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# Research Institutes in the ERA

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# Summary

This is the final report of a study looking at the past and potential future of research institutes in Europe. In contrast to the universities, which are widely studied, the institutes are barely part of the EU policy discussion and the discussion about the European Research Area. The study therefore focuses on institutes in six fields, aiming to provide a broad spread of analysis that can improve understanding of the institutes and underpin policymaking in the institute sector.

The overall aim of the study is to provide a basis for informing EU- and national-level policies about the role of research institutes in the development of the European Research Area[1] (ERA). If the ERA is to become a reality, then aspects of Europe's institute system will need to be tuned towards effectiveness and efficiency at the European level and not only, as at present, the national level. We therefore place particular emphasis on issues related to internationalisation and the international division of labour.

**Method**

We started by trying to understand the institutes via a literature review. We were especially interested in the driving forces that promote change, in order to understand how trends in the institute system relate to the development of the ERA. Based on the literature, we then selected six sectors for closer study, aiming to look at their history over the past two decades and from these histories to deduce further (possibly sector-specific) historical change drivers. In a third step, we invited people from each of the six sectors to foresight workshops in Brussels, to discuss their views on future trends, drivers of change and policy needs in their sectors. Based on these three components, we then analysed prospective changes in the institute system using scenarios and developed a series of policy options and recommendations. The literature review, case studies and foresight workshop report are available in the appendix to this report (separate volume).

**The Research Institute Sector**

Research institutes, variously defined, account for almost half of Europe's public expenditure on R&D, yet they are in many respects almost invisible. There are no systematic statistics about them. What they do is to a large extent undocumented. The institutes have been consistently ignored until very recently in ERA development and discussions, despite their key nodal role in the Framework Programmes. Very little reform has taken place in the institute sector, except for changes to bring former Soviet-style academies into line with EU practice. Unlike the universities, the institutes are barely present in discussions of research policy, especially at the European level.

The terminology of institutes varies among languages and institutional traditions. Our definition is well captured in the German language as 'extra-university research institutes'. The other defining characteristic of research institutes is that they are at least in part state-financed in order to provide social returns by addressing market failures. In other words, they perform tasks that cannot be achieved by markets.

Europe-wide, research spending through institutes is slowly declining, while that through universities has been rising. There is a small number of very large institutes in Europe but most of the sector is nationally organised so that individual institutes are typically small. The proportion of income the institutes get from markets and from

[1] *Towards a European Research Area*, Communication from the Commission to the Council, COM(6), January 2006

abroad has slowly been rising and they are increasingly cooperating with the universities, though the tasks that institutes and universities undertake are typically very different from each other.

There are broadly three kinds of research institutes

- Scientific research institutes
- Government laboratories
- Research and Technology Organisations (RTOs)

After discussion and in order to fit with the priorities of the Commission, we did case studies of the Space and Plant Science sector in the category 'scientific research institutes', government laboratories in Marine, Geology/Earth Sciences (Geosurveys) and a group of the largest RTOs.

**Drivers of Change in the Institute Sector**

The general literature suggests that changes in the institute sector are driven primarily by: technological convergence; increasing university links; globalisation; commercialisation and a long run increase in the importance of markets; organisation and scale; and (not least) by policy. Our case studies suggested that other important drivers of change include: duplication of facilities and activity; in most areas a shift towards more applied research; and the emergence of new societal challenges such as climate change, food supply and safety that needed to be addressed in part through research and innovation.

Combining results from the case studies with those of the foresight workshops, tended to confirm these trends and underscored the fact that the institutes face customers whose needs are constantly becoming more sophisticated. Each sector has its own characteristics and is at a different stage in terms of the degree to which it is organised at the European level. EU-level organisation plays strong role in Space and Metrology but has so far had little influence over the Plant Science sector. Others are in between these positions. Analysis at the sector level shows in each case scope for adding value to the sector and to the ERA more broadly through greater coordination at EU level.

We worked with three scenarios

- **Alpha**: an enhanced 'business as usual' trajectory in which the research institute system evolves in ways which are better than present
- **Beta**: a trajectory in which the research institute system evolves in ways which are worse than present
- **Delta**: a trajectory in which the research institute system evolves in ways, which are extremely different to the present

The Delta scenario centres on the idea of greater European integration with strengthened policy measures in place to promote achievement of ERA objectives.

Foresight workshop participants generally thought Alpha was the most likely scenario, though some were anxious that the need in many countries to reduce the state budget could make Beta more likely. But there was also broad agreement that Delta was a more **desirable** scenario, and we were able to identify at least some of the policy actions needed.

**Research institutes and the ERA**

The idea of ERA has been evolving since it was introduced in 2000. Today it is, in effect, to build a globally competitive research and innovation system optimised at the European level. It is clear that tackling the grand challenges at EU level will become part of the agenda. Recent expert group reports have begun to identify the potential of the institutes to contribute and the importance of actually creating the common market in knowledge and knowledge services envisaged from the first ERA Communication but that is not yet in place.

The ways in which the institutes are funded today tends to lock them to the national level and fails to encourage the cross-border competition needed to improve the quality and performance of the sector as a whole. We conclude that the institute sector plays important roles in the European innovation system. It needs its own policy measures and should not be conflated with the universities. Increasing Europe's share in the funding of the institutes and its ability to operate as a trans-national customer will be key to triggering needed rationalisation and improvement in the institute sector. Article 169 has been used in a constructive way to coordinate and rationalise institute activity in metrology.

**Policy objectives**

Policy objectives for the RTOs in the context of ERA should be

- Integrating European knowledge markets to create a common market for knowledge and knowledge services
- Removing barriers to research institutes building globally competitive and naturally viable scale[2] through competition and specialisation
- Exploiting the capabilities of the RTOs to tackle the grand challenges, once these are defined and integrated into EU research and innovation policy
- Ensuring that Community provision of research infrastructure addresses not only the needs of basic research (ESFRI) but also of the institute sector
- Supporting the self-organisation of research institute sectors at the European level via organisations such as Eurogeosurveys and their connection to areas of developing policy need at European level
- Supporting developments in the institute sector that are **disequilibrating**, ie that combat existing lock-ins and enable new and existing institutes or groups of institutes to build positions in competition with others that overall strengthen the 'offer' of the European institute sector and its global competitiveness

**Policy Recommendations**

Some of these objectives will be promoted by the manner of implementation of measures that are not specific to research institutes, notably the way in which particular instruments are used to tackle the grand challenges. Specific consideration should be given to the role of research institutes in designing these interventions.

An urgent need is proper statistics about the institute sector. The Commission should ask Eurostat to establish definitions and collect statistics about the institutes, as is done for the university sector, and should encourage the OECD to act in a similar way.

The Commission should adopt a tiered approach to supporting integration and structural change, in order to address the different stages of development at which individual institute sectors find themselves. One level is to offer support through planning or exploratory actions, enabling groups of institutes to develop common research agendas and strategies addressing needs at the European level. A second level is to invite groups of institutes collectively to develop new intellectual capital (technology platforms or capabilities) at the European level that they subsequently can exploit in their wider operations. A third level is to provide competitive funding for shared infrastructure, enabling specialisation and division of labour while reducing unnecessary duplication in the sector.

As EURAMET has demonstrated, Article 169 provides a good opportunity to begin to implement a reorganisation of an institute sector, based not only on a common strategic plan but also competition. Where the Commission can identify institute sectors that link to EU policy needs, it should actively solicit them to establish Article 169 arrangements.

