



PRACTICAL GUIDE

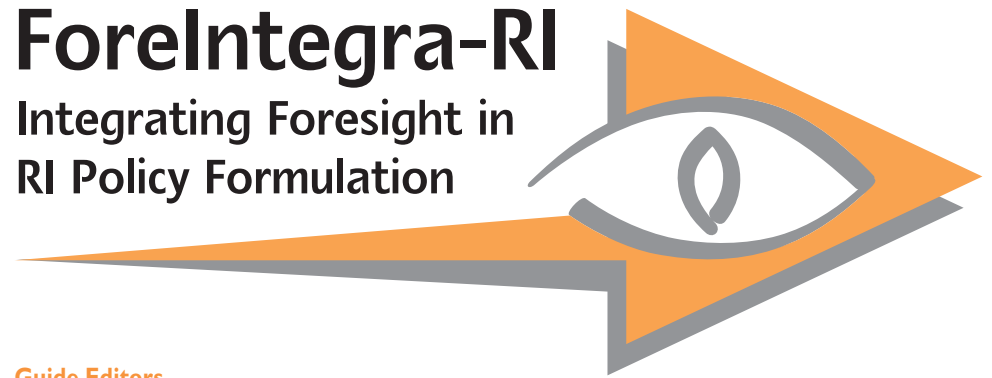
for Integrating Foresight in
Research Infrastructures
Policy Formulation

ForeIntegra-RI



ForeIntegra-RI

Integrating Foresight in RI Policy Formulation



Guide Editors

PREST (UK)

Michael Keenan and Rafael Popper

Guide Authors

ARC Fund (Bulgaria)

Maria Alexandrova, Denitsa Marinova and Daniela Tchonkova

PREST (UK)

Michael Keenan and Rafael Popper

IE HAS (Hungary)

Attila Havas

About the Guide

This guide has been produced as part of a European Commission funded project (ForeIntegra) aimed at integrating foresight into research infrastructures (RI) policy and decision making. The project was carried out with a consortium led by Applied Research and Communications Fund (ARC Fund, Bulgaria); and with PREST, Manchester Institute of Innovation Research of the University of Manchester, (PREST, UK) and the Institute of Economics, Hungarian Academy of Sciences (IE HAS, Hungary), as main partners.

Acknowledgements

We would like to gratefully acknowledge the helpful contributions of several people to this Guide, specifically Kristian Borch (Risø National Laboratory), Maria Carvalho Dias (DG Research), Svend Christensen (University of Southern Denmark), Liam Downey (Euragri), Elie Faroult (DG Research), Peter Keet (Dutch Ministry of Agriculture, Nature and Food Quality), and Fons Werrij (Wageningen University), Jennifer Cassingena Harper (Malta Council of Science and Technology), Luke Georghiou (University of Manchester), as well as the other participants of the ForeIntegra Scenario Workshop in Budapest. The usual disclaimer applies.

Legal Notice

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use of which might be made of the following information.



FOREINTEGRA-RI

A practical guide for policy makers and managers of existing (and future) research infrastructures (RIs)

Introduction	4
What is foresight?	6
Who uses foresight and why?.....	7
What challenges might foresight address?	8
How could foresight address these challenges?.....	11
How to organise and manage foresight exercises?.....	13
How to design a foresight methodology?	16
When could foresight be usefully deployed?	20
How could foresight reorient a national facility?	21
How could foresight formulate a RI roadmap?	24
How could foresight network facilities?.....	27
How could foresight scope large-scale RIs?	30
Final remarks	33
References	34
Endnotes.....	35

LIST OF BOXES

Box 1: Some common uses of foresight	7
Box 2: Different rationales of public research systems (RS).....	9
Box 3: Some existing guidelines on using foresight.....	13
Box 4: The Foresight Diamond	17
Box 5: Key features of common foresight methods	18
Box 6: Key features of a comprehensive foresight methodology.....	19
Box 7: Foresight 'RP Diamond' to reorient a National Facility.....	23
Box 8: Foresight 'RP Diamond' to formulate a RI roadmap	25
Box 9: Foresight 'RP Diamond' to Network Facilities	29
Box 10: Foresight 'RP Diamond' to scope large-scale RIs.....	31

LIST OF TABLES

Table 1: Major characteristics of different research systems.....	9
Table 2: Some relative scales of foresight exercises	14

INTRODUCTION

To be excellent in science logically requires a wide range of high-quality research infrastructures (RIs). Scientists and managers of RIs have no doubt of this, and in an abstract sense, neither do tax-paying citizens. However, most RIs are expensive, and by definition, are long-term investments. At the same time, the costs of ever more complex RIs are increasing, and the demands for new facilities growing as scientific frontiers continue to broaden. This leaves policy makers in a difficult situation: they are inclined to serve the scientific community, but know that they cannot cover the astronomical costs of ever more complex RIs from the public purse alone. The excitement and promises of new facilities can be high – and yet the costs somehow need to be controlled.

Thus, policy makers face a difficult challenge: while the views of a wide range of stakeholders, with their different and sometimes conflicting interests, need to be taken into account, there is a lot at stake in terms of future scientific capabilities, with consequences for socially, environmentally, and economically sustainable development. Strategic choices have to be made, with significant immediate financial repercussions, and potentially huge long-term implications. While the constraints are severe, opinions might significantly differ, and no evidence exists in a strict sense.

Foresight is definitely not a panacea to address this difficult challenge, but it can assist decision-makers in several ways. For instance, it can reduce technological, economic or social uncertainties by identifying alternative futures and various policy options; it can lead to better informed decisions by bringing together different communities of practice with their complementary knowledge and experiences; and it can build public support by enhancing transparency, and thus improve overall efficiency of public spending.

It is because of this potential that we have developed this Guide on using foresight in the field of RIs. This Guide is not intended to provide specific details on how to manage and facilitate a foresight process – many such guides already exist that can be readily consulted for this purpose (see Box 3 for a listing). Our aim is to highlight the specific features of running foresight processes in this particular domain. With this in mind, we explore a number of specific challenges faced by scientists, RI managers, and policy-makers acting at different levels of governance. To be addressed, many of these challenges require new modes of governance, and a more effective and efficient orchestration of RI policies with broader science, technology and innovation policies.



In this sense, foresight seems to be an appropriate tool to address two major types of challenges in the field of RI. First, it can address the gap between the current operation of existing RIs and their potentially more efficient use, by devising and systematically considering alternative governance, organisational and financial models. Second, it can thoroughly explore the gap between the provision of current RIs and future needs, derived from likely S&T, environmental, societal and economic developments. By so doing, it can offer 'futureproof' RI strategies.

The Guide is organised as follows. First we offer a pragmatic, short definition of foresight, and explicate some of its main principles. We also show who the potential users of foresight are, and what they can expect. Then we explore a number of challenges that are likely to be relevant for a large number of RIs, and suggest ways that foresight could be used to address them. We then present a framework for designing a foresight exercise, and discuss some of the issues concerned with selection of appropriate methods. To illustrate the

use of foresight, we develop detailed hypothetical cases tailored to specific RI challenges. These cases illustrate how to devise (in foresight jargon, how to "scope"), organise, and manage a foresight exercise, and how to select the appropriate foresight methods from a large tool box.

As a final word of introduction, we would like to stress the decisive role of contexts. It is not only the specific challenge to be addressed that needs to be taken into account. Several major factors would also be at play in determining the extent to which a foresight project can be successful. These include personalities (who can act as champions or 'enemies' of foresight), organisational cultures, the wider environment, conflicts of interest, and available resources, among others. One cannot account for all these factors in any Guide, and therefore no 'blueprint' or 'best practice' can be devised on formulating and managing a foresight project – we can only offer some reasoned guidance.



WHAT IS FORESIGHT?

The term 'foresight' refers to an open and collective process of purposeful, future oriented exploration, involving deliberation between heterogeneous actors in science and technology arenas, with a view to formulating shared visions and strategies that take better account of future opportunities and threats.

As this is a rather broad definition, it is perhaps helpful to set out some essential principles of foresight:

- **Principle of future-orientation:** foresight is a future-oriented activity, though not in a predictive sense. In fact, foresight assumes that the future is not pre-determined, but can evolve in different directions, depending upon the actions of various players and the decisions taken today. In other words, the future can be actively shaped, at least to some extent, and there is a certain degree of freedom to choose among alternative, plausible futures, and hence to increase the likelihood of arriving at a preferred (selected) future state.
- **Principle of participation:** foresight values the multiplicity of perspectives, interests, and knowledge held across a dispersed landscape of actors, and seeks to bring these together in processes of deliberation, analysis, and synthesis. Thus, foresight is not the preserve of a small group of experts or academics but involves a wider number of different groups of actors concerned with the issues at stake. Moreover, the results of foresight often have implications for a wide variety of actors, so it is important to involve these as far as possible throughout the process.
- **Principle of evidence:** foresight relies upon informed opinion and interpretation, as well as creative approaches in formulating conjectures on the future. However, these are seldom sufficient on their own and are complemented with various sorts of data from trend analyses and forecasting, bibliometrics, and official statistics, among other sources. Clearly, the future cannot be known with certainty and it is impossible to test conjectures on the future in the same way as one might test scientific knowledge claims. However, the plausibility of conjectures – as well as the original insights that they bring – are essentially 'market tested' by the decision-makers who rely upon such information. If they are to be convinced of foresight's worth, then results should be based upon a sound knowledge base.
- **Principle of multidisciplinary:** foresight recognises that many of the problems we face today cannot be understood from a single perspective nor the solutions found within a single discipline. Accordingly, foresight intentionally seeks to transcend traditional epistemic boundaries, bringing together different disciplines in processes of deliberation that result in improved understanding and new working relationships.
- **Principle of coordination:** foresight enrolls multiple actors to participate in decision arenas where conjectures on the future are contested and debated. Supported by various data and opinion, the foresight process aligns participant actors around emergent agendas, resulting in a coordinated mobilisation of people and resources.
- **Principle of action orientation:** foresight is not only about analysing or contemplating future developments but supporting actors to actively shape the future. Therefore, foresight activities should only be undertaken when it is possible to use act on the results.



WHO USES FORESIGHT AND WHY?

Foresight is now a well-established tool used by policy makers, strategists, and managers. It has been widely applied at the national level by science ministries and research funding agencies for developing shared long-term visions, for setting research priorities, and for strengthening interactions within STI systems.

Foresight is being increasingly utilised in regions to formulate regional science and innovation policies. It is also used in organisations – both public and private – for scanning future threats and opportunities, and for formulating and future-proofing long-term strategies. A list of the common uses of foresight is provided in Box 1.

