solutions, they must also anticipate the consequences and reverberations of their own embedment. The products or processes they propose must be integrated into the relevant markets, satisfy the rules and standards laid down by government and/or the relevant sector, and be accepted by the public (in the case of products directly consumed by or otherwise affecting the lives of citizens). Tools from cluster 3 (table 14) aim to anticipate the nature of this embedment and the likelihood of it being realised in practice.

Finally cluster 4 is there to remind us that case studies should also consider those management practices which were in fact in operation at the time of the thought experiment (how did project managers proceed, what did they do, and on what were their decisions based?) and to reflect on these arrangements to see how our management framework might fit into / add to established procedures, and to determine what incentives (from whom and where) might be needed to promote its use.

Box 12: Tools/Concepts to map and diagnose the project
source: version 1 of management framework (October, 1999).

1. Tourbillon *states*:

fluid vs. specific: Abernathy (1978); Garud (1994); Rip & Schot 1999).

extent of internal stabilisation (through boundary objects) and *external convergence* (through Obligatory Passage Points) --terminology from Vissac (1995)

Perhaps diagnosis of *extent of irreversibility*, and the *gelling metaphor* (Rip & Schot 1999).

2. Innovation journey *stages*:

Kline & Rosenberg (1986) and other diagrams with feedback loops. New Product Development literature is full of stage models; cf recent developments (cf. Reed, ASEAT 1999).

Innovation *journey* metaphor with stages as increasing realisation (Rip & Schot 1999).

3. Mapping of evolution of the project

This mapping takes place in ways that avoid the implied success bias of 1.1 and 1.2; include possibility of shift in problem definition and disappearance of the original project: cf. RTD lines of activities (and their contexts) which continue, branch, merge, consolidate, and can disappear (Vergragt in *Social Studies of Science* (1988), Dits and Zeldenrust theses, Science Dynamics Amsterdam).

Table 13: Internal and external consistencies now. List of possible tools and concepts

source: version 1 of management framework (October, 1999).

<i>Tool</i>	<i>Comments / Status</i>
2.1. <i>Stability indicators</i> (Schaeffer,1998), <i>institutional analysis</i> , including frictions, tensions, formative moments (Dolfsma, 1999), ...	Stability ³ indicators are related to Actor-Artefact-Agenda frame Van Lente (1993): For <i>actors</i> : heterogeneity, actor-interrelated-ness, quasi-market structure; For <i>artefacts</i> : degree and kind of materialistaion; technical interrelatedness; For <i>agenda</i> : dominant learning parameters.
2.2. <i>Logic of integration</i>	still to be transformed into tools
2.3. <i>Organisational learning</i>	Trace evolving competencies through the performances (overlap with 2.5). Trace efforts to learn.
2.4. <i>Fictive scripts</i> (of the actors, to some extent already of the emerging artefact in the RTD project) in combination with mapping of the outside world.	To be traced through interviews (cf. De Laat, 1996), or by reading the project (interpreting its assumptions about the world).
2.5. <i>Learning curves plus</i> (from promise-requirement cycles to learning by doing): structured expectations about increasing performance in relation to actual performance (cf. also Moore s Law: chip manufacturers diagnose inconsistency between their present products and processes and what is predicted by Moore s Law).	Progress reports and other documents to higher levels in the organisation. Minutes of progress meetings of the project teams. It would be useful to check external documents, e.g. consultancy reports about developments.
2.6. <i>Links between focal actor/organisation and industry structure and its dynamics</i> (in a broad sense, so including Pavitt s innovation patterns, Nooteboom s cycle; consistency is appreciated in different ways depending on the strategy (e.g. stretch versus fit).	Sectors have a certain division of roles (division of labour), to which focal actor (carrier of RTD project) can accommodate or not. Actions and reactions in this respect can be traced.
2.7. <i>Stakeholder and user interactions</i> , and <i>mapping of linkages and alliances</i> generally.	Deuten <i>et al.</i> (1997) maps (cf. Toulouse paper Rip). H kansson (1987) on industrial networks. Also check for segmentation of networks and the possibility of local as well as global networks (Callon, 1992), and similarly production networks and policy networks (Smit & Van Oosterhout, 1999)

³ Stability is defined as an absence of radical or structural (technological) changes. Stability can both be perceived as a desirable and as an undesirable situation, depending on the agenda of the actor involved (Schaeffer, 1998).

Table 14: List of possible tools and concepts to anticipate on embedment

source: version 1 of management framework (October, 1999).

Tool	Data required to work with the tool
1. <i>Knowledge reservoirs</i> (to which the RTD project contributes) and the new combinations created out of them: the range of possibilities is shaped (and limited) by content of the reservoir, its structure, access, and the activities of the entrepreneurs of various kinds.	TEN (extended) analysis of networks in the sector(s). Specific links of RTD project (or cluster of projects) with existing TEN. Potential to transform existing TEN (cf. also Vinck). Qualitative appraisal of links with entrepreneurs, utilisers etc.
2. <i>Dynamics of architectural innovations</i> : dominant design cycle (cf. also Nooteboom), technological transition routes (Geels), regime analysis generally.	Depending on the specific tool, overall historical assessment of state/stage of the meso-level pattern, or specific indications and indicators. Judgement (perceptions) of actors at the time.
3. <i>Social simulation models</i> building on the structure of the sector (cf. attempts by ?? to create impact indicators), which often include impact assessment by anticipating on functionalities.	Works when links between RTD and impact have been articulated and aligned. Example of medical sector -- but has to be checked for new developments, e.g. new stakeholders interfering with earlier alignments.
4. <i>Advanced (and enlightened) technological forecasting and interactive foresight exercises</i> (with analytic support).	Which of these have been used at the time (why, how)? If there are enough expectation statements (about paths and impacts) in the data, we can set up a fictive exercise.
5. <i>Traditional technology assessment</i> (Arthur D. Little, Philips,), <i>multi-level technology assessment</i> and <i>sociotechnical scenarios</i> .	Which of these have been used at the time (why, how)?

4.3 —The thought experiment on wind energy or how to reconsider the catalogue of tools and concepts

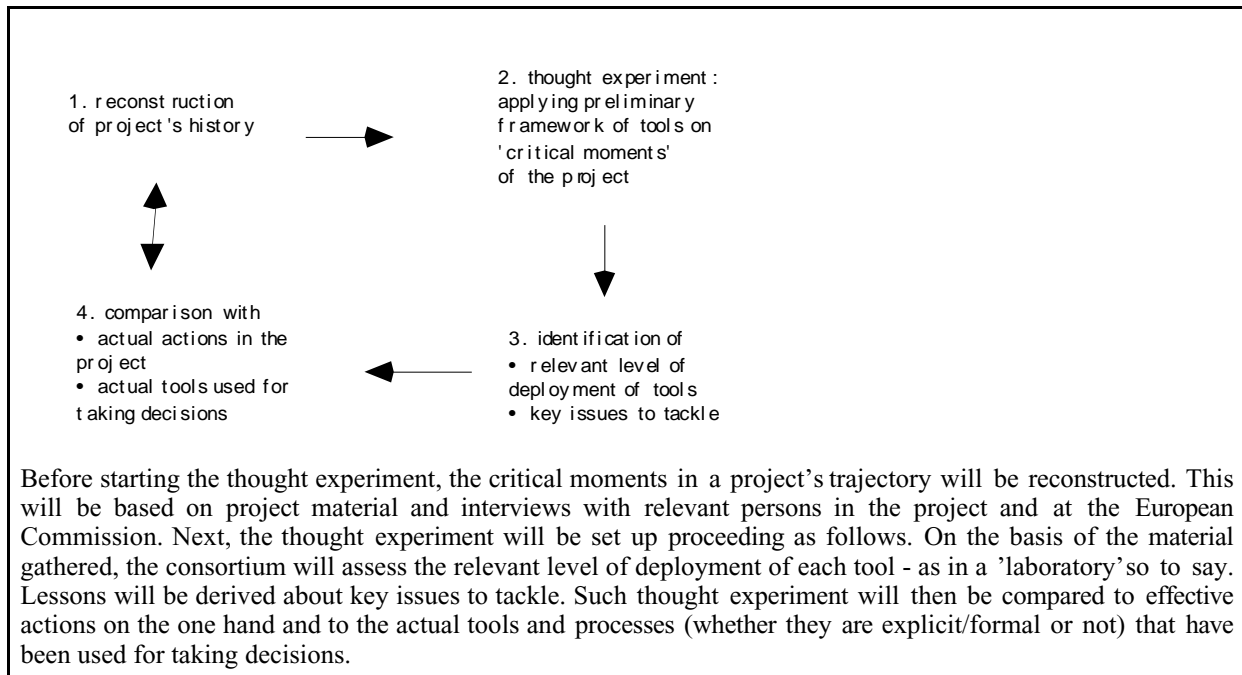
The central objective of the retrospective case studies was to test the initial management framework through a thought experiment focused upon critical moments in the trajectory of the selected project. Box 15 recalls the process envisaged. However this presupposed that we had a nice list of proven tools to test. Section 4.2 illustrated the difficulty we faced when confronted with clusters of concepts, each being very different animals, and hardly any of which had been turned into instruments with clear instructions for use in practice.

In developing the protocol for the retrospective case studies (October 1999) we proposed to select just one or two tools, within each cluster, that were perceived to be relevant to the case and for which data collection was within effective reach. In making this selection, two preparatory steps were undertaken: (a) preparing a brief chronology and a rationale of the case, (b) determining between one and three critical moments at which the thought experiment should be applied. This allowed us to decide which tools to test and to organise the necessary data collection accordingly. The experimental application of tools was to be at two levels: first, how would a participant use the tool, from his/her position, and second, what would an analyst do? The former was important to allow (counterfactual) conclusions about what would have happened, had the actors had our tools available. To make the experiment work, we had to collect data on the actions actually taken during the course of the project, and on the tools used for making decisions at critical moments. As initially expected (see box 15), the first moment in our assessment was to compare the analyses and conclusions we arrived at (through the application of our tools) to the record of steps and actions which were actually taken. The second was to compare the tools we mobilised with the actual tools and processes (whether they were explicit/formal or not) that were used when taking decisions. However, the situation prompted us to add another criterion which de facto became central: namely, the feasibility of using the selected tools in concrete situations and their value in producing information perceived to be relevant for the dynamics of project.

Box 15: About the thought experiment

Source: project technical annex

The cases will be analysed with the aid of a thought experiment. Such an approach has already proven fruitful in energy strategy making (De Laat 1996). The necessary material will be gathered in order to investigate what would have been the use of the different tools identified in the management framework, for selected critical moments of the case studied.



As mentioned in point 2, energy was one of our two selected areas of focus. Though we benefited of the accumulated knowledge of the ECN team, the selection of the Large Wind Turbines and the WEGA programme was made after a thorough check of other possible projects. Box 16 explains the reasons why this project was selected.

Box 16: The reasons for choosing the WEGA set of projects

Source: Report on the case of Large Wind Turbines, May 2000.

we learnt of an EU programme on developing large-scale wind turbine development (WEGA) which began in 1985 and has completed two phases. It is currently in its third phase. WEGA consisted of a prominent set of projects involved in building and testing megawatt (MW) turbines, rather than just researching their feasibility on paper. Its ambitions and expectations, the range of players involved and their interests and positions evolved significantly through some 10 plus years, experiencing both crises and successes along the way. In particular, the field appeared to have evolved along two, separate and parallel paths of relatively small and large turbines only to more or less converge in the 1990s. While the EU's own turbine programme represented the large-scale pathway in the early years, it was said to have played no small part in the technological and market convergence that followed. More broadly, wind turbine development was - and continues to be - at a stage which is sufficiently expansive and mature to encompass a set of views and players beyond those in the research projects themselves. In other words, the wider world not only exists but may be identified as such. In sum, WEGA had enough data points in time to yield a trajectory and institutional data points to yield a map of the broader domain

With analysis of existing documentation and a few semi-structured interviews (in Brussels, UK, Netherlands and France) supported by the insider knowledge of ECN participants in the programme, an overview of the WEGA programme, and its three successive phases, was produced (see report, pp. 7-17) and 3 critical moments identified (in 1985, 1990 and 1996). These were the moments on which the thought experiment was applied. The choice was made that the teams which had done the field work should also undertake the thought experiment during a two-day workshop designed for this purpose (Petten, December 1999). The main question governing the thought experiment was summed up as follows: how practical and

useful are the tools in a situation where we as social scientists are trying to advise EU managers on anticipating the future world of their project(s)?

431- Positioning the intervention of the MF

Before undertaking the thought experiment, it proved necessary to address three main issues. First, the 'fictional' audience for the advice had to be clarified. The then head of the EC programme was targeted (on the grounds that this person would have been in a strategic position and would have the capacity to redirect the action). Second, we had to acquire a clearer picture of the key actors involved and the options offered at the critical moments at which the thought experiment was to be applied. Third, when going from project to project + in the collection of data, an issue was immediately raised which touched upon the boundaries of our own advisory role: boundary setting appeared critical both for the capacity to make meaningful analytic and strategic judgements, and because it can contribute to the framing of the management framework's role:

- Boundaries define the scope of influence of key actors. Hence, a boundary helps identify the audience for whom the management framework is best suited.
- Boundaries render visible who/what is included or excluded by a certain activity.
- Boundary setting implies the possibility of *crossing* boundaries. Hence, boundary setting helps actors articulate their relative position while also broadening their point of view and identifying possible zones of action.

The thought experiment focused on clusters 1 and 2 only, that is mapping and diagnosing the innovation journey in context, and tracing internal and external consistencies or alignments. All tools and concepts were tested for cluster 1. Tests in cluster 2 focused on indicators of stability. The main results are summed up below.

432- Mapping and diagnosing the innovation journey in context. Lessons derived from the application of proposed tools.

The following paragraphs gather the main lessons derived from the systematic application of all the tools included in Cluster 1.

Tool by tool the conclusions are the following.

- (i) As we expected, some of the innovation journey tools were relatively straightforward to apply and useful in their results. The TEN map shown ... would seem to be an essential first step in orienting the case or project in its context (p 25).
- (ii) With a few adaptations of the protocol, the states and stages tool is also a robust, useful first base to help project managers situate themselves in the technological development cycle (p 25). This helps to focus on the right questions, and to anticipate the next stage. It is in this respect, adapted to the question of what's next (p.34).
- (iii) Mapping boundaries can be a bit shallow in that decisions about what is in and what is out are pretty arbitrary. Nevertheless, it is a useful exercise. It has the benefit of identifying areas of overlap in the convergence zone, and of identifying external issues/actors and interests which might be drawn in (p.32).

The main perceived limit of the states and stages tool is its still its linear vision. It tends to promote an internal and continuous vision of technology development. For example, in the wind turbine case, the succession of stages was not that clear. One way around this is to think about states and stages in another way, that is in terms of boundaries, of what is inside and what is outside the project or programme. This would then merge the states and stages and mapping boundaries tools with the added advantages of simplification and user-friendliness that a merger would bring. Questions that need to be addressed in order to decide on next steps could then be posed: what is left outside at the time the decision is made? What is outside that is needed inside for next round? (pp 34-35). A boundary map consists of three main boxes: (a) the first box represents the internal world of the project, as it stands at the critical moment of assessment, (b) the second box represents the convergence zone . This is the set of actors and activities that the manager needs to identify as those that ought to be brought into the inner world if the desired future vision is to be achieved. (c) The third box contains elements in the rest of the wider world that the manager decides, on the basis of the strategic assessment, are not relevant to the development of the project (p. 39).

(iv) The attempt to describe the gap between present and future was somewhat hard to carry out retrospectively since it is difficult to exclude knowledge of what did happen next. Since the aim of the exercise is still worthwhile, it should be absorbed into the more extended tool that does exist for anticipating the future, namely, the notion of a fictive script (p. 33).

(v) The brief exercise on extent of gelling and irreversibility perhaps helps more in raising questions that ought to be asked and speculating on possible answers rather than in providing specific, detailed outputs.

Both tools are not tools as such. However, their core ideas may be absorbed into other operational tools such as the fictive script. Their job also appears to be already performed by the stability indicators.

(vi) A last issue questioned the level at which the tools are best applied, reinforcing the initial choice made: Our thought experiment showed that most of the tools in the cluster are more properly applied in relation to a specific actor managing a relatively bounded project.

The conclusions we derived can be summed up as follows: the mapping and diagnosing sequence should be reorganised around the self-description of the innovation journey, extended TEN should be used to characterise the present situation, and we should look for a merger of the states and stages and boundary mapping approaches.

433- Tracing internal and external alignments

The application of the logic of integration tool did not appear relevant, while cognitive embedment, though being directly connected to our objectives, is a concept for which a tool has yet to be invented (see box 17). The core of this part of the experiment was thus focused on stability indicators.

Box 17 - Lessons derived from the thought experiment on Large Scale wind turbines

Source: Report on the case of Large Wind Turbines, May 2000, p. 38.

Logic of integration: In sum, the tool is limited by the nature of a design conceived mainly for project management within firms, on the basis of well identified objectives and resources, and a materialised artefact. It would require to be adapted in order to be used in situations of radical innovation and uncertainty, where resources may not even exist or be capable of identification as such.

Cognitive embedment is not yet a tool. The aim is to help project managers confront their own future visions or fictive scripts in relation to the reservoir of knowledge embedded in the project Plus... Focusing on key moments, the encapsulated visions of the world, collective cognitive maps, and learning targets that become apparent in key articles, reports, and proposals are unpacked. The boundaries of what is known and what needs to be known may also be interrogated. The strategic vision of the individual using the tool could then be developed in light of insights into the collective dynamics of debates and controversies linked to different networks in the project Plus. The tool would therefore help focus attention on the necessity of building a vision in order to shape the collective knowledge map in the future. In sum, the basic insights regarding 'cognitive embedment' could be developed into a tool along with a protocol for its use.

Table 18 describes the main stability indicators included, the sources needed and the methods used to deploy them. Despite its time consuming nature, the stability indicators tool is certainly a good complement to the picture, helping anticipate the force of inertia and irreversibility at play in the societal context of the project (p. 25). The main perceived limits of this tool are the time consuming nature of data collection and treatment, as well as a deterministic quality suggested by the quantitative requirements of the tool in its full form. While the irreversibilities of today condition the future, they do not strictly determine it. Internal changes in an already institutionalised technological field is still possible; indeed, some changes may be enabled by institutionalisation. For purposes of interpretation, a more qualitative approach such as that adopted in fictive scripts may be called for.

Table 18: main stability indicators used in the Petten experiment

Source: Report on the case of Large Wind Turbines, May 2000.

<i>Indicator</i>	<i>Sources</i>	<i>Methods, scoring</i>
Number of networks	Databases, interviews, introductions and acknowledgements in papers	Number of authors or papers. Links between authors by text analysis
Heterogeneity	Actor-descriptions in titles and introduction papers.	Define different poles (e.g. Science, Technology, Users, Regulation, etc.) Count.
Actor interrelatedness	Interviews, references, dedicated databases	Number and frequency of seminars, journals, international committees (e.g. IEA-Annexes, etc.)
Geographical extension	Paper headings of papers in databases	Number of countries involved
Quasi-market structure	Databases	Number of papers per actor; Herfindahl-index
Degree and character materialisation	Interviews, review papers	Installed units, number and size of research structures
Technical interrelatedness	Interviews, (review) papers	Description of related existing technologies and sub-technologies needed
(Dominance) learning parameters	(Review) papers, comparing expert opinions by interviews	Description of parameter and its historical dev. trends + degree of consensus

(Dominance) prospective type-applications combinations	(Review) papers, comparing expert opinions by interviews	Description type-application combinations + degree of consensus
(Dominance) prospective chronology	(Review) papers, comparing expert opinions by interviews	Description labelling types in generation, + degree of consensus

434- Conclusions arrived at (debriefing of the experiment at the Twente meeting, January 2000): the need for a full redefinition of the management framework

The Petten experiment had a major impact upon the development of the project. The exercise of putting a preliminary management framework, mainly based upon ideas extracted from academic sources, to the test with respect to both a prospective and a retrospective management situation proved rather useful. The practical constraints associated with real life management situations led us to simplify and render more operational tools and concepts found in the literature. Also, the main dimensions of the management framework had to be defined more precisely and translated into practically efficient tools. We became for a while what John Law rightly called hybrid engineers linking scientific and practical management worlds together.

The conclusions presented at the debriefing meeting in Twente (January 2000) (see also Progress report 2) can be grouped under five headings: (i) we clarified the target of SOCROBUST. (ii) and (iii) We appreciated the centrality of two key dimensions: boundaries and anticipations. (iv) This enabled us for the first time in the project to consider a preliminary characterisation of embedment. (v) This in turn clarified the conditions and constraints we needed to take into account when developing the next version of the management framework.

1) A clarification of the focus of SOCROBUST

The thought experiment demonstrated that the approach needed to be rooted in practical management life. It had to focus on an actor with a given capacity for action. Put another way, the focus on project managers (as opposed to portfolios managers) was confirmed.

The case study also enabled us to better clarify the type of projects to which our approach is suited, that is cases where the market does not exist and has to be constructed. The creation of a space for competition is a central outcome of the projects, and a central criterion of embedment.

Within such situations, Socrobust does not have the goal of shaping the management of the innovation process as a whole. In the management of radical innovations, it should be positioned as a specific contribution to decision making which is especially focused on societal embedment.

2) The critical notion of boundaries

One important lesson concerned the specification of project boundaries and the relevance of this for project management. We came up with the strong idea that managing the social

dimensions of risky projects meant being able to carefully define an *inside* and an *outside* world of the project, and to specify *boundaries* between the project and the wider society. This represents a significant departure from more traditional project management approaches. As a result of our first experiment, the setting of such *boundaries*, and the articulation of the *inside* and *outside* worlds were considered to be the central challenge for managing risky innovative projects and thus the main dimension which the Management Framework had to tackle.

To organise the next version of the MF we thus considered that: (i) Each project de facto defines an *inside* and an *outside* and sets boundaries between these two worlds; (ii) Each project defines ways and channels of communication between, and articulation of, those two worlds.

An operational *Management Framework* needs to help managers better describe the moving *boundaries* between their project and society, and monitor the mechanisms through which the *inside /outside* articulation is arrived at.

3) The central role of anticipations made

Another key lesson stressed the role of *anticipations* in risky project management. Economists have long emphasised the role of *anticipations* in investment behaviour. Management Scientists have established *scenarios* as a key management tool which can be used, under condition of uncertainty, to anticipate the future. In the same way as the boundaries define an *inside* and an *outside* world to the project, *anticipations* define a present and a future world of the project. In the case of risky project management, we have applied this idea in a specific way, combining both boundaries and *anticipations*. Following this logic, the cornerstone, and the feature which requires our attention is the project manager's vision of the future world. In the construction of the next version of the MF, we thus added a third consideration: (iii) each project formulates and incorporates *anticipations* and assumptions about the way the *outside* world is going to behave in the future.

By *anticipation* we consequently mean scripts of the future world inscribed in the innovation project. Unfolding this vision of the future and eliciting the assumptions made by managers is central to the Management Framework.

4) A first understanding of societal embedment

By clarifying these two points, the Wind energy experiment helped us clarify and operationalise what was meant by *embedment*. For Socrobust, *embedment* means both the design and monitoring of the boundary between the *inside* and the wider world of the project, and the articulation of these two worlds in the present and in the future. We consequently looked for tools that would help managers better describe and manage the boundaries of innovative projects. Along the same lines, evaluation of the relevance of the boundaries set by the project manager, assessment of the strength and relevance of their assumptions about the behaviour of the *outside* world, and evaluation of the actions taken to stabilise this external world should constitute the basis for the Socrobust Societal Assessment. Together, they should provide a measure of the uncertainties and risks which projects face.

5) The need for a complete reshuffle of the management framework

The Wind report concludes by identifying the need for a simpler, more user-friendly version of the MF. It calls for the adoption of real tools and the absorption of most of the concepts into these existing tools. It also notes that, in some cases, we have to develop new tools. In addition, it concludes that the MF is not just a toolbox (and to the extent that it is, we are still obliged to define the process for applying each tool) in that we should also specify the order in which tools should be used. In commenting on this sequence the report suggests starting with existing project narratives and practices. It then proposes a two step process: first delineate actors' visions of the actual and the future world, and then, in interaction and discussion with managers, concentrate on the project boundaries.

The meeting in Twente took stock of these analyses. It confirmed that: (i) the MF should justify the choice of tools and in simple terms explain the tools and how to use them (In particular we should establish a brief for managers participating in the experiment); and (ii) a limited list of tools should be selected and each tool clearly described (see box 19).

Box 19- Definition and characteristics of a SOCROBUST tool

Source: Minutes from the Twente meeting, January 2000.

A tool is a stand alone procedure answering given problems and producing specific results.

In consequence the boxes which present them should be read on their own. A potential format is the following.

Position the tool within the framework (tentative at this stage, but important for our common understanding) and describe the specific problem addressed

Describe the expected output of the tool

Present the characteristics of the tool

Explain its deployment

Think of a paradigmatic example to make it more concrete for readers

We considered that we still lacked tools with which to anticipate societal embedment. Discussion of this point led to the suggestion that we design a process in which description and diagnosis were clearly separated from assessment.

A sequence was then determined, starting with a initial representation of the project manager's own narrative. Subsequent interaction is then designed to elicit the project manager's view of the project's boundaries, both in the present and in the future, and to record the actions they intend to take in order to bring about the necessary transformation. The output of the method can be summed-up in the following three questions: where are the boundaries today, where do the actors want to locate the boundaries of their project tomorrow, and how does the MF help them do so by enriching their knowledge about the wider world (by scanning) and hence about the relation between the wider world and their own project.

With this as a proposed sequence, the discussion focused on selecting tools which would, in fact, help to achieve these goals. The conclusions were as follows:

- The project unfolding sequence has to be based on some techno-economic mapping tool. The fictive script might be a basic tool with which to enter into interaction with managers, provided that the tool was better settled (the experiences with it show that the tool suffers of a certain fuzziness, and it takes a lot of interpretative work from the part of the analyst when used at a project level) and clearly inscribed in the sequence.

- There is then the need for some scanning, that is some method of technology and competition watch. This was seen as a problem both in selecting adequate tools for the job, and in transforming the information gathered into relevant knowledge.

- Assessment came next. Here our conclusion was that, contrary to the two preceding steps where tools were available once the sequence had been clarified, this was an area in which genuine development work was needed. This led to the suggestion of re-reading the literature around knowledge management, organisational learning and cognitive embedment (i.e. visions of industry and market building, path dependence, irreversibilities, lock-in and dominant design). Further enquiries about the resources offered by the literature on impact assessment should also be made.

435- A first on-going check before the final shaping of the tool

The wind case is still on-going and at the point of market emergence albeit with different national variations within the EU. 10 years ago, nobody would have even expected wind energy to become a relevant part of Europe's energy production. Today, a whole set of new regulations, institutions, incentives and tariff structures have emerged. Could an experiment be made with specialists in the field so as to test their understanding of the approach in action, and to check on what these specialists might learn from application of the approach? A workshop took place in Paris (March, 23, 2000)⁴. Its objective was to test the SOCROBUST approach by moving from the past to the present situation and pushing specialists to consider future directions through the eyes of our framework. The framework was implicit and only present in the way members of the SOCROBUST team questioned the specialists (see box 20). The conclusion was interesting in that specialists in the field identified research issues critical for future embedment but so far not addressed by any public research programme: these had to do with the physical network of distribution. By turning the retrospective case of Wind turbine development in Europe into a more prospective experiment about the future of Wind Energy in Europe, we were obliged to turn our attention from technology to the wider question of market emergence, a question of which technology is only one aspect. It thus confirmed us in the potential utility of the approach, if only by widening specialists/managers' perspectives on the societal embedment of their project, and reopening debate about the sequence of actions which should be taken next.

The experience also revealed limitations relating to our application of the method. This demonstrated the need for an established procedure, and a clear relationship between ourselves and the project managers. This led us to adopt a consultancy style interaction. By this point, all elements were in place for a full revision of the management framework, including revision to the notion of management framework itself.

Box 20 - Paris Workshop on the future of Wind Energy

Source: meeting notes, May 2000

⁴ This was complemented by interviews done by ECN and CSI with managers in production firms such as Nedwind and Jeumont.

Participants

Peter Karnoe (PK) and Kristian Nielsen (KN), Copenhagen Business School
Bernard Chabot (BC) and Pascal Berlu (PB), ADEME, French Environment Agency
Bastiaan de Laat (BdL) Technopolis France
Bianca Poti (BP) CNR-ISRDS, Italian National Research Centre
Gerrit Jan Schaeffer (GJS) ECN, Netherlands Energy Research Centre
Philippe Laredo (PL) and Eric Jolivet (EJ), Armines-CSI, Ecole des Mines de Paris

Documents distributed for the meeting

Chabot, B Le développement de l'énergie éolienne Encyclopédie Uni.
Chabot, B L'analyse économique de l'éolienne Revue de l'énergie
Chabot, B From Costs to Prices EWEC 99
Chabot, B L'énergie éolienne au prochain millénaire Revue de l'énergie
Karnoe, P Path creation and dependence in the Danish Wind Turbine Field
Karnoe, P Approaches to innovation in modern wind energy policy CEPR
Menanteau, P. L'énergie éolienne: la réussite d'une dynamique d'innovation incrémentales
Nielsen, KH Technological Trajectories in the making

Main conclusions

The discussion was organised in two steps. The first step was to get hold of past developments, through two complementary views, the one we developed on European intervention (through the WEGA project) presented by Gerrit Jan Schaeffer, and the comparative analysis of grass root Danish development vs top down US one by P. Karnoe (with the support of K. Nielsen). The discussion highlighted the very different trajectories in the US, with P. Karnoe demonstrating the inability of the two networks to converge, and in Europe where G.J. Schaeffer illustrated their progressive merger via the different actions undertaken by the EC programmes. This peaked with the 1998 EU directive on wind energy which paved the way for the public shaping of national wind energy markets.

The second step was more of an open discussion driven by a set of questions about the conditions under which this emerging market can stabilise and develop. It was introduced by B. Chabot, an economist from ADEME in charge of developments in reproducible energies (well aware of the new institutional frameworks, especially in Germany). It helped identify and better characterise relevant issues and problems: role of tariffs and/or subsidies, new legal requirements, next generation R&D (is there still a need for breakthrough innovations?), social innovations (as the Danish co-operatives), the role of the grid (is there a need for a radical transformation to promote distributed production facilities?). While all other points were witnessing research activities, experiments and developments, the last point mentioned appeared critical for the future deployment of wind energy, while nearly no research activities nor experiments could be identified.

5- A PROTOCOL FOR INTERACTION WITH MANAGERS

The Paris workshop confirmed the viability of the proposed approach and, following this, the decision was taken to develop a standard Socrobust methodology which would be applied to a variety of cases. The procedure incorporated rapid feedback loops, allowing us to evaluate and learn about its impact. The basic principles were set out in a two page leaflet sent to all managers of the selected projects (see section 2) to help them decide whether or not to become involved in the experiment. A preliminary methodological note was drafted by CSI and discussed in a restricted workshop in Paris involving CSI and the Universities of Twente and Lancaster, with the participation of Technopolis (May 2000). The final methodological note was produced in June 2000, in time for the first case to take place (EUROVET). It was revised and extended in July 2000 incorporate lessons from the first case and from discussions in the 4th project meeting (Paris, July, 12 and 13, 2000). The following paragraphs (taken from the second progress report) describe the protocol we adopted.

51- A Protocol for interaction as the cornerstone of the Method

The Method had to meet two important targets: being flexible enough to adapt to a variety of situations, and being a useful tool for managers. As a consequence, considerable importance has been given to developing a protocol for interactions with managers in developing the methodology. The set of tools is therefore only one part of the SOCROBUST approach, the other part has to do with the role of researchers interacting with project managers with the help of these tools. Responsibility for adapting the tools, of presenting and explaining them in simple and operational terms rests with the researchers. In other words, if it was to be developed in the future, the SOCROBUST method would consist of two main components: a) a set of tools with an accompanying guideline for use and b) expertise in innovation project management and in the application of Socrobust.

52- A Consultancy based protocol

What is the most operational and natural form of interaction between project managers and external experts? It seemed to us that a consultancy model offered a series of advantages over the typical research interaction. One of the main advantages of a consultancy type exchange lies in its more respectful character towards project managers' habits, language and rhythm. For business people, time is precious —recall Benjamin Franklin's famous words to a young tradesman time is money —and it should be economised as much as possible. Getting maximum output from minimum time investment would be an important dimension of user friendliness. In terms of protocol design the implication was to minimise the time spent interacting with the manager: the aim was just two interactions of 2 to 3 hours each before delivering a report. The second implication was to optimise the process of producing the final confidential report so that managers could get the results within an agreed timeframe. Experience showed that although this was feasible, it was not an easy thing to do.