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[2] Comparisons with the USA are often made in defining the aims of EU research and innovation policies. However, it is not self-evident that the scale or monolithic structure of key US government laboratories would be optima for Europe. Rather, an evolutionary approach is needed to discover the scale and degree of competition that is appropriate in each European sector

Perhaps most fundamentally, however, the Commission should tackle the fact that there is not really a functioning cross-border market for institute research and services in the EU. In particular, there is no cross-border competition for 'competitive' government projects, so that the degree of competition is nationally limited and the institutes to not receive adequate market signals or incentives to encourage specialisation or improved performance. At the detailed level, it is not clear what all the obstacles are to opening up such markets. The Commission should ensure that these obstacles are studied and then aim to institute a reform to overcome them.

# 1. Introduction and Method

This is the final report of a study looking at the past and potential future of research institutes in Europe. In contrast to the universities, which are widely studied, the institutes are barely part of the EU policy discussion and the discussion about the European Research Area. The study therefore focuses on institutes in six fields, aiming to provide a broad spread of analysis that can improve understanding of the institutes and underpin policymaking in the institute sector.

The overall aim of the study is to provide a basis for informing EU- and national-level policies about the role of research institutes in the development of the European Research Area[3] (ERA). If the ERA is to become a reality, then aspects of Europe's institute system will need to be tuned towards effectiveness and efficiency at the European level and not only, as at present, the national level. We therefore place particular emphasis on issues related to internationalisation and the international division of labour.

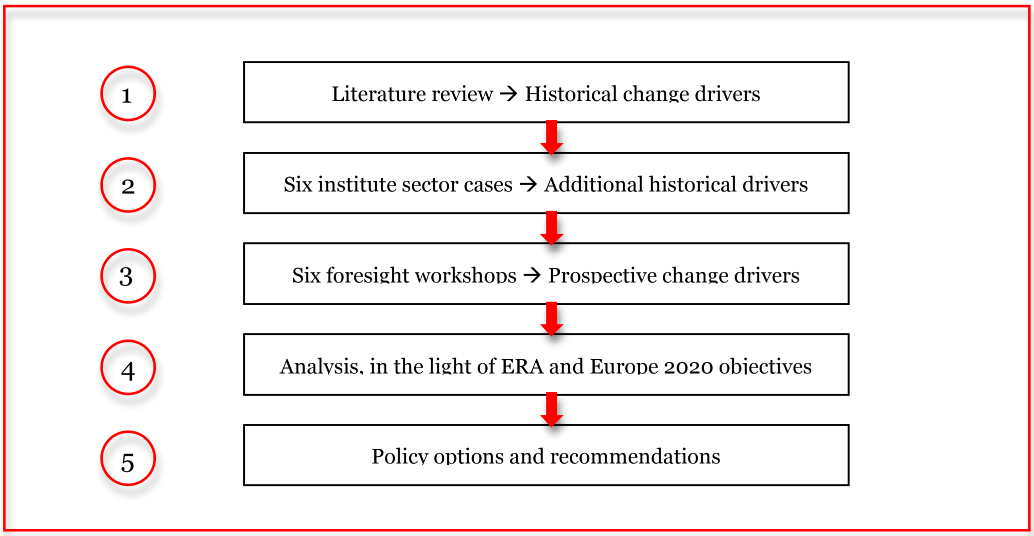
We started by trying to understand the institutes via a literature review. We were especially interested in the driving forces that promote change, in order to understand how trends in the institute system relate to the development of the ERA. Based on the literature, we then selected six sectors for closer study, aiming to look at their history over the past two decades and from these histories to deduce further (possibly sector-specific) historical change drivers. In a third step, we invited people from each of the six sectors to foresight workshops in Brussels, to discuss their views on future trends, drivers of change and policy needs in their sectors. Based on these three components, we then analysed prospective changes in the institute system using scenarios and developed a series of policy options and recommendations. The literature review, case studies and foresight workshop report are available in the appendix to this report.

## 1.1 Our approach to the study

Figure 1 shows the logic of our approach to the study. We started by trying to understand the institutes via a literature review. We were especially interested in the driving forces that promote change, in order to understand how trends in the institute system relate to the development of the ERA. Based on the literature, we then selected six sectors for closer study, aiming to look at their history over the past two decades and from these histories to deduce further (possibly sector-specific) historical change drivers. In a third step, we invited people from each of the six sectors to foresight workshops in Brussels, to discuss their views on future trends, drivers of change and policy needs in their sectors. Based on these three components, we then analysed prospective changes in the institute system using scenarios and developed a series of policy options and recommendations.

[3] *Towards a European Research Area*, Communication from the Commission to the Council, COM(6), January 2006

Figure 1 Approach to the Study




## 1.2 Methods

We conducted the literature review by searching for relevant documents in both the peer-reviewed scientific literature and the wider research and innovation policy literature

- Using Scholar Google and Google to search for publications via combinations of keywords involving 'institute', 'research institute' and 'public' together with a range of other terms
- Cross-checking the indices of *Research Policy*, *Research Evaluation* and *Science and Public Policy* – the key journals in research and innovation policy – to identify relevant articles potentially omitted from the Google searches
- Searching web sites of institutes such as Joanneum Research, VTT Technology Studies and TNO, known to have an interest in studying research institutes
- Referring to earlier literature reviews in the area by MioIR, NIFUSTEP and Technopolis and, where relevant, revisiting publications collected for those reviews
- Reviewing contributions to conferences and other activities of the European Association of Research and Technology Organisations (EARTO)
- Reviewing team members' publications in the area

We inspected a number of publications, notably evaluations of individual institutes, and rejected them as not offering generic insights that go beyond the individual institute. These were excluded from the review. We then systematically reviewed the remaining publications identified, looking for discussions of change drivers for institutes.

Based on the literature review, we proposed to the Commission that we select two fields for deeper study, within each of three types of research institute.

- Scientific research institutes
  - Nuclear physics
  - Civil Space
- Government laboratories
  - Transport (road and rail)
  - Metrology
- Research and Technology Organisations (RTOs)
  - ICT hardware, especially microelectronics

- Large RTOs, primarily belonging to the EUROTECH group (which groups the largest EARTO members)

While by no means the only possible cases, this selection provided not only a balance of examples across the three types of institute but also allowed exploration of certain policy-critical areas in Europe, areas of competitive importance and a mix of fields, some of which have already begun to be structured by European policy and others of which have been little affected so far. After discussion and in order to fit with the priorities of the Commission, we revised this list to

- Scientific research institutes
  - Space
  - Plant science (which also has government laboratory functions)
- Government laboratories
  - Marine
  - Geology/Earth sciences (geosurveys)
  - Metrology
- RTOs
  - Selected members of the EUROTECH sub-group of EARTO

For each field, we used a combination of existing databases (notably the EUROLABS database) plus Internet searches to assemble 'long-lists' of European institutes (reproduced in the Appendices to this report). We approached these with a request for current and historical data about turnover, employment, funding, publications, international activities including the Framework Programme and views about the drivers of change in the shape and performance of the field over the past twenty years.

From these long lists, we then selected about ten institutes per field for interview and closer study. In choosing these institutes we aimed to cover a diversity of scale[4] and a good spread across old and new members of the EU (plus Norway). We interviewed representatives of these short-list institutes (see Appendix for a full list and the checklist and data collection grid used in the survey and interviews).

Based on the interviews and data collected, we wrote an account of each of the six fields, aiming to identify change drivers and to describe patterns of change in the past twenty years or so, as a basis for subsequently running foresight workshops for each field. Based on these accounts, we set out three scenarios – one positive, one negative and one involving disruptive transformation – for the future development of the research institute sector as a whole and used the materials we had gathered to work out what these were likely to mean for each of the fields. The accounts were sent back to those interviewed for comments, which have as far as possible been incorporated into our account.