Box 1: Some common uses of foresight

Informing decision-making processes

- Formulate funding and investment priorities for public policies
- Provide anticipatory strategic intelligence to innovation system actors
- Identify new S&T, business, societal, policy and political opportunities
- Evaluate existing strategies against potential futures, and devise future-proof strategies
- Detect and analyse weak signals to 'foresee' likely future changes and to gain insights into complex interactions and emerging drivers of change
- Increase awareness of possible risks, and hence the basis for more effective contingency planning, and the design and development of appropriate forms of resilience
- Develop reference material for policy-makers and other actors to use, broadening the knowledge base around which decisions are made, thereby resulting in better informed public policies or organisational strategies

Assisting the implementation of decisions

- Build hybrid networks and strengthen communities
- Deepen dialogue with society and improve governance
- Disrupt 'lock-in' thinking and challenge fixed mindsets
- Improve implementation by enabling buy-in to decision-making processes
- Increase understanding and trust between participants, thus building shared agendas
- Aid communication, understanding and collaboration across boundaries, be they geographical, organisational or disciplinary in nature
- Develop widely shared visions of the future with which actors can identify and thereby better co-ordinate their activities, be they individuals or organisations

Creating new capabilities

- Enhance strategic capabilities of organisations by helping to develop a language and practice for thinking about the future – something that is often termed a 'foresight culture'
- Enhance the standing and image of organisations using foresight, showing them to be future-oriented and open, and attractive places for investment

It is perhaps also worth highlighting what foresight **cannot do**. For example, foresight cannot substitute for decision-making processes, but it can ensure that they are better informed. Neither can a foresight process, on its own, overhaul a national policy or the strategy of a research centre. It can significantly contribute to these, but other measures will also need to be implemented for such changes to take effect. Furthermore, although the development of shared

vision is emphasised, foresight cannot be expected to lead to universal consensus. Differences will remain, but these should become better known and understood. Finally, foresight requires a commitment to action if it is to achieve its intended effects. Whilst the act of performing foresight itself creates dynamics of change, these typically need to be built upon and further supported if the full potential of foresight is to be realised.

WHAT CHALLENGES MIGHT FORESIGHT ADDRESS?

Some of the challenges around RI should first be considered before turning to the ways foresight could be useful. A basic challenge lies with the breadth and varied meanings given to the term ‘research infrastructures’. For the purposes of this Guide, RIs are defined according to the ESFRI (European Strategy Forum for Research Infrastructures) definition, as follows:

Research infrastructures are tools that provide essential services to the scientific community, across the range of scientific and technological fields. Examples include libraries, databases, biological archives, communication networks, research vessels, satellite and aircraft observation facilities, observatories, telescopes, synchrotrons, accelerators. They can be ‘single-sited’, ‘distributed’ or ‘virtual’.¹

Accordingly, the concept of RI is not concerned with everyday research equipment used only by researchers in a single research group, but with facilities that are shared, often with researchers working for other institutes, and that tend to require extensive capital investment and active management. Nevertheless, the ESFRI definition still encapsulates a wide variety of facilities and sites. It lies beyond the scope of this Guide to explore this variety, but important factors around which differences are commonly found include modes of governance, geographical significance and distribution, planning timescales for setting up RIs, and funding sources. Such factors are important to bear in mind, since foresight will be used differently and for distinct purposes according to the context of application. This will be demonstrated below, where a series of hypothetical uses of RI foresight are outlined.

Yet, even with this variety, there are a great many common, or similar, challenges facing RIs – challenges that call for a longterm perspective to be taken and where solutions require the commitment of multiple actors. A selection of the main challenges are summarised below, along with some of the promising expectations around RIs.

Greater complexity, increased costs

Many critical facilities across Europe are nearing the end of their useful life. Furthermore, as the frontiers of research are pushed back, RIs are increasingly becoming more complex and more expensive, to the point where the costs of many envisaged new facilities, or their major upgrade, cannot be met by individual countries as in the past. Thus, there is a noticeable tendency towards increasingly large joint RI projects, even in fields where this has not traditionally been the case, such as in the social sciences and humanities. Such RIs need a long lead time and extensive expertise to be developed, as well as a sustainable institutional frame that allows them to be open to, and used by, the largest interested community of scientists, customer industries, and potential users. Aligning funding cycles and priorities, setting up governance structures, preserving open access based on excellence, and concluding political negotiations on site selection, are just a few of the challenges that policy-makers face in such situations. Yet, at the current time, there is insufficient coordination across the European Union in this area, though things are certainly getting better since the establishment of ESFRI.

Improving operations

Another challenge relates to the fact that many RIs do not operate as optimally as they could. Indeed, some commentators believe that a shift in emphasis is required – away from concerns about funding new RIs (hardware) towards better use and management of existing RIs. Questions around funding, interoperability, open access on the basis of merit, meeting educational and training needs, and data conservation, are central management concerns. Such questions require strategic responses that take a long view, but the necessary strategic capabilities – including foresight – are underdeveloped in many facilities. Moreover, better co-ordination of RI is needed – in national and EU spaces – to achieve more efficient utilisation of resources and skills. Further efforts are needed to reduce the duplication and sub-optimal use of resources arising from the current lack of co-ordination.

Knowledge transfer

There is often a need to better harness the knowledge available at RIs for socioeconomic benefit. Some commentators go so far as to suggest that knowledge transfer needs to be prioritised over and above new knowledge generation and have called for the development of increased capacities in this area. It is perhaps more helpful to think of this issue not so much in terms of unlocking a repository of knowledge, but in changing the way that knowledge is generated in the first place (see Box 2).

Clearly, this requires the development of a dialogue and understanding between the co-producers and users of knowledge, including industry, public regulators, and society itself. In this way, RI can serve the research and innovation system broadly, and not just the host/funded institutes. However, the necessary funding and eligibility rules to encourage collaboration and co-investment are often weakly developed or even absent, as are IPR regimes.

Box 2: Different rationales of public research systems (RS)

Although new knowledge is generated by many actors, publicly financed research organisations and research infrastructures – here put together as research systems – are still playing a predominant role in these processes. Research systems, in turn, can be organised in various ways, taking into account their main rationale: knowledge can be produced for distinct main purposes, and thus public research organisations are governed in different ways. Mechanisms and tools for setting their agenda, evaluating their activities and disseminating their results are defined accordingly. RIs are also arranged in this broader logic, aligned with the overall rationale of a research system.

The table below provides a rough, somewhat simplified comparison of three distinct research systems. These are to be understood as ‘ideal types’ (as defined by Max Weber), i.e. none of them could be found in historical (actual) cases. They are rather sharp characterisations of distinct research systems than descriptions of any ‘real life’ case. The aim of presenting these three ideal types is to highlight the major differences of research systems: these might be important inputs when considering alternative policies, as well as broad organisational and institutional arrangements for RS.

Table 1: Major characteristics of different research systems (RS)

	Pure science RS	Business oriented RS	Citizen oriented RS
Rationale	Boost national prestige, achieve scientific excellence	Produce S&T results so as to enhance competitiveness	Achieve S&T results so as to improve quality of life (and enhance competitiveness)
Research organisations	Strategic directions: set exclusively by scientific considerations Governance: mainly by scientists Evaluation: publications, citation Dissemination: aimed at scientists	Strategic directions: driven by business objectives Governance: dominated by business people, involving scientists Evaluation: patents, commercialisation Dissemination: aimed predominantly at business clients (implications for IPR)	Strategic directions: driven by societal aims Governance: representatives of citizens play a decisive role, but all stakeholders are involved Evaluation: a well-balanced set of societal (socio-economic) relevance and scientific excellence criteria Dissemination: aimed at citizens, scientists, and other stakeholders
Mind sets and attitudes of researchers	Focused on ‘pure’ science issues	Driven by a business logic	Driven by societal issues
Funding of research	Public	Mixed: public, private, and public-private partnerships (PPP)	Predominantly public, with important PPP initiatives

New modes of governance

Further, many facilities hosting RI are locked into long-standing and outdated systems of governance that are in need of renewal so as to better reflect the new realities of conducting research in the twenty-first century. For example, many national facilities in the European Union are more than forty years old and were established at a time when science was seen as a more or less autonomous activity to be left to the scientists to organise themselves. This model is not universally accepted any more, and certainly will change in the next 15-20 years – or even faster (see Box 2 on different rationales of research systems).

Better mainstreaming RI in policy

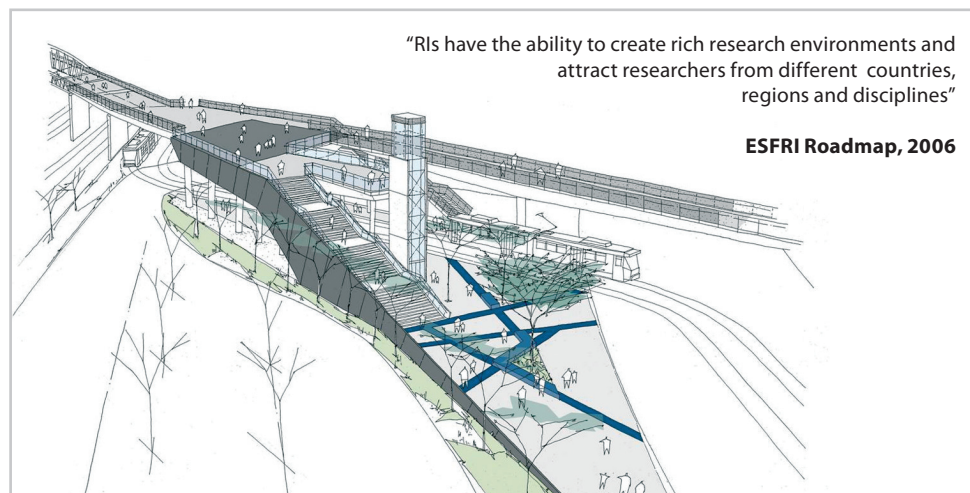
Finally, there is an increasing need to better mainstream RI considerations into national and EU science, technology and innovation policies. There are signs that this is beginning to happen – for example, several countries have developed new RI strategies or roadmaps, while at the EU level, ESFRI has been established. However, things could go much further. To provide one example, the overwhelming majority of research and technology foresight exercises conducted at the national level pay little, if any, attention to RI. Instead, RI considerations are largely black-boxed. If they are mentioned, it tends to be in the form of calls for new facilities to be built. The profile of RI then needs to be heightened to better reflect its importance.

RI also holds out much promise...

So these are some of the many challenges associated with the establishment and operation of RIs. At the same time, however, there are many promises made around RIs. For example, following the 2006 ESFRI Roadmap Report, RIs can be seen as a focal point for bringing together a wide diversity of stakeholders – in multidisciplinary spaces – to look for solutions to many of the global problems faced today (including energy security, climate change, food security, to name but a few), in addition to inspiring new research ideas and attracting young enquiring minds.

Moreover, RIs provide very unique opportunities to train skilled people and researchers while stimulating knowledge and technology transfer. Regarding the latter, many RIs play an important role in building the interface between academia and industry. For instance, where RIs have their site, often “technology clusters” of associated industry or so-called technology parks can be found.

Such strategic centres for transfer of knowledge offer either better possibilities for interdisciplinary research contacts or greater attraction to firms heavily relying on new knowledge. As a result, this can be an opportunity to increase the public-private interaction also in the funding of research activities.



HOW COULD FORESIGHT ADDRESS THESE CHALLENGES?

Given these challenges, the question remains as to how foresight could be constructively used in the area of RIs. The examples given below will show that foresight has wide application possibilities, and can be used by policy-makers, funding bodies, directors and managers of RIs, and researcher-industry coalitions advocating the development of new or upgraded RIs.



Clearly, long lead times are necessary in the planning of new RI, and foresight can be used to better anticipate future needs through trend projections, detection of possible discontinuities, and exploration of complex interactions through cross-impact analysis, for example. Scenarios that capture different patterns of use and operation could help to devise future-proof RI plans, improving their flexibility and resilience.

Such exercise could be organised by a policy-making body (e.g. a national ministry or the EC), or a coalition of interests (e.g. groups of scientists and industry bodies). It is likely that such an exercise would do more than improve the plans for RI; for example, through engaging a broader constituency of interests, foresight would also be useful for promoting the RI more widely and for developing a shared vision of its configuration and use.

New build and upgrades are only some of the challenges around RIs. Perhaps more important are the challenges concerning the improved operation of existing RIs. Again, foresight can be useful here, providing new models of governance and practices around the operation of existing RIs, with the purpose of increasing their relevance and improving their effectiveness. Foresight can introduce fresh perspectives that question the ways in which things are done and that offer new insights. In this sense, foresight is ‘disruptive’ – but in a constructive sense. Such visioning needs to be more than a paper exercise, and should endeavour to involve all major stakeholders. The participatory nature of foresight will be useful here, building ownership of the vision and its associated strategic choices, and thereby improving the likelihood of successful implementation.

A major challenge for existing RI concerns knowledge transfer. RIs offer potential as focal points of multidisciplinary problem-solving, making links among different areas of science and with areas of application. Foresight can be useful here for establishing arenas of strategic dialogue between researchers and the user community. This dialogue should result in the identification of areas for co-operation, and build trust and understanding between knowledge producers and users, thereby contributing to the development of shared agendas as the basis for collaboration.

The practice of foresight itself has the potential to enhance the strategic capabilities of those responsible for managing and funding RIs, by helping to develop a language and practice for thinking about the future – something that is often termed a ‘foresight culture’. In this sense, foresight can be thought of as a learning process that introduces new ways of thinking and new strategic practices. These have some very practical uses in an RI context: for example, such strategic capabilities encourage prioritisation, both in terms of investments and in terms of deciding who gets precedence in using RIs. Long-term thinking also encourages preparation for the future, something

that is extremely important with respect to human resource development and training, as well as to large investments.

Finally, consideration of RI needs to be better mainstreamed in national and EU science, technology and innovation policies. In this respect, it should be noted that foresight has been used extensively to raise the profile of topic areas and organisations. The foresight process also catalyses the self organisation of coalitions of interest that are better placed to attract resources. Clearly, this function of foresight could be useful for RIs. For example, foresight could be used to enhance the standing and positive image of a particular facility, showing it to be future oriented and open, and hence an attractive place for further investment.

These are some possibilities for the use of RI foresight. But it is also useful to illustrate use through concrete examples. Unfortunately, as already mentioned, foresight has been barely applied to the RI area, so there are few actual cases to draw lessons from. For this reason, a few hypothetical cases are set out later to illustrate the contexts and potential use of RI foresight.



HOW TO ORGANISE AND MANAGE FORESIGHT EXERCISES?

There already exists a considerable amount of guidance on organising and managing foresight exercises (see Box 3), and even a greater literature around the methods used. This Guide will not repeat this guidance, but will instead distil many of the key messages from the perspective of research infrastructures.²

Box 3: Some existing guidelines on using foresight

There have already been produced several guides on using foresight, though none specifically address foresight in the context of RIs. Nevertheless, these can be useful for obtaining more detailed guidance that lay beyond the scope of this Guide.

The European Commission (EC) has created the FOR-LEARN Online Foresight Guide, which provides details on recommended steps, methods, and case studies – <http://forlearn.jrc.es>

In addition, the EC has funded several guides on regional foresight, including:

- The Practical Guide to Regional Foresight, which has been translated into several European languages - <http://cordis.europa.eu/foresight/cgrf.htm>
- Blueprints for Foresight Actions in the Regions, which consists of five documents, each devoted to outlining steps for planning a foresight exercise in different sorts of regions. http://cordis.europa.eu/foresight/regional_blueprints2004.htm
- FUTURREG Toolkit, which provides guidance on applying futures thinking in regions. <http://www.futurereg.net>
- Regional Foresight – Boosting Regional Potential, which summarises the main messages from earlier EC guides on regional foresight – <http://www.innovating-regions.org>

Staying with Europe, the European Foundation for the Improvement of Living and Working Conditions has published a Handbook of Knowledge Society Foresight. <http://www.eurofound.europa.eu/publications/htmlfiles/ef0350.htm>

Internationally, the United Nations Industrial Development Organisation (UNIDO) has also published foresight guidance in the form of a two volume Technology Foresight Manual <http://www.unido.org/en/doc/45321>

Finally, a few national governments have produced guidance on using and planning foresight. For example, the UK Government has produced a Strategic Futures Planning Toolkit. http://www.foresight.gov.uk/horizon_scanning_centre/good_practice

A number of steps or phases characterise a well-organised foresight process. For the purpose of this Guide, these are arranged under the following four headings:

- Context and Rationales
- Pre-foresight & Recruitment Phases
- Generation Phase
- Action & Renewal Phases

Context and Rationales

From the outset, there needs to be clarity around the following sorts of questions: What is the purpose of foresight and why is it being used? Who is the

exercise for and what will it cover? By answering these questions, the rationales and objectives of an exercise can be defined, as can its expected outputs and outcomes.

One of the main purposes of foresight is the identification of emerging areas of research that hold promise for socio-economic and scientific developments. Often these critical developments cross established disciplinary frontiers, and may be overlooked by the traditional disciplinary organisations of science.

But in the context of RIs, there may be many other purposes of foresight – some of which have been articulated earlier. These are further illustrated in the hypothetical cases set out below.

A **foresight exercise** can be organised for a variety of end-users. In the cases set out below, policy makers at national and European levels are shown to be major beneficiaries, along with the managers of facilities. But others are also likely to benefit from a foresight exercise, not least the scientists and technicians with a stake in research infrastructures. Increasingly, businesses are involved in using (and sometimes jointly funding) RIs, and are also likely to profit from a foresight exercise.

As for coverage, also known as the scope of an exercise, there are a wide range of possibilities around RIs. For the purpose of this Guide we will package them into three major groups:

- Facility Exercises, focused upon the operations and strategy of individual or small networks of RIs;
- Domain Exercises, focused upon particular scientific disciplines, economic sectors, or significant themes, topics, or problems;
- Public Policy Exercises, focused upon the policy needs of central (often national) administrations.

Pre-Foresight and Recruitment Phases

Before getting started, a number of important questions need to be asked, for example: Who will sponsor the foresight exercise, and how long will it last? What is the time horizon and why? Who will be participating in the exercise? And who will organise and manage the exercise, and how will this be done? By answering these questions, a framework for conducting a foresight exercise can be developed.

Scale	Description	Duration
Punctual	Mini exercises (e.g. success scenario or visioning workshop)	1 to 2 months
Small	Focused with a small number of methods (sectoral, thematic or problem-oriented)	3 to 6 months
Medium	Focused & multi-method (sectoral, thematic or problem-oriented)	6 to 12 months
Large	Fully-fledged (multi-scope)	1 to 3 years
Continuous	Foresight programmes and permanent observatories (many exercises including fully-fledged ones)	Ongoing

Foresight exercises are most commonly sponsored by government agencies. At national level, foresight activities tend to be funded by ministries (e.g. S&T, economy, trade and industry, and so on.), research funding councils, and academies of science, among others. In the context of RIs, foresight exercises may be paid for by individual facilities. They may also be sponsored on a larger scale, for example, in the case of international infrastructures, by numerous governments or international organisations (e.g. the European Commission).

There are both 'internal' and 'external' factors influencing the duration of an exercise.

- Internal factors are inherent to the nature and relative scale of an exercise, (e.g. the territorial scope and disciplinary coverage, the number of methods used, the number of stakeholders involved, and other logistical and managerial issues which are intrinsic to any research activity).
- External factors are related more to the socio-economic, political and administrative contexts of the country, region or institute in which the exercise is taking place, for example, political support, commitment and engagement of key stakeholders, and the level of response of key sponsors providing financial support to the exercise.

With these factors in mind, Table 2 (below) provides a classification mainly based on internal factors, in particular, the relative scale of exercise activities.

Table 2: Some relative scales of foresight exercises

The **'average'** time horizon of a foresight exercise is 10 to 20 years. However, the time horizon should be consistent with the pace of development of the sector or theme the exercise is focused upon. For example, it is possible to find a 5-year time horizon in rapidly changing sectors such as ICT as well as 50-year time horizon where changes are expected to come at a much lower rate, e.g. the energy sector, demographics, and the like. In the context of RIs, the purpose, nature and scale of facilities – which have implications for their expected life spans and the levels of long-term investment required – are likely to influence heavily the choice of time horizon.

There are many types of participants in a foresight exercise, from those who provide knowledge and insights on specific sectors or areas (experts) to those who understand the socio-economic, political-co-institutional, as well as legal framework of the context in which the exercise takes place (government officials, business entrepreneurs, civil society) to those who actually organise the exercise (research groups, consultants, etc.).

There are many options available for organising a foresight exercise, including in-house, semi-detached, and outsourced configurations. The pros and cons of these different options focus mostly around notions of autonomy and connectivity (with an apparent trade-off between the two). For example, an exercise that is entirely managed and organised by an external team of consultants will have the advantage of autonomy and independence, but runs the serious risk of being disconnected and insufficiently embedded. The reverse may be true for an exercise managed entirely in-house. Overall, the management of key issues such as the budget, the work plan and the meetings is generally coordinated by a single management team. However, the organisation of specific activities and tasks is often distributed among other partners, particularly in larger-scale exercises.

One of the crucial activities in foresight is that of recruiting experts and 'key stakeholders' through the whole process. This is why recruitment is often presented in the literature as a standalone phase that requires continuous planning and allocation of valuable resources, e.g. money, time and (occasionally) personal contacts.

Generation Phase

Drawing upon the essential principles of foresight set out earlier, the following questions can be asked: How will new knowledge be generated? How will the foresight exercise achieve sufficient future orientation? How will it be participative? How will evidence be used to provide for a well informed exercise? How will the exercise ensure that a wide spectrum of expertise is utilised? Discussion of these questions – with reference to the foresight methods 'Diamond' (see Box 4) – can lead to the identification of suitable methods.

A sensible way of organising methods into a coherent methodology is to think of the generation phase as consisting of three key main stages:

- **Exploration:** What are the main issues, trends, and drivers that are likely to be significant in the future? Moreover, how do 'key stakeholders' understand / frame the context in which the exercise is being conducted?
- **Analysis:** How do the context and main issues, trends and drivers influence one another? How can the knowledge generated in the exploration stage be synthesised?
- **Anticipation:** In light of the previous analysis, what futures might be anticipated? Is there a desirable (normative) future, and if so, what could be the most likely constraints on its realisation? What could be the mainly unlikely but highly disruptive events (i.e. 'wildcards')?

Many methods can contribute to the exploration, analysis and anticipation stages. For example, while interactive methods (e.g. futures workshops and citizen panels) are useful to explore how different stakeholders understand the context of an exercise, evidence-based techniques (e.g. trend analysis or benchmarking) may be more convenient to identify major driving forces. In addition, expertise-oriented methods (e.g. roadmapping, Delphi and expert panels) may prove powerful tools in the analysis stage, especially for interconnecting key issues, trends and drivers, and for helping participants to distil and combine their knowledge. Finally, creative methods (e.g. brainstorming and scenarios) are more likely expected to contribute to the anticipation stage by creating success

scenarios, identifying possible disruptions, etc. We return to a more detailed discussion of methods and methodology below.

Action and Renewal Phases

It is typically necessary to follow-up the main generation phase of foresight with a separate phase of results dissemination and implementation. The questions here include the following: How will desired scenarios and shared visions bring about the coordination and mobilisation of actors – thereby leading to an active shaping of future developments? How will research priorities be identified and articulated? How will innovation and change be promoted? How will decision-making be informed?



A further important consideration concerns the learning and embedding of foresight as practice, and consequently the development and renewal of capacities to regularly use foresight tools to inform decision-making processes.

In this sense, the action and renewal phases are about transformation. They look at possible implications and lessons that can be drawn for present-day decision-making and strategy. In essence, they centre attention on how the future could be shaped for the better. They take into account the practical steps necessary to implement the findings of the exercise, and consider how foresight as practice can become embedded in organisations and communities. Consideration of these questions before an exercise begins can increase the likelihood of a successful outcome.

HOW TO DESIGN A FORESIGHT METHODOLOGY?³

The main objective of a foresight methodology is to help organisers and practitioners to better carry out their foresight exercises. Box 3 (above) lists a large variety of sources where the reader can find plenty of material on methodological issues. We do not discuss these here, but instead, we make use of a comprehensive framework to position some of the main foresight methods. This framework is known as the Foresight Diamond and has proven to be particularly effective as a tool for designing a foresight methodology. Two main steps tend to be carried out:

- 1) Selecting appropriate methods;
- 2) Articulating or combining methods, i.e. designing the methodology.

Selecting appropriate methods

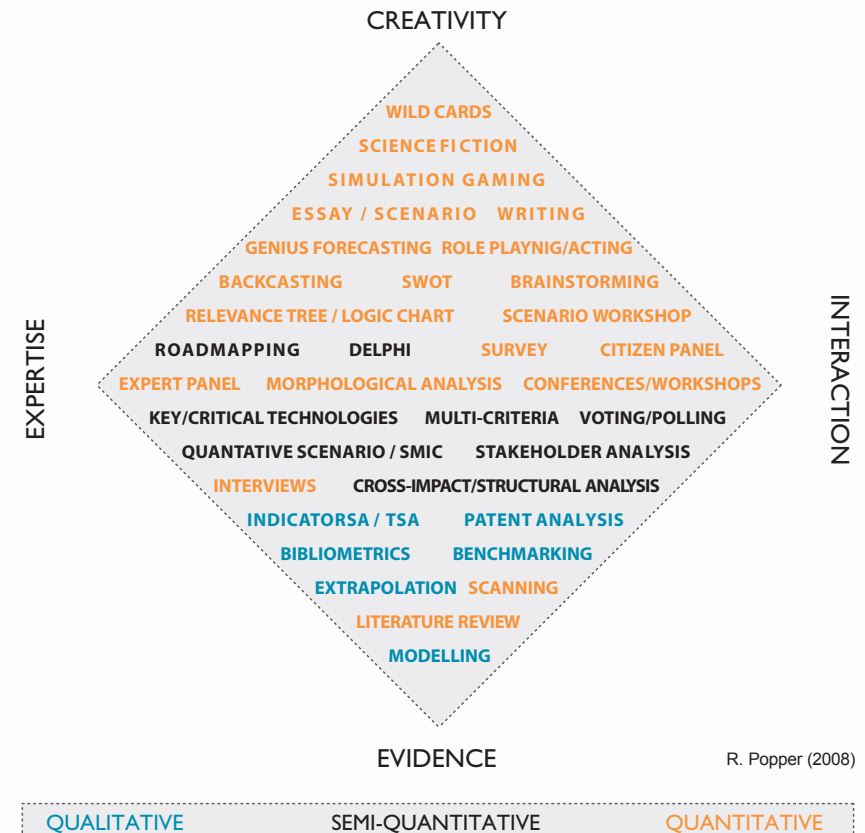
There are various considerations involved in the selection of appropriate methods. Here we will refer to three that are most important:

- To have a ‘full’ list of methods; i.e. including most commonly as well as less commonly used methods;
- To know what to expect from each method, i.e. understanding key features; and
- To have a set of criteria for retaining some and abandoning others.

Box 4: The Foresight Diamond

The Diamond includes some thirty three methods in terms of the main type of knowledge source on which they are mainly based. These sources of knowledge (creativity, evidence, expertise and interaction) are certainly not fully independent from one other; however, it is possible to use them to highlight the most representative features of each method. Similarly, the Diamond emphasises the type of technique, using different colours.

Qualitative techniques use **blue** style, Semi-Quantitative use **black** and Quantitative use **orange**.



The Diamond provides a long list of methods, but for reasons of space, we only discuss the top ten “most widely” used methods in European foresight.

The selected methods are described below in alphabetical order (see Box 5). The descriptions provide a flavour of what can be expected from the methods and introduce some of their key features.

Top 10 foresight methods⁴

- Benchmarking
- Brainstorming
- Delphi
- Expert panels
- Futures workshops
- Key / Critical technologies
- Roadmapping
- Scenarios
- SWOT Analysis
- Trend extrapolation

Box 5: Key features of common foresight methods 5

Benchmarking is commonly used for marketing and business strategy planning and has recently become more popular in governmental and inter-governmental strategic decision-making processes. It focuses on what others are doing in comparison to what you are doing by comparing similar units of analysis in terms of common indicators (e.g. research capabilities of key sectors, market sizes of industries, etc.).

Brainstorming is a creative and interactive method used in face-to-face and online group working sessions to generate new ideas around a specific area of interest. Aiming at removing inhibitions and breaking out of narrow and routine discussions, it allows people to think more freely and move into new areas of thought, and to propose new solutions to problems. The first step involves sharing and exchanging views from a selected group of people. These views are gathered and made available for inspection as they arise, crucially without being criticised or discussed in depth. Subsequently, all ideas are discussed and clustered into categories (e.g. social, technological, environmental, etc.).

Delphi is a well-established technique that involves repeated polling of the same individuals, feeding back (sometimes) anonymised responses from earlier rounds of polling, with the idea that this will allow for better judgements to be made without undue influence from forceful or high-status advocates. Delphi surveys are usually conducted in two, and less commonly three, rounds. They are most often employed to elicit views as to whether and when particular developments may occur, but the technique can be used for any sort of opinion or information – such as the desirability of specific outputs, impacts of policies or technologies, etc.

Expert Panels are groups of people dedicated to discussion and analysis, combining their knowledge concerning a given area of interest. They can be local, regional, national or international. Panels are typically organised to bring together “legitimate” expertise, but can also attempt to include creative, imaginative and visionary perspectives. In many exercises, panel members are also expected to influence the decisionmaking environment (e.g. through disseminating results, building networks and reaching commitments, etc.).

Futures workshops are events or meetings lasting from a few hours to a few days, in which there is typically a mix of talks, presentations, and discussions and debates on a particular subject. The events may be more or less highly structured and “scripted”: participants may be assigned specific detailed tasks. The feedback of participants is used to improve the scope of the foresight process.

Key / Critical Technologies involve the elaboration of a list of key technologies for a specific industrial sector, country or region. Typically, a technology is said to be ‘key’ if it contributes to wealth creation or if it helps to increase quality of life of citizens; is critical to corporate competitiveness; or is an underpinning technology that influences many other technologies. Which ever way the method is implemented

(expert panels or surveys, for instance), it implies some prioritisation process (such as voting). The exercise is most often oriented to emerging technologies, but may involve more familiar ones too.

Roadmapping is used to outline the future of a field of technology, generating a timeline for development of various interrelated technologies and (sometimes) including factors like regulatory and market structures. It is widely used by high-tech industries, where it serves both as a tool for communication, exchange, and development of shared visions, and as a way of communicating expectations about the future to other parties (e.g. sponsors). It requires inputs from people with deep knowledge about the focus area. The method has occasionally been applied to topics other than technology development, and the term “roadmap” is used loosely to describe all sorts of forward planning accounts of expected or hoped-for stages of development.

Scenarios refer to a wide range of approaches involving the construction and use of scenarios – more or less systematic and internally consistent visions of plausible future states of affairs. They may be produced by means of deskwork, workshops, or the use of tools such as computer modelling. Scenario workshops commonly involve working groups dedicated to the preparation of alternative futures. There are numerous ways of articulating and elaborating such scenarios – for example, using a 2*2 matrix cross-cutting key parameters; using “archetypal” scenarios such as “better than expected”, “worse than expected”, “different to expected”, and so on. But one can also find workshops aiming at the creation of an aspirational or success scenario, for example, elaborating a vision of a desirable and feasible aspirational future. Such a scenario requires the identification of specific objectives, targets and actions towards its achievement.

SWOT Analysis is a method which first identifies factors internal to the organisation in question (e.g. particular capabilities, brands, etc.) and classifies them in terms of Strengths and Weaknesses. It similarly examines external factors (broader socio-economic and environmental changes, for example, or the behaviour of opponents, competitors, markets, etc.) and presents them in terms of Opportunities and Threats. This is then used to explore possible strategies – developing and building on strengths and overcoming or accommodating weaknesses, providing insight as to the resources and capabilities required to deal with changing environments, and so on. It is a very widely used for strategy formulation and decision making.

Trend extrapolation is among the longest-established tools of forecasting. The method provides a rough idea of how past and present developments may look in the future – assuming, to some extent, that the future is a kind of continuation of the past. There may be large changes, but these are extensions of patterns that have been previously observed. Essentially, it is assumed that certain underlying processes – which may or may not be explicated – will continue to operate, driving the trend forwards. In practice, of course, most, if not all, trends will confront limits and countertrends at some point in their evolution.

Articulating or combining methods

In addition to a general understanding of key features of foresight methods, it is important to have a well-defined set of criteria for retaining and/or abandoning methods in the methodology. This is why at this point we would like to remind the reader that:

- the methodology must be chosen after objectives are defined and not vice versa; and that,
- the selection of methods may be affected by resources, such as budgets, availability of expertise, political support, technological and physical infrastructure, and time.

When designing methodology options, it is important to keep in mind that there are many ways in which a particular selection of methods can be arranged. Each arrangement or sequence provides a unique approach for carrying out a foresight exercise. For example, the sequences below are two out of 720 different ways in which a selection of six methods could be organised.

- Benchmarking ► Brainstorming ► Delphi ► Expert panels ► Futures workshops ► Scenarios.
- Scenarios ► Futures workshops ► Expert panels ► Delphi ► Brainstorming ► Benchmarking.
- And so on...

Of course, some of these 720 sequences are less likely to work as well as others, and it is important to recall the stages highlighted earlier in the description of the Generation Phase when designing a methodology. Moreover, designing an appropriate methodology should take into account the use of at least one method from each pole of the Diamond, representing the key features of a comprehensive foresight methodology (see Box 6).

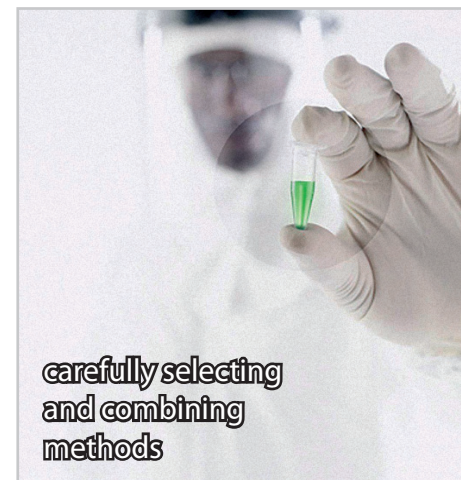
Box 6: Key features of a comprehensive foresight methodology

Creativity: The mixture of original and imaginative thinking is often provided by technology ‘gurus’, via genius forecasting, backcasting, or essays. These methods rely heavily on the inventiveness and ingenuity of very skilled individuals, such as science fiction writers or the inspiration that emerges from groups of people involved in brainstorming or wild cards sessions.

Expertise: The skill and knowledge of individuals in a particular area or subject is frequently used to support top-down decisions, provide advice and make recommendations.

Interaction: Expertise often gains considerably from being brought together and challenged to articulate with other expertise (and indeed with the views of non-expert stakeholders). And given that foresight activities are often taking place in societies where democratic ideals are widespread, and legitimacy is normally gained through ‘bottom-up’, participatory and inclusive activities, it is important that they are not just reliant on evidence and experts.

Evidence: It is important to attempt to explain and/or forecast a particular phenomenon with the support of reliable documentation and means of analysis of, for example, statistics and various types of measurement indicators. These activities are particularly helpful for understanding the actual state of development of the research issue.



**carefully selecting
and combining
methods**

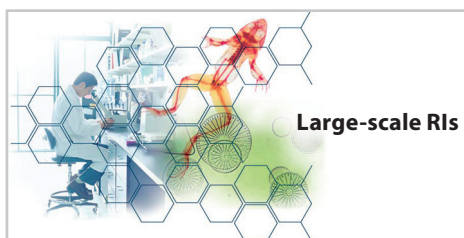
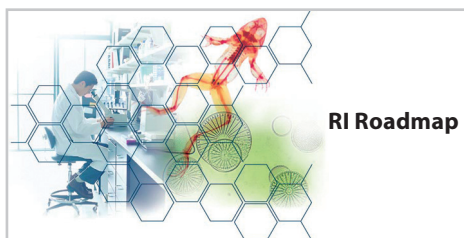
WHEN COULD FORESIGHT BE USEFULLY DEPLOYED?

The previous sections have suggested a number of rationales concerning the use of foresight for RIs, but it is also useful to illustrate application through concrete examples. Several of the guides highlighted earlier in Box 3 include case studies of foresight in action – essentially as a means for lesson drawing. At the current time, as foresight has been barely applied to RIs, there are few, if any, actual cases to refer to. For this reason, four hypothetical cases have been created to illustrate the contexts and potential uses of RI foresight.

The choice of case topics is intended to illustrate a range of situations in which foresight could be usefully employed in the area of RIs. Thus, we do not seek to demonstrate the varieties of foresight that could be employed, but rather to show the varieties of situations in which foresight could be used.

Accordingly, we have selected case topics at four different scalar levels, as follows:

- National Facility Foresight: this is where a national research facility seeks to reorient and modernise its focus and operations through the use of foresight
- National RI Roadmap Foresight: this is where a national science ministry decides to conduct a foresight exercise with the purpose of creating a roadmap of its future RI needs and investments
- Facility Network Foresight: this is where several sub-critical national facilities come together across a region of Europe to collaborate on their operations and to coordinate their investments
- Large-Scale RI Foresight: this is where a coalition of interests advocating the new build of a large-scale European RI use foresight to scope various available options and to further convince policy makers and funding agencies of the merits of their proposals



The cases use the same structure that was outlined earlier for the planning of foresight exercises. The methodological approaches suggested are not definitive and each exercise could in fact be done in many different ways. We would therefore not encourage clones of what are hypothetical exercises, but instead to consider them as inspirational points of departure.

HOW COULD FORESIGHT REORIENT A NATIONAL FACILITY?



Context and Rationales

A large national facility finds itself at a crossroads. Its core grant from the national science ministry is to be gradually reduced to half its current level over the coming five years, in exchange for an immediate, though modest, cash injection to fund new facilities and early retirement packages. As things stand, much of the facility's equipment is increasingly obsolete and in need of modernisation or replacement, and it is generally under-utilised or utilised inefficiently. Moreover, staff turnover is low, with too little 'new blood' coming through the facility. There is some contact with the private sector, but it is felt that there is much greater potential for such collaboration that remains largely untapped.

A new director has been appointed to reinvigorate the facility and to reorient its operations, though this will be a major challenge given the problems and constraints – but things cannot continue as they are. The director is therefore looking to develop a new vision that will revitalise the facility's mandate and use. This vision should be based more firmly upon an innovation agenda, particularly as new (private) sources of funding will need to be found. This vision should be inclusive 'internally' and 'externally' and should contribute to the formulation of a strategic action plan that will revive the fortunes of the facility.

A foresight exercise is proposed as part of the process of the facility's reorientation. Foresight's participatory principle is seen as being well-suited to achieving the engagement and commitment of staff members – and, significantly, of the external organisations that the facility's director is hoping to interest in future collaboration. Moreover, it is important that the facility's reorientation takes

account of likely future developments and that any strategic action plan is sufficiently resilient to future change and discontinuity.

Accordingly, the objectives set for the foresight exercise are as follows:

- To rethink the facility's role in a national R&D and innovation system
- To develop an ambitious, yet feasible, new vision for the facility
- To identify strategic areas of research in line with pressing needs of society or science and technology development and innovation, in which to redirect the operation of the facility and thereby ensure the sustainability and leading position of the facility in the long run
- To devise a strategic plan to realise the vision and deliver on the strategic research priorities identified
- To develop a long-term and strategic culture across the facility, thereby ensuring that the foresight exercise is not just a punctual one-off activity

Expected outputs from the exercise include a desirable vision for the future reorientation of the facility, and an accompanying roadmap setting out the facility's new research priorities, its research agenda, its positioning on the market of R&D and innovations, and a coherent set of present-day and near-future actions needed to realise the vision. In the course of the process, the foresight exercise will generate other outputs, such as new information on technology trends and their alternative future projections, international benchmarking results, and insights on likely industry demands for R&D, to name but a few.

Pre-foresight and Recruitment Phases

The sponsor of this exercise is the research facility itself and its duration is around 10 months, reflecting the need to feed the results into the facility's new strategy, which must be implemented in the next financial year. Compared to the other cases presented in this Guide, this exercise has the shortest time horizon at just 10 years. This not only reflects the dynamic field in which the facility operates, but also takes account of the need for the facility to reorient and adapt its operations in the shortest possible time.

Given the rapid need for the exercise's results, the facility draws upon external consultancy help to contribute to the deskwork and to facilitate workshops. However, a deliberate decision is taken from the outset for the exercise to be managed from within the facility itself. This is for several reasons: first, the facility's state-of-the-art, as well as its status-quo, is best known by its own staff (researchers, management, and technical staff); and secondly, since the intention is that foresight should become a regular activity in the facility (even a key competence), it is important that the practice of foresight and its associated types of thinking are learned and embedded in the organisation. Complete outsourcing of the running of the exercise would largely prevent this learning and embedding from taking place. Accordingly, the organisational structure of the exercise is as follows. First, a central team of 2-3 full-time persons, reporting directly to the Director, are appointed to organise the exercise. They are responsible for the day-to-day management of the exercise, the preparation of reports, and the organisation of activities. Process consultants are hired for the duration of the exercise to provide continuing advice and occasional analytical input. They are also engaged to help facilitate meetings and workshops. In addition, a steering group is appointed, consisting of the Director (chair), heads of division, and a handful of external experts/stakeholders from the public and private sectors. This meets every 1-2 months to review progress and to discuss emerging results. Wider participation is achieved through several rounds of workshops, involving a mix of (mostly) internal staff and external experts/stakeholders from the public and private sectors. These workshops are described further below.

Generation Phase

As in all cases in this Guide, no particular foresight methodology is deemed as best. For this particular case, a very applicable and appropriate approach may be structured around scenarios of alternative future developments, which bring along a number of other methods and techniques, needed prior to crystallizing the scenarios (such as environmental scanning, trend extrapolation, etc.). All these would be used in support of a process to develop a number of visions of the future (in the form of scenarios), and identifying the most desirable one for the facility's new positioning and re-structuring.

The steps to be followed are shown in Box 7. Emerging trends and drivers – and potential discontinuities – are first examined in order to identify both the threats and opportunities facing the facility, in terms of likely science and technology developments, the evolution of funding and commercial environments, and (most importantly) the changing nature of the governance of science and national scientific facilities (Stage 1). This is done through deskwork, carried out by the central team, the process consultants, and external experts. It involves a combination of science frontiers studies (literature review), environmental scanning, and trend extrapolation. In addition, an international benchmarking exercise is carried out – in order to compare the facility's capabilities and strategies with similar facilities elsewhere. Taken together, the data produced from this deskwork is synthesised as part of a SWOT, with all findings published in a facility 'status report'.

Not forgetting that foresight is a participatory process, the status report is used as an input into a series of workshops involving all operating divisions of the facility and selected external stakeholders (Stage 2). The aim is to bring together facility scientists and external experts to review the results of the deskwork and to make sense of it. The latter is critical, since the position of the facility and the main drivers shaping its contextual environment need to be widely understood. This requires that attention is paid to the process of the workshops, to ensure that this sense-making occurs.

Using the feedback from the workshops, the central team, working with the steering group and process consultants, engages in scenario writing (Stage 3). A number of contrasting, yet plausible, scenarios are generated that illustrate multiple futures in terms of qualitatively different changes in the environment and the respective reactions to those changes by the facility. A series of scenario workshops – involving the same participants as the first round of workshops – are used to explore alternative options for turning around the fortunes of the facility in the alternative future worlds. These emergent options constitute the building blocks for a new facility vision.

A draft of this vision is developed by the central team and the steering group. Further, backcasting of the vision helps to identify a set of targets and milestones that will need to be achieved if the vision is to be realised (Stage 4). Taken together, these elements constitute a roadmap for reorienting the facility towards more desirable development directions. The roadmap includes clear operational targets for scientific outputs, commercialisation income, collaborative projects, human resource development, and so on. Feedback on the draft vision and accompanying roadmap are sought through a one-day conference of staff and external stakeholders, before being finalised and fed into the strategic planning process (Stage 5).

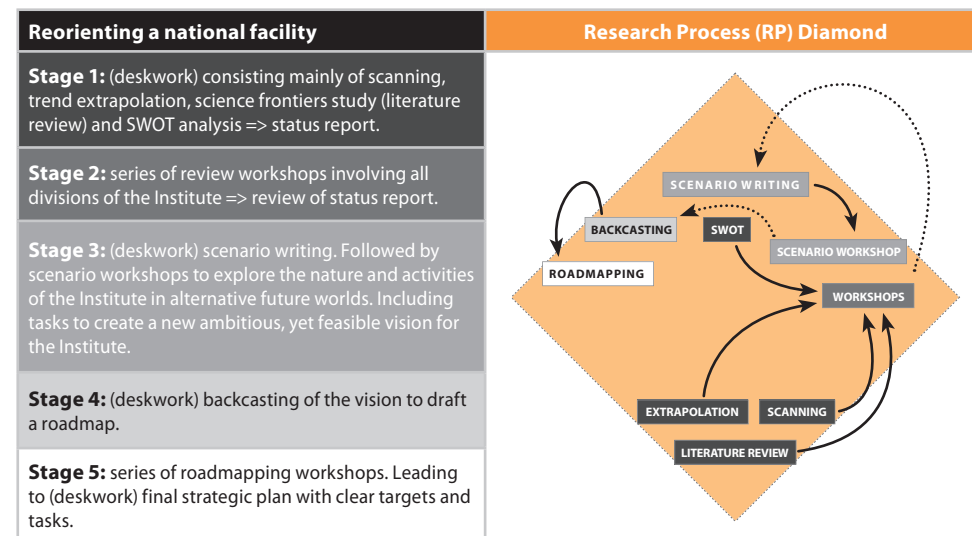
Action and Renewal Phases

The roadmap provides a useful guide and reference for implementation, and several working groups are established to follow-up on concrete proposals. Moreover, the design of the exercise has deliberately sought to actively incorporate in the foresight process many of the key stakeholders who are responsible for follow-up action, both internally

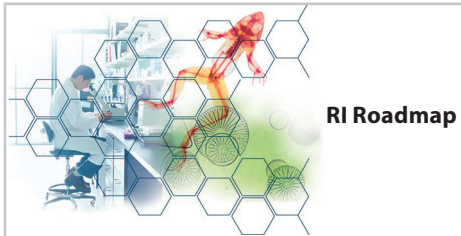
and externally. Through their involvement, they are more likely to be committed to implementation of identified action towards the realisation of the vision. Further, the exercise has resulted in the exchange and sharing of knowledge, the launching or strengthening of networks, cultural changes, and the building of strategic capacity among participants.

As for renewal, the exercise has provided a new sense of purpose to the facility and has led the director to commit to regular foresight-like processes being established in the facility. These include a permanent horizon scanning activity, focused upon monitoring major changes or novelties in the external environment (including S&T developments) – changes that would strongly impact the facility's activities and its strategic research agenda and would thus lead to the need to reconsider the actions being taken. In addition, the foresight exercise will be repeated within a 4-5 year period to upgrade the vision of the facility's future and to update the action plan within an evolving context.

Box 7: Foresight 'RP Diamond' to reorient a National Facility



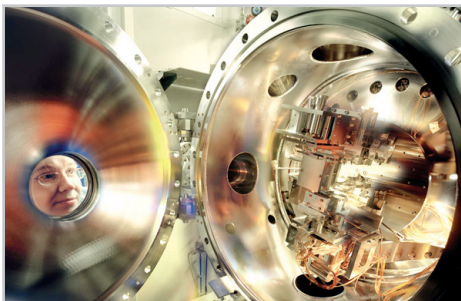
HOW COULD FORESIGHT FORMULATE A RI ROADMAP?



Context and Rationales

A few EU Member States (e.g. Sweden, the UK, etc.) have developed national strategic roadmaps for their RI, with much interest in other countries to conduct similar exercises. Accordingly, the national science ministry of a New Member State has decided to conduct a RI roadmapping exercise, with the aim of identifying likely RI requirements – including new build and upgrades, reformed operating practices, and participation in international facilities – that will meet the research needs of the country over the coming two decades.

A national foresight exercise is organised jointly by the science ministry and the academy of sciences with the purpose of building this strategic roadmap for RI. A 'regular' strategic roadmapping exercise already presumes a future-oriented and consultative approach, but the use of foresight introduces a multiplicity dimension to the future, to reflect the inherent uncertainty around many of the relevant issues. Thus, the foresight exercise's overall goal is to arrive at a national strategic RI roadmap, which should be based upon a shared vision derived from scenario analysis and backcasting.



Accordingly, the exercise has the following objectives:

- To take stock of current and planned RI provision over a 20-year time horizon taking into account future opportunities and threats
- To consider the long-term sustainability of national RIs in terms of their scientific excellence, management, ease of access, upgradeability, technology transfer, and scope of services, with a view to ensuring that they are productive and viable
- To produce a detailed roadmap – covering all the main scientific disciplines - that sets out targets and milestones and that points out recommendations, for example, on approaches for funding of major RI investments (new-build and upgrades)
- To ensure commitment, engagement and balanced participation of a wide range of national stakeholders in a process of meaningful deliberation

The main expected output from the exercise is the national strategic roadmap for RIs that sets out national priorities and recommendations for follow-up actions. In the course of the process, the foresight exercise will generate other outputs, such as synthesised audit data on current national RIs and international benchmarking results.

Pre-foresight and Recruitment Phases

The exercise is sponsored by the national government, specifically the national science ministry, and has a time horizon of around 20 years (to 2030) reflecting the long lead times necessary in the planning and establishment of some of the most strategic RIs. The duration of the exercise is around one year, thereby allowing time for wide consultation with various scientific and user communities.

The organisation and day-to-day management of the exercise is outsourced by the ministry to a specialist unit in the national academy of sciences, where experience in using scenario and technology roadmapping techniques resides. Some of the staff from this unit constitutes the project team, which is overseen by an exercise steering committee of key

stakeholders appointed by the ministry. Its role is to approve interim outcomes and milestones, validate the RI roadmap, and promote more widely the exercise's results.

Given the wide variety of different RI in the national space, it is necessary to establish a number of disciplinary expert panels to cover all of the main areas of science. Their task is to design a future-proof vision for a national RI in 20 years time. Members include leading scientists (from academy institutes and universities), research directors of research-intensive companies, and national policy makers, all of who are relatively straightforward to recruit given the high national profile of the exercise.

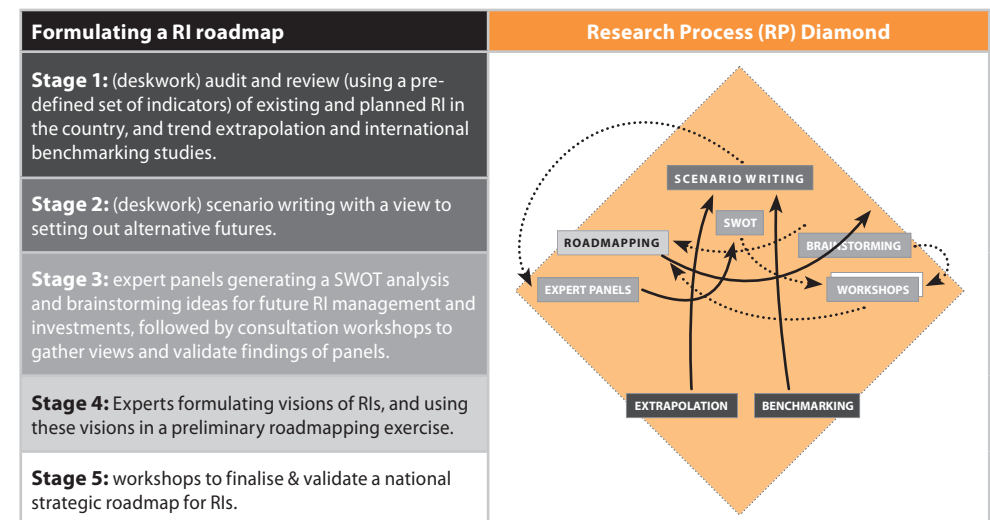
Generation Phase

The exercise's methodology is shown in Box 8. It begins with a period of intensive deskwork, dedicated to auditing and reviewing existing and planned RI in the country (Stage 1). This is carried out by the project team using a pre-defined set of indicators, ensuring comparability between data gathered around a variety of RIs. Information is collected through a mix of surveys and data mining of existing information sources. In addition,

trend extrapolation and benchmarking studies are conducted with a view to better anticipating future developments and learning from overseas experiences, respectively. On the basis of this data, the project team generates contrasting, yet plausible, baseline scenarios to be used by the expert panels (Stage 2).

It is at this point that the expert panels begin their work, each meeting 3-4 times over a six month period and holding a couple of open workshops for ideas generation (e.g. through brainstorming) and validation (Stage 3). The panels' aim is to assess the strengths and weaknesses of current and planned RI provision over the coming twenty years, using the multiple baseline scenarios developed by the project team to take into account possible opportunities and threats (SWOT analysis). Through this process, the panels formulate 'future-proof' visions of RIs, and through a backcasting exercise, draft roadmaps that set out the various RI priorities for their areas of science (Stage 4). These drafts are then brought together, and through processes of synthesis and negotiation – which take a further four months to conduct through a series of workshops – a national RI roadmap is generated that will guide future national investments (Stage 5).

Box 8: Foresight 'RP Diamond' to formulate a RI roadmap



Action and Renewal Phases

The roadmap provides a useful reference for policy and decision-making, and is used by R&D funding agencies as a framework for RI investments. Moreover, the roadmap and its recommendations shape the agendas and mobilisation of communities of interested actors, with expert panel and steering committee members especially active in organising for the recommendations of the roadmap to be implemented.

As for renewal, some countries have already repeated their roadmapping exercises some 4-5 years after the original exercise was carried out. The New Member State being considered here follows a similar pattern, so that the exercise essentially becomes a process of permanent 20-year horizon scanning for socio-economic demands and for new S&T to support the policy development in the field of research, innovation and RIs.



HOW COULD FORESIGHT NETWORK FACILITIES?



Context and Rationales

Several small-medium sized countries in central Europe have existing national centres in a common area that need some upgrading, as well as significant investments in expensive new RIs. There is little possibility of any one country being able to afford to pay for the new RIs on their own, and in any case, they would be better utilised if shared by researchers/industry from several countries in the region. There is the possibility that loans can be secured from the European Investment Bank to fund some of the capital investment, whilst Structural Funds might also be used for similar purposes. The preferred development model is one which sees the national centres maintaining a core set of competences and technologies, but with each centre developing complementary expertise and instrumentation centred on a particular speciality. The idea is that all national centres will be open to the academic and industrial communities across the region (and possibly beyond), and will provide, on a project basis, access to production and experimental facilities.

A foresight exercise is organised with the purpose of scoping the scale, design, operation, and whole-life costs of the new international network of upgraded national centres. The specific objectives of foresight are as follows:

- To map existing strengths and weaknesses, and to explore complementarities and overlaps of the networking centres
- To identify future S&T and socio-economic opportunities and threats that should be addressed
- To illustrate the unsustainability of the old management and business models and to demonstrate the 'need' for international collaboration
- To function as a forum for involvement and participation of stakeholders in different countries
- To build a strong vision that the participants of the network can sign up to
- To strengthen the strategic capacity of managers of the national centres, as well as national policy makers

Expected outcomes include an efficiently functioning network of upgraded facilities, better placed to respond to emerging scientific developments and growing multidisciplinary, to meet the demands for new and diverse services, to ensure better access to unique equipment and data bases, to attract young researchers, and to improve harvesting and exploitation of existing knowledge.



Pre-foresight and Recruitment Phases

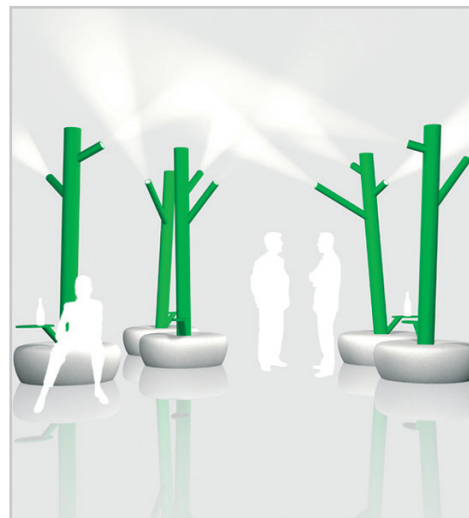
The exercise is promoted by national science ministries in participating countries, and they provide some of the funding. In addition, the European Commission covers about half the costs of the exercise. Given the complicated nature of the issues and institutional landscape, the exercise has 18-month duration. The time horizon is 10-30 years, the choice being dependent on the expected life span of RIs under consideration.

The exercise is organised and managed by a mix of strategic planners from the national facilities and an international consultancy specialising in foresight processes. Together, these constitute the project team. Its distributed nature – which is required for local knowledge and embeddedness – necessitates the need for regular face-to-face meetings and for special attention to be paid to communication processes. In addition, a transnational steering group of facility directors and national policy makers is established, together with several small transnational working parties of leading scientists and research managers.

Furthermore, national working groups are set up around each of the existing centres – in order to collect and process national data, as well as to make sense of foresight results in a localised context. There is a great deal of overlap in membership between all of these groups to ensure communication, while the working language of the transnational groups is English. Members are drawn mostly from the research centres themselves, national ministries, and from an array of other interested stakeholders, including business representatives and branch associations.

Generation Phase

The overall methodology is shown in Box 9. The exercise begins with an extensive programme of deskwork involving the preparation of ‘future outlooks’ on several of the sub-fields that constitute the area, the mapping of existing strengths and weaknesses, and exploration of complementarities and overlaps across the current national centres, and an international benchmarking exercise (Stage 1). Starting a little later but also working in parallel, a survey is carried out by scientists, industrialists, and public policy makers in order to capture the likely S&T needs of user communities (the ‘application’ sector). This leads to the identification of key technologies (Stage 2). Following this, national and international working groups brainstorm around the emerging results of the exercise with the purpose of generating topic statements for an international online Delphi (Stage 3). The latter is a means of consulting more widely around issues of uncertainty and likely importance.



Drawing upon the results of earlier steps, the project team draft several scenarios that portray the region’s scientific and industrial profiles in different worlds, depending upon the level of collaboration between and the governance and renewal of the national centres (Stage 4). These are used to illustrate to a wide audience the unsustainability of ‘business as usual’ and to demonstrate the ‘need’ for international collaboration. They are also used in a scenario workshop to generate a strong future vision (in the form of a ‘success scenario’) that the national ministries, national centres, and national communities can sign up to, and lead to the proposal of concrete recommendations for moving forward through a backcasting exercise (Stage 5).

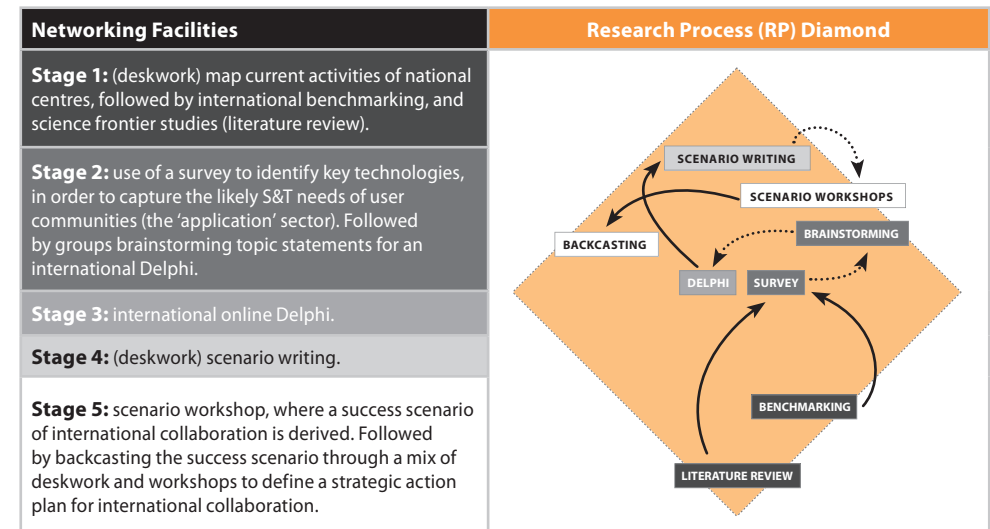
The elaboration of the success scenario on the future network requires development of actions under several important topics, such as (a) design of common research agendas for applied and advanced research; (b) opportunities for acquiring and sharing equipment, knowledge and skills; (c) new access schemes to national centres’ resources; (d) new collaboration modes and diversification of services; (e) increase in multidisciplinary of research fields; (f) gaining pan-European significance; (g) optimisation of knowledge exploitation and innovation processes; (h) communication across the network of facilities; and (i) design of the infrastructure of the networked facility (centralised with sub-nodes, virtual, etc.), determined by its function.

Action and Renewal Phases

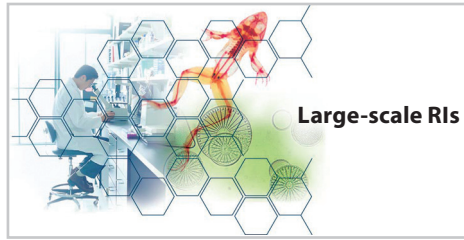
Once the results of the exercise have been generated and recommendations articulated, the national and international structures put in place are transformed into implementation bodies. An important challenge is to attract the necessary funding – both from national governments and the EC – to carry through the recommendations. But with clear plans based upon extensive research and consultation, it is much easier to convince funding bodies of the merits of the network. The foresight exercise has not only created this useful codified output that is useful for follow-up action, but has also provided a forum for the involvement and participation of stakeholders in different countries. The strategic dialogue space afforded by foresight has aided communication, understanding and collaboration across geographical and organisational boundaries that would otherwise have been difficult to bridge.

Since the network could become a large facility even with pan-European significance, regular strategic thinking exercises should be conducted for identification of major breakthroughs in related fields that might require adjustments of the network’s vision. This could be done through successive rounds of foresight or through the establishment of a permanent horizon scanning unit.

Box 9: Foresight ‘RP Diamond’ to Network Facilities



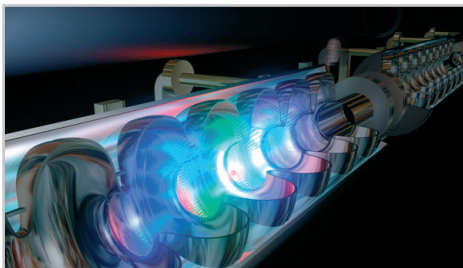
HOW COULD FORESIGHT SCOPE LARGE-SCALE RI'S?



Context and Rationales

The **ESFRI roadmap** contains several proposals for major investments in EU-wide large-scale RI. Proposals have reached different degrees of maturity in different fields, which range from technical aspects to institutional development, from involvement of user communities to financial issues. In the case outlined here – which is intended to be a non-specific, ESFRI-type proposal – a coalition of researchers and industrialists have been working on a concept for a new large-scale RI. Most are convinced of its need, though other possibilities are not being discounted, including the upgrading of existing RIs. There is less agreement on the location of any new large-scale RI and its precise technical specifications, and a number of competing factors need to be taken into account to inform these and other decisions.

The **coalition** is currently dominated by participants from a few Member States, and one of the successful outcomes of foresight should be to widen this constituency. Moreover, a number of funding agencies will need to be strongly convinced of the merits of the proposed large-scale RI. It is therefore important that they are enrolled as early as possible, with foresight offering the prospects of



an open, non-committal space for future-oriented dialogue and exploration. Accordingly, a foresight exercise is carried out by some of the proponents of the large-scale RI using EC funding earmarked for the scoping of new RIs.

The **specific objectives** of the foresight exercise are as follows:

- To anticipate future science and technology developments and the likely future needs of researchers and industrial users. Such an analysis allows for a prioritisation of required features/characteristics of the RI, as well as identification of likely future upgradeability requirements
- To extend and strengthen the coalition of interests around the idea of the proposed large-scale RI through engagement in the foresight process
- To demonstrate the long-term sustainability of the new large-scale RI in terms of its scientific excellence, management, ease of access, upgradeability, technology transfer and scope of services

The **main outputs** from the exercise are detailed alternative options for preparing funding proposals for the new RI. As for outcomes, the exercise should lead to a better understanding of the issues around the proposed RI. It should also lead to its promotion on to policy agendas, and mobilise a wider array of actors to further support the initiative.

Pre-foresight and Recruitment Phases

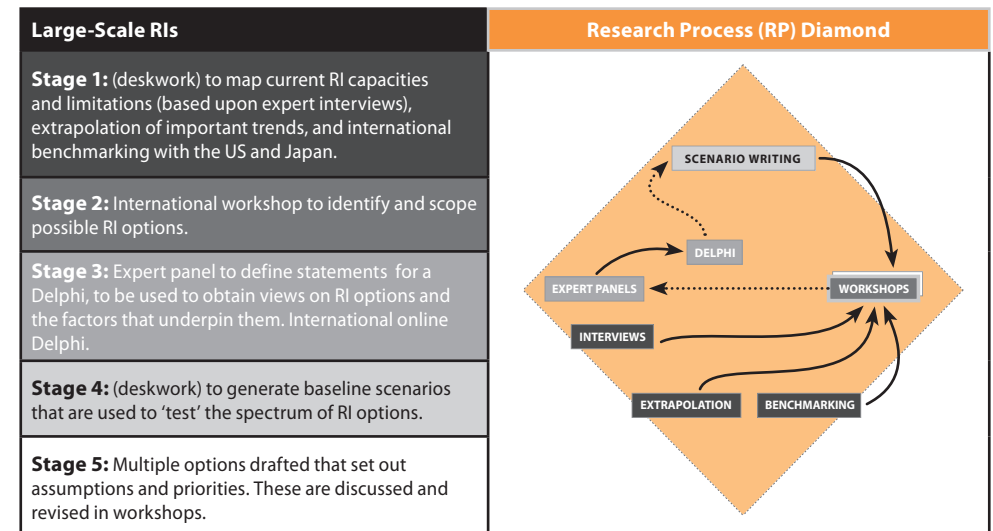
The **exercise** is funded through a grant from the EC's Seventh Framework Programme and has duration of 15 months. The time horizon is 10-30 years, the choice being dependent on the expected life span of RIs under consideration. The exercise is organised and managed by an international research consortium (project team) that includes the major existing facilities in the domain area, as well as a centre with foresight competences. A steering group – composed of stakeholder representatives from several EU Member States who have expressed an interest in future participation or use of the new large-scale facility – is also established. In addition, an expert panel – composed in part by members of the project team, but also by other experts from outside of the project – is appointed to generate Delphi topic statements (see below).

The **exercise** seeks to promote international cooperation and networking of a large set of participants, including scientists, RI managers, policy-makers, industry, state agencies, investors, and societal groups. These are identified through an initial stakeholder analysis. Since hard discussions on location (if a centralised facility), subordination (if a networked facility), and/or the intellectual property of data (if a virtual facility) are expected, the project team should be prepared to manage tensions among international participants in order to achieve some modicum of consensus and to keep to the time schedule.

Generation Phase

The **methodology** for the exercise is shown in Box 10. As with the other cases featured in this Guide, the exercise begins with a significant amount of deskwork performed by the project consortium, with the purpose of mapping current RI capacities and limitations (Stage 1). This work is supported by a programme of expert interviews dedicated to exploration of scientific frontiers and their likely RI requirements. In addition, extrapolation of important trends and international benchmarking with the US and Japan are also carried out in order to provide important contextual background to the exercise.

Box 10: Foresight 'RP Diamond' to scope large-scale RIs



Action and Renewal Phases

The **international** and multi-institutional nature of the proposed large-scale RI could cause some difficulties in the implementation of the foresight recommendations that need to be considered at the outset of the exercise. However, if the process is managed well, involving wide consultation and debate, then misunderstandings should be minimised, and only feasible options considered.

Since the new RI is envisaged to be a sustainable and adjustable structure with long-term impact in its domain area, repeating the foresight exercise in 4-5 years time might be useful for scanning the changes and novelties in the external environment and for rethinking strategic issues.



“RIs of pan-European relevance provide unique opportunities for world-class research and training as well as to stimulate knowledge and technology transfer...”

ESFRI Roadmap, 2006

FINAL REMARKS

This Guide has sought to introduce the practice of foresight to the domain of research infrastructures. It does not claim comprehensiveness, and indeed, we have highlighted several existing guides that can be consulted for more detailed information on matters of organisation and methodology. Instead, the Guide is intended to serve as an appetiser, hopefully stimulating those working with RIs to make use of foresight in their decision-making processes.

If, as a result of reading this Guide, you may now be thinking of organising a foresight exercise of your own, then it is essential to adapt your approach to local contexts and available resources. The latter, notably in the form of available time, funding, and the skills and competences necessary to run an exercise and to implement its recommendations, are often in short supply.

Skills can be acquired, in part, through methods training seminars for the participants of a foresight process, though competences can only be developed through learning-by-doing. But this should not discourage the novice – mistakes and setbacks will be inevitable, but rewards will be far greater for those who try.

As a final point, it is important to bear in mind that foresight processes do not replace existing strategic planning processes, but rather complement them. Policy making and other decision processes can benefit greatly from foresight, as indicated by its growing popularity and embeddedness across many public agencies and large private firms. But it is essential to acknowledge the limits of foresight, lest expectations will be unrealistic and disappointment will take hold.



REFERENCES

Web Links

- FP7 Capacities Programme - http://cordis.europa.eu/fp7/capacities/home_en.html
- European Strategy Forum on Research Infrastructures (ESFRI) - <http://cordis.europa.eu/esfri/>
- European Research Advisory Board (EURAB) - http://ec.europa.eu/research/eurab/index_en.html
- European Foresight Monitoring Network (EFMN) - <http://www.efmn.eu/>
- European Union—Science and Technology Foresight - <http://www.cordis.lu/foresight>

Publications

- ESFRI (2006) European Roadmap for Research Infrastructures, Luxembourg: European Communities; available at <http://cordis.europa.eu/esfri/roadmap.htm>.
- EURAB (2003) Recommendations on Research Infrastructures, Brussels: European Commission; available at <http://ec.europa.eu/research/eurab/>.
- Research Councils UK (2005) Large Facilities Roadmap, Swindon: RCUK; available at: <http://www.rcuk.ac.uk/cmsweb/downloads/rcuk/publications/lfroadmap2005.pdf>.
- Swedish Research Council (2006), Guide to Infrastructure, Stockholm: Vetenskapsradet
- Keenan, M. and Miles, I (2008), 'Scoping and Planning Foresight', in Georghiou, L., Cassingena H., J., Keenan, M., Miles, I., and Popper, R., The Handbook of Technology Foresight, Edward Elgar, UK
- Miles, I., Cassingena H., J., Georghiou, L., Keenan, M., and Popper, R. (2007), 'New Frontiers: Emerging Foresight'. in Georghiou, L., Cassingena H., J., Keenan, M., Miles, I., and Popper, R., The Handbook of Technology Foresight, Edward Elgar, UK.
- Popper, R. Keenan, M. and Butter, M. (2005), Mapping Foresight in Europe and other Regions of the World: The EFMN Annual Mapping Report 2004-2005, report to the European Commission, Delft: TNO.
- Popper, R. (2008), 'Foresight Methodology', in Georghiou, L., Cassingena H., J., Keenan, M., Miles, I., and Popper, R., The Handbook of Technology Foresight, Edward Elgar, UK.

Images of European RIs

- Lightsources.org
- Jodrell Bank Observatory (Manchester, UK) – <http://www.jb.man.ac.uk/>

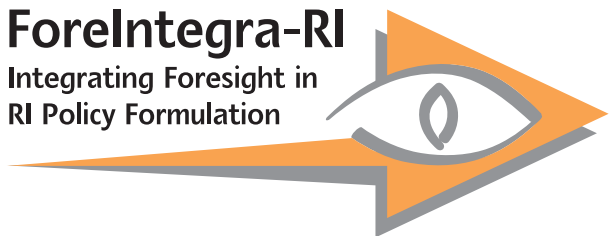
ENDNOTES

Endnotes

1. See ESFRI website at <http://cordis.europa.eu/esfri/>
2. This section is mainly based on Keenan and Miles (2008), Miles et al (2008), and Popper (2008)
3. Based on Popper (2008)
4. Based on Popper et al (2005) and Keenan et al (2006)
5. Based on Popper (2008)



ForeIntegra-RI
Integrating Foresight in
RI Policy Formulation



Copyright © 2007 ForeIntegra. All Rights Reserved.