Another important feature related to our previous decision to concentrate on project management. This view led us to retain an approach in which only one person, the coordinator of the EU supported project, was to be interviewed and interacted with.

53- A light and compact version of Socrobust as experimental test bed

The objective assigned to SOCROBUST was two fold. First, we had to maximise the variety of situations dealt with by one single protocol and one single set of tools - the project is above all conceived as an experimental test bed, a laboratory prototype. At the same time, we had to keep the set of tools as simple, easy to use, and as light as possible so as to meet the requirement of manager friendliness. This resulted in the development of a supposedly one-week *SOCROBUSTt "Light" diagnostic*: a kind of pre-diagnosis for managers and an experiment designed to determine which tools were useful and robust and which required further development. With this in mind, we voluntarily set ourselves rather stringent limits, minimising interaction time, minimising the range of tools deployed, and minimising the overall time spent on each case. The reason for this was to maximise the amount we might learn through trying to apply the same tool to a wide variety of project situations, covering diverse aspects of each of the case study projects, and doing so in a standardised manner.

In order to cope with the various management situations we were to encounter, and in order to be portable, handy and rugged enough to be handled by different researchers and within a limited time scale, we designed a light and compact version of SOCROBUST. In exactly the same way that Microsoft Works combines very simplified versions of Excel, Word, and Access all in one, SOCROBUST Light and Compact combined the full set of tools but simplified and linked together in a consistent, all in one framework. When using the Works word processor, it is always possible to transfer data to the full version of the more sophisticated Word for longer term and/or more sophisticated treatment. The same had to be true for the different components of *SOCROBUSTt light*: they had to form a consistent but simplified package, but one in which each element might be extended and expanded separately should further detail be required.

Given the self imposed time constraints, the protocol is designed as a one-shot affair consisting of two interactions with project managers, one for description, the other for analysis. This meant abandoning the prospect of monitoring project dynamics and transformation. The project's learning trajectory is therefore not the central focus, instead, the method concentrates on the project's boundaries. In practice, this led us to opt for a method which contrasted an internal view of the project with a view of the project as located within a wider world of competing projects. As a consequence, the dynamics of the project have to be traced back and forth not in real time, but verbally and through inscriptions (the documentation and archive of the project). The scope for directly monitoring the project's transformation and even for monitoring the transformation induced by SOCROBUST itself is therefore limited.

This limitation justified the inclusion of two parallel feedback loops built into the protocol. The first was to involve someone in the role of an observer. Their task was to take notes about both the application of the protocol and the manager's first reaction to the tools: how well did he/she understand the method as a whole, and each of the different tools? The second

feedback loop involved an additional feedback/evaluation session once the consultancy job was finished. This final session (which was to become a de facto fourth step in the method, see next section) provided an opportunity for the manager to evaluate the method and the interaction: how useful was it for him/her? What did he/she learn? How might the method be improved, — i.e. to render it more consistent with the manager’s own language and habits, how could it be made more manager friendly? For this step it was decided that a neutral researcher, in the sense that he/she had not been involved in the previous interaction, would conduct this final evaluation session. This would, we hoped, make it easier for the manager to provide their own opinions freely, and to be as critical as they wanted.

54- A three step protocol

Instead of establishing a list of possible project situations and a corresponding list of tools, we designed a standard process built around the implementation of a limited set of tools each being robust and simple enough to cope with a variety of situations. As mentioned above, this allowed us to maximise the value of the experiment. The protocol for interaction with managers consisted of 3 main steps. It is presented in graph 20. Table 21 displays the activities involved and the role each played, including the evaluation session (which acted as a fourth step).

Graph 20: the protocol for interaction with project managers
 Source: Progress report 2, December 2000.

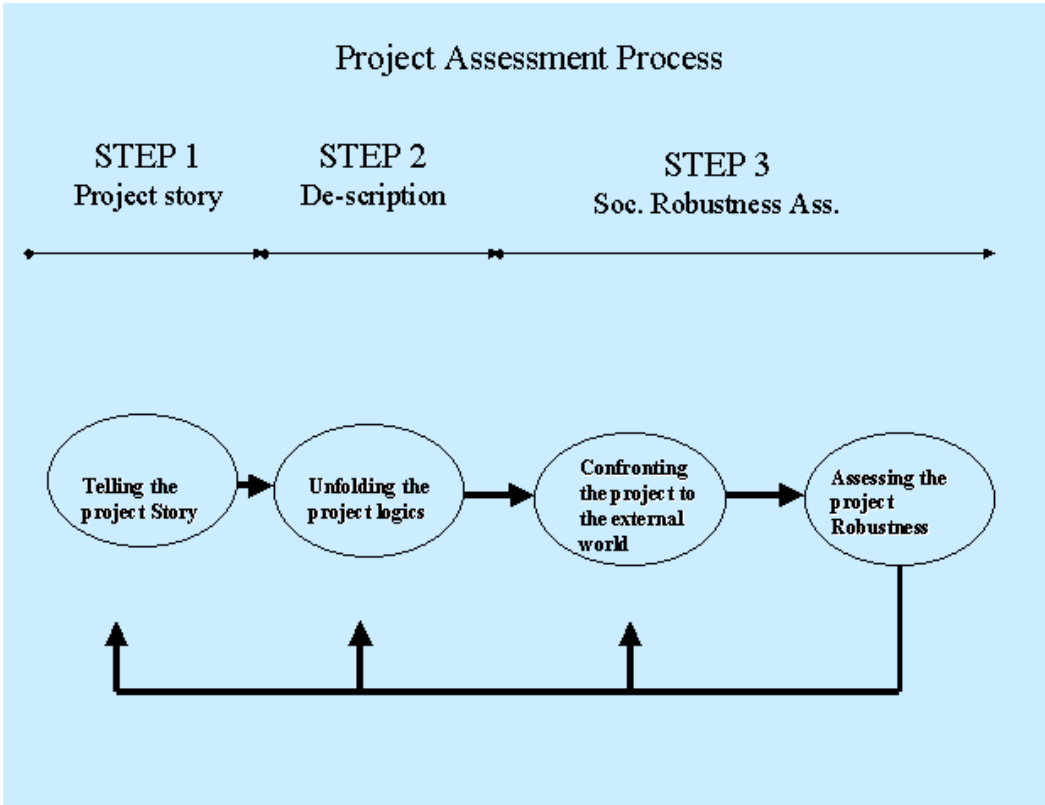


Table 21: the protocol for interaction with project managers, main activities and players

Source: Progress report 2, December 2000.

Steps	Overall Story	Analysis	External check	Assessment Report	Evaluation
Team Players	-Consultants	-Consultants -Observer	-Toulouse Web searcher	-Consultants -Reviewers	-Evaluator

- Step 1, *Project Story*, is devoted to assembling an overall story of the project studied. What is the project's history, and what are its dynamics? Two researchers are in charge of meeting the project co-ordinator of the case studied. They conduct a rather conventional interview (an interview guide was produced for the Eurovet case and revised after June 2000). One researcher acts as the main consultant and carries out the interview while the other researcher, the assistant consultant, is taking notes and keeping track of the session. While the main consultant is animating the discussion, the assistant keeps the record of the interaction. This role proved essential for subsequent interpretation of the project story and in preparation for the second interview.

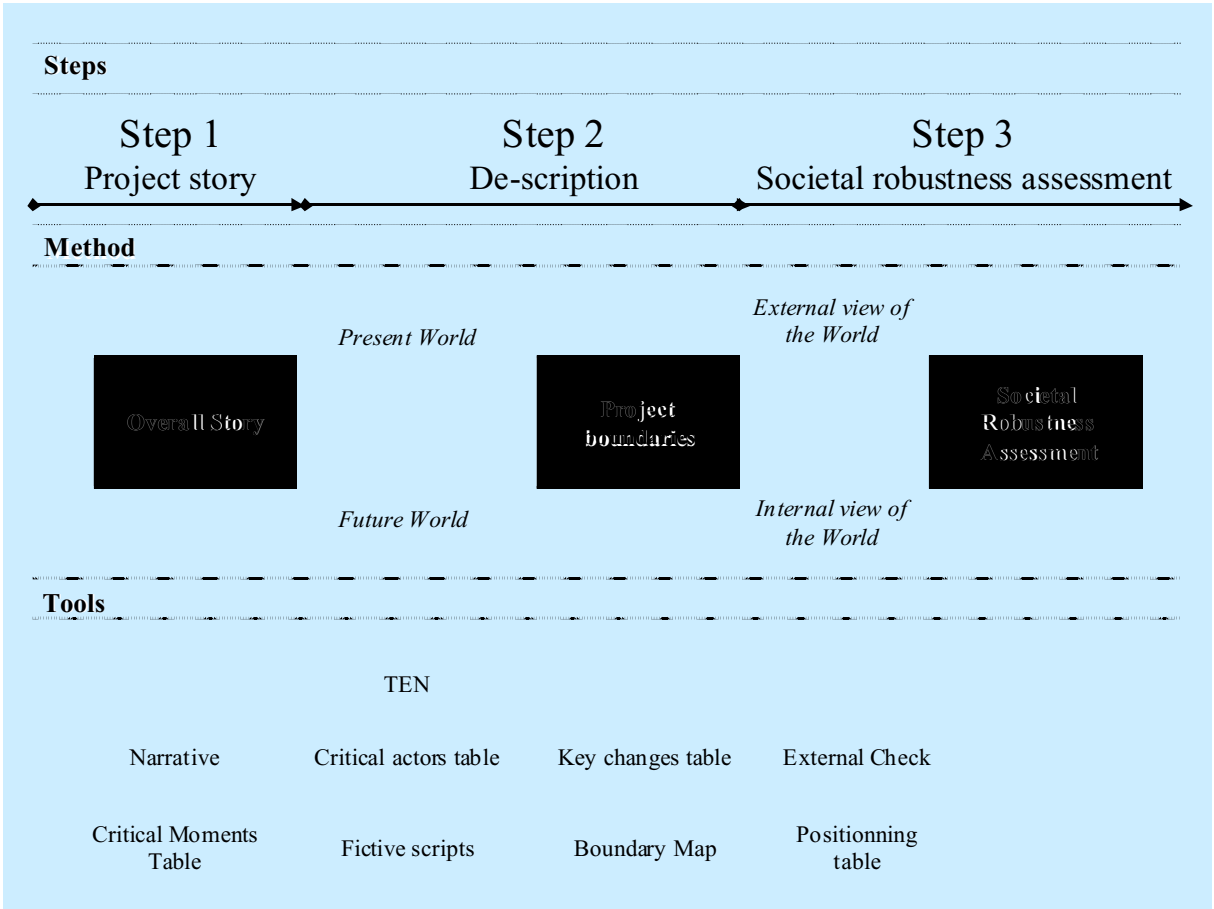
- The purpose of Step 2 is to *unfold the project logic*. What are the main elements involved in the present development of the innovation? What are the key steps for it to succeed in the future? At this point, both the researchers involved in step 1 play a consultancy role, preparing a consulting session based on the application of SOCROBUST's interaction tools (see graph 22). Again, while one is interacting with the manager, the other is keeping track and taking notes of the session. Where possible, we added, even if time and budget constraints were too tight for us to do it systematically, an additional observer. Unlike his/her two colleagues, the observer was not interacting with the manager directly but taking observer's notes, that is to say making comments about the implementation of the method, about the reactions of the manager to the different tools and to the method as a whole.

- Step 3 locates the internal view of the project derived from the two earlier sessions, with reference to the wider world of competing projects and society. What are the main alternatives to the innovative project, what are the main controversies about the choices it supposes? Each team of two consultants is required to formulate a series of key words and itemise key information they would like the *external check* to focus on. The University of Toulouse, with the help of Armines, focused on the searches following a protocol proposed by Armines after the first test done on EUROVET (September 2000). This external check is a precondition for making the *Societal Robustness Assessment*. How well prepared is the project to develop and adapt to the wider world of society? The original team of two consultants is responsible for producing the evaluation of the project and the delivery of the confidential SOCROBUST Societal Assessment Report to the project manager. To begin with, no clear format was devised. All we had to go by were the principles discussed in the May workshop, proposed in the June methodological note, and further discussed in the 4th project meeting (July). The next section will show that the development of a report format and its first implementation on the EUROVET case required 4 months of intensive work and exchange. The stabilisation of the format was critical for all the other cases.

- The evaluation session (which became step 4) involved a retrospective discussion with the project manager, the purpose of which was to learn about both the relevance and limits of the method, the conditions of its implementation, and what would be required for managers to be in a position to incorporate such a method in their project management practices.

55- An overview of the tools for steps 1 and 2 (as they were formalised before the on-going tests)

Graph 22: the protocol for interaction with project managers, the tools deployed
 Source: Progress report 2, December 2000.



Step 1 - Project Story

The project story consists of a short narrative summarising the history and purpose of the case studied. The aim is to agree upon a common series of facts about the case, for further discussion and analysis with the managers.

To do this, we decided to combine two different ways of telling the project story. The first is linear, following a chronological sequence. Unfolding the project over time is a very basic way of retrieving its dynamics and helps to counter the sense that the present has no history. Chronology, projecting things over a time scale, in itself provides a sense of genealogy. On the other hand, chronology and linearity have to be complemented if they are not to give a

distorted, homogenous sense of time. The second and complementary way of telling the story is therefore based on the identification of critical moments and important events. Time can only be made linear and causal in a world of certainty. In risky and innovative projects, time is irregular and whirling. The issue is then to identify those moments punctuated by irreversible events which channel a progressive path. Retrieving these critical moments allows us to develop a rich account of the project story, an account that relates basic facts to the states of the innovation journey. This is generated through the use of two tools.

The first one is called the *Project Narrative*. This is a tool that is often used in sociology, and it helps to provide a linear account of the basic features of the project story. The project narrative is traditionally developed through an interview session with the project manager.

The second and complementary tool used is the *Critical Moment Table*. This tool has been created within Socrobust as a complement to the rather linear vision provided by the narrative. The *Critical Moment Table* lists the key events that punctuate the project trajectory, it also characterises them—how important are they, how influential have they been on the overall project dynamic, how reversible have they proved—and links them to the steps of the innovation cycle. The method of characterising each key event has evolved over time: we experimented with more exhaustive and shorter versions, before arriving at the one proposed in this final report.

The critical moments table and the project narrative are both written after the first interview with the project manager. They are then presented to the manager for validation and discussion during the second interview. Validating the *project narrative* is important to ensure that the research team understood the baseline of the case studied and the main facts to be analysed. In addition, in discussing the critical moments table, the manager is helped to outline his/her visions and goals and, interactively, think about those from a different, more sociological perspective.

Step 2 — De-scription

Time is certainly an important aspect of project management. And space is no doubt another one. For social scientists though, space is not mainly geographical and what matters here is not so much mileage as social distances and proximities. The space that matters is not made of a systematic sampling of all entities residing in an area, as could be captured from a satellite view, but rather, of the networks of entities that matter for project managers, namely those that are part of their world, that compose their project world.

As was learned from the previous steps, project managers segment the world into what is considered relevant for their project—building its internal world—and all other aspects—which remain external to the project. They de-facto establish *boundaries* between these worlds and constantly consider ways of linking and articulating them.

In Step 2, Project De-scription, we return to the narrative provided in step 1 and, drawing upon this material, identify the networks in which the project is currently embedded. This step considers the range of organisations and interests involved, as well as the strength and nature of the alliances and linkages between them. Artefacts, technical devices, norms and rules which support (and sometimes organise) these exchanges are identified. The aim is to

characterise the project manager's vision of their project's socio-technical world and of its boundaries and margins.

To develop this description of the project world and its boundaries, the following combination of tools is used sequentially:

- (a) 2 periods of mapping the relevant space. These are encapsulated in the Present TEN and Actor Table for the present, and the Future World map for the future (1 & 2 below)
- (b) 2 analytic tools for identifying the changes required for the project to be successful, these result in the key changes table and boundary map (3 & 4 below).

The first mapping exercise deals with the Present Network of the project, describing the main actors, and the key human and non human entities of which it consists and which interact with it. We use two tools to describe the present world.

The first is a *TEN map* (Techno Economic Network map) as elaborated by Callon et al. 1992 and 1997. TEN maps provide a sort of socio-technical snapshot of the main entities connected to the project, also revealing their centrality to the project and the nature of the linkages involved. The scheme we are using distinguishes between four main poles, four areas of the social world labelled science, technology, users and regulation. Whether a project is centrally linked with entities in the scientific or in the technology poles for instance, provides important information for the analyst. Symbols of different shape, position, shade and size are used to represent the relative importance of the entities, and the nature and strength of their relationships one with another. We gradually came to the conclusion that a practical and revealing approach to TEN mapping as to provide the project manager with a blank TEN scheme and coloured pens with which to complete the map in his/her own terms during the second meeting.

The second and complementary tool is the *Key actors table*: the purposes of this is to enrich and extend the description of each relevant entity. Building on the *TEN map work*, the table lists the key actors identified and analyses their involvement in the project, the type of interest they have in it and the nature of relationship they have with the project manager.

The second method used to describe the social world of the project investigates the vision of the future as held by managers and as embedded in the innovation. The Future World as we conceive it here is an ideal society tailored for the innovation. In other words, each innovative project formulates anticipations and assumptions about how society should look and how it will behave towards the innovation in the future. By implication there is a projection of an utopic society inscribed in each innovation where (i) rules, norms, codes of conduct have been stabilised and so provide the infrastructure for the emergence of an industry (Granovetter 1998), and where (ii) market characteristics (i.e. for us user-producer-prescribers relations) have been set. Our goal here is to render this vision of the future as explicit as possible.

The tool we use to help managers articulate their visions of the future is a TEN map of the future working world. Again, the manager constructs this by drawing on an empty scheme with coloured pens. An important advantage of this method is that the manager is already accustomed to the TEN mapping having used this tool to represent the present state of his/her project..

The analysis then proceeds by bridging the gap between the present state of affairs and the imagined future, concentrating on differences between the descriptions of the *present world* and the *future world*. This feeds into analytical tools 3 & 4.

The third analytical tool identifies the steps required to go from the present to the invented future. This is done through a backcasting exercise undertaken with the project manager. The tool used to support this exercise is called the *Key Changes Table* and has been specifically created by the Socrobust team for this purpose. The manager is asked to identify the key steps that would lead from the present to the future world. Each step is then listed in the *Key Changes Table*, where it is described in some detail, and its implications are identified. Who are the most affected actors and practices, what source of opposition might be anticipated, and what needs to be changed and routinised?

The fourth and last analytical tool identifies the project *boundaries*. As mentioned earlier, each innovative project builds boundaries between an internal and an external world, corresponding to its managers vision. Boundaries are represented in the *boundary map*. The boundary map is made of three main boxes. Box one starts with the present and builds on the key changes table in identifying the main actors that can and should be acted upon today. These are organisations and arrangements on which the project promoter is currently concentrating as part of his/her present strategy. Box two describes actors and arrangements, to be involved at some point in the future. Box three identifies actors and circumstances, which have a bearing on the project s future, but which cannot be changed or influenced by the project promoters themselves.

56- An open issue: how to implement the assessment

The first two steps of the method were based on tools which have already been used in different settings. The challenge was thus less one of undertaking a completely new development, than of tailoring existing ideas and methods to our specific needs. However, the tailoring entailed a number of important developments. For example, all the tables (the critical moments table, critical actors table, key changes table) went through a successive process of refinement as changes were made to the characterisation of entities, that is to the definition and specification of the columns of tables. Similarly we felt the need to distinguish between a first visualisation of the future network of the project and a further visualisation of the future working world. Finally the boundary map acted as a recapitulation of the boundaries of the project. Its main role was not to introduce many new insights, but to introduce to the key changes table.

Such was not the case with the assessment and, after further review of the literature, concentrating especially on technology assessment, we concluded this step presented a number of challenges in response to which we needed to develop our own tools from scratch.

Our notion of the assessment stage was threefold:

(a) It had to confront the assumptions made by the project (as expressed in the key changes table and in the boundary map) with evidence about the wider world. Since it was directed by

the assumptions made, there was no need for an all round technology and competition watch , rather what was needed was a guided external check .

(b) It had then to describe the positioning of the project within this wider world and specify its margins of manoeuvre. Our initial consideration was that each key change should be reviewed and that this reviewing would allow us to position the project with reference to the wider world, hence the notion of a positioning table. This would in turn provide the foundation for an assessment of the project s societal robustness.

(c) Finally, since we had chosen to enter into a form of consultancy interaction, we had to produce some (tentative) recommendations and at least suggest actions which should be taken to increase the chances of successful societal embedment.

Going from principles to practice was another issue, and we do not know of any other experiment to have done so in real time and at short notice. We had to rely upon our initial conceptualisation of the problem (enriched by the literature review) in order to devise a completely novel approach. The fourth project meeting (July 2000) was in great part devoted to this issue, using the EUROVET case — which had already undergone the first two steps —to help define the approach. It was also clear, again looking at the EUROVET case, that helping managers to formalise the innovation journey; to characterise the critical moments (step 1), and to unfold the present network, the future working world and the key changes required (step 2) was itself enough of an achievement for the project managers to have no regrets about participating in the experiment. On this basis we went ahead without having finalised the third step which was to bring us to our core objective!

6- THE CASE STUDIES AND THE LESSONS LEARNT

Table 23 lists the case studies done and highlights the collective nature of the research process. Apart from Twente, all teams acted as main consultants. We were able to have observers in 5 cases out of 8. External checks were mostly conducted by the University of Toulouse, with support from Armines while internal reviews of the reports were mostly done by Armines with the support of the University of Twente. All evaluations were conducted by the same person in Armines (who had not participated in the cases before, other than in reviewing the reports). The table also shows that 3 of the 8 cases were abandoned at an early stage: 2 cases were selected very late and the first interview could only take place in late December 2000 and early February 2001. The time taken to complete the other cases obliged us to bring these 2 cases to an end after the first encounter. This was all the more necessary since they were complex cases requiring significant involvement. Another case went through its first two steps, leading to a provisional first report, however, and we shall have to reflect on this, the case was risky but not uncertain, meaning that it did not break any pre-existing arrangement and thus did not require any re-alignments (see section 2 above). This positioning was however the result of a learning process in the which the project initially anticipated wide ranging changes in ways of informing customers about medicines, but finally ended-up complementing the role of pharmacists. The five other cases went through the whole process, including the evaluation session.

This section reviews our own critical points/moments in this process. It will start with the painful elaboration of the assessment process. Three aspects of this will be reviewed in some detail: the external check; the construction of two new tools (the positioning table and the capacity for action table) and the formatting of the recommendations. Second, we shall discuss the role of the evaluation sessions within the overall SOCROBUST process and explain the role of these third moments of face-to-face interaction as forms of strategic analysis. This will lead on to questions about the report and the assessment process per se. Other insights and lessons about the different tools will then be analysed together since they have implications for updating and optimising the method. The results derived from the case experiments are embedded in the methodology presented in the previous chapter. The final version of the methodology will therefore not be presented again.

Table 23: Case studies and their deployment

Case	Eurovet	Tappe	DEO	Retransplant	M2DM	Tesemed	Eusland	Fasme
Consultants	Lancaster Armines	Lancaster	ECN Lancaster	Toulouse Armines	ISRDS Armines	Madrid Armines	Armines	Madrid Toulouse
Observer		Armines	Armines	ISRDS	Lancaster	Toulouse		
Web Searcher	Toulouse	Toulouse Armines	ECN Toulouse	Toulouse Armines	Toulouse Armines	Madrid		
Reviewers	Armines Twente	Armines Twente	Armines Twente	Armines Twente	Armines Twente	Armines		
Evaluator	Armines	Armines	Armines	Armines	Armines			
Step 1	done	done	done	done	done	done	done	done

Step 2	done	done	done	done	done	done		
Step 3	done	done	done	done	done	partly		
Report sent	sent	sent	sent	sent	sent	no	no	no
Evaluation session	made	made	made	made	made	no	no	no

61- Producing the assessment: from principles to the positioning and capacity for action tables

Discussion at the Paris workshop in May helped to distinguish between the different dimensions of change on which the assessment was ultimately based. The literature is quite well developed when it comes to characterising the dimensions of change associated with the development of a new dominant design, new paradigms or architectural innovations. It is, for example, widely agreed that the transformations involved have to do with technology and with producer-user relationships. Works by David and others have also made the point that such developments are most often accompanied by new infrastructures, both material (such as the telephone network or the railway lines or more recently the information highways) and intangible (in the form of new norms or new standards such as the famous QWERTY keyboard studied by David). We came to the view that to qualify as such, the architectural innovations we studied should promote at least one of these types of change. In other words the cases studied should be faced with uncertainty and should raise issues about societal robustness which have to be addressed. When this is not the case, then our tools need not be adopted (see the above mentioned case). Such an approach, again grounded in our review of the literature, led us to re-focus our description of the future working world (in step 2, see later) and to organise our review of key changes with reference to the three dimensions of the technological space, the institutional framework and user-producer relations (and design). A project's positioning can then be assessed with respect to each of these three dimensions. In this way the Paris discussion solved the problem of assessing project positioning through reference back to our own initial assumptions, and by clarifying the three dimensions outlined above.

From dimensions to criteria

Having decided to focus on these three dimensions we then had to determine criteria with which to assess project positioning. To this end we returned to the central assumptions made about architectural innovations, which is that they seek to break pre-existing arrangements and thus require new alignments. It is difficult to think of how this might be achieved without there being a place where the necessary changes and adjustments are discussed and debated and where an agreement of one kind or another emerges. A typical example here would be the production of new norms or new standards. In following this line of argument we pick up and connect with work done in science studies about controversies. (This association is, in fact, already made in the title of our work - SOCROBUST - since the concept of robustness derives from the study of debates and controversies in science. The basic article on the subject by A.

Rip (1985) deals with cigarettes and smoking and thus addresses a wider range of issues than those associated with traditional scientific controversies.). Drawing upon this work we decided to adopt the same set of criteria for each dimension. In each case we would ask about:

- controversies: do they exist? how important are there? and which aspects are controversial?
- fora: is there any organised forum? how is it/how are they organised? Which actors are involved, and how relevant is it/are they for other actors?
- the degree of codification and alignment arrived at or at stake (type of closure).

Determining the existence of relevant controversies is a first step in considering the realism or potential acceptability of the new world proposed by the innovation. A second step is to discover whether a space, an hybrid forum, exists where the controversy can develop, and where actors can exchange views and slowly develop ways of evaluating the different proposals made, and the different directions on offer. A third step is to see whether the project's visions and proposals become central within the forum: are they shared by other participants, are they internalised or naturalised in proposals made by other stakeholders?

It is thus possible with these one (existence) plus two (forum, centrality) categories to appreciate the project's capacity for action .

First dimension: knowledge sharing and technological space

The concept of technological space comes from economics and relates to technological cycles, paradigms and lock-in. Following these ideas, cycles are composed of two steps: variety creation (learning by exploration) and selection, ending in the establishment of a standard and a shared body of technology and knowledge. Abernathy's work on the automotive sector relates to this. The end result of such a cycle can be described as follows: knowledge should be shared and sufficiently stabilised so that users can rely on a certain quality and regularity of product. It is not only the knowledge to be mastered that counts, but also how that connects to the wider base of knowledge which is already shared. The more or less shared status of the knowledge is thus a first dimension to look for when considering architectural innovations. However economists care more about the result than the process. They consequently talk of lock-in and standardisation, distribution, diffusion, the adoption of standards. For our project, it is not enough to define the outcome for it is the process which we have to identify.

In concentrating on process we can nonetheless make a link with the notion of path dependence, provided we differentiate between path and time dependency. From our perspective, development is not driven by time but by the social construction of irreversibilities. It is thus connected to critical moments, which we define as steps where blackboxing takes place; meaning that given elements become so irreversible that they change the project's future trajectory. However nothing becomes irreversible without first going public . If projects do not go public, they do not know if they are generically or societally robust. Without taking further steps to test this aspect, they are only robust within a confined space . The challenge is therefore one of opening up a new space within which to initiate debate which tests and challenges the assumptions made. It is therefore important for projects to be positioned within relevant controversies. Viewed in this way, controversies provide the means of creating alignment and generalising the proposals which the project puts forward and

on which its future depends. When a project seeks to change one aspect of society, some people will object. These objectors are vitally important: projects need opponents. They need controversy in order to reach the point of lock in and it is for this reason that we consider the place of the forum to be so crucial. In the wind case which we studied, the so called Madrid meeting was such a defining forum.

In practical terms this means that our role is to question the project managers along the following lines. We might, for example, on this aspect which you consider central for the success of your project, there is a controversy going on without you, is this as you intend? or You say your innovation is robust but where was it collectively constructed and established as such? In effect we need to link controversies to the innovation journey and to the dynamics of the whole project.

The criteria for identifying convergence are therefore that: we can identify relevant controversies, define the space in which they develop, and specify the form of agreement which will have the effect of materialising irreversibilities. Naturalisation may be a better term to use in describing this process than closure, for it does not signal the end of the story. Take the example of the injection of coal in blast furnaces as studied by E. Jolivet. Everybody believed that it was impossible to inject 100 kg of coal into a blast furnace. The innovators - who proposed otherwise - had to take note for this was an opinion shared and expressed in all the congresses of the international technical association. In considering the way forward they had to assess the strength of all those existing beliefs, standards, and rules which would have to be transformed if they were to succeed. In this, they had to decide who should be convinced, when and how. Experiments were organised which had the effect of defining the terms of the proof: a new alignment of expectation being the outcome of this process.

This experience implies that we should have a procedural rather than a substantive discussion with the manager. He/she is the sole person to decide what is important, to determine what knowledge he/she wants to naturalise, what forms of naturalisation / closure are relevant, and how she/he is planning to achieve it. Rather than arriving with a ready-made list of variables, we provide tools with which to help managers think through the process of architectural innovation with reference to the specific situation of their own project.

Second dimension: the institutional framework

This second dimension draws upon our knowledge of institutions: markets do not exist without institutions and in each market, institutions set the rules of the game. Rules about property rights, legal powers, and more broadly, political and institutional contexts are necessary for transactions to occur, and for the game to be played. For architectural innovation the question is this: how suitable is the institutional framework for the proposed innovation, how compatible is the innovation with the present rules of the game which organise the targeted market, and if not, what institutional developments are needed to create the market conditions which the innovation requires.

The institutional context is the framework that makes it possible for user-producer relations to exist, and that defines their respective roles as actors. Take the following example from Health Telematics. A database of validated cases and images was established for use in diagnosing the main lung diseases. This was used by general hospitals to help diagnose patients before

referring them to more specialist services. It worked perfectly, and no mistakes were made over a six month period. However the demonstration was abandoned and no new telematic service was created on the basis of it. The reason for this lay in the legal framework and the allocation of responsibility for diagnostic error and for updating the database in the light of new knowledge. This example highlights a crucial issue: how well does the proposed innovation fit the existing frame for collective action.

This dimension differs depending upon the types of spaces and fora involved. Specialised papers and technical congresses constituted the fora for the first example (discussed above) but in this context the relevant fora include those of parliament, regulatory authorities, and the media. To manage a project, you not only need knowledge about how the result might be achieved technically, but also knowledge about the relevant rules/codes for regulating what is possible and not possible, and knowledge about what is and is not a fair game. It is not only a matter of law, but a matter of authority. It is not only a matter of defending knowledge for if you have to change society, you also need to change the rules and the compulsory routines. This is the dimension of generic infrastructures and of rules and laws which define not the why but the realm of how and what can be done.

If we take the example of the wind energy case, this realm refers both to the EC directive (as a generic rule) and to specific German and Spanish laws (being central to the creation of given markets). But we also refer to the grid, the physical infrastructure which is as important as the legal framework in determining the possible emergence of a market for wind energy. These two dimensions are simultaneously part of the institutional framework. The second dimension concerns thus the legal, administrative and regulatory environment as well as the necessary physical infrastructure.

Third Dimension: Designs & user-producer relations

The question here is not so much one of sharing collective knowledge, or rules for collective action, but of building relevant relationships and of selecting relevant spokespersons so that the project's network is well positioned with respect to other competing networks representing different sociotechnical solutions.

In the real world, products only acquire value through use and adoption. One aspect of this dimension has to do with shaping the competences needed by future users. Another is defining the characteristics which the product must have in terms of quality and performance. As an example, we can think of Vincent Mangematin's analysis of competition between two innovation projects relating to electronic guidance systems for cars. One was implemented by Renault/Philips who took Automobile clubs to be their lead users/spoke persons. The other was implemented by Mercedes/Siemens who took infrastructure managing authorities (motorways companies and public bodies handling infrastructures) to be their lead users. The same story holds in the wind case where Danish manufacturers viewed farmers and co-operatives as their lead users, in contrast to American producers who worked hand in hand with utilities and with the military. The issue here is not one so much one of making generic choices (where collaboration between potential competitors is often fruitful, as demonstrated by works on EC projects), but of the selection of specific actors to work with in developing and thereby defining the innovation: choose the wrong lead user - i.e. one that does not

adequately represent the target audience - and the product you develop will not have the characteristics required, nor will your actual audience be convinced that you have demonstrated your case.

In this third dimension, we take on board the results of innovation studies, here recognising the process through which users, and the functionalities of the product are co-shaped. This may be a contested process with spokespersons of different networks entering into competition here, competition that is between different users' views, for example, of what the bicycle is or should be used for (Bijker). Users do not know what they are going to want in the future. The manager therefore has to think about different possible spokespersons, about their relevance, and about the dimensions and aspects with reference to which they qualify as good and suitable evaluators.

It was not at all obvious how these concepts should be operationalised. This was either because potential tools (like information acceleration) are very prescriptive and normative, or because they lead to very generic conclusions. An alternative way of dealing with these aspects was to focus on the specification of intermediaries. In most cases, there are more actors involved than users and producers, for product chains nearly always include prescribers (for example, large supermarket chains, doctors, advertising...). Another possible point of entry was to test the representativeness of the spokespersons selected: are there other spokespersons who might represent contrasting visions of the products and of the value to and competence of potential users? Here, we should not lose sight of self-organised, autonomous users' collectives, such as patient associations. Knowledge about the spokespersons selected is also important since they could well have multiple commitments.

The selection of spokespersons relates to a series of other choices and consequences. Analysing this will therefore help to articulate and make explicit the implied meaning of a good and appropriate performance in each case. Comparing the choice made to other potential choices (via an external check⁵) creates the space for further discussion with project managers. Does this mean that we should undertake a specific analysis of the spokespersons enlisted or that we should develop a table which characterises them in terms of what brings them together, what is the relevance of the criteria they bring with them, and hence what types of performance criteria are they likely to favour? The answer is no but, there should be a moment when the users and spokespersons who are enrolled in the project are reviewed against the whole canvas of possible spokespersons for the project, including those competing with it: in other words against all those who are willing to contribute to debate and constitute the forum.

The assessment process in practice

To sum up, we made the assumption that innovations are architectural when they disrupt at least one of the three above-mentioned dimensions. Such changes imply the existence of a public debate: in other words changes affecting the societal infrastructure must be collectively discussed if they are to be taken up and affect a world wider than that of the

⁵ If the spokesperson exist on their own, they would have made themselves readable, visible, and we can access the inscriptions.

project. This calls for the development/ existence of a forum where debates can take place and where controversies can develop and be resolved. The capacity to create or position the project in such a forum constitutes a first criterion against which to judge the societal robustness of the project. The second dimension follows logically: the views or assumptions inscribed in the project must become central to participants in this forum, if the way is to be paved for success. The project manager's capacity to influence relevant debate is thus a second criterion against which to judge the societal robustness of architectural innovations.

Project manager's assumptions about the world with respect to these three societal dimensions (technological, regulatory, user-producer) are tested through *the external check* — and a synthesis of the results obtained is represented in *the positioning table*. The job of defining the project's and the project manager's margins for manoeuvre using our two criteria (existence of relevant space/forum for debate and centrality) is handled with the help of *the capacity for action table*.

Even as late as July 2000, the two elements - the positioning table and the capacity for action table - were not differentiated. The differentiation happened in practice with the analysis and writing of the first case, EUROVET. This move was further discussed in the 5th project meeting in Roma. We shall see that this was a central move since, during the evaluation sessions, the positioning table was central to the discussion.

The external check

The *external check* is a procedure designed to capture external views of the project world. Embedment is, as noticed earlier, based on the articulation of the inside and outside worlds of the project. Drawing on the *Future World*, *Boundary mapping* and *Key Changes table*, an information search organised around the project manager's core about the future of the innovation is carried out. The purpose of the external check is to test the consistency of the assumptions made about the future world, and to identify other possible or existing assumptions (developed enough to be articulated on the web).

The University of Toulouse has a well established competence in technology and competition watch, so the task of the external watch was shared. This also meant that the consultants were obliged to identify and articulate the key assumptions to be examined through the external check. Since not all assumptions can be checked, the consultant has to use his/her judgement in determining those which are central. This step needs to be given further thought when fully operationalising the approach.

A full technology and competition watch is very costly and time consuming and was not compatible with the objectives of the present project (a feasibility study only). A very light-weight search method was therefore defined, the implementation of which was shared by the University of Toulouse and the consultants (in 2 cases) or with Armines (in 3 cases). Standardised searches on the internet have been tested and have proven to provide new insights. The selection of assumptions to investigate relates to the specification of the key changes required. The translation of these key changes into corresponding if... then

questions generates a series of propositions around which the search is organised⁶. A two stage search process starting with the daily papers and then ranging more widely so as to pick up websites specifically related to precise elements of the given assumptions proved to be quite effective.

It was important to include relatively long descriptions of the external search and the results it generated in order that our conclusions were credible to and accepted by the project managers. Two methods were adopted for feeding the results of the search back to the managers.

For EUROVET we identified three potential threats and challenges and used the results of our internet searches to define plausible scenarios. We were then able to pose the question: how would the project fare should these trends develop? We used these scenarios as a kind of sounding board - a point of reference against which to consider the project's ability to cope or survive under new conditions. Drawing upon the results of the internet search we constructed fictional but nonetheless credible stories as a means of dramatising the implications of potential threats and challenges for the project promoters' present strategy. In this case, where the project had underestimated two possible alternative scenarios, the technique of bringing these to life by means of fictional scenarios provided a very precise focus for the discussion which later took place about future possible directions. These three scenarios were central in highlighting gaps in the assumptions then being made by the project and the project manager (e.g. taking the existing administrative structure for granted; working exclusively with partners based in national administrations) and of revealing the very different anticipations made by others (e.g. about the changing relation between supermarket chains, their suppliers and their consumers, and about the potential emergence of third party certification of health and safety). However the SOCROBUST evaluator found that at the third meeting, he had to conjure up yet more graphic images (for example what might happen in the Basque country, or in Scotland, etc.) before the project manager fully grasped the issues at stake⁷.

For DEO, it appeared more appropriate to represent each of the key changes identified in terms of a set of assumptions to check. There was not a direct correspondence between the key changes and the assumptions: in this case, the five key changes generated 7 assumptions which could be tested individually. The result of this was to bring together a wealth of information about the existence and relative importance of particular actors (e.g. ESCOs), to highlight the expectations of specific manufacturers, and to reveal the significance of existing legislation about energy-efficiency measures and the possible involvement of grid operators in

⁶ The external check is not checking the robustness of the project, but this of the assumptions made by/within the project. Should we consider then that we take the project as a carrier about a given set of assumptions about a potential technology? The answer is a part yes, since there are many chances that, as far as technology is concerned, anti-programmes or multiples (cf Cowan, after Merton) will address similar issues (may be proposing very different answers), and surely no, since many of the architectural innovations we have faced in our cases, relate more about uses (and delivery) and about the institutional framing of markets (rules, norms, etc.). Different framing in these two other dimensions of architectural innovations might put forward very different technological issues.

⁷ The discussion noted that such images should not be in the report but kept as a resource in the strategic interaction.

embedded generation. Each was reviewed in turn. This involved an exposition of the arguments and evidence at stake and led to the development of dedicated tables and images, together accounting for nearly a quarter of the final report. The same approach was adopted for RETRANSPLANT and M2DM. This style was chosen by the consultants when the external check revealed evidence which called into question some of the assumptions made but which did not challenge the whole approach.

The positioning table

The results obtained by the external check are used in preparing a *positioning table* that situates the internal vision held by the project manager in the wider context of the external World — as a specified through and approximated through the *external check*. The positioning table therefore serves to link the key changes (as expressed by the project itself) to the results of the external check⁸. It checks the consistency of the assumptions made by the projects.

The *positioning table* synthesises and summarises the project manager's main assumptions about the future (project world), characterises the most challenging alternative position found (alternative approaches), identifies the potential allies and opponents to be anticipated, and details the stabilising factors/elements or the key moments/turning points expected (see box 24). It ends with an evaluation of the position of the project (the SOCROBUST view). This construction — based on a recognition of irreversibilities, anti-programmes, allies and opponents, and the capacity to circumvent them — reflects and encapsulates the major lessons of the socio-economics of innovation. It thus provides an assessment, by describing the risks the project takes by virtue of its internal coherence and the relevance of the boundaries drawn around it.

Box 24 - Explaining project positioning

source: Eurovet socrobust report.

The project positioning table summarises our evaluation of the project's societal robustness. It is divided into three horizontal bands: position in the technological landscape; position in the legal, administrative and regulatory environment, and the positioning of demand, of users and of markets. Projects may need to transform (or benefit from the transformation of) the status quo across all three dimensions if they are to succeed.

In order to arrive at a view of the present state of societal robustness, we check on where the project stands with respect to major alternatives in each of these dimensions, and we check on the strength and character of the project's potential allies and opponents.

The first column describes the project's current focus and purpose.

The second identifies other possible methods, strategies, directions and options.

⁸ At one moment in the discussions in Lancaster, it was said that the positioning table gathered together a set of elements a strategy has to take into account and answer one way or the other. We consider this definition as counterproductive. We are not normative here, we do not know more about the project than project managers themselves. What SOCROBUST provides is a means of making explicit the key changes required, as seen at a given moment in the project trajectory (we can further make the assumption that these key changes will evolve along with the project trials and the learning derived, thus the interest of the periodicity). The external check is there to test the consistency of the assumptions made about the future world, and identify the other assumptions made (developed enough to be articulated on the web). There is no external norm that applies there about the type or number of assumptions to be tested.

The third explains where the project stands with respect to these alternatives.
The fourth and fifth identify potential allies and opponents given the project's present focus.
The sixth column gives our assessment of the project's societal robustness in each of the three horizontal dimensions. We use the symbols J, K and L to represent our view of the present strategy.

Implementation of the positioning table for actual cases helped develop it to the point at which we now consider it to be quite safe as a prototype. The following points explain why we have reached this conclusion.

First, the preceding steps of the processes (unfolding the project and external check) have made it *experimentally* quite simple / straight forward to develop the positioning table, and to operationalise concepts which are otherwise difficult to materialise. This, we guess, should be considered to be a significant result of our project. Project managers did not discuss or challenge the three dimensions of architectural innovations around which the positioning table is organised — whether the terminology adopted was limited as in DEO (where the terms used were simply technology, regulation and market), or more developed as in EUROVET, (where the reference was made to technological landscape, legal, administrative and regulatory environment, demand, users and markets) —but were simply taken to be an empirically relevant way of structuring the information provided. In other words they were common sense .

The relevance was further emphasised by what happened with the TAPPE case. In this case, we were in the position of questioning the project manager about an EC project which had been finished for nearly two years but which was, in his eyes, part of a wider project which had been actively developed since and which constituted a major concern for the company and the core partners they had worked with during the life of the EC project. It was striking that the project manager agreed with all the items identified as central in the positioning table, and was moreover in a position to explain what had happened since. With hindsight there was not one element to add nor one which was had not proved relevant. At the Lancaster meeting we took this to be proof of the robustness of the method adopted. It also helped to solve in practice an issue which remains difficult to address at the conceptual level, that is the relation between the internal and external articulation of the project. This change of register and this jump beyond the institutional borders of the assessed project is crucial in the dynamics of the assessment.

Two practical issues were further identified regarding the implementation of the positioning table:

- One issue was how it might be applied. The positioning table for EUROVET listed all the key changes identified and analysed them in turn. Since the table identified potentially incompatible directions, the manager reshuffled the options and alternatives, taking one as a reference scenario, and looking at the others as possible routes to keep in mind so as to remain flexible enough to cope with them should they develop. In other cases the decision was made to organise and represent the key changes in terms of the three dimensions (key changes

addressing more than one dimension were disaggregated accordingly⁹). As mentioned, this was readily accepted by the managers who considered it to be common sense .

- the other issue had to do with filling in the table. Project managers often considered the headings we used and the comments we provided to be too general. It appears important to be specific, to name things (like the food supply chain and third party certification, home safety/quality standards, etc.) and even to mention examples, i.e. which other actors are already doing the things mentioned etc., and that this makes it easier to absorb, appropriate, and internalise the implications. Since the assessment part of the report is no longer framed by the project manager s world, but instead addresses the (usually wider) world of the project, we have greater freedom of expression, and are able to deploy a wider range of resources in making ourselves understood.

The capacity for action table

How should we organise our conclusions and suggestions or recommended actions? In the first two projects undertaken we tested two complementary approaches. With DEO we focused on the dynamics of the project, distinguishing between activities devoted to alignment or enrolment, the former being designed to consolidate the present network, the latter seeking to enlarge it to make it more relevant to the final objective. The discussion with the manager de facto reintroduced the notion of the spaces and places in which the project was debated (fora) and the capacity of the project to influence the outcome of debates in this/these spaces. This prompted us to focus on a different approach for the last cases made.

Box 25: definition of enrolment and alignment actions

Source: DEO socrobust report

With actions of *enrolment* we mean those actions that aim at extending the current network. In other words, if enrolment is successful, the inner box of the Boundary Map on page 19 will be extended to include more actors.

A weaker form of enrolment is involvement: getting the right actors interested.

With actions of *alignment* we mean those actions aimed at enhancing the mutual positive influence of the actions of all the actors that are relevant for reaching the ideal future . If actions are well aligned they enforce each other, if they are not, they work against each other.

In these cases we first tried to characterise the margins for manoeuvre, concentrating here on the architectural dimensions of the project, hence the capacity for action table, and then considering potential next step actions¹⁰. We review both methods here. Box 26 presents the argument which informs the design of the capacity for action table. For each dimension, the table identifies the three following elements: the project s goal (that is its preferred arrangement or the context favourable to the project s deployment and success), the loci of debate (that is the capacity to join or build relevant fora in which to engage with others

⁹ The issue remained open as whether the notion of key change should be better characterised and those addressing more than one dimension requiring to be further disentangled, the unfolding being satisfactory only when there was an adequation between key changes and dimensions.

¹⁰ A first experiment in EUROVET considered the possibility of a global robustness assessment. This proved both quite banal (only very generic expressions) and counter-productive, since opening no lever for action. We then decided to skip it and focus on what to do next .

regarding the necessary reshaping) and the room for action, that is the ability to enlist key actors in those fora, to ensure that the project is not marginalised and that its goals are internalised by relevant groups.

Box 26: presenting the capacity for action table

Source: Retransplant socrobust report.

The three central dimensions organise our assessment of the capacity for action of the RETRANSPLANT project which is expressed in the following table. There are two aspects to this capacity. One is the ability to join, find or formulate a context and a space in which to engage in debate and discussion with other competing or complementary interests. Change cannot be engineered single-handedly. Such a forum is therefore needed if practices and expectations (whether relating to the technological landscape; the legal administrative and regulatory environment; or the positioning of demand, users and markets) are to be re-shaped. The second, equally significant capacity concerns the ability to make a difference in these fora, and to steer events and interests such that the project and its pre-requisite changes are not marginalised or pushed out of the frame but are instead taken up as natural solutions. Finally it is important to recognise that project promoters cannot always change the world, some forces are just out of reach and can at best be monitored passively. The capacity for action table aims at rendering explicit the margins of manoeuvre that a project has for shaping an adequate future world in which it will be successful.

The cases showed that the points revealed by the capacity for action table had to be explained to project managers (thus the central role of the last interaction). In doing this we had to take account of the fact that project managers found notions like those of fora and public debate to be rather strange. The essence of the argument is clear (if there is a change in society, there should be a place where it is discussed and negotiated and decided), but not the way it is presented!

Formulating recommendations

The role of the capacity for action table is to highlight the project's margins for manoeuvre. There is obviously a strong connection between a given project positioning (as represented in the positioning table) and the types of actions that can be thought of, e.g. the non existence of a relevant forum either suggests that the project should be redefined (so as not to require one) or that steps should be taken to create one. For example, projects which occupy a marginal position in a given forum have options to be responsive (to agreements arrived at) and/or to remain flexible (to avoid irreversibilisations in those aspects that are under debate). A recognised position within a forum often requires significant investment in shaping agreements that will enable the closure of that forum (often eating into resources that could be more directly useful to the project). A specific debate arose again in our last meeting about the relationship between the state of development of a project and the type of assessment and recommendations that might be made about it. This was exemplified by the two projects, Eurovet and DEO. The conclusion (see box 27) was that different states of development did not call for a different approach, at best called for a different application of the tool.

Box 27: From capacity for action to recommendation, influence of the state of development of projects

Source: minutes of the Lancaster meeting (February 2000).

Are the differences between EUROVET and DEO linked or not to their present state of affairs, one being in a state of exploration, the other at market emergence? Basically DEO falls under something we know and has

been quite extensively studied (cf. fuel cells) and there is an easy jump from the assessment (here revealed by the positioning table) to the recommendations. This easy jump can be described along two directions: complete the network and make it converge (cf. AFME work among many others), and in the wider world, foster the creation of a specific science/technology community (or technological space) that will build credibility for the technology at large (cf. strategic niche management). By and large, the exchange and the discussion have complemented it: there is not only the need for a technology micro-CHP community, there is also the need for sharing the conditions under which micro-CHP can be installed into houses (quality/safety standards) and this requires a specific arrangement. Such jump was far more difficult to do with a project in a state of market emergence. The three dimensions provided a step by step approach. This enabled to eliminate those dimensions for which things were stabilised (this contains a dual meaning: classical approaches in marketing or for technology can be put into action when needed under normal procedures, monitoring of possible destabilisation factors remains the core activity for societal robustness). This focused attention on those aspects which required attention: IT community building and stakeholder involvement for EUROVET first implementation in Bulgaria. It was clear that this capacity for action table and the clear recommendations that derived from it were a critical element in the credibility of SOCROBUST (especially considering that our correspondent had made a try-out approach, stopping his description with the prospect of the contract in Bulgaria, not having described the redefinition in partnership which had accompanied it).

Recommendations took the form of action verbs which reflect the location of the project within the space for debate. Box 28 lists them. On average a report used 5 of them, thus entailing a combination of actions. It tells us that there is not one specific task or workpackage (to use the EC language) that should be devoted to societal robustness or to addressing the social and political dimensions of projects. The three dimensions (technological, institutional and market related) require ad-hoc answers and specific actions. Four complementary aspects are of further relevance:

(i) in all projects there are dimensions beyond the project's margins for manoeuvre but which appear central to the future success of the project (meaning that either they should remain stable or that they should evolve in one direction —and not in another). These have to be passively monitored on a on-going basis, so that actions can be taken, as soon as events unfold. Here the action is to monitor. This action is often linked to others designed to maintain flexibility (here see the way exploit has been used).

(ii) Most projects can however be pro-active and act as market shapers (cf. Courtney), that is be active in creating, building, and establishing an adequate space for debate, or at least contributing to, or encouraging its emergence. They can also be more active in an existing space, for example, in pushing forward their views, in fostering their naturalisation and their take-up by other relevant groups. The significance of these two types of action was frequently underestimated. Discussion showed that this was in part due to projects' typically traditional orientation (i.e. subscribing to the conventional view that social and political problems could be resolved once the technology was fixed) and because of EC constraints (which, besides technology, focus on exploitation - taken at best as an emphasis on user-producer relations, but in a way which omits all other dimensions and thereby prevents the allocation of resources to them). There is thus an issue of missing incentives from funders, sponsors and decision-makers.

(iii) The innovation journey had often led to irreversibilities in the project trajectory. However these irreversibilities were soon forgotten and hardly thought of again despite the fact that most of the projects we reviewed already had a life of more than 5 years. In some cases, competing projects had made other choices and opted for or opened routes already abandoned by the project in question. In combination these two points meant that project managers had

difficulty understanding the terms under which the competition with other recognised projects developed. For this reason we included action verbs such as reflect upon (routes not taken), and/or think about, explore (possible other routes) and in one case, abandon the present course.

(iv) Many action verbs address the present network or the one that should be established as a result of actions on-going or under consideration. Many of these verbs specify actions to undertake or compromises to make as to ensure adequate and more durable involvement on the part of other necessary actors. In many of the projects with which we dealt, the need for actions of this kind was seriously underestimated: as a consequence the present network was fragile, as was the durability of the results achieved so far. Our use of verbs like extend, enrol, exploit, take care, strengthen, and discuss, all reflect these sorts of issues.

A final comment from the cases is that the separation between the capacity for action table which is our assessment, and the recommendations which represent our interpretation of what the assessment means in practice, is central to the relevance of our work. Project managers can, for instance, agree with the assessment but identify other means of addressing the challenges which have been identified. In any event, the method proved to be especially useful partly because the project manager is free to determine which suggestions to pursue in his or her own way, and which recommendations to adopt (or not).

Box 28: the action vocabulary used for making recommendations

Source: the 5 socrobust reports made.

Monitor (a given controversy, the emergence of organised groups, the legal environment and the debates about possible change...)

Reflect upon (the routes not taken)

Think about, Explore (possible other routes, options)

Build, prepare, establish, or contribute to/ encourage such actions (a forum, a community, the naturalisation of the project within an identified forum)

Discuss (the model underlying the project with other actors in the project)

Strengthen (the links between actors in the project)

Take care of (the involvement of adequate actors and their participation in the experiment)

Exploit (the potential included in the present project avoiding too early choice)

Extend, enrol (other actors)

Develop (demonstrations, given attributes...)

Abandon (a given route or given ambitions).

6.2- From an evaluation session to a strategic interaction

We now have all the ingredients with which to build the report. Box 29 visualises the three components, and shows using the M2DM report, that the tables alone account for some 13 pages. When presentations, explanations of the approach and of the construction of the tables, graphs and boxes, including the project narrative and elements of the external check, were included, we ended up with reports of between 35 and 45 pages. This was some way off our intended target of a 15 page report. In the last few cases, we devised new methods to facilitate the analysis: one was to have, as for M2DM, two documents: one consisting of the analytical tools and associated explanations. We also considered producing the external check as a separate document given that most of the findings are recapitulated in the positioning table.

However we managed the process, our project managers were confronted with a rather lengthy report which required some time to read, not to mention the time needed to understand our approach and vocabulary (we can mimic consultants, but it is very difficult to share their expertise in presenting results and preparing written documents).

Box 29 - Structure of a SOCROBUST report

INTRODUCTION

PART 1 THE PROJECT STORY

- 1.1 Project narrative
- 1.2 Critical moments, past and future

PART 2 UNFOLDING THE PROJECT

- 2.1 Mapping the present project network
- 2.2. Anticipating the future world
- 2.3 Identifying key changes
- 2.4 Reviewing the project s boundaries

PART 3 THE SOCROBUST ASSESSMENT

- 3.1 An external check
- 3.2 Project positioning
- 3.3 Lessons and recommendations

List of tables, boxes and graphs: the case of M2DM socrobust report

Part 1: The Project story

- Critical moments Table 2

Part 2°: Unfolding the project

- Critical actors table 3
- Explaining the graphs 4
- Present M2DM network 5
- Future M2DM network 6
- Future Diabetes working world 7
- Key changes table 8
- Boundary mapping 9

Part 3°: Assessment of M2DM societal Robustness

- M2DM positioning table 10
- M2DM capacity for action table 12
- M2DM general recommendations box 13

The evaluation session began as a joint reading of the report, generally starting with the key changes table since the elements which came before, (the project story and the critical moments table) had already been discussed or produced with the consultants (the present and future TEN and future working world, though not always for the latter). Discussion of the key changes and of the way they had been characterised and represented, of the results the external check, and careful analysis of the positioning table (in nearly all the cases, line by line and cell by cell) accounted, in all cases, for between one and a half to two hours of interaction during which debate focused on the content of the project per se, on its different dimensions, on the assumptions made, their credibility, their potential for practical realisation. We then entered the second part of the interaction which dealt with our assessment of the margins for manoeuvre and our recommendations.

Here the nature of the interaction changed as we turned to the formulation of strategies for the future. This experience showed that reports can be the object of more than one translation and that there is, for the consultant, a first process of checking on the project manager's understanding of the report, and then exploring the types of action, or the levers for action that might be pulled (e.g. in DEO, changing quality standards for house building were not directly mentioned in the report as a target, being rather considered as an obligatory passage point). It also showed that in most cases the project managers had not grasped what we meant by debates, fora, controversies, closure, internalisation or naturalisation. For them debate meant that there was an opponent and hence a problem, hence the fewer controversies the better. What conclusions should we draw from these observations about our approach? Before answering this question, two elements have to be taken into account:

- First, in 4 out of 5 projects, the project manager skipped over the capacity for action part in his initial comments and went directly to the main recommendations. These were considered interesting enough to start a discussion about how they could be translated into actions. Does this mean that we should blackbox the process and simply present the results? The answer is clearly no when one looks at the recommendations which they found difficult to accept. By and large these were recommendations relating to the need for external monitoring (i.e. for early warning) and those dedicated to the creation of for a where these did not already exist.

- This is why the evaluator (P. Lar do for all cases) considered it necessary to come back to the process through which the recommendations had been arrived at. The evaluator had to find further words and provide more examples with which to explain that classical project management lessons do not apply, and that what works for incremental projects might prove to be positively damaging in the case radical innovation projects that have to change established rules or/and markets. He had to use the fact that their projects had already, at one time or another, been faced with, or were presently facing social, regulatory or political difficulties. He had to explain that these could be anticipated and addressed just like any other technical or marketing problem. The general argument was accepted, when rephrased in this way, and helped managers make sense of those recommendations which were otherwise difficult to understand and absorb.

From this experience (which was repeated in all cases), we reached four main conclusions at our 6th project meeting.

(i) In our own assessment, the prototype method and reporting framework worked quite well at the level of content, but significant further developments are required to make it more immediately comprehensible and useful for project managers. However, we can confirm that the strategy of relating one tool to one clearly identified procedure to one issue, has proved successful.

The sequence can be set out quite clearly:

- the key changes table is for identifying the challenges,
- the external check is for checking their consistency,
- the positioning table is for positioning the project vis vis these challenges,
- the capacity for action table is for identifying margins of action, and room for manoeuvre,
- the recommendations represent our interpretation of what the assessment means in practice, i.e. for what to do next.

Such a clearly established sequence enables us to address one difficult issue in our interaction, namely that of linearity . We know that innovation processes are not linear, but a sense of linearity is essential if managers are to define actions and to act. We are thus not saying that this second type of linearity is bad. On the contrary this is a way of reducing complexity and as such represents a management resource. Our purpose is to check whether the type of linearity which project managers propose is consistent (given the step they are about to take).

(ii) We can now be clearer about our notion of project. We do not address the project at large , nor the potential paradigm it embeds. We address one project manager faced with decisions to make or to propose to other managers within his/her hierarchy¹¹. The consulting interaction supported by our methodology focuses on, and addresses this project manager. However this also means that we also do not stick to institutionalised projects (such as projects supported by EC programmes), since in quite a number of cases, project managers do not view these to be stand alone projects, but understand them, instead, to be one element in a wider project. It is this wider project which deserves attention and which it is relevant to investigate, to unfold . This latter situation can be understood as one in which we investigate the project plus as initially suggested in the preliminary management framework. This is not an important issue as long as the application of the method is bottom-up (i.e. asked for by the project manager him or herself). However, it could become an issue (and was in a way for us since we took institutionalised projects as our entry point) if our method was to be applied top-down , e.g. as part of a systematic monitoring process initiated by project funders (say the EC)¹².

¹¹ This archetypal situation was not however the most common one, and this has implications regarding the need for wider experimentation. In EUROVET, we were working with a SME, the project was a major investment, the project manager was part of the board and participated actively in strategic decision making. In DEO, the project manager was an outsider, which means that, being a consultant hired for managing the project, he remained at a distance from the main stakeholders and investors, the gas companies; he further highlighted the different embedding of the project in the different gas companies, at the same time the capacity to turn the project in a given direction, might position the consultant as an obligatory point of passage (for the development of quality standards). For RETRANSPLANT we dealt with a university researcher who co-ordinated a set of developing SMEs (with a rapid replacement turnover) and professionals organised around one key figure and located in another country. Whatever the results, any further development or application will be in their hands. TESEMED, also managed by a University professor, sought to establish a new service and probably a new start-up to initiate (even experimentally) this new service. Finally only in TAPPE did we find the typical situation initially thought of, i.e. that of a manager located in a large company with the task of managing a portfolio of projects. In this case, the project studied was in part hollow per se but was at the same time central to the development of a wider portfolio of projects (i.e. the establishment of public e-procurement) decided upon in a top-down fashion, a process that the project manager, affected by the results of these decisions, questioned.

¹² The experience showed that hollow projects turned clearly visible when discussing the future network or the future working world, it also clearly enabled to distinguish between those which explore the world and those which promote one answer (collective experiments).

(iii) The third important conclusion deals with the process per se. In its present form, it does not represent a methodology that managers can deploy themselves. It remains a procedure for use within a consultancy situation. This means that:

- the effective application of the methodology relies upon the consultant's embedded knowledge, i.e. his/her views on innovation dynamics, his/her know how and skills regarding strategic project management.
 - the tools represent more than an heuristic device which allows project managers to better describe their project. They go beyond the project managers present focus and interests in order to reveal dimensions that would otherwise remain buried. In this, effective use of the tools allows projects managers to see aspects that have been blackboxed, and to formalise underlying assumptions about the project and its environment.
 - the report does not stand alone, its requires interpretation and discussion during a third interaction which focuses on strategy making and action, in the light of the assessment made.
- In its present form the SOCROBUST process is a method for use in a consultancy style interaction supported by a four, and not a three, step process.

(iv) This transformation from a stand alone framework (as at first intended) to a framework for use in a consultancy interaction is critical for the future of the method and for the specification of a target audience. Before reaching any definitive conclusions on this point, we must however clarify whether the approach is structurally ill suited for use as a portable instrument or whether SOCROBUST could be developed into a stand alone methodology in the future (this might, for instance, take the form of a quasi expert system). Our fourth conclusion (see further developments in next steps) was that it would be useful to devise a means of testing the viability of such a development. To do this we might develop a learning website and follow the visitors ability to circulate through it, to download materials, and to question us (or for us to contact them about their use of the site).

6.3 — Other lessons derived from the experiment

In this last sub-section, we review, tool by tool, the lessons learned about part 1 and 2 of the process (part 3, the societal robustness assessment has been already dealt with in 6.1). They are all important for operational purposes, but none call into question the process or its articulation. The most important lessons for us has to do with the use of the techno-economic network and the fictive scripts. The cases confirmed the value of these tools in helping managers look differently at their projects and although we made quite a few operational developments there is scope to strengthen these processes still further. Many lessons relate to the way the tools worked and how they helped managers crystallise their views and quite a few have to do with vocabulary (this is clearly, as mentioned in the preceding sub-section, an issue we shall have to consider seriously in the future). All these lessons have been incorporated into the second chapter of the methodology. The reader not interested in incremental improvements can therefore go to the next section directly.

Project story

At the Lancaster meeting, we learned an important lesson about the credibility of the consultancy process. It lay, in great part, in our capacity to describe the project the way the project managers saw it. Discussing the critical moments table, even in the third strategic interaction, proved to be important since it helped to uncover forgotten, hidden or very recent developments which the project manager, having read the report, now considered to be important. This retrospective enriching of the project story might well be an important output of the process.

The evaluation sessions showed that the reconstruction of the project story (i.e. a the project narrative which summarised key elements in just three pages), worked well. It provided a good introduction to the interaction, and in this case, it was an important source of information for the evaluator (who had not been involved in the process up to that point). The question we discussed at Lancaster was this: could the project manager have written the same introduction alone? Our conclusion was that, even when self-assessing their projects, project managers should ask someone external to the project to undertake this specific exercise.

Critical moments table

The active way in which the critical moments table was developed and discussed, is an important asset. Reviewing it again in the third interaction helped uncover further hidden facts (e.g. external assessment of market opportunities in EUROVET). We can thus consider it to be a fairly stable tool. However, it can still be improved (point 1) and, depending upon the situation, its future part might become more or less important (point 2).

- Two potential improvements deal with the dimensions of irreversibility and source. (i) The column labelled irreversibility only has meaning when explained, and the categories of weak, strong, and medium are not in themselves useful. In one case, the notion of branching — linked to ideographs (branching, whirling, zigzagging, etc) — was suggested by a project manager. (ii) The column labelled source was not subject to much discussion especially in cases where the response was mainly internal. This was because again the categories adopted were not very well explicated. One way forward here would be to always explain why this column is filled in the way it is, and to make clear the grounds on which such judgements are made.

- Future critical moments have only been developed and explored in projects positioned in a situation of market emergence, i.e. having much in common with our prospective wind case. Rendering visible the project manager's scenarios for the future represented a way of highlighting key factors (most of which are external to the project as presently constructed) including the project's degree of flexibility¹³. It represents a first introduction to our

¹³ We had in Lancaster a discussion about the capability of the project manager to build these scenarios. In Eurovet, these were included into its presentations but not formalised. The second interaction should help to test the elaborations by the consultant. In this case, our correspondent (who was not there for the second interaction) recognised himself in the scenarios, as if they were of his own making. This was also a result of the timing of the interaction as to facilitate appropriation, a point we have to think when looking at the reduced

approach, while remaining in the project manager's world and while using the manager's own terminology. For projects which remained more on the exploration side of our typology, this exercise had less meaning. In fact one result of the SOCROBUST process might be to uncover the wealth of potential futures, and within these, identify the one(s) the project implicitly favours.

The use of the TEN approach

We have to differentiate between our use of the TEN concept in the interaction process and the background knowledge that we bring to the process. We no longer use TEN as a benchmarking tool (with which to assess the completeness of networks, using Callon's characterisation of networks). For our purpose, TEN represents a means of identify actors to be mobilised in building a market while recalling that market shaping (here is the background knowledge) *de facto* deals (simultaneously or not) with science/technology, production/delivery, regulation and usages.

In our representation we do not include a discrete market pole. We have to make it clear here that the whole TEN and the whole future working world describe one market and its constituent elements and dimensions. We have to ground our analysis in the construction of markets, demonstrating that public shaping is not limited to the development of technical standards for interoperability, but that it includes quality issues (see the parallel of cars and computers), collective issues (such as recycling or road safety: think how a strict collective compliance of maximum speed limits could change requirements for vehicles or a multiplication by five of gas taxes on our use of collective transport, etc.), and changing practices/expectations (think of the relations between patient and health professionals).

At Lancaster, we also discussed the practical use of these concepts. Our conclusions are as follows. We do not have to force the actors to describe their present network in terms of our canvas. If it has no meaning for them to separate the science and technology poles, and if they consider it to be important to have a producer pole distinct from science and technology, we should follow their inclinations. In this way we use the TEN mapping as a means of exploiting our background knowledge and of uncovering what the managers take into consideration (but did not formalise as such until this meeting). However the map must remain theirs.

Future TEN and future working world

The use of the future TEN in EUROVET was critical in highlighting the dual nature of EUROVET as a standard on the one hand (we know that standards are often embedded in artefacts, as was the case in the pre-internet model of EDI diffusion linked to TAPPE), and as specific applications on the other. It was thus very important in revealing the role of artefacts/devices as non human actors, an aspect which remains a key issue for this methodology. In this case, the future TEN encompassed issues relating to all four poles, focusing, especially on those to do with regulation.

version of the process used for TAPPE and DEO, where the appropriation really took place during the third strategic interaction.

However, it lacked any clear representation of potential prescribers, that is of people in a position to specify or influence the specification of the systems in question. This was a significant omission for the role of prescribing institutions provided an important focus for the final strategic recommendations and for discussion of the next steps (both in term of implementation of the first full size application of EUROVET and in term of new avenues to explore). A similar conclusion was drawn from DEO. What would have been useful in this case was a set of future working worlds (using the proposed triangular approach see below. Our argument here is that prescribers are central to the dynamics of market emergence, and so to the formulation of scenarios in which the project becomes more widely embedded). In this case, earlier reference to the prescribing function would have highlighted a critical feature identified by the project manager when discussing potential scenarios, i.e. the separation (or not) of electricity production and distribution facilities (having already taken for granted the separation of both from the management of the physical network). Questions about the detailed characteristics of the market (as anticipated when the project s ambitions are fully realised) — for example, what types of actors are involved, what degree of specialisation do we observe, what is the nature of the relationship between products and services, or between producers and service providers — have been central issues for both M2DM and RETRANSPLANT.

We therefore felt the need to develop the notion of the future working world, changing our approach somewhat and asking, directly, what might the market look like when the project has achieved its goals and the situation has stabilised? Recent management literature suggests that market relations can no longer be described in terms of the relation between producers and users alone. Prescribers, whether these be distributors (cf. the role of large hypermarket chains), professionals (cf. the role of doctors, architects or installers in the building industry), advertising or even third party agencies (such as health insurance systems), also play a critical role. We thus included (even for EUROVET), a description of such a stabilised market situation represented in terms of a triangle of (anticipated future) relations between producers, prescribers/mediators and users/customers, these being embedded in regulations, norms, rules, codes and other standards that frame market interactions.

In this we added another tool with which to visualise the future world. As well as developing a future TEN (describing the stabilised network of allies once the innovation was successful) we introduced a scheme with which to describe the market in which the future innovation would be embedded.

A final note on the future working world: the TAPPE case, being on e-markets, was very instructive. The notion of future working world could only be made clear when adapting it to the project manager s language, that is this of a changing business model . This worked well provided that we did not limit the unfolding of the new business model to a representation of user-producer relations alone (this was a point to which our interviewee responded very positively!).

Critical actors table

We developed three versions of the table. For EUROVET (the first case done), each actor was characterised in terms of 9 attributes (i.e. 9 columns). This was too elaborate, especially since there was no serious problem regarding partnerships within the project, roles having been quite clearly established over time. The next time round we tried a shorter version, using just 4 attributes for TAPPE and DEO. This limited version failed to capture and track the nature of different actor s involvement in the project, an aspect which, on reflection, we missed. We also missed a variable with which to characterise the project's importance (or otherwise) within the actors global strategy. A revised six column table proved more satisfactory.

The location of the critical actors table in the SOCROBUST sequence remains debatable. At the moment, it follows the description of the present TEN. However, it could be relocated and introduced after the future TEN and the future working world. There are good reasons for considering this option.

If we want to keep the unfolding process visible, then the effort invested in clarifying the heterogeneity of the present project (through its partnerships AND the other actors perceived as key by the project manager) has to be represented in the report. This is all the more important if we imagine this report being used in a monitoring process (the PROTEE learning pact, cf. section 7). But it might also be that the process of identifying key changes reveals new critical actors, about which the project manager might have only very generic knowledge. In this case an additional table might be necessary (if only to highlight possibilities for future partnering), however, the columns should be specially adapted for this situation. They should, for instance, detail the reason why nominated actors are key; identify their principal mode of functioning; indicate something about internal alignment and relevant spokespersons, and specify those aspects of the project which favour their enrolment (present and/or future) and/or which would require significant change (as compared to the present).

One point raised during the discussion at Lancaster was that we had only limited understanding of the project manager's company (or organisational situation more generally), a feature which proved to be very important when considering future strategy. Is this an aspect that should be covered in the text, or should we think of a specific development of the critical actors table so as to include the project manager's own organisation? Our conclusion was that in a consultancy style interaction, an introductory paragraph (in the section on critical actors) should be included to describe the project manager's position within his/her organisation, including some comment on the rules of the game for making strategic decisions about the project's future. This has no meaning when SOCROBUST is part of a wider framework (cf. Chapter 7).

Boundary mapping

Lengthy discussions took place in Lancaster about the role of the boundary mapping figure. The concept of the project boundary has been crucial in developing the methodology, but the tool, as developed, does not seem to play the role we expected.

In the paragraphs devoted to TEN, the map comes first and the explanation next. Here we do the reverse. In the third evaluation session on EUROVET we (the evaluator and project manager) discussed the boundary map first and then went into great detail about the key

changes table. In DEO, RETRANSPLANT and M2DM, we hardly discussed the table because the project managers were much more concerned to discuss each of the points identified in the key changes table. In TAPPE, the project manager concluded that the boundary table grouped together features which should, in his view, belong in different categories. The general comment was that the tiered boxes distinguished between: what you are acting upon now, what you know you will have to do next or soon, and what you have to be careful about and watch. In other words, the boundary table acts as a summary of the second step: square 1 of the boundary map indicates what the project has already acquired, aligned, or achieved. Square 2 indicates the directions for change, while square 3 highlights what is to be monitored (passively or actively).

Intellectually the boundary table acts as a tool for summing-up the project's present situation as seen by project managers. As such, it could be useful for them, provided they consider it to be a recapitulation of their views (formal and informal). However, this has not been the case up to now. If the table is to act as a summary of the manager's understanding and view of the project, we should not add any further elements based, for example, on our knowledge of innovation dynamics, or of our knowledge of the sector. Instead, we simply help him/her identify issues he/she has not already addressed directly (if he/she considers this to be useful) and use the process to pin down his/her assumptions to be considered in the external check.

However this exercise does not fit neatly into the sequence of the SOCROBUST process. In the event, it was the articulation between the key changes and the external check which proved crucial: it is this which structures the transition between the unfolding and the assessment parts of the methodology. This link is also central to the relevance of the assessment.

Even so, the notion of boundaries remains useful for project managers to visualise what it is they consider, and what leave out of the realm of direct and indirect action. For this reason we suggest keeping the boundary map but to relocate it in the sequence, using it, instead, to represent differences between the present network and what has to be achieved if the future working world to become a reality. It also appeared that some sort of hierarchy is needed to organise the elements included in each square. This should be done not by listing them in rank order, but according to a typology designed to distinguish between aspects which are unavoidable, those which are central in pushing/blocking the process (the lead- ... enlarging Von Hippel terminology), and those which will have to be, but which are also expected to become involved without the project manager having to make any deliberate effort.

Key changes table

Whatever the comments made here, the key changes table proved to be a real success. DEO used the initial skeleton in full (9 columns, on top of the identification of key changes) while EUROVET and the other cases only used 6. The difference between the two lies in the qualification of the change (in terms of the extent, rate of change, and specification of critical factors) and in the identification of entry points. The discussions with project managers showed that the issue of entry points was central in both cases, even if it took time to articulate them (in the case of EUROVET, the report indirectly highlighted this lack of articulation and the final strategic interaction helped in building/formulating this). A further

proof of success is demonstrated by the external check: the key changes table informs the specification of core assumptions and questions (see 6.1).

In EUROVET, though the list of key changes was not discussed, there was extensive debate about their presentation. Although 7 key changes were identified not all pertained to the same trajectory or to the same temporal frame. In this case the project manager suggested grouping changes relating to the same trajectory together, so as to highlight the different scenarios. A column to characterise the temporal dimension would have helped resolve debate about whether the various scenarios were complementary or contradictory. This would have highlighted the fact that EUROVET has yet to address one of the key changes at all, and that another of the changes identified would take the project in a significantly different direction (this was recognised by the project manager who was in a position to take account of recent events not known at the time of the assessment). There are many lessons to be learned from this situation.

One is the need for periodic assessment, and the project manager's capacity to update the sources of the assessment — mainly the tables. This is addressed in the chapter 7.

Another relates to the fact that many projects, even at the market emergence phase, envisage more than one potential future. Not everything is irreversible and care is often taken to keep doors ajar and leave a number of avenues open for future development. The table has to cope with all these potential futures. That they are complementary or mutually exclusive is not important, what is at stake is the specification of actions needed to keep these options open (or to be centrally positioned with respect to one or another), and to remain conscious of the nature of the bets made in taking one but not another route (and more ambitiously to acquire a capacity to track the potential for future realisation, so as to monitor and anticipate change).

A third issue concerns the consistency between the scenarios explicitly formulated by the project manager (cf. future critical moments) and those represented in the key changes table. To the extent that they rely on similar key changes, there is no reason why the project manager's initial visions should not be reformulated, extended, or merged. The unfolding of the project's future vision(s) will have been undertaken (at least partly) with the project manager (though not the production of the boundary mapping and the key changes table). As a result, his/her ideas may have already moved on, a possibility that has to be accounted for in the critical moments table included in the final report (as was the case for EUROVET). Thus the trade-off is not only one of presentation, but also of credibility with the project manager. This again raises the issue of the periodic assessment. If the SOCROBUST process is repeated, the results of the first round will have been internalised and this should be reflected in the future critical moments table. How the tools are used and the tables completed through successive rounds is, at this point, an open issue that requires further testing and experimentation.

Wrapping-up: the operational lessons

The 5 cases made gave us confidence in the potential of the approach, and at the same time generated so many new insights and lessons as to suggest that the development process was far from over. The initial hypothesis of this feasibility study was thus fully confirmed.

More than that, and as we hope this section has shown, the lessons, though numerous, are in great part convergent.

7- RETURN TO THE MANAGEMENT FRAMEWORK AND THE INSERTION OF SOCROBUST IN A WIDER FRAMEWORK

We have developed a method which can be used to assist managers in assessing a project's societal robustness. This has two important implications requiring further clarification. Both were discussed in the Lancaster meeting.

First, we had been working towards the definition of a standard process applicable in whatever situation. In practice the deployment of some of the tools might take more time and require more elaboration in certain circumstances (as was revealed, for instance, by the difference between cases which were still exploratory as opposed to those which were at the point of market emergence), yet the basic format was the same. Does this mean we had abandoned the notion of a management framework or that such a framework no longer applies? Two articles published during the life of the project (Noori, 1999 and Cooper, 2000) helped us think this issue through again. Both underlined the need for periodic evaluation of project situations, and both used the terminology of management framework to encompass a whole realm of activities, including evaluation. This linked in with the conclusions of another EC supported project, PROTEE, (which CSI was also coordinating) which concerned the monitoring of new developments in transport (focusing on systems for container handling). The first section, 7.1 describes the relationship between the development of SOCROBUST as a bottom-up method and PROTEE as a top-down approach for the monitoring of breakthrough innovations.

Second, the SOCROBUST methodology, in its present form, cannot be self-operated by the project manager. A consultancy style interaction is considered central. This means that the method still requires and relies upon specific knowledge about innovation processes. Is this knowledge so specialist that it cannot be absorbed either by project managers or by those who monitor them? Or is this conclusion, rather, a reflection of the fact that further effort is required to formalise the process so that it can be self-operated? If so, and this is a rather common situation when dealing with a feasibility study, additional exploration is needed to establish the possibility of developing such a stand-alone method? 7.2 addresses this second issue which is central in our definition of next steps.

7.1- Architectural innovations, uncertainty and their corporate monitoring

One major characteristic, if not THE major characteristic, of projects involving architectural innovation is that they face uncertainty. Or to take the operational definition of Courtney and al (1997), they face true ambiguity. The main result of another EC supported project, PROTEE, was to demonstrate (even in actual decision making processes) that in such cases, decision making could no longer follow the usual financial methods for rating investments and calculating associated risks because no probability could be given to any potential outcome of

the process. The way ahead proposed here was to shift to another regime, and to organise decision making through the a different set of procedures focusing on the descriptibility of projects. This required the following elements.

(i) Because project-related decision-making is not a one-off event, it was necessary to establish a learning pact between those who fund (the directorate general of a company, a public authority, etc) and those who operate (the project team and its managers), a pact within which both parties would exchange ideas about the dynamics of the project. Periodicity was thus at the core of the process.

(ii) As this kind of monitoring is a costly process, criterion for success had to be clearly set out: success was not defined as successful entry in the market, but as the project s capability to enter into normal investment procedures, i.e. a project would be successful when it could be monitored and evaluated in the terms normally used to assess investments.

(iii) The interaction, which can be considered as a pro-active evaluation, is built around a renewed description of the project. This description is based on a re-reading of the sociology of innovation and the identification of three main pathologies which failed projects have suffered from. These are, following Latour's denomination, lack of realism, lack of strategy; lack of falsifiability. A set of indicators have been developed for making sure that

(a) the project is not ballistic, by questioning its future world, its richness, its heterogeneity, the nature of uncertainties and the degree of flexibility (or irreversibility via the obligatory passage points) it contains,

(b) the project promoters are not paranoid, by questioning the negotiability of the project, its knowledge of anti-programmes, the capacity to take coherent view of opposition, the degree of modularity of the project and thus its capacity to absorb change,

(c) the trials proposed will test critical dimensions of the project and make it possible to enrol new allies (and not remain within the sphere of those already convinced), by questioning the expertise mobilised, the argumentation of trials proposed, the logics of action/translations deployed (against enrolment aimed at), thus questioning the relevance and/or the criticality of the new step proposed.

(iv) This analytical description enables judgement to be passed upon the project and its proposed course of action. This involves a grading of the learning curve the project goes through; a judgement about its capacity to retroact, that is to adapt to the lessons learned to date, and to integrate tensions (is any project capable of holding all the recognised tensions together —what is termed in the sociology of science, a hopeful monster), its capacity to remain flexible (are irreversibilities so demanding as to require unlikely societal changes —what American analysts refer to as white elephants and French engineers usines gaz) and, finally, an exercise to better qualify and address uncertainties already identified (or in the successful final encounter to check that these have been absorbed so that the project is no longer a hopeful monster but a tamed animal that can enter a normal company life).

This long description highlights the other dimension of SOCROBUST. SOCROBUST is not only designed to help project managers assess the societal robustness of their projects and devise the corresponding actions. It is also designed to help them organise the periodic

interactions they have with those who make decisions about future funding, through the provision of a better, i.e. a more relevant description of their project. This was, for instance a clear outcome of the EUROVET interaction. One can interpret the SOCROBUST process as an organised way of meeting all the criteria of project descriptibility as identified by PROTEE. Our experience in PROTEE was that this approach worked very well for company decision-makers, who readily entered into such a description of projects, quickly identifying and discussing the risks¹⁴ taken. However this was not the case for project managers who were neither prepared nor equipped for such an interaction. Another approach had to be developed to address this issue, hence CSI's interest in promoting SOCROBUST.

In a way, then, there is a project plus associated with SOCROBUST, realisation of which does not condition SOCROBUST's adoption by project managers, but which on the contrary, helps with the wider dissemination of these strategies (at company or programme level). This wider framing also provides a context for SOCROBUST, positioning it as a compulsory passage point for any organisation or programme dealing with breakthrough innovations and considering adopting the PROTEE management process at a meso or macro level.

7.2- SOCROBUST and prerequisite knowledge of innovation dynamics

The Protesian learning process mentioned above helps minimise the risk of becoming trapped in a stereotypically linear sequence of action —such as going from pilot to prototype, and from there entering a scaling up process en-route to the production of full size artefacts or systems. It is nonetheless important to locate and recognise certain types of achievements and to identify typical situations likely to be encountered during the course of a project learning curve and which, on the basis of past experience, contain clues as to the chances of successful embedding, if not success per se. The questions of how to consider the achievements made to date and of what can be considered relevant action in given situations remain. But it is not sufficient to say, in response, that organisational decision makers (and to a lesser extent project managers) only option is to learn from experience, capitalising upon the numerous projects they have to monitor. Is there only learning by doing? In acquiring experience, do they build up a totally specific asset which mixes a dual contingency, that of an organisation trajectory/history and that of the of the current activity in question? Is there no room for inter-organisation and cross-sectoral learning? If we assume that this is in fact possible, then one crucial issue is to consider a renewed taxonomy of project states (a static description) and possible next steps (a dynamic one)¹⁵, so as to produce a preliminary taxonomy of trials and so as to consider means of mapping typical trails.

In addressing this challenge we considered two courses of action, one looking at literature on the innovation journey (and descriptions of project states and next steps), the other exploring

¹⁴ We face here a language difficulty between the positioning of a project (with its uncertainties) and the financial appraisal by corporate managers (where the central notion is the financial risk taken).

¹⁵ We often associate states and stages. But is the use of stages useful and what for? Looking at varied dictionaries, it is more often related to static places (where action takes place) rather than to the transformation process of one initial state into a desired one.

and testing the kinds of skills and capacities which would be required of interested (but not knowledgeable) project managers.

The innovation journey and its states and steps

Rip et al. proposed a mapping of the innovation journey in context. The idea of an innovation journey - viewed here as a concept embodying the trail of trials (itself a difficult notion to absorb) - is clearly a central concept upon which we can build upon and which has long history in the management literature (Van de Ven and colleagues).

However should we only conceive of the terminology of innovation journey as an addition to that of the traditional steps (concept, pilot, prototype, development, introduction, adoption/diffusion), that is as a means with which to introduce consideration of the space in which such steps take place (e.g. notions of protected space and strategic niche management)? Should we not also emphasise the whirling dimension of innovation processes, meaning that that they are so path dependent that no typical trail can be described but at the same time acknowledging that projects are obliged to pass through given states if they are to succeed? This second option is considered further in the following paragraphs.

Latour has suggested differentiating between exploration and collective experiments. The prospective experiment on wind power, and P. Karnoe in particular, suggested adding a third situation, namely that of emerging markets. This offers clear linkages between Rip et. al. s notions of niches or protected spaces. However both apply more widely in that they address the issue of how stabilised environments are created and maintained during a certain course of action (which is a different definition than that used by market analysts). From a very different perspective, Noteboom (1999), proposes a quite similar approach when speaking of the exploration of novel combinations (which he calls accommodation, and which leads to a novel architecture), before consolidation via experimentation and repeated trials, generalisation and differentiation, being followed by reciprocation (when anomalies and misfits make visible the boundaries of the script s potential), and in turn paving the way for another cycle¹⁶.

These elements, however limited, remain the only ones referred to in the existing literature (cf. its complete absence in the glossary of social shaping concepts established by COST action (1999)). Two potentially complementary strategies might be adopted in response. One is to embark on a re-reading of major monographs of innovation stories, the other is to conduct a transversal assessment —a real size experiment in monitoring an array of radical innovation projects either within a public authority supporting such projects or at the corporate level of a large firm involved in fostering such activities.

¹⁶ It is interesting to note that in his description of a cycle, Noteboom starts with the consolidation phase and ends with accomodation. Its fourth figure (p 146) is however clear about the very macro application of his analysis. Exploration is linked to industrial districts and loose intra-firm networks, consolidation/generalisation is linked to mergers and acquisitions, MNE integration and tight intra-firm networks, differentiation and reciprocation to alliances.

Establishing and testing the capacities required to implement SOCROBUST

The second issue is critical when thinking about SOCROBUST's future. One option is to highlight its specificity. This is consistent with the view that project managers are unlikely to have the capacity to absorb the kind of knowledge required to implement the SOCROBUST process in practice. If such a conclusion is well founded, we should focus our attention instead on consultants and more widely on professionals in a position to assist project managers (the latter can be internal to large firms, within for instance, the radical innovation hubs proposed by Collarelli O Connor and Rice, 2001). The alternative is to suspend judgement on this point, to recognise that such a conclusion is provisional, and to keep open the possibility that with further development SOCROBUST could, in fact, be used to good effect by project managers themselves.

We considered that the latter position should be tested before we turned back to the former. We made two attempts in this direction. The first was to begin to design the kind of output envisaged at the start of the project, that is a book setting out the method, the concepts on which it depends, and the experience of putting it to the test. The whole Amsterdam workshop was devoted to this issue, E. Shove proposing the British ladybird book series as a potential model (these little books seek to explain technical issues to young non specialists). Although the discussion suggested that this would not be an easy task, A. Rip volunteered to make a first attempt (January 2001). This confirmed our suspicions: even after drastic selection and simplification, the sequential treatment required by a book meant that this was a really complex and difficult exercise.

We therefore decided to completely redirect our efforts and exploit the opportunities afforded by the world wide web. The reasoning behind this approach is as follows. Managers of risky innovations are always faced at one time or another with the problems we address and are looking for a better understanding of these situations, if not for solutions. We therefore assume that they would readily consult a well located website¹⁷. Using this technology, the test would then be to see what types of questions and enquiries these interested managers pursued, where their priorities lay, what types of downloading were undertaken, and what use they made of the material provided. The two first points can be dealt with by internet tracking tools, the last requires direct interaction¹⁸.

A preliminary investigation of existing web-sites design methods (Lancaster, January-February 2001) convinced us of the complexity, ambition and cost of such an approach. We thus decided to shift all remaining resources (apart from finishing the 5 cases) to establishing a pre-functional design brief for a potential website. This strategy appeared to make more sense than the idea of simply gathering together all those who had participated in the experiment (these people had, after all, already expressed their views during the evaluation sessions) and a

¹⁷ This requires adequate key wording of the presentation page and of the architecture for search engines like Google to make it appear in good position.

¹⁸ This interaction can be promoted by managers themselves (if we provide direct access to the team) or by ourselves through ex-post questioning (diverse solutions can be thought of for doing this).

limited set of interested persons,¹⁹ as was initially proposed. Annex 1 to this report presents the results of this exercise including: (i) a first functional design, (ii) a first exploration of how to represent one element (the present TEN), including presentation of the underlying concepts, the principles of the tool, its location in the overall process and an example of its use, and (iii) a first tentative presentation for non specialists of the full process.

8- TO CONCLUDE: NEXT STEPS

What have we done to prepare our own next steps and how do we see them? These are the two questions which we would like to answer in concluding this step of the project.

1- We have forced ourselves to completely rewrite a positioning paper which locates the work done and the results achieved in the context of relevant management literature. This paper clearly identifies the new elements we have brought to this debate. The positioning paper, which is the present chapter 1 of this final report, has been already circulated and discussed not only with colleagues in the field but also with managers (with an established background in project management). By definition, it could only be written after the event, meaning at the very end of the project.

2- We have tried to expose in as operational as possible a manner the method as we see it now and as we would like to experiment with it on a wider scale (see below). This is the present chapter 2, a chapter which could again only be produced after the event, that is after the results of the last cases had been gathered in.

3- From the start we tried to be reflexive about the process per se. This has become all the more important in that: (i) there has been a significant change in the approach adopted during the lifetime of the project, (ii) we have been obliged to make sometimes drastic choices between potentially attractive concepts, and the reasons why opted for one rather than another route had to be rendered explicit, (iii) we have connected this project to another developed within a different frame with a different approach, so as to redefine what we consider to be a relevant management framework, and (iv) it is through this process that we have progressively outlined what we now consider to be the relevant trials to enter into to test whether we can develop a SOCROBUST prototype and in our own terms, return to normal project calculability .

4- We now identify two relevant and complementary trials to be undertaken next.

¹⁹ This was reinforced by the dissemination work done on PROTEE. Here we devised a training course for the managers of the French research programme on transport, called PREDIT. It took one full day for persons interested by not knowing the method, even after having read reports and short presentations written in common language, to be in a pro-active position discussing the potential use, the problems they foresaw and the possible developments.

- (i) We need to solve the issue of absorptive capacity and of specificity . We consider that a relevant test would be to require foreigners , newcomers , to be set free to use the method on their own in order to see what they get out of the experience and how those interested in it wish to continue learning. We see the development of a website dedicated to the presentation of the method, accompanied by a systematic tracking / follow-up of visitors to this site, as a way to provide such a proof . The initial work of functional design which we have already undertaken suggests that it is feasible to think of developing such a site, but that this would require a significant investment (probably in the order of 100 000 EURO). Not only that, we have found, during the course of our case studies, a SME which has developed products along the lines we are considering here

- (ii) We need to enter into a wider experiment involving periodic redescriptions of project robustness, either designed to help individual project managers, or as part of a more encompassing framework involving a PROTEE approach to project monitoring. We have been discussing this prospect for over a year now with one national programme on transport technologies. And we are negotiating a similar experiment with a large multinational firm. In both cases, this involves at least two teams from different countries. Since the method is quite unusual for our partners, it requires important initial investment, and in particular the development of training courses.

5- The latter are the most concrete and visible output of the method. Two complementary courses have been devised based upon an initial exposition of the issues, problems and principles. One involves students in looking at a fresh case (with which we already have some connection and for which we have at least partly done the work ourselves), applying the process (the method is cut short in that students are provided with the results of an external check on the issues they have identified) and then entering into a discussion with the project manager about the issues the project confronts. This was done on the French telebillettique project managed by the Parisian transport utilities. Another more confined exercise, consists of using the existing cases as a point of reference. In this exercise, one acts as teacher, the other as project manager (which enables mimicking interactions), the students then undertaking the web search and producing a report (transparencies) which they present to the manager . These courses remain experimental, and they require further development for entering the normal framework of master's courses in the management of innovation.

The feasibility study has proven fruitful, even if the fruit is quite unlike that which we expected. We consider that we have proven our capacity to learn and adapt. The method proposed is still able to integrate all tensions it is faced with, and should therefore be considered as a hopeful monster . Not only that, the two trials we propose take us far away from our previous circles (so the project is not yet a white elephant). According to all PROTEE criteria, our funders should continue to support us! At least that is the conclusion we hope they will reach.

PRODUCTIONS OF THE SOCROBUST PROJECT

List of case study reports reports (all reports with * are confidential)

The case of Large Wind Turbines, First Retrospective case Study in the Framework of the SOCROBUST Project. by G.J. Schaeffer and R. Nahuis (ECN), E. Shove and S. Raman (Lancaster University) and E. Jolivet (CSI/Armines), May 2000, 39 pages.

* Socrobust Eurovet Report, by E. Shove, E. Jolivet and the Socrobust team, November 2000, 44 pages

* Socrobust TAPPE Report, By S. Raman, E. Jolivet and the Socrobust team, December 2000, 32 pages

* Socrobust DEO Report, by G. J. Schaeffer, S. Raman, E. Jolivet and the Socrobust team, January 2001, 37 pages

* Socrobust RETRANSPLANT Report; by H. H reng, E. Jolivet, H. Penan, C. Vicens and the Socrobust team, April 2001, 44 pages

* Socrobust M2DM Report, by B. Poti, S. Raman, E. Jolivet and the Socrobust team, May 2001, 37 + 13 pages

Literature reviews and reading notes (for operationalisation of concepts)

Literature review on science, technology and innovation studies, E. Moors, A. Rip and G.J. Schaeffer, preliminary version september 1999, final version, december 1999 (12 pages + bibliography).

Literature overview (in view of establishing the management framework), E. Moors and A. Rip, December 1999, 16 pages.

Literature review on management (project management, logic of integration, strategy, competences), M. Frechet, H. H reng and H. Penan, first version (French) september 1999, translated version, october 1999,

Literature review on organisational learning, B. Poti (September 1999 revised January 2000, 11 pages).

Literature review on technological discontinuities, E. Jolivet, (December 1999, 19 pages).

Note for the operationalisation of organisational learning, E. Jolivet (November 1999, 9 pages).

Note about knowledge institutionalisation and the co-ordination of industrial investments, E. Jolivet (december 1999, 28 pages).

Note for discussion on learning curves with an operational perspective, E. Jolivet (November 1999, 8 pages).

Note on alignment in the business area, B. Poti (March 2000, 9 pages + 6 figures).

Literature review on knowledge management and innovation, C. Garcia, april 2000 (18 pages + bibliography)

Literature review on management, updated version June 2000, final version October 2000, 92 pages including bibliography.

Notes on selected literature on breakthrough innovations, P. Lar do (July 2001, 32 pages).

Project Progress reports (E. Jolivet and P. Lar do)

- Overall progress Report n₁, March 2000, 18 pages

- Overall progress report n₂, January 2001, 27 pages

- Overall progress report n°3, June 2001, 9 pages

List of internal documents produced

Technical Annex to the project — December 1998, 12 pages.

Tools available — initial state of the Art, March 1999, 8 pages.

The Management Framework —General Considerations and Preliminary version —A. Rip, September 1999, 11 pages.

The Management Framework — Revised Preliminary version, by ARip, October 1999, 8 pages

The protocol for case studies, Version 1, by A. Rip and E. Moors, October 1999, 6 pages.

Methodological Note for the test case studies, by P. Lar do and E. Jolivet, Paris, June 2000, 16 pages.

Interview guideline, by E. Jolivet, June 2000, 3 pages.

Note on the external info search, By E. Jolivet, September 2000, 4 pages.

Presentation of the approach, How to assess the socio-political dimensions of projects, Health Concertation Meeting, November 2000.

Notes from evaluation meetings by P. Lar do: Tappe (December 2000, 9 pages), Eurovet (January 2001, 11 pages), DEO (February 2001, 9 pages), Retransplant (May 2001, 5 pages), M2DM (May 2001, 5 pages).

Ladybird attempt of presentation of the method, by A. Rip, January 2001, 15 pages.

Socrobust web site functional definition, by M. Watson, preliminary version, February 2001, revised version, March and April 2001 (9+5+7 pages).

Minutes of meetings (all by E. Jolivet and P. Lar do)

- Kick-off meeting, Brussels, May 3-4, 1999, 10 pages + annexes

- Meeting 2, Toulouse, September 27-28, 12 pages + annexes

- Meeting 3, Twente, January 30-February 1, 15 pages + annexes

- Paris Workshop on the future of winde energy, March 23, 9 pages + annexes

- Paris Workshop on methodology for test cases, May 18-19, 10 pages + annexes

- Meeting 4, Paris, July 12 and 13, 10 pages.

- Meeting 5, Roma, September 15, 5 pages

- Meeting 6, Lancaster, January 2001, 23 pages.

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ANNEX — FONCTIONAL DEFINITION OF A POTENTIAL SOCROBUST WEBSITE

1. FONCTIONAL DEFINITION — DRAFT (8 PAGES)

2. THE SOCROBUST PROCESS, ILLUSTRATED AND EXPLAINED (7 PAGES)

3. AN EXEMPLE OF ARTICULATION - TOOL 3, STEP 2 (5PAGES)