The foresight exercise was held on 9 February 2010, in Brussels. Invited experts from each of the fields were first briefed all together about the process for the seminar then split up into six groups: one per field. We used an exploratory approach, asking "what if" questions about the future, based upon the identification of sets of drivers of change, each group being facilitated by one of the project team. We attempted to develop 3 scenarios for each group, being based on "better than present", "worse than present" and "transforming". This enabled the experts to consider different drivers, trends and counter-trends and how they might unfold and interact. Using more than one scenario also helps to develop robust policy and strategy conclusions across different paths of development[5].

4 Except in the case of the Large RTOs, where the intention was precisely to focus on the bigger organisations

5 This section is based upon a longer account of scenario methods, found in Miles, Ian "Scenario Planning" Theoretical Paper for UNIDO Workshop, 9-12 October 2006, Prague, Technology Foresight for Practitioners – A Specialised Course on Scenario Building.

The workshop format brought together senior managers and directors of public research institutes in the six sectors. The experts had all taken part in the first part of the project through interviews, which focused upon trends and changes in their sector of public research. They had in advance of the workshop the initial scoping paper for their sector. The restricted time available meant that most of the discussions were focused upon the drivers and the scenarios arrived at varied in how far they had taken shape.

Figure 2 Structure of the Scenario Workshop Day

| Activity | Notes |
|---|---|
| **Welcome and Instructions** | In plenary |
| **Session on Drivers** | In six groups, discussion seeded by drivers identified in the scoping report. Identify further drivers. Selection of top five drivers by voting or consensus, including degree of certainty of effects on the research institute system in the sector. |
| **Session on Features** | In six groups, starting with features in scoping report, brainstorming and voting or consensus on which features best characterise each scenario – alpha + (better), beta (worse) and delta (transforming) |
| **Groups present drivers and features/scenarios** | In plenary |
| **Session on Actions** | In plenary using carousel, experts visiting flip charts to record actions for policy makers (national, EC and research institutes) |
| **Wrap Up** | In plenary |

The first session of the workshop discussed "drivers" – factors that are liable to shape the future of public research institutes. The six break-out groups (geological surveys, plant science, civil space science and technology, marine science, metrology and large research institutes) were each provided with a list of drivers provided by the project team, and invited to comment on or revise these, and to add further domain-specific drivers. The STEEPV[6] framework was suggested as a possible guide for thinking about drivers that might have been neglected. The groups then proceeded to identify the most important drivers influencing their domains. The features session focused upon ways and dimensions in which the research institute s within each sector might change or stay the same when the drivers we have identified act upon them. We suggested a list of features in advance and displayed these, but some of the groups chose their own features as being more relevant. We discussed these in relation to the three scenario types, ie what would the features of the research institutes in the sector look like in the alpha-plus, beta and delta scenarios

- **Alpha**: a trajectory in which the research institute system evolves in ways which are better than present
- **Beta**: a trajectory in which the research institute system evolves in ways which are worse than present
- **Delta**: a trajectory in which the research institute system evolves in ways, which are extremely different to the present[7]

Groups undertook this task in slightly different ways: some began by brainstorming possible developments and then classifying them, while other sought to find an Alpha-plus, Beta and Delta change to characterise each dimensions. While the workshop was not able to develop detailed analysis of the three scenarios that relate to these

[6] STEEPV refers to the domains of science, technology, economy, environment, policy and values, where experts are promted to consider changes in each domain and whether these are relevant drivers.

[7] These are subtly different from the alpha-beta-delta scenarios briefly outlined in the background reports; alpha + (better than) was chosen over alpha (business as usual) as it proves useful to prompt thinking beyond the "business as usual" trajectory.

trajectories, the classification of possible changes into these three groups provides a good starting point for developing coherent and consistent scenarios around this framework.

Each group selected the most important possible changes confronting their domains. The six break-out groups presented their feedback to a plenary meeting, and following a brief discussion the workshop moved to consider the policy and strategy actions.

A “carousel” method was used here: participants joined with other members of their break-out groups, but instead of retiring to a different room to debate issues, they proceeded around a number of “stations” in the large meeting room. The workshop participants have offered comments on the draft sector workshop write-ups. Reinforcing an earlier point, the groups were all highly productive in terms of exchange of views and debate, but not all groups arrived at consensus and scenarios. This is normal in this type of event, but leads to varying types of result across the six groups.

## 1.3 Structure of the report

This document brings these elements together and aims to draw policy conclusions. In Chapter 2, we summarise our backwards facing work on the past and present of the institutes. In Chapter 3, we bring together the past- and future-based scenarios for the six institute fields. In Chapter 5 we discuss potential future roles of the institutes in the ERA and the policy measures that could be used to improve the effectiveness of the institutes as implementers of the ERA vision.

Reported separately in the Appendix are

- The literature review
- Selection and execution of case studies of six fields in which institutes are important, looking backwards to try to learn from history what the drivers of change have been and what they tell us for the future development of the sectors
- The foresight exercise, involving representatives from the six fields, aiming to exploit their expertise and knowledge to think more explicitly about the future

## 1.4 Limitations

Like all studies, this ones has limitations

- Limited resources meant that would could not explore all sectors in the depth to which we would have liked
- The lack of official statistics for the research institute sector makes it impossible to get a good overview of it or its components, especially as most institutes are understandably reluctant to assemble statistics for studies such as this one
- The field coverage chosen means the study explores less than would be desirable in the scientific research institute and RTO sectors. This should be examined further in future work
- The scope and timing of the foresight exercise was limited by the availability of experts from the six fields and their ability to devote time to an external exercise for which they were not being paid

## 1.5 Disclaimer and acknowledgements

We have attempted wherever possible to check our data and interpretations back with those interviewed and others in the relevant fields. Inevitably, there is not universal agreement on everything. The interpretations made by the authors in this report and the associated appendices (separate volume) are our own. It should not be assumed that the European Commission, our interviewees, the institutes that are the subject of the study or anyone else necessarily agrees with us.

We are immensely grateful to all the people who devoted time and effort to the project during our 'fieldwork' and especially to our project officers at the European Commission – Marie-Christine Brichard and Julia de Clerck-Sachsse – for their support and guidance.

# 2. The Research Institute Sector

Research institutes, variously defined, account for almost half of Europe's public expenditure on R&D, yet they are in many respects almost invisible. There are no systematic statistics about them. What they do is to a large extent undocumented. RTOs have been systematically ignored in ERA development and discussions, despite their key nodal role in the Framework Programmes[8]. A recent review of reforms in the public research base across the EU confirms that very little reform has taken place in the institute sector, except for changes to bring former Soviet-style academies into line with EU practice[9]. Unlike the universities, the institutes are barely present in discussions of research policy, especially at the European level. There is a small 'grey' literature about them but very little in the 'white', peer-reviewed literature. As Crow and Bozeman remark[10] they are "the neglected stepchild of public policy."

Europe-wide, research spending through institutes is slowly declining, while that through universities has been rising. There is a small number of very large institutes in Europe but most of the sector is nationally organised so that individual institutes are typically small. The proportion of income the institutes get from markets and from abroad has slowly been rising and they are increasingly cooperating with the universities, though the tasks that institutes and universities undertake are typically very different from each other.

There are broadly three kinds of research institutes

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After discussion and in order to fit with the priorities of the Commission, we did case studies of the Space and Plant Science sector in the category 'scientific research institutes', government laboratories in Marine, Geology/Earth Sciences (Geosurveys) and a group of the largest RTOs.

The general literature suggests that changes in the institute sector are driven primarily by: technological convergence; increasing university links; globalisation; commercialisation and a long run increase in the importance of markets; organisation and scale; and (not least) by policy. Our case studies suggested that other important drivers of change include: duplication of facilities and activity; in most areas a shift towards more applied research; and the emergence of new societal challenges such as climate change, food supply and safety that needed to be addressed in part through research and innovation.

This Chapter sets out some background on the research institute sector and, describes the roles they play in the innovation system as well as why the state funds them, then summarises the change drivers evident from our six sector case studies.

## 2.1 Research Institutes in the European Innovation System

Developments over the past three decades confirm this picture of the institutes as the neglected stepchild. The research institute sector is at once large and poorly mapped. Unlike the Universities, for example, it does not have its own category in the OECD

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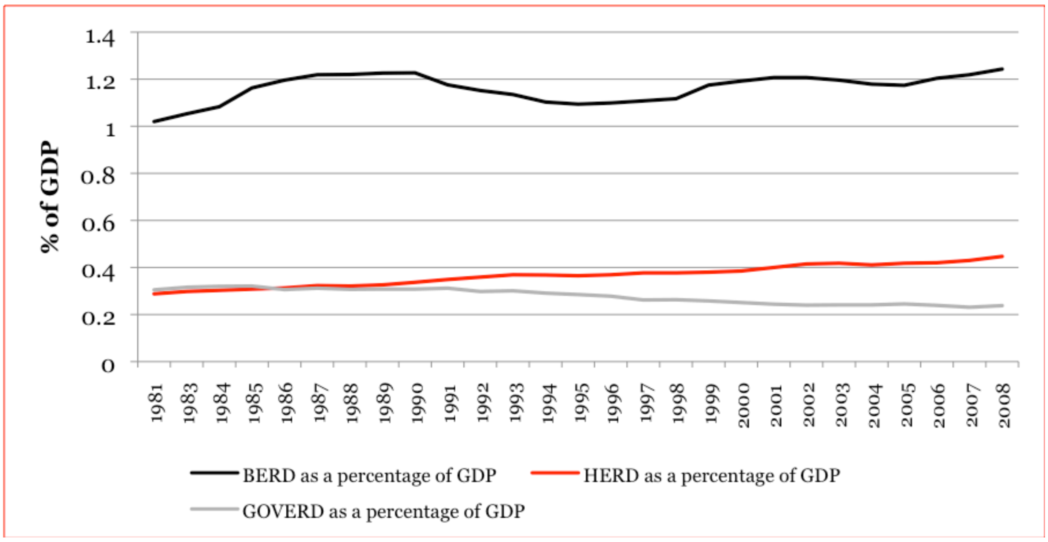
[8] European Research Advisory Board, *Research and Technology Organisations (RTOs) and ERA*, December 2005

[9] Paul Simmonds, *Activities of the EU Member States with Respect to the Reform of the Public Research Base*, Report of the ERAWTCH ASBL, Brussels: European Commission, ERAWATCH service, 2008

[10] Michael Crow and Barry Bozeman, *Limited by Design: R&D Laboratories in the US National Innovation System*, New York: Columbia University Press, 1998

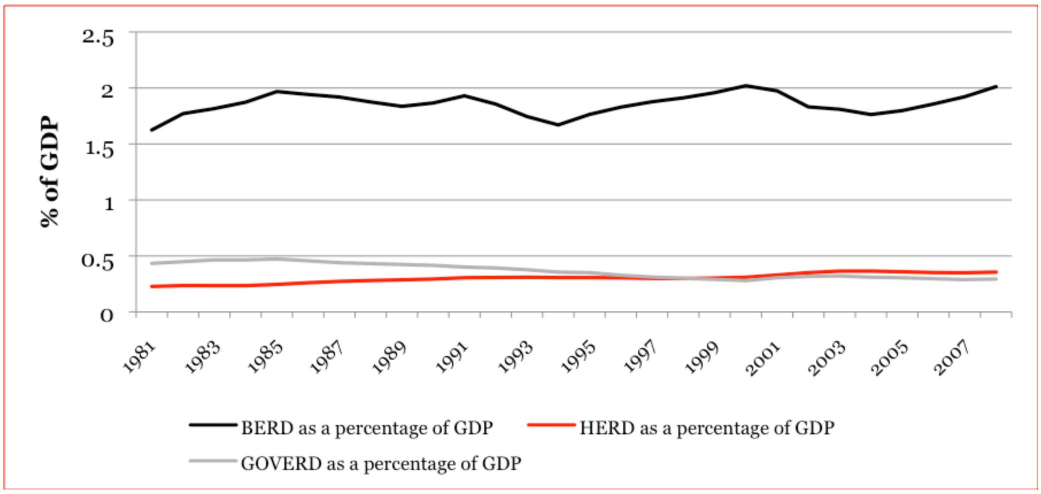
R&D statistics.  The closest statistical proxy for the sector is the OECD's Government Expenditure on R&D (GOVERD) measure.

Figure 3 Trends in EU-15 R&D Expenditures



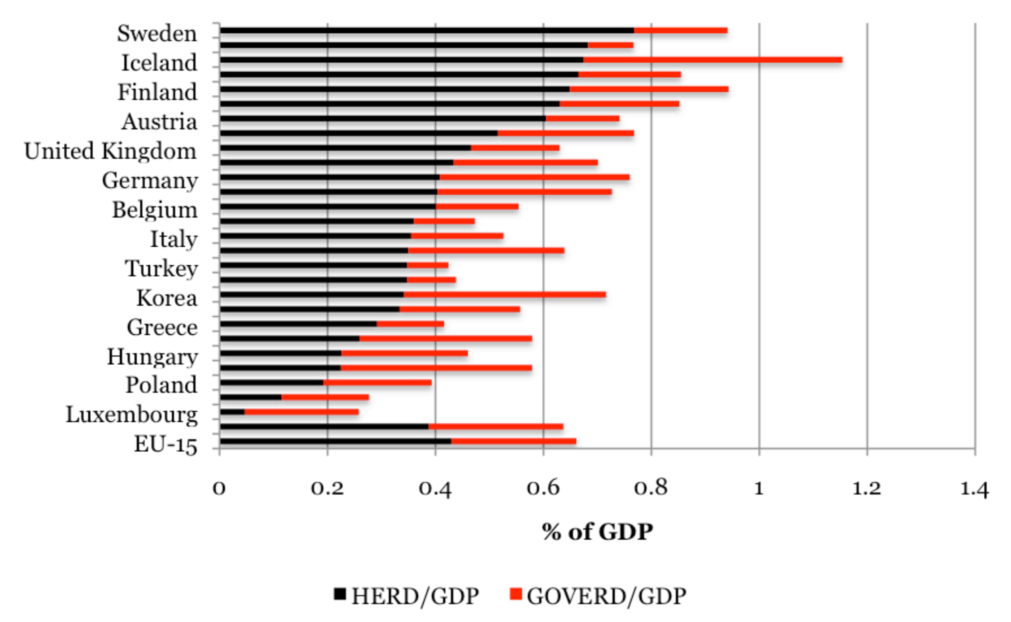

At the start of the 1980s, Europe spent similar proportions of GDP on public R&D done by the universities (HERD) and GOVERD.  There is an OECD-wide trend for the share of GDP devoted to HERD to increase and that represented by GOVERD to fall – and this shift is taking place more quickly in Europe than the USA (Figure 3, Figure 4). It may be that some of the decline in GOVERD represents Europe taking a post-Cold War peace dividend by reducing its efforts in defence research.  However, the wider meaning of this is that, while the character of state R&D overall is becoming more scientific, the US effort continues to focus to a greater extent than the European one on mission-orientated research.

Figure 4 Trends in US R&D Expenditures




However, the division of labour between the universities and the institutes is far from uniform.  Figure 5 shows the very different positions taken by different countries.

Figure 5 Shares of GDP Devoted to HERD and GOVERD (2007)




HERD = Higher Education Expenditure on R&D. GOVERD = other GOVernment Expenditure on R&D
**Source:** OECD, Main Science and Technology Indicators

While the number of EU research institutes is large, employment is fairly concentrated to a modest number of major organisations. Figure 6 shows (on the vertical axis) the cumulated number of employees in the 754 institutes whose details are in the EUROLABS[11] database plotted against the number of institutes ranked by size. Some 50% of employment is within the 28 largest institutes while two thirds of the employment is contained within the 77 largest institutes.[12] This concentration is one reason why we were keen in this study to capture some of the largest RTOs that employ a significant proportion of the people in the sector. EUROLABS focused on the larger institutes, so it is clear that – despite the degree of concentration – in practice there is a very long 'tail' of small organisations in the European institute sector.

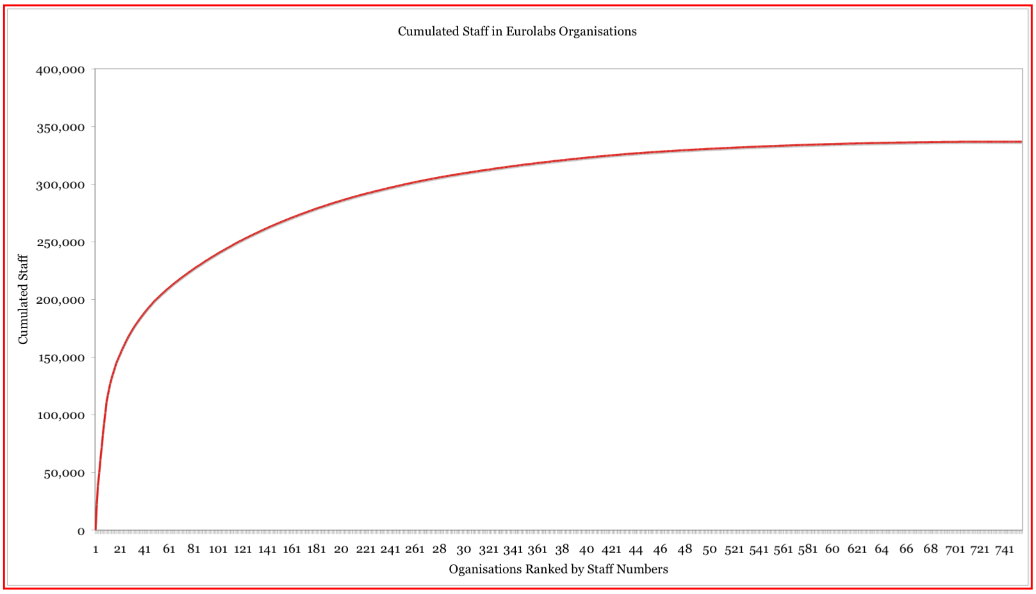
The largest institutes in the EUROLABS database the large, multi-institute German organisations (Hemlholtz, Max Planck, Fraunhofer), research councils with their own institutes (CSIC, ENEA) and a handful of large government labs in France, the UK and Germany in defence, energy, health and agriculture. The French space institute (which in 2008 had 2376 people) and the German aerospace organisation (currently 6450) are on the list. Beyond them and Fraunhofer, there are no institutes in the sectors covered in this study among the very largest European institutes. The government labs and institutes we cover are therefore very much smaller than their US equivalents such as NIST in standards and metrology (currently 2900 people), the US Geological Survey with about 10,000 staff or NASA with some 18,000[13].

[11] PREST, *A Comparative Analysis of Public, Semi-Public and Recently Privatised Research Centres*, Manchester University: PREST, 2002

[12] In fact, EUROLABS does not treat Max Planck, TNO or VTT as single organisations. There have been important mergers since the EUROLABS data were collected, such as those creating Tecnalia and AIT. Hence EUROLABS tends to understate the degree of concentration in the institute sector.

[13] Source: respective websites, accessed July 2010

Figure 6 Employment Pareto for Institutes in the EUROLABS Database




The lack of official statistics about research institutes is an important problem. In a significant sense, they do not and will not exist as 'objects' for policy (especially European policy) unless and until there are official statistics[14]. Voluntaristic attempts to map or describe the institutes provide only very partial views of the sector. Even among the six fields on which we focused, organisations' willingness and ability to provide data were very varied – too varied to enable a consistent treatment. That said, the spotty data that it proved possible to obtain suggest

- There is not much growth in the sector. Where institutes grow it tends to be through mergers rather than via organic growth
- There is a movement in the way states fund institutes to increase the proportion of competitive funding and reduce the automatic 'core' funding – as well as to make increasing demands (in terms of performance indicators) in relation to the use of core funds
- The institutes are publishing more in peer-reviewed journals than in the past. Increasingly they co-publish with others, especially universities
- The share of income that institutes obtain from abroad is rising. One element of this is Framework Programme participation, but the proportion of income from the private sector abroad is also going up. In practice, however, national R&D funding remains national, so there is little evidence yet of the emergence of the common market in research and related services that forms part of the ERA vision

Almost every EU country has a research institute presence in each of the six fields explored here. Coverage is quite complete in government laboratory fields, because these address the production of public goods needed by the state. In contrast, national involvement in space technology is clearly optional, so not all countries are involved. In the RTO area, we focus only on the largest, so our list is incomplete by definition. However, all EU-15 countries except Ireland have RTO systems. Newer member states have a variety of arrangements, in many cases driven by a choice between maintaining an extra-university research sector in the control of a national academy of sciences or merging the academy institutes into the universities. The issues raised in this report

[14] For a wider discussion of how statistics generate or enable the creation of policy constructs, see Benoît Godin, Measuring Science: Is there basic research without statistics? Project on the History and Sociology of S&T Statistics Working Paper No. 2, 2000

are therefore of general interest and conclusions emerging at the end of the project will be of interest across the European Union and beyond.

## 2.2 What Research Institutes Do

The terminology of institutes varies among languages and institutional traditions. Our definition is well captured in the German language as 'extra-university research institutes' – we explicitly exclude university departments or faculties, even if these are in some systems described as 'institutes'. Many institutes (in our sense) are located on university campuses – some are even owned by universities – but they stand outside the normal organisation of the university and their staffs are not normally regarded as academic 'citizens'.

The other defining characteristic of research institutes is that they are at least in part state-financed in order to provide social returns by addressing market and systemic failures. In other words, they perform tasks that cannot be achieved by markets.

Laredo and Mustar argue[15] that institutes are traditionally assumed to be doing applied research, generally based on a 'linear model' idea that basic research is the job of the universities and that institutes exist to translate the wisdom of the scientists to a grateful industry, which should put them to use. They contradict this idea, arguing that this three-way division of labour was never accurate and that aspects of the research roles of all three actors are converging.

One reason that institutes are not well discussed is that 'research institute' is something of a 'bucket' category that contains many, heterogeneous things. At the cost of some simplification (since some multidivisional institutes can inhabit more than one category) we have defined three categories of institute.

- Scientific research institutes
- Government laboratories
- Research and Technology Organisations

Historically, some **scientific research institutes** have their origins in Research Councils or Academies of Science, which were simultaneously research-funding and research-performing organisations. Such institutes tend to do fundamental or applied science and to have a very high proportion of core funding in their income. In many parts of Western Europe, the funding and performing functions of Research Councils have been separated some decades ago. In France, a decision was finally taken in 2009 to separate the funding function of CNRS from research performance, transferring most of the responsibility for managing what will become ten thematic institutes to universities[16]. In the former Soviet bloc, Academies of Science tended still to control their own institutes up to the end of the 1980s. Since then, some of these countries have separated out the institutes as independent organisations or transferred them to universities; in others, the Academies continue the old Soviet, integrated model.

Scientific research institutes, such as the Max Planck institutes in Germany, CNRS in France or the institutes of the national academies of science in various of the new member states, largely do the same kind of research as universities and correspondingly get a high proportion of their income in the form of block grants.

A second category of research institutes – often but not always referred to as '**government laboratories**' – focuses on producing public goods to meet knowledge needs of the state or wider society. Sometimes referred to as 'sector' institutes, they are generally owned by the state and their main function is normally to deliver services

[15] Philippe Laredo and Philippe Mustar, 'Public sector research: A growing role in innovation systems,' *Minerva*, 42, 2004, 11-27

[16] *Research Europe*, 9 July, 2009

and policy-relevant information to government. Examples include nuclear research, marine institutes (which mix counting fish stocks with more fundamental work in marine biology) and metrology. Generally, the bulk of their income comes from the ministry whose policy mission they support[17]

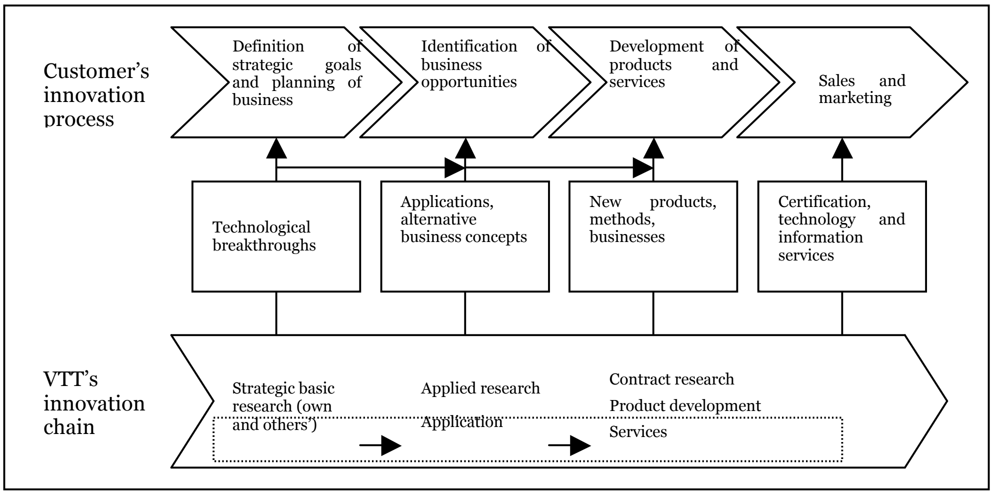
A third category of **Research and Technology Organisations** or 'applied research institutes' tackles the needs of industry for knowledge and a range of knowledge-related services. Large-scale examples include VTT Finland, the Fraunhofer Society in Germany or TNO Netherlands but there are also smaller and more specialised institutes. Their origins are often as testing laboratories, product and process developers for industry or branch-based research associations but they focus on user- or problem-orientated research for the benefit of society and normally win the greater part of their funds competitively. Typically, their role is to assume some of the risks of industrial innovation, helping companies to go beyond what they would be able to do, based on their technological capabilities.

RTOs tend to operate with an explicit or implicit innovation model that involves

1. Exploratory research and development to develop an area of capability or a technology platform
2. Further work to refine and exploit that knowledge in relatively un-standardised ways, often in collaborative projects with industry
3. More routinised exploitation of the knowledge, including via consulting

Figure 7 shows VTT's version of this model. (VTT is the main Finnish RTO.) In principle, RTO core funding is primarily intended to pay for the first, exploratory stage, where the RTO develops knowledge and capabilities needed to support its industrial customers. This is the key thing that distinguishes an RTO from a technical consultancy. The public money is used to create the capabilities the institute needs to take companies 'one step beyond' what they could otherwise do, thereby providing social returns by de-risking innovation[18].

Figure 7 VTT's Innovation Model




**Source:** VTT

[17] Paul Simmonds, *Activities of the EU Member States with Respect to the Reform of the Public Research Base*, Report of the ERAWTCH ASBL, Brussels: European Commission, ERAWATCH service, 2008

[18] Sverker Sörlin (chair), Erik Arnold (rapporteur), Birgitte Andersen, Jørgen Honoré, Pia Jørnø/ Erkki Leppävuori and Ketil Storvik, *A Step Beyond: International Evaluation of the GTS Institute System in Denmark*, Copenhagen: Forsknings- og innovationsstyrelen, 2009

## 2.3 Why Research Institutes are Publicly Funded

The idea of 'market failure' leading to under-investment in research has been the principal rationale for state funding of R&D[19] in the post-War period. It applies to all three categories of Research Institutes. Of course, governments had been funding research long before the economics profession produced a reason. Arrow is generally credited with describing the three major sources of market failure, which – from a neo-classical economic perspective – make it useful for government to fund research

- **Indivisibility**, because of the existence of minimum efficient scale
- **Inappropriability** of the profit stream from research, leading to a divergence between public and private returns on investment. This results from two essential (and economically efficient) freedoms that scientific researchers have: namely to publish and to change jobs
- **Uncertainty**, namely divergences in the riskiness of research respectively for private and public actors

Arrow's argument was particularly relevant to more 'basic' (and, by implication, generally applicable) forms of knowledge because capitalists' inability to monopolise the results of such research meant they would be least likely to invest in it. This is a key reason for the state to invest in research at scientific research institutes.

The argument for state funding of government labs is that they produce public knowledge goods for which the state is the only customer – or for which no other customers exist. These public knowledge goods may be used by the state itself, be passed on to society and the economy or both. Metrology is an example where both missions apply.

Subsidy of RTOs relies partly on the same argument: it is clear that unsubsidised technology consultants are unable to build the kind of technology platforms and capabilities as the RTOs can, and then to exploit them for the public good. The other part of the argument for subsidising RTOs is to reduce innovation risk, allowing companies to tackle innovation opportunities that would otherwise stretch them beyond their technical capabilities. In some cases this could be expected to trigger technological learning by the companies involved; in others, typically in areas like technical services, the RTOs provide access to tools and techniques that individual customers could not develop or acquire for themselves. Either way, reducing risk is expected to increase the rate of innovation and influence economic growth. In effect, RTOs allow companies to take a step beyond what their own technological capabilities would allow and this enables them to do more innovation.

## 2.4 Backwards Drivers

This study uses two sets of drivers to consider the research institutes sector. We refer to those evident in the institute literature and those derived from our sector cases as **backwards drivers** because they derive from looking back at the history of the institutes, trying to understand why they are in their current situations and what driving forces are acting upon them today. The foresight component, which we discuss in the next Chapter, looks forwards, based on the deliberations and discussion of the institute sector experts who participated in the study's foresight exercise in February 2010. We refer to the drivers they identified as **forwards drivers**. We go on to combine these backwards and forwards drivers to think about the future of the institutes and the policy requirements that this generates.

[19] Ken Arrow , 'Economic Welfare and the Allocation of Resources for Invention,' in Richard Nelson (Ed.) *The Rate and Direction of Inventive Activity*, Princeton University Press, 1962; see also Richard Nelson, 'The simple economics of basic scientific research,' *Journal of Political Economy*, 1959, vol 67, pp 297-306

### 2.4.1 Backwards Drivers Identified in the Literature

In our earlier literature review, (see Appendix) we identified a number of broad change drivers for the institute sector, discussed here.

**Convergence**. There is widespread agreement that many technologies are becoming increasingly science based, with research making an important contribution to technological progress. A second convergence trend is towards 'hyphen technologies' (micro-electronics, bio-technology, etc) that cross traditional disciplinary boundaries. More generally, it is believed that growing technological complexity means that research has an increasingly systemic character. These trends clearly have implications for institutes' thematic specialisation, driving them towards a wider range of disciplines. Major impacts are felt in the RTO sector: scientific institutes and government labs are driven respectively by their specialised missions and their state customers rather than by industrial users with a wide range of multi-disciplinary problems. They nonetheless need to cope with the changing nature of knowledge in their fields, such as the growing importance of molecular biology in life sciences and agriculture.

An important consistency among research institutes' histories is that their customers grow increasingly sophisticated over time as industrial development proceeds, as production becomes more technology-intensive and as people throughout society become more involved with knowledge production through the 'massification' of education that Gibbons et al[20] say is one of the reasons for the growth of Mode 2 knowledge production. By 'Mode 2' they mean knowledge production outside the traditional university discipline framework, driven by problems rather than theory and typically involving a range of different types of actor. The process of development therefore requires that industrially orientated RTOs increasingly move towards more demanding research, as some of their services become more commonplace and can be delivered by the private sector without subsidy.

There is a clear convergence among the RTOs on the idea that the nature of the research they could and should be doing is Mode 2. SINTEF publicly expresses this using the Gibbons et al slogan for Mode 2, "Problems solved in the context of applications". Even the institutes with roots in testing are moving this way. The institutional implication is that the old 'three-hump model' of universities doing fundamental research, institutes doing applied research and handing results over to industry to put to use no longer works – if, indeed, it ever did. It implies a need for a much closer symbiosis between institutes and universities, and therefore to the need for the kind of close university links that, for example, SINTEF and Fraunhofer employ.

**University links**. Institutes are responding to convergence by increasing their overlap with universities. This is partly done by involving PhD students in the work of the institutes, helping the institutes develop and renew capabilities. At the same time, the universities are under growing economic and policy pressure to adopt a 'third mission' of supporting society and the economy. As a result, some are trying to compete not only with the scientific institutes but also with the RTOs, in delivering services to industry[21].

Van der Meulen and Rip pointed some fifteen years ago[22] to a growing convergence between scientific research institutes and universities in a number of countries. There

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[20] Michael Gibbons, Camilla Limoges, Helga Nowotny, Schwartzman, S., Scott P. and Trow, M., *The New Production of Knowledge*, London: Sage, 1994

[21] Erik Arnold, Neil Brown, Annelie Eriksson, Tommy Jansson, Alessandro Muscio, Johannah Nählinder and Rapela Zaman, *The Role of Industrial Research Institutes in the National Innovation System*, Vinnova Analysis VA 2007:12

[22] Barend JR van der Meulen and Arie Rip, *Research Institutes in Transition*, Delft: Eburon Publishers, 1994

is a clear trend for the large, Western research councils that still own scientific research institutes (CNRS, CSTI) to work more closely with the universities. The degree to which post-Soviet scientific academies have done so (or been merged with universities) varies from country to country. Some government labs (Denmark) have actually been merged into the university sector and the operation of government labs by universities is a well-established tradition in the USA. Research institutes show a uniform trend towards having a higher share of PhDs in their staffs and closer teaching and doctoral student links with universities.

**Globalisation** is widely discussed as a change driver in the institute world, as elsewhere. It can have quite different implications among different types of institute. Scientific research institutes share scientists' more general propensity to cooperate internationally. This happens more in 'basic' than applied disciplines and in small than large countries, as well as extra-scientific reasons, such as former imperial links or mobility patterns[23]. There is clear and continuing growth in international scientific collaboration[24], although the rate of growth seems now to be tailing off, suggesting the approach of some kind of natural limit. Motivations for international cooperation in the research community visible in the literature include[25]

- Access to leading edge and complementary know how
- Combination of competences and data located in different countries to tackle issues too complex for researchers from one location
- Finding solutions for complex scientific and technical problems that could not be solved with domestic resources alone
- Cost and risk sharing, especially when large infrastructures are needed for basic science (e.g. particle accelerators) or product development (e.g. international telecommunication networks)
- Access to funds
- Recruitment
- Access to research subjects or data that are geographically specific
- Access to markets
- Influencing regulatory regimes or standards
- Improving the impact and visibility of one's research

Government labs increasingly confront task duplication, a need for specialisation, a re-division of labour and in some cases closure of duplicative facilities. For example

> *In the field of metrology, the evolution of the association of national standards laboratories from EUROMET to EURAMET and the accompanying EU programme iMERA (implementing metrology in the ERA), which coordinates research, are expected to lead to the sharing of resources under a follow on. Even now, this is happening bilaterally*

[23] J Davidson Frame and Mark P Carpenter, 'International Research Collaboration,' *Social Studies of Science*, 9 (4) 1979, 481-497

[24] Wagner, C. and L. Leydesdorff (2007) 'Globalisation in the network of science in 2005: The diffusion of international collaboration and the formation of a core group', MIMEO, av. at http://users.fmg.uva.nl/lleydesdorff/cswagner07/index.htm; Adams, J., Gurney, K. Marshall, S (2007): Patterns of international collaboration for the UK and leading partners (Summary report). A report commissioned by the UK Office of Science and Innovation. June 2007. http://image.guardian.co.uk/sys-files/Education/documents/2007/07/13/OSICollaborationSummaryRepo.pdf; Adams, J. (2008): Measuring collaboration and linking it to policy, Presentation at the Conference Drivers Conference on Drivers of International Collaboration in Research, Brussels, October 13-14

[25] Archibugi, D. and S. Iammarino (1999) 'The Policy Implications of the Globalisation of Innovation', *Research Policy* 28(3): 317-336; Beaver, S.D (2001): Reflections on scientific collaboration, (and its study): past, present, and future, *Scientometrics*, 52, pp. 365–377; Wagner, C. (2006): International Collaboration in Science and Technology: Promises and Pitfalls; in: Box, L.; Engelhard, R (ed.), *Science and Technology Policy for Development. Dialogues at the Interfaces*, London/New York/Dehli; pp. 165-176; Edler, J; Flanagan, K., McMorris, I; Cox, D.; Gaynor, L.; Mina, A; Cunningham, P. (2008): *A Study on and concept development for Ireland's International Engagement in Science, Technology and Innovation*, Dublin/Manchester

*between some of the larger laboratories. Since the same standards no longer have to be supported by research in multiple sites, joint programmes and arrangements for traceability lad to an overall freeing up of resources and thereby improve effectiveness … there is scope for measures to address structure and governance to promote development of the kind of scale that would facilitate pan-European operation.*[26]

RTOs have reasons to diversity geographically, keeping in touch with their customers, while institutes focused on fundamental research may do better by building scale at one location. In practice, globalisation moves by traditional RTOs have been limited. In the current situation, where institutes are funded by individual countries (or sub-sets of countries, like regions or branches of industry) there is little external incentive for internationalisation, even if – viewing individual institutes as if they were businesses – it would in many cases make commercial sense to do so. Indeed, this is clear from the cases of privatised RTOs like Qinetiq and PERA in the UK or IABG in Germany, whose transformation from subsidised RTOs into commercial Contract Research Organisations (CROs) has both freed and encouraged them to set up multiple offices abroad.

This situation may change in the future. Leijten argues[27] that internationalisation is becoming a key need for RTOs in the 21st Century, even if the extent to which this is to be done via institutional expansion or by networking in future is unclear. The example of IMEC shows that there can be large local benefits if an institute acquires an internationally strong position, with the institute sucking in research employment, capabilities and knowledge that benefit the local economy[28].

**Commercialisation and long run increase in the importance of markets**. Almost all institutes are in some way engaged in the '3rd task' of commercialisation, but often in ways that are rather unreflective. Over a very long period, the institutes have tended to derive a growing proportion of their income from R&D markets (competing for public as well as private work) but the extent to which this has happened varies by type of institute. Scientific institutes are only marginally affected.

As a result of the growing need to be 'businesslike' in accessing markets many institutes are trying to improve their business processes and their staff's awareness and understanding of business as well as research. This included attempts to make people 'IPR-aware' in a way they have not previously been by improving and documenting laboratory practice and more deliberately looking for commercialisation opportunities.

The debate in recent decades about the role and ownership of government laboratories means that commercialisation missions have been added to their duties in many cases. These range from spin-out through selling intellectual property, joint or contract research with large companies, transferring knowledge to small companies (for example through the widely-copied US SBIR programme) to industrial extension. This pushes government labs to become more like RTOs.

The RTOs' core business is, to a large extent, commercialisation but in a form where they commercialise **through** their customers' activities. They therefore need to tread warily in trying to take control of intellectual property or spinning off companies.

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[26] Report of the ERA Expert Group, *Challenging Europe's Research: Rationales for the European Research Area (ERA)*, EUR 23326 EN, Brussels: DG-Research, 2008

[27] Jos Leijten, 'The Future of RTOs in the European Research Area', Contribution to the DG Research expert group on the future of key actors in the European Research Area, Delft: TNO, 2005

[28] Sverker Sörlin (chair), Erik Arnold (rapporteur), Birgitte Andersen, Jørgen Honoré, Pia Jørnø/ Erkki Leppävuori and Ketil Storvik, *A Step Beyond: International Evaluation of the GTS Institute System in Denmark*, Copenhagen: Forsknings- og innovationsstyrelen, 2009

**Organisation and Scale**. Some institutes seek increased scale. RTOs increasingly believe that they need to be polytechnic in order to service wide-ranging customer needs, and to be big enough in each specialisation to be attractive to customers and be visible internationally. Scientific research institutes may need to seek scale in order to compete for increasingly international funding sources.

There has been a long-standing drive towards having larger, more polytechnic RTOs. This process began twenty years ago in Norway[29] and has in recent years seen a consolidation of much of the RTO effort into SINTEF[30]. Sweden is moving to a single system of RTOs and government labs[31]. A handful of countries have major, divisionalised applied research institutes, all of which have attempted internally to restructure over the past decade

- Austria (Austrian Institute of Technology), a conglomerate originally based on the Seibersdorf institute to which others (eg Arsenal) have been added and which is increasingly a joint owner of competence centres with universities and industry
- Finland, where VTT has internally restructured itself to focus more on technologies and less on branches of industry
- The Netherlands, where TNO has undergone a similar transformation
- Germany, where the Fraunhofer Gesellschaft's attempts to restructure have largely been defeated by the autonomy of the individual institute directors
- Sweden, where the Industry Ministry has successively encouraged mergers among the institutes and has now created a structure of four fairly large, technology-based (as opposed to the previous branch-focused) institutes
- Denmark, where the GTS institutes (they are not commonly owned but receive their block funding through the GTS umbrella organisation) have successively merged, halving the number over the past decade

The major RTOs are reducing the number of divisions or departments and tending towards matrix structures to achieve this. Some are adding interface functions – guides or gatekeepers to help potential customers find their way into the largest of the institute groups. Institute managements are generally organising formal customer satisfaction surveys. In some cases, increased central functions appeared to be reducing the agility of the institute[32].

**Policy**. The effort to generate an ERA provides an important set of change drivers. If the idea of a European Research Area is to become a reality, then research resources will need to be much more concentrated. Now that EU research policy has shifted to make increasing use of 'variable geometry' and the Commission is taking its mandate to 'structure' the ERA more seriously, EU-level incentives for cross-border restructuring may well appear. At present, national boundaries and national funding represent major sources of geographical lock-in.

To date, EU policy influence national over government labs has largely been limited to supporting the creation of EU-wide associations and enticing them into the Framework Programme.

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[29] Hans Skoie and Einar Ødegård (eds.), *De teknisk-industrielle forskningsinstitutter i 1990-årene,* Rapport 5/90, Oslo: NAVFs Utredningsinstitutt, 1990

[30] Jon Gulowsen, *Bro mellom vitenskap og teknologi: SINTEF 1950-2000*, Trondheim: Tapir Akademisk Forlag, 2000

[31] Sverker Sörlin, *En ny institutssektor: En analys av industriforskningsinstitutens villkor och framtid i ett närings- och innovationspolitiskt perspektiv,* report to the Industry Ministry, Stockholm: Royal Institute of Technology (KTH), 20 June 2006

[32] Tomas Åström, Marie-Louise Eriksson, Lars Niklassen and Erik Arnold, *International Comparison of Five Institute Systems*, Copenhagen: Forsknings- og innovationsstyrelen, 2009

The ERA Expert group claims[33] that RTOs ought to be central to the ERA but are largely locked into the national level by their funding arrangements. Cross-border income from government is negligible, so we are very far from having a common market in research services (even if in practice successful RTOs notably VTT, SINTEF, TNO, GTS and Fraunhofer now obtain a significant part of their industrial incomes from cross-border sources).

### *2.4.2 Backwards Drivers Supplemented by the Six Cases*

Figure 8 shows where these drivers turn out, based on the six case studies, to be important. It also introduces some other drivers and potential drivers emerging from the sector studies. Only in relation to the issue of duplication within Europe does any driver relate to all the sectors.

Convergence is important in plant science, where molecular biology and informatics are becoming increasingly central and in geosurveys, where there are greatly increased opportunities to use informatics, not just for modelling and simulation but also for visualisation. And of course the trend is clear in the RTOs, which are highly polytechnic.

University linkage is increasing in almost all sectors. It is less important in space, however, where many countries took an institutional decision some years ago that space should be handled in specialised institutes and not in universities[34].

While globalisation is crucial to the RTOs, because their customers are globalising, it is less so in the other sectors, which have strong ties to the national level. Space cooperation has started to move from the European to the global level and the marine institutes are tied into ICES. The pattern in geosurveys is very variable. Former imperial country institutes tended to work internationally – not just in former colonies but also more widely in developing countries, usually with aid agency or World Bank funding. However, in these post-imperial times, the motivator is money rather than empire. The institutes that, under increasing pressure on government budgets and with national policy pressure to be 'relevant', are most reliant on external income are also those that seek international work. But this work is largely extra-European. The European institutes increasingly cooperate in building databases but do not step into each other's national territories.

More commercial activity by the geosurveys – ranging from providing minerals mapping services to companies down to small-scale surveys and data for households – is reflected in their increasingly applied activities. Geosurveys are in the unique position that once the basic surveys are done they are done and the institutions must necessarily find ways to apply the basic survey data. Commercial uses of space are growing, and there was a limited increase in the commercial activities of the plant science institutes. (We do not show an increase in commercialisation activity for the RTOs because, while they have a lot of commercially orientated activity, there does not seem to be a trend towards increasing it as a proportion of what they do.)

The driver towards scale we identified in the literature applies, in practice, only to the RTOs and is itself driven by the desire to be polytechnic. The more government-orientated institutes have grown to an appropriate size and – as long as they focus on the national space – have little incentive to grow further. This stability could, however, disappear if EU-level incentives appear. Already, the steps being taken towards ERA affect the majority of the sectors. In the space sector, this continues a long cooperation tradition. In metrology, there is increased division of labour

[33] Report of the ERA Expert Group, *Challenging Europe's Research: Rationales for the European Research Area (ERA)*, EUR 23326 EN, Brussels: DG-Research, 2008

[34] As ever there are exceptions. For example, in the UK Guildford University has a respected space group that, amongst other things, builds satellites

organised at the European level and the marine institutes are forced to confront the Common Fisheries Policy. RTOs have benefited strongly from the Framework. On the other hand, the problems tackled by the plant scientists and geosurveyors are so far sufficiently local in character that they can avoid pressures to readjust to the European level.

Figure 8 How Drivers Affect Institute Sectors

| | Space | