Science and Public Policy, volume 33, number 6, July 2006, pages 399–410, Beech Tree Publishing, 10 Watford Close, Guildford, Surrey GU1 2EP, England

Socially robust knowledge

Transdisciplinarity: a new mode of governing science?

Sabine Maasen and Oliver Lieven

What exactly does it mean to integrate extra-academic types of knowledge, interests and values into the procedures of scientific knowledge production? In this paper, we shall approach these questions from a 'lab study perspective', investigating the discourses and practices that constitute doing transdisciplinarity. Based upon an ongoing empirical research project, we call for a novel perspective: the task of producing 'socially robust knowledge', often couched in terms of extended responsibility of science* vis-à vis *society, can also be regarded as a specific instance of neo-liberal rationality in research practice and science policy, at large. As scientific claims to accountability and truth have come under critique throughout the last decades, they now have to be reworked on the micro-level of transdisciplinary projects. Transdisciplinarity is thus revealed as a new mode of governing science in society.

Professor Dr Sabine Maasen and Olivier Lieven are at the Programm für Wissenschaftsforschung, Universität Basel, Missionsstrasse 21, CH-4003 Basel, Switzerland; Email: sabine.maasen@unibas.ch; Tel: +41 (0)61 260 21 99/89; Fax: +41 (0) 61 260 21 97 <hhttp://pages.unibas.ch/wissen/>

TODAY, WE HAVE BECOME accustomed to the discursive triad of 'risky science', 'decision-making under uncertainty' and the need for 'extended expertise'. A quick glance at any programme in science policy, for example the White Paper on Governance in the European Union, will yield instructive passages like the following:

> Human knowledge and the scientific and technical applications that derive from it are advancing at an unprecedented rate, affecting every field of human activity and are increasingly present in our daily lives. This phenomenon is at the origin of major changes that are taking place in society — leading to a shake-up in the governance of our society. Scientific and technical development is expanding the frontiers of knowledge as well as the incidence and relevance of uncertainty and risk. Government is constantly raising increasingly complex scientific and technological questions. It is important, however, that this trend does not lead to a situation in which scientists are called to participate in the exercise of power, with ordinary citizens being excluded. (*Enhancing Democracy*)

Passages such as this attempt to link various notions in an easy-going manner. It is first established that we live in a *knowledge society* that pervades all domains of our individual and societal practices. Contrary to earlier hopes, however, we now realize that there is a co-evolution of the benefits and risks that arise in this knowledge society. In particular, the old promise that more knowledge would eventually lead to a safe, just and sustainable way of life has not

Sabine Maasen is a professor of science studies at the University of Basel, Switzerland. Her training is in sociology, psychology and linguistics. She has published articles and books in the sociology of science and knowledge including *Biology as Society, Society as Biology: Metaphors* (with E Mendelsohn and P Weingart, Kluwer, 1994); *Metaphors and the Dynamics of Knowledge* (with P Weingart, Routledge, 2000). Currently she works on the science–policy interface (doing transdisciplinarity, scientific advice to politics) as well as on the scientific and political dynamics of the neurosciences (eg *Voluntary Action: On Brains, Minds, and Sociality*, with W Prinz and G Roth, Oxford, 2002).

Oliver Lieven is Scientific Assistant at the programme for science studies at the University of Basel. He has studied political science, history and philosophy in Frankfurt/Main, and primarily works on transdisciplinarity and science policy issues.

materialized — not least due to the fact that more knowledge goes hand-in-hand with more non-knowledge and the uncertainty resulting from it. Second, our knowledge society has therefore also become a *risk society*. This co-evolution of knowledge and risk is vividly apparent in political decision-making; the increased dependency on scientific knowledge and experts is accompanied by an increased mistrust in those experts whose knowledge can no longer be regarded as neutral, objective and reliable (Bimber, 1996). Today, both scientific knowledge and expertise are increasingly thought to contribute to *producing* rather than *reducing* risk.[1]

While the project of improving knowledge remains, this task is no longer left to scientists alone. Rather, and to engage the third link in the initial quotation, there is a drive towards 'extending expertise'. What has become known as 'democratizing expertise' not only refers to ubiquitous access to scientific expertise, but also refers to assigning the status of expert to all kinds of knowledge holders, scientific or otherwise, and including citizens, administrators, consumers and so on. A general shift is seen to be taking place from a *legitimation through knowledge* to a *legitimation through participation* (Abels, 2003; European Commission, 2000). In academic discussions, this development has been accompanied by a discourse on the 'robustness' of knowledge and on the dispersal of sites of knowledge production outside of the established universities and research institutions (Gibbons *et al*, 1994; Nowotny *et al*, 2001).

This move has resulted in many forms and forums of joint knowledge production, reaching from citizen panels to transdisciplinary research projects. Both ends of the continuum have differing goals. Citizen panels are based on information and discussion about forefront research. They lean strongly toward the political end of the spectrum and mainly focus on *joint deliberation of policy issues* that are science-based and politically or ethically sensitive, with environmental and health issues being on top of the agenda. By contrast, transdisciplinary research practices are directed toward solving complex policy issues and address scientific knowledge production proper. Environmental research is again a major area of activity, but also in the domain of health we can find this novel approach of *including citizens in the activity of knowledge production*.

Both ends of the spectrum form the underlying assumptions of this paper. In particular, we focus on the specific responses to the increasingly unruly relation of science and politics, that is, scientific knowledge production and political decision-making. The proliferation of scientific knowledge and expertise for virtually every policy domain gave rise to both a *scientization of politics* and a *politization of science*, and has called for a new alignment of science and politics. Although most commentators agree with this diagnosis, they emphatically disagree with respect to the therapy required. While one faction is of the opinion that the emerging alignment ultimately leads to a blurring of the boundaries between science and politics (and, indeed, should have this effect; eg see Nowotny *et al*, 2001 in place of many others), the other faction insists on the preservation of their intrinsic differences (eg see Weingart, 2001)

This latter stance is in keeping with Luhmann's (1984) position on the differentiation of science and politics; it is postulated that science should ultimately produce truth, whereas political decisions should safeguard power. Indeed, many interactions in a knowledge-based society occur between science and politics, and do not necessarily lead to an intermingling of codes or subsystems. Rather, the nature of the relationship between science and politics is said to be one of "coupling" (Luhmann, 1984). For example, if decisions are science-based, they strive to rely upon and legitimate themselves by claiming "true" knowledge; yet for politics, the truth of the knowledge in question is not a goal in itself but a means to make lasting decisions that keep the decision-makers in power (Maasen and Weingart, 2005). While superficial observation seems to suggest a 'blurring' at the interface of science and politics, the analytical specification we favor focuses on the consequences that the mutual reference of the systems has for each of them.

Transdisciplinarity is a case in point for what 'coupling' means in this context. It promises to circumvent the schism between scientific expertise and policy-making by organizing them in a participatory way. The involvement of stakeholders is to make sure that the 'right problem' gets addressed 'in the right way'. Joint problem definition is thought to order the configuration and cooperation of disciplines and the extra-scientific actors involved. Hence, joint problem definition, interdisciplinary coordination and stakeholder involvement are designed to accomplish extended accountability of scientific endeavors by way of a complex and iterative process of knowledge production.

We shall argue that the inclusion of stakeholders as a third element in the relation of science and politics is not quite the remedy for its unruliness as some authors and many practitioners in transdisciplinarity seem to hope. The flip-side of extended accountability in knowledge production by participation is increased control(ling). Control(ling) is exerted by a *new form* of arranging knowledge production so as to ensure both scientific and social accountability throughout the entire process. Continuous monitoring, reporting and the accomplishment of visible results are the most prominent measures taken to achieve this goal.

We argue that the easiness with which transdisciplinarity and other forms of extended accountability have become accepted requires two more explanatory elements. First, on the micro-level, transdisciplinarity rests on each member's willingness and competence to assume extended responsibility for *both* the research proper and the usefulness of its results. The last section of this study will therefore make a case for transdisciplinarity as a mode of accountability by 'responsibilization' of all actors involved — be they scientific, political, industrial or lay. Second, on the macro-level, the acceptability of transdisciplinary forms of knowledge production occurs in a society that more recently has come to label itself as an *audit society* (see Gibbons *et al*, 1994; Power, 1997). In this society, all kinds of audit reign as prime principles of social organization and control. From this perspective, transdisciplinarity can be regarded as a further element of audit, this time designed to bring scientific and societal goals into mutual agreement. Extended accountability of science is hence the result of both extended responsibilization of all actors involved and ubiquitous instances and institutions of audit in contemporary society — with science being one of the more recent targets of auditing.

Exploring transdisciplinarity *in vivo*

First, we will address the recent appreciation for, and praxis of, transdisciplinary research as yet another instance of rearranging science and politics for their mutual alignment. Key to this new mode of knowledge production is problem-orientation interdisciplinarity, as well as participation of extra-academic stakeholders. The role of the latter when 'applying' the results of a 'purely' scientific research is to contribute a specific expertise — their knowledge, interests and values — for integration before and during the research process rather than only afterwards. From the point of view of an advocate of transdisciplinarity, such a mode of knowledge production is to ensure that one identifies and solves 'real world problems', as opposed to such problems remaining isolated in the 'ivory tower' of self-contained academia. The goal is socially robust knowledge.[2] But what exactly does it mean to integrate extra-academic types of knowledge, interests and values into the procedures of scientific knowledge production? What does it mean epistemologically, organizationally andnormatively?

Extended accountability of science is the result of both extended responsibilization of all actors involved and ubiquitous instances and institutions of audit in contemporary society

We shall approach these questions from a 'praxeological perspective', looking at the discourses and practices that constitute *doing transdisciplinarity* (Knorr-Cetina, 1981). To this end, our analysis will be based upon an ongoing empirical research project studying two transdiciplinary endeavors of which this article is a first report. Both projects, Alpha and Omega, have been initiated and steered by a group of scientists from two different institutions.[3] We wanted to know how the notion that the respective project is a 'transdisciplinary' one is maintained by the different actors involved. 'Different actors' here refers to the disciplinary actors from various scientific fields including engineers, technicians and so on, plus the extra-academic actors such as administrators, consumers, users, entrepreneurs and so on. Which functions do the different actors/stakeholders assume throughout the process, with specific respect to the *scientific* aspect of knowledge production?

The analysis is an exploratory one, based on two projects, both of which are concerned with environmental issues and aim to develop products associated with resource usage, yet differ markedly with respect to the extent and type of including participants. While Alpha tries to acknowledge but, at the same time, minimize stakeholder input in order to 'get their science done', by contrast, although for the same reason, Omega maximizes stakeholder input.

- *Alpha* This project is developing a new approach to urban water management. It investigates new technologies for controlling wastewater of private households for improved wastewater management, and consists of eight work packages involving economists, engineers and natural and social scientists. The Alpha project is based at a huge public research centre in Switzerland and delivers both fundamental research across several disciplines of science as well as prototypes of the specific technologies.
- *Omega* This project is designing a simulation model for the spatial development of a specific alpine region. The goal is to produce a learning

tool for contextualized understanding of natural and social processes of the region as it is confronted with climate change. Such a tool will provoke changes in agriculture, tourism and other domains of local life, and is intended to support decision-making about the region's future rather than being a decision tool itself. Our interest in this project is that it is a joint venture between various scientific facilities and members of the political administration of the region.

By way of analyzing protocols of participant observation, important documents (eg grant proposals, reviews, public brochures) and expert interviews, we try to trace *transdisciplinarity in the making* on three levels of discourse (Brand, 2000):

- The normative level of discourse: How do the different actors involved process the norms and values? How do they negotiate conflicting values? How do they go about integrating their *knowledge about goals*?
- The operative level of discourse: What exactly do the different actors involved consider as coordinated procedures to reach their goal? How do they go about integrating their specific *knowledge about transformation*?
- The analytic level of discourse: How do the different actors articulate and coordinate their knowledge? How do they go about integrating their *knowledge about systems*?

Given that transdisciplinary projects are fraught with the expectation to meet and adequately address scientific *and other* demands (political, economic, public), and can hence be conceived of as micro-instances of the new alignment between science and politics, various problems and pressures are to be expected in general. Notably, *negotiating, coordinating* and *integrating* heterogeneous types of knowledge, values and interests are bound to cause complexities that border on the irresolvable task of rendering incommensurabilities commensurate.

By way of illustration, we will first focus on the more general insights that we have gained, and address various kinds of pressures that transdisciplinary projects must cope with. Second, we will sketch their reactions to these pressures — wherever one looks, the reaction is about processing pressures. Based on these observations, we will then account for the intricacies of transdisciplinary research as a way of making science socially accountable, in ways that far exceed science-specific means and that ultimately rest on each member's responsibility for the transdisciplinary project.

Exposure to pressures

Both the Alpha and Omega projects share the basic pressures of content, time and social context.

Content

With respect to content, both projects address complex problems that ultimately require a technological answer (innovative technological pathways for managing wastewater in urbanized areas or producing an interactive learning tool). While they differ in the amount and the quality of third-party involvement, such as administrative actors from political or financial sectors, both projects subscribe to the basic requirement of being applicable. Apart from being disciplinary projects, a uniting feature of the two projects is that they both attempt to work on their problems by confronting their specific standards with adequate complexity so as to produce a viable solution, not by reducing complexity of their standards. This calls for increased efforts with regards to the types of knowledge that are consulted, values considered and methods used, as well as for the overall design of the project and the complexity of operative procedures.

More elaborate project designs cannot prevent, but only provoke, an ambivalent task. On the one hand, each project needs to produce a result that can justly claim to be a solid technological answer to the problem. On the other hand, the scientific actors as well as the extra-scientific participants must be disciplined. As far as the scientists involved are concerned, their research must be framed in such a way as to allow their results to be part of a 'matrix of doables'. In a transdisciplinary project environment, this affects the methodological standards of the disciplines involved. Notably, the gain in knowledge about the system addressed and hence the possibility of generalizing the results obtained from a local problem are at risk.[4]

As far as the extra-scientific participants are concerned, their input must also be disciplined. While Alpha tends to separate their input by way of encapsulating it in a special work package and a steering committee with no real power to intervene into the research proper (Alpha I: 18), Omega maximizes stakeholder input, yet tries to control time, place and project format. Much thought and activity revolves around moderating discussions and operating with methodical devices so as to order the stakeholders' data and deliberations. These devices (cf below) function as, albeit less visible, strategies of normalization (Foucault, 1977, 1980), recently observed in various kinds of participatory settings (see Cooke and Kothari, 2001).

Time

With respect to time, both projects must produce their knowledge and the procedures of technologies resulting from it within a limited period of time. There is always time pressure. While this has become a truism for most forms of research, the problem is aggravated in transdisciplinary projects because not only must members process a heterogeneous set of inputs, they must also address a heterogeneous set of audiences. Hence, throughout any transdisciplinary project each stage of affairs is the object of many reports and presentations. Peers, clients, heads of the academic institutions hosting the project and funding agencies all want to report and present for promotion, evaluation and control.

For this reason, presentations not only multiply but also diversify, depending on the audiences and the goals. Presentations for peers must not be too superficial, and presentations for public audiences should not only focus on the ultimate product but also show 'where the science is'. The tensions between the diverse stakeholders and their varying demands lead to a very time-consuming amount of internal coordination for external presentation — a burden that is shouldered specifically by the heads of a transdisciplinary team. Not surprisingly, pragmatic approaches toward reporting (and preparing such reports) prevail. Virtually all team leaders of both projects have attended courses in project management and/or team management or intend to do so shortly.

Social context

With respect to social context, transdisciplinary projects, by definition, are composed of highly heterogeneous groups. Both interdisciplinary communication and, even worse, communication with extra-disciplinary stakeholders give rise to many kinds of misunderstandings due to problems with language and a lack of insight into the processes and cultures of *doing* science or into the professional standards required. For this reason, most scientists we studied take special care in explaining not only their results but also how they got there. Most significantly, they meander between two basic positions. Either they present themselves as 'practical experts' or as 'theoretical skeptics'. Both positions, however, can produce disappointments. By choosing the option of the practical expert, scientists are forced to neglect deeper discussion and reflection, and only in some cases do they manage to save those questions and interests for further disciplinary projects. By choosing to be theoretical skeptics, scientists and technicians run the risk of boring or irritating their stakeholders.

Heterogeneity and fragmentation concern not only the procedures of knowledge production (transdisciplinary, supra-local projects and programs), but also the objects of knowledge production

Normally, the stakeholders are uninterested in learning about problems and contingencies; they simply want to know what can and cannot be done. A major part of negotiation concerns mutual understanding and role definitions. Frequently, scientists encourage their stakeholders "to tell us whether we are on the right track and what they deem an adequate presentation of goals ('what's the use')". The scientists, in turn, try to select their stakeholders' inputs so as to determine a "realistic measure of what can and can't be done".

Pressure management

These content, time and social pressures lead to a tendency of *processing*, rather than solving the multiplicity and uncertainty of knowledge and values. For the time being, we have three tentative results with respect to the *hows* of doing transdisciplinarity. They each refer to one level of discourse.

1. *Processing values and goals* In transdisciplinary projects under high pressure to produce solutions for real-world problems, we see a strong tendency to produce at least preliminary and always presentable results at all stages of the project. Second and most importantly, we see a strong tendency to process non-understanding throughout the project. After just one year, the Omega project team discusses whether the simulation model they are producing is intended to be a learning tool or a decision tool. While the modelers carefully opt for the former, the politicians involved decidedly want a decision tool, designed to later legitimate certain political decisions. This kind of problem, with specific regard to *knowledge about goals*, is processed as mutual, yet largely tacit, non-understanding. The supreme goal for the scientist is not to lose the stakeholders' commitment.
2. *Processing uncertain and fragmented knowledge* Both transdisciplinary projects are torn between producing methodologically reliable knowledge and integrating the multiple extra-scientific notions and values involved. At the same time, there is the need for a quick technological fix of a complex problem. We observe a strong tendency to process uncertain and fragmented notions by 'doables'. Alpha cultivates a jargon of 'deliverables', with each work package required to deliver their respective results that are then coordinated in a piecemeal fashion. In doing so, the recourse to pragmatic support by team and project management is crucial — they enforce systematic production, delivery and integration of fragments of knowledge. The tight schedules of meetings that bring together scientists of all work packages are testament to this 'delivery-culture'. In other words, uncertain and fragmented *knowledge about systems* is processed rather than acknowledged.
3. *Processing stakeholder input* The participation of

extra-scientific actors is full of tensions. The demand for outcomes that are not only scientifically reliable but also profitable, ethical, sustainable and safe provokes all kinds of negotiations. In both projects, the scientists we study do much to secure the support of their respective stakeholders. Specifically, they try to address the values and pieces of knowledge articulated by those stakeholders in such a way that they remain recognizable for them. While Alpha could show its product at an early stage (a prototype) and was then 'free' to modify the science behind it, Omega was virtually flooded by stakeholder input before having any such product for presentation. Once it precipitated that the promised result (the integrated simulation model) would not be achieved, Omega took pains to create another, albeit 'surrogate', result (the narrative scenario). Both reactions (early prototype, surrogate 'end' product) are specific, if different, reactions to the fact that the scientists need to *translate* their stakeholders' knowledge, expectations and values to achieve a disciplinarily or technically sound project. Integrating extra-scientific *knowledge of transformation* is processed by a series of careful translations so as to keep the extra-scientific actors committed.

These preliminary observations are in line with the claim that there exists a new regime of knowledge production (Rammert, 2002). In this view, scientific innovations are increasingly accomplished by heterogeneous and distributed networks. Heterogeneity and fragmentation concern not only the *procedures* of knowledge production (transdisciplinary, supra-local projects and programs), but also the *objects* of knowledge production:

1. One can no longer expect the closure of novel subject domains. Rather than resulting in new disciplines, the new regime of knowledge production rests on flexible interactivity of diverse fragments of knowledge for solving local problems. In order to do this, one needs institutionalized opportunities for negotiating the problem-specific patchwork of those disciplinary and extra-disciplinary fragments of knowledge.
2. Further, this fragmentation of knowledge results in problems of synchronizing it. Considering the varying timelines of knowledge production in various disciplines, not to mention linking it with extra-disciplinary inputs, the coordination of mutually dependent data becomes a major difficulty. This leads to an ongoing effort to plan, monitor and assess 'deliveries'.
3. Finally, the new regime of knowledge production requires more networking activities to link all the actors involved. As a result, all actors assume more tasks and skills. The scientists, in particular, complement their traditional research and teaching competences with skills in management, fundraising and start-up knowledge. Fundraising has become a major ongoing activity in larger projects or programs, rather than simply a single activity before project commencement.

From this perspective, it seems that transdisciplinary projects and programs act as both the product and the co-producers of a new form of knowledge production. However this new regime is labeled — "Mode 2" (Gibbons *et al*, 1994), "post-normal science" (Funtowitz and Ravetz, 1993) or "triple-helix of innovation" (Etzkovitz and Leydesdorff, 2000) — the new demands mentioned above increasingly align university-based research with other sites and forms of knowledge production (see Guggenheim, pp. 411–421, this issue of *Science and Public Policy*). It is noteworthy that all diagnoses put the *trans* of transdisciplinary arrangements on center stage. Most diagnoses, however, remain silent on the subject of the *disciplinarity*, that is, its effect on scientifically sound knowledge production. Most authors seem to take it for granted that going transdisciplinary is inevitable, if not always desirable (eg see Nowotny *et al*, 2001; Hirsch Hadorn, 2000). Yet, it may be worthwhile to pause for a moment and think about transdisciplinarity *vis-à-vis* its most prominent prerequisite: participation. While we would not deny the enriching effects of participation for (inter) disciplinary research, we would like to emphasize its disciplining effects for the transdisciplinary enterprise as a whole.

In the following sections, we will advance in four steps. We will first scrutinize the role of participation in transdisciplinary settings and second address its societal context (called audit society). In the third and fourth steps, we illustrate its mode of governing the science–society relation by trust and by enterprising science, respectively, and assess the effects of the scientists and stakeholders responsible.

Participation, in transdisciplinary settings

Participation as enlightenment

Unlike linear models of popularization (Hilgartner, 1990), transdisciplinary settings establish a 'symmetry of enlightenment'. Not only is it the scientists' duty to enlighten their stakeholders, it is also the stakeholders' responsibility to inform the scientists and supply their knowledge about "how things really are, here with us" (cognitive) and "what we think should be done" (normative). This symmetry of enlightenment enforces repeated efforts in aligning and translating different demands. Scientific decisions about which information is to be used and which is not must be defended.

For example, Omega failed to deal effectively with the complexity of information given by its stakeholders and is now in the position of having to legitimate its novel course of action. Most data and deliberations delivered by the stakeholders will no longer feed directly into the integrated modeling of the project, but will instead be the basis of a 'by-product' specifically addressing their stakeholders. Indeed, in reaction to the information overflow they invented a novel method, a 'narrative scenario', describing in prose "what happens if …?" (eg with respect to tourism, what will happen if the mean temperature rises by 2°C and less snow falls?). In other words, Omega felt obliged to produce a surrogate for the originally intended integrated simulation model — a surrogate they do not really need for their own work (Omega6: l, 840ff; Omega I/I: 7). Hence, the force of mutual 'enlightenment' promotes the responsibility for product-orientation even when the original outcome cannot be achieved.

Participation as public relations

Omega explicitly addresses their stakeholders as 'multipliers'. The project events including the stakeholders are therefore not only arenas of information and deliberation, but also (if not foremost) activities meant to accomplish mutual trust and understanding (Omega I/I: 6 and Omega I/II: 15: "credibility of scientific work"). Alpha, while mostly avoiding direct contact with stakeholders, still feels compelled to produce popular accounts of their work (eg Workpackage I and public brochure). In a more indirect way, the projects themselves are instances of public relations, as they are intended as arenas of mutual learning. Yet, again we find obstacles. In Alpha, scientists lament the fact that the very visibility and plausibility of their 'product' obscures how innovative and intricate the scientific and technological work behind it is. By contrast, the scientists in Omega only rarely enlighten their stakeholders about the specificities of their scientific practice, and more often than not reproduce clichés of themselves sitting in an ivory tower (Omega1: 2072/79; Omega6: 973; Omega2: 170). In both cases, however, participation enforces public relations activities precisely because sustained input and acceptance by their stakeholders is a basic resource of the process as a whole.

Participation as control and intervention

Both Alpha and Omega projects proceed differently in ascribing and performing the tasks of controlling and (mutual) knowledge production. While Alpha tries to uphold the traditional division of labor (scientists do the science; the steering committee and the management do the controlling), the scientists in Omega take pains to do everything themselves; a key vehicle being the careful assignment of various tasks to their stakeholders throughout the process. At closer inspection, however, things become more complicated.

As far as Alpha is concerned, a continuous series of meetings between the project leaders, their steering committee and management is to ensure that scientific, organizational and financial issues and the communication to the broader public proceed as planned. In case of conflict in either or several domains, interventions are produced and implemented. It is mainly the steering committee that represents the participating stakeholders' (ie the politicians' and corporate actors') views.

In contrast to this 'network of control', the scientists in Omega rely on an ambitious procedure of stakeholder involvement. Once informed, the stakeholders must provide their knowledge and normative demands in a methodical way, and a series of meetings is to ensure that both the information and deliberation required are given in the order and the format requested by the scientists and their modeling task. But because the scientists are unsure how to steer their stakeholders, they engage a moderator for the initial stages. Both the employment of a moderator and other means of controlling the participants' input are testament to the scientists' attempts to not lose control.

In our view, *enlightenment*, *public relations* and *controlling induced by stakeholder involvement* give rise to enforced monitoring of the information supplied and used, the normative claims considered and the products delivered. Not surprisingly, with respect to participation, both projects proceed differently. Alpha produces both scientific results and the ultimate 'product', yet it limits contact to the broader public and the steering committee to an absolute minimum. Omega, by contrast, intensively engages in stakeholder participation (accompanying groups, satellite groups), yet fails to make use of a signifycant amount of the data gathered. The ultimate goal has now been split into two: a 'scientific' goal (integrated model without participation, to be accomplished in a follow-up study) and a 'public' goal (a narrative scenario). Other than as part of a steering committee, the local stakeholders are not in the position to actively 'intervene' and, for example, demand that the promised product should be accomplished.

Nevertheless, in a more subtle manner the scientists will not risk losing the symbolic capital gained throughout the process of intensive interactions — particularly in relation to a follow-up study that could potentially require their input. In both cases, therefore, participation of stakeholders does have a strong controlling function, and this is strongly evidenced by the scientists' measures taken to discipline the process as far as possible.

This is not to say, however, that stakeholders are the new agents of control. Rather, all participants — scientific, political, industrial or lay — are gathered in a network of exchanging and deliberating knowledge in the service of producing a useful (ie safe, sustainable, profitable, etc) outcome. This not only creates a network of control but also a network of mutual responsibility (Omega I/I: 8)). In order to contextualize this recent self-evidence of increased and enlarged responsibility for science and its outcomes, one must refer to the novel self-description of Western societies as audit societies. When it comes to science and society, governance by knowledge and trust and the use of enterprising science are key elements.

Transdisciplinarity in an audit society

In our view, our (albeit tentative) results and the seeming self-evidence of a new regime of knowledge production give rise to the thesis that transdisciplinarity responds to the novel demands of a knowledge society (eg see Stehr, 1994) or a risk society (eg see Beck, 1986; Japp, 1996), respectively. A major aspect of knowledge societies is to cope with complexity, risk and uncertainty in various domains (orientation, education, innovation), and on various levels of societal organization (individual, institutional). Transdisciplinarity appears to be one answer among others that is able to readjust the science–society relation by establishing new 'bonds'.

On the most abstract level, society recasts itself as an audit society, while science recasts itself as being accountable. The new link between society and science consists of rendering science 'socially accountable' by way of including stakeholders in defining and evaluating knowledge produced in transdisciplinary settings. Novel types and procedures of governance by knowledge emerge that organize and steer the production, dissemination and evaluation of knowledge. As the sites of producing and processing knowledge multiply, the sites (ie the institutions and procedures) of governing knowledge also diversify. Round tables, ethics commissions and citizens' juries are among those at the more political end of the spectrum, designed to organize participatory deliberation of issues at the science–politics interface. At the more scientific end of the spectrum, going transdisciplinary is one way to cope with heterogeneous, if not conflicting, types of knowledge and values in the audit society. Yet, what kind of answer is this? The answer is twofold. The first solution is about *governing the science–society relation by trust*, and the second is about *governing it by enterprising science*.

Governing the science–society relation by trust

In our view, transdisciplinarity is not so much a reaction against the *cognitive* distance between science and society as a reaction against the *social* distance between the two. Both cognitive distance and social distance are historical achievements that allowed science to become increasingly independent of church and state influences. This allows the production of epistemically robust knowledge, and is a successful specialization as long as negative experiences with science do not disrupt the acceptance of such new knowledge. Recently, older forms of social protest have been complemented, if not replaced, by participatory forms of assessing science technology projects. Transdisciplinarity is designed to go one step further; it should not only *assess* but also jointly *produce* knowledge. Transdisciplinarity thus subscribes to all measures that make knowledge not only epistemically robust but also socially robust. But how is this achieved?

While we would not deny that transdisciplinary research has a cognitive relevance for all involved (including stakeholders), this does not lessen the cognitive distance between scientific and extra-scientific actors. This is due to the difference between cognitive and epistemic goals, providing scientific and other forms of knowledge production with different standards of accomplishing and legitimizing knowledge (see Williams, 2001). Scientific knowledge production proceeds on the basis of *epistemic goals*; it aims at a methodical analysis of innovative knowledge that is rigorously reviewed by peers. This procedure does not apply to non-scientific knowledge production. In contrast, the quality of cognitive goals is not controlled with equal systematicity and evaluative rigor. Nonetheless, *all* participants in transdisciplinary research settings demand high quality of the knowledge produced und therefore contribute their share (eg local experience or statistics). The important difference is that although all actors can contribute data and deliberations, only the scientific actors may translate data and deliberations into research-oriented knowledge production. In other words, transdisciplinary settings allow for *mutual learning* but not for *joint research*.

Rather than bridging the *cognitive gap*, transdisciplinarity seems to bridge the *social gap*; it is a means of building up trust toward potential users, political decision-makers and industrial entrepreneurs. Wherever the knowledge and values of the latter play a role, the procedures become translated in order to accomplish a scientifically sound application. Due to this translation, the input from stakeholders becomes invisible. What is visible, however, is the participation itself, and this is what builds up

Scientific knowledge production proceeds on the basis of epistemic goals; it aims at a methodical analysis of innovative knowledge that is rigorously reviewed by peers. This procedure does not apply to non-scientific knowledge production

trust and bridges the social (but not so much the cognitive) gap. Transdisciplinary projects can hence be seen as *microcosms of 'visible research'*. They function as one of the multitude of ways to realize 'public outreach'. Extra-scientific actors gain access to scientific-technological practice and — willy-nilly — come to learn about research as uncertain and yet trustworthy, given that it adheres to certain scientific standards. At the same time, they become part of the game. The name of the game: *enterprising science*.

Enterprising science

Interestingly enough, transdisciplinary projects find themselves propagated and performed in the midst of a society that characterizes itself as neo-liberal; that is, each individual has become responsible for him- or herself. After the welfare period, the new message is that we all should become *enterprising selves*. We thereby gain both autonomy and heteronomy at the same time. Not surprisingly, this also seems to be the case with science in society. Its increasing autonomy (eg the autonomy of universities) is paralleled by an increasing amount of heteronomy (eg the amount of controlling in all domains and on all levels of scientific practice and institutions).

Hence, is not the call for transdisciplinarity also the call for bridging the gap between science and society on the basis of individual scientists who need to produce both epistemically and socially robust knowledge? We think, yes. It is within this scheme that a certain procedure (ie participation of stakeholders) and a certain goal (solution for real-life problems) become rational and obligatory. It is true enough that the old contract between science and society no longer holds. In the meantime, finding a new contract is shouldered by individual researchers who try to reconcile different disciplinary standards and approaches, as well as different extra-scientific demands, in one project that must result in some sort of societal application.

In our view, this is indeed a new mode of knowledge production; a society that is increasingly governed by knowledge must co-develop procedures to govern science by way of adding procedures of social accountability. The plea for participation proceeds by establishing a kind of mutual translatability of macro-economic, industrial, social, political and ethical concerns into practicable programs. This achieves reform of technical and organizational dimensions of scientific work in line with a new image of the identity of the citizen in advanced liberal democracies. Transdisciplinarity is hence a way of enterprising science. It stands to reason that this new mode of governing science will become a new paradigm for all kinds of knowledge production, be they trans-, inter- or mono-disciplinary. Indeed, as some authors argue, the "politics of accountability" have already infiltrated academia at large (eg see Strathern, 2000; Shore and Wright, 1999).

In summary, the task of producing 'socially robust knowledge', often couched in terms of extended responsibility of science in society, can also be regarded as a specific neo-liberal rationality in science policy. It fosters continuous monitoring and regulation — features that can also be observed in transdisciplinary knowledge production. As scientific claims to accountability and truth have come under severe critique throughout the last decades, they now have to be reworked on the micro-level of transdisciplinary projects. They must put the individual actors under increased pressure toward organizing participation and aim at the applicability of research by way of integrating heterogeneous forms of knowledge and values. Transdisciplinarity thus reveals itself as a new mode of governing science in society.

Extended expertise as civic responsibility

Contemporary research is cautiously optimistic, and rests on the following premises:

- Public participation and support *can* produce more scientific effectiveness, given a transdisciplinary framework (Balsiger, 2005);
- Conflict *can* be a resource in terms of learning and social-institutional innovation (Dente *et al*, 1998); and
- The public *can* go beyond narrow interests and accept a socially inclusive view of risk management (Halfacre *et al*, 2000).

While we would not deny this entirely, we do emphasize three recent shifts that have occurred in this philosophy.

First, transdisciplinary practice affects the notion of expertise. On the one hand, the concept of expertise appears to be extended to the point of denoting almost any kind of knowledge. More often than not, it is indistinguishable from experience accumulated in the course of pertinent professional or lay activeties. Hence, all participants in transdisciplinary projects or programs are granted the status of expert. On the other hand, the scientists involved are also affected; expert scientists have to synthesize all available knowledge and thereby transgress the boundaries of their discipline. Moreover, as they must address audiences that are almost never composed entirely of fellow-experts, their propositions must be sensitive to a wider range of demands and expectations, and relate to the heterogeneous experience of mixed audiences (cf Nowotny, 2003: 152). In other words, *scientific expertise is transgressive* by necessity.

Second, participatory settings, including transdisciplinary ones, can be called 'agora' — a hybrid domain in its own right. As we see it, however, this is not a domain of *primary* (Nowotny, 2003: 156) but of *secondary* knowledge production. In this intermediary domain — neither purely scientific nor purely political — knowledge of various sources, as well as competing values and interests, can be discussed and negotiated. Here, political positions can be developed as a result of joint expertise and deliberatively produced policy recommendations. In so doing, participatory settings (although with no direct influence) *resonate* in the political subsystem (Sclove, 1994; Edwards, 1999).

Third, it should not go unnoticed that participatory variants of knowledge-based decision-making are careful stagings of mutual learning and deliberative reasoning that manage to reduce, albeit as 'special events', three types of complexity: factual, temporal and social. The *factual* complexity is reduced by coordinated procedures of producing, discussing and deciding about (piece of) knowledge. The *temporal* complexity is reduced by doing what can be done, given a novel state of knowledge or an altered set of values, and pertinent decisions will return to the agenda — most likely requiring another transdisciplinary project. The *social* complexity of the interaction of heterogeneous actors (politicians, industrials, administrators, scientists, lay experts) is reduced by recourse to the participants' civil competences. This exercise allows for temporary understandings and compromises on a case-by-case basis, and it rests on a basic resource that it co-produces in the course of the exercise: responsibility (Maasen and Kaiser, 2005).

In other words, where expertise is transgressive in transdisciplinary settings, the institutional stucture is hybridized and the (participatory) processes are carefully staged. Knowledge production ultimately relies on its participants addressing each other as members of the general citizenry. In this capacity and the social responsibility deriving from it, they have to synthesize their respective knowledge and stakes according to the Common Good. In particular, transdisciplinary projects as "mini-republics of ideas" cannot do without the responsible lay citizen; "[w]hether through direct participation or through organized questioning, the public has both *a right* and *a duty* to ask experts and their governmental sponsors whether appropriate knowledge is being deployed in the service of desired ends" (Jasanoff, 2003: 159, italics added). The multiplicity of forms and forums in which science is today asked to produce socially robust knowledge should not obscure the bases they rest on. Ultimately, they both rely on and contribute to bringing about the responsible citizen (Sutter, 2005). Scientists, politicians, industrial actors and lay experts are addressed in two capacities: as experts *and* as citizens.

Following those authors who proclaim the 'end of the social', it seems difficult to understand what provides appeals to responsibility with such plausibility: Responsibility for what, to whom? Are our highly individualistic societies not, in principle, antithetic to civic activities? From a 'governmentalistic' point of view (cf Foucault, 2000), however, one arrives at the opposite conclusion: modern political governance makes use of everybody's capacities to conduct themselves and others. In this view, neoliberal societies fundamentally rely on techniques of governmentality. Such technologies consist of "mundane programs, calculations, techniques, apparatuses, documents and procedures through which authorities seek to embody and give effect to governmental ambitions" (Rose and Miller, 1992: 175). Among the latter, we find participatory technology assessments, citizens' juries and transdisciplinary modes of knowledge production, all said "to strengthen civic discourse" (Belluci *et al*, 2002: 278; Skorupinski and Ott, 2002). Participation, wherever it occurs, thus becomes a "technology of citizenship … by which government works *through* rather than *against* the subjecttivities of citizens" (Cruikshank, 1999: 69, italics added). In time, participation as a mode of responseble self-government becomes a political technology.

This development is a highly ambivalent one, however. In line with Weber's analysis (Weber, 1993/1920), the increase in autonomy (the *possibility* to know and decide) is inevitably accompanied by an increase in heteronomy (the *need* to know and decide) in ever-more science-based policy institutions, on ever-more issues and in more or less rigid procedures. The involvement of subjects and their capacity to commit themselves to responsible decisions is a double-edged sword. While the emergence of inclusive forms of knowledge-based decision-making certainly advances democratic values of participation in societal decisions under uncertainty, it also advances responsibilization (O'Malley, 1996), that is, a generalized individualization of societal risk-taking (Lemke *et al*, 2000). However, by demanding of all individuals an orientation toward the Common Good,[5] society re-emerges instead of disappears. Our society is therefore neo-liberal and "neo-social" (Lessenich, 2003: 81) in that the radical individualism of the former concept fosters new forms of becoming social by, among other things, *going transdisciplinary*. Transdisciplinarity thus reflects and relates to the wider processes of science, politics and governance in modern societies.

Notes

1. On the distinction between danger and risk, see Luhmann (1991) and the introduction to this issue of *Science and Public Policy* (p. 394).
2. The alleged distinction between 'ivory tower' and 'real-world problems' is maintained by those who deem transdisciplinarity a solution to the alleged maladaption of science and the outside world. Ironically enough, however, not only systems theory but also virtually all extra-scientific actors in our study insist on science as being epistemologically 'different' (ie innovative, non-trivial, informing everyday knowledge. In a recent study we substantiate this observation (see Maasen and Lieven, submitted).
3. Both projects are thus instances of a specific kind of transdisciplinary cooperation. Our approach deliberately excludes endeavors initiated by stakeholders (economic or political) in order to bring the various effects of the transdisciplinary programmatic on science itself to the fore.
4. This has not necessarily to be the case whenever research

is application-oriented and interdisciplinary (see Adams *et al*, this issue of *Science and Public Policy*, pp. 435–444). If, however, if is also participatory, this seems to cause an additional pressure toward locality of problem-solving.

5. This analysis may disappoint those who claim transdisciplinarity a social democratic or 'green' project rather than a neo-liberal one. Indeed, while their rhetoric and interests situate them at opposite ends of the political spectrum, the structural implications of their stance *vis-à-vis* the academic mission is not dissimilar. "In both perspectives, the cultivation of intellectual curiosity and the pursuit of research are rendered merely frivolous and irresponisble dilletantism" (Amit, 2000: 223). Both promote what D'Andrade has called a "moral model of scholarship" (D'Andrade, 1995).

References

Abels, Gabriele 2003. *Experts, Citizens, and Eurocrats: Towards a Policy Shift in the Governance of Biopolitics in the EU*. Europe and Integration online Papers (EIoP) **6**(19). Available at <http://www.eiop.or.at/eiop/texte/2002-019a.htm>, last accessed 3 August 2006.

Amit, Vered 2000. The university as panopticon: moral claims and attacks on academic freedom. In *Audit Cultures: Anthropological Studies in Accountability, Ethics and the Academy*, ed. Marilyn Strathern, pp. 217–235.

Balsiger, Philipp W 2005. *Transdisziplinarität*. Munich: Wilhelm Fink.

Beck, Ulrich 1986. Risikogesellschaft: Auf dem Weg in eine andere Moderne. Frankfurt: Suhrkamp.

Bellucci, Sergio *et al* 2002. Conclusions and recommendations. In *Participatory Technology Assessment: European Perspectives*, eds. Simon Joss and Sergio Bellucci, pp. 276–287. London: Centre for the Study of Democracy.

Bimber, B 1996. *The Politics of Expertise in Congress: The Rise and Fall of the Office of Technology Assessment*. Albany: State University of New York Press.

Brand, Karl-Werner 2000. *Nachhaltige Entwicklung und Transdisziplinarität: Besonderheiten, Probleme und Erfordernisse der Nachhaltigkeitsforschung*. Berlin: Analytica.

Cooke, B and U Kothari eds. 2002. *Participation: The New Tyranny*. London: Zed Books.

Cruikshank, B 1999. The Will to Empower: Democratic Citizens and Other Subjects. Ithaca: Cornell University Press.

D'Andrade, Roy 1995. Objectivity and militancy: a debate, I: moral models in anthropology. *Current Anthropology*, **36**(3), 399–408.

Dente, B, P Fareri and J Ligteringen 1998. *The Waste and the Backyard: the Creation of Waste Facilities: Success Stories in Six European Countries*. Dordrecht, Boston and London: Kluwer Academic Publishers.

Edwards, A 1999. Scientific expertise in policy-making: the intermediary role of the public sphere. *Science and Public Policy*, **26**(3), 163–170.

Enhancing Democracy: A White Paper on Governance in the European Union. Available at <http://europa.eu.int/comm/governance/index_en.htm>, last accessed 3 August 2006.

Etzkowitz, H and L Leydesdorff 2000. The dynamics of innovation: from national systems and "Mode 2" to a triple-helix of university-industry-government relations. *Research Policy*, **29**, 109–124.

European Commission 2000. *Science, Society and the Citizen in Europe*. Working document.

Foucault, Michel 1977. *Discipline and Punish: The Birth of the Prison*. Harmondsworth: Penguin.

Foucault, Michel 1980. *Power/Knowledge: Selected Interviews and Other Writings*. Brighton: Havester Wheatsheaf.

Foucault, Michel 2000. Die Gouvernementalität. In *Gouvernementalität der Gegenwart: Studien zur Ökonomisierung des Sozialen*, eds. Ulrich Bröckling, Susanne Krasmann and Thomas Lemke, pp. 41–67. Frankfurt: Suhrkamp.

Funtowitz, S O and J R Ravetz 1993. The emergence of post-normal science. In *Science, Politics and Morality: Scientific Uncertainty and Decision Making*, ed. R von Schomberg. Dordrecht, Boston and London: Kluwer Academic Publishers.

Gibbons, M, C Limoges, H Nowotny, S Schwartzman, P Scott and M Trow 1994. *The New Production of Knowledge*. London: Sage.

Halfacre, A C, A Matheny and W Rosenbaum 2000. Regulating contested local hazards: is constructive dialogue possible among participants in community risk management? *Policy Studies Journal*, **28**(3), 648–667.

Hilgartner, Stephen 1990. The dominant view of popularization. *Social Studies of Science*, **20**, 519–539.

Hirsch Hadorn, Gertrude 2000. What are the relevant differences in research questions between disciplinary and transdisciplinary research? Available at <http://www.unibas.ch/mgu/sagufnet/workshop/contributions.html>, last accessed 15 December 2005.

Japp, Klaus 1996. *Soziologische Risikotheorie. Funktionale Differenzierung, Politisierung und Reflexion*. Weinheim and Munich: Juventa.

Jasanoff, Sheila 2003. (No?) accounting for expertise. *Science and Public Policy*, **30**(3), 157–162.

Knorr-Cetina, Karin 1981. *The Manufacture of Knowledge*. Oxford: Pergamon Press.

Lemke, T, S Krasmann and U Bröckling 2000: Gouvernementalität, Neoliberalismus und Selbsttechnologien: Eine Einleitung. In *Gouvernementalität der Gegenwart: Studien zur Ökonomisierung des Sozialen*, eds. U Bröckling, S Krasmann and T Lemke, pp. 7–40. Frankfurt: Suhrkamp.

Lessenich, Stephan 2003. Soziale Subjektivität: die neue Regierung der Gesellschaft. *Mittelweg*, **36**(4), 80–93.

Luhmann, Niklas 1984. *Soziale Systeme*. Frankfurt: Suhrkamp.

Maasen, S and O Lieven submitted. Transdisziplinäre Forschung: Verbote eines 'New Deal' zwischen Wissenschaft und Gesellschaft? For *Transdiziplinarität*, eds. Paul Berger and Wolfgang Zierhofer. GAIA.

Maasen, S and M Kaiser 2007. Vertrauen ist gut. Verantwortung ist besser. Wissenschaft und Politik in der Vertrauenskrise: Weiter mit Verantwortung? In *Gekauftes Gewissen: die Rolle der Bioethik in Institutionen*, eds. C Rehmann-Sutter, J L Scully, R Porz and M Zimmermann-Aklin.

Maasen, S and P Weingart 2005. What's new in scientific advice to politics? In *Democratization of Expertise? Exploring Novel Forms of Scientific Advice in Political Decision-Making. Sociology of the Sciences, 24*, eds. S Maasen and P Weingart, pp. 1–16.

Nowotny, Helga 2003. Democratizing expertise and socially robust knowledge. *Science and Public Policy*, **30**(3), 151–156.

Nowotny, H, P Scott and M Gibbons eds. 2001. *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*. London: Polity Press.

O'Malley, Pat 1996. Risk and responsibility. In *Foucault and Political Reason*, eds. A Barry, T Osborne and N Rose, pp. 189–207. Chicago: University of Chicago Press.

Power, Michael 1997. *The Audit Society: Rituals of Verification*. Oxford: Oxford University Press.

Rammert, W 2002. Technik als verteilte Aktion. Wie technisches Wirken als Agentur in hybriden Aktionszusammenhängen gedeutet warden kann. Technical University Technology Studies Working Papers. TUTS-WP-3-2002. <http://www.tu-berlin.de/nsoziologie/crew/rammert/articles/SelectedArticles.html>, last accessed 3 August 2006.

Rose, N and P Miller 1992. Political power beyond the state. *British Journal of Sociology*, **43**(2), 173–205.

Sclove, Richard E 1994. Citizen-based technology assessment? An update on consensus conferences in Europe. Available at <http://www.manymedia.com/loka/loka.1.12.txt>, last accessed 7 August 2005.

Shore, C and S Wright 1999. Audit culture and anthropology: Neo-liberalism in British higher education. *Journal of the Royal Anthropological Institute*, **5**(4), 557–575.

Skorupinski, B and K Ott 2002. Partizipative Technikfolgenabschätzung als ethisches Erfordernis. Warum das Urteil der Bürger/innen unverzichtbar ist, ed. by TA-SWISS. Available at <http://www.ta-swiss.ch/www-remain/reports_archive/publications/2002/DT31_Bericht_kompl.pdf>, last accessed 3 August 2006.

Stehr, Nico 1994. *Knowledge Societies*. London: Sage.

Strathern, Marilyn ed. 2000. *Audit Cultures: Anthropological Studies in Accountability, Ethics and the Academy*. EASA Series. London: Routledge.

Sutter, Barbara 2005. Von Laien und guten Bürgern: Partizipation als politische Technologie. In *Wozu Experten? Wissenschaft und Politik: Sozialwissenschaftliche Diagnosen einer Beziehung im Umbruch*, eds. Alexander Bogner and Helge Torgersen. Wiesbaden: Verlag für Sozialwissenschaften.

Weber, Max 1993. *Die protestantische Ethik und der "Geist" des Kapitalismus*. (Textausgabe auf der Grundlage der ersten

Fassung von 1904/05 mit einem Verzeichnis der wichtigsten Zusätze und Veränderungen aus der zweiten Fassung von 1920). Bodenheim: Athenäum Hain Hanstein.
Weingart, Peter 2001. *Die Stunde der Wahrheit*. Weilerswist: Velbrück.
Williams, Michael 2001. Kontextualismus, Externalismus und epistemische Massstäbe. In *Erkenntnistheorie: Positionen zwischen Tradition und Gegenwart*, ed. T Grundmann, pp. 165–187. Paderborn: Mentis-Verlag.

All documents used have been generated during the work on the empirical study mentioned above.

Project Omega

- Omega I/I: First interview with the coordinator of the project Omega, 29 August 2003.
- Omega I/II: Second interview with the coordinator of the project Omega, 24 September 2004.
- Omega1: Project meeting to set up the process of participation on 23 May 2003.
- Omega2: Meeting of scientists and stakeholders on 3 June 2003.
- Omega6: Meeting of scientists and stakeholders on 23 September 2004.
- Proposal of the project (August 2001).

Project Alpha:

- Alpha I: Interview with the two project managers on 7 July 2004.
- Proposal of the project (December 1999).
- Public brochure to explain the project to a wider public (2003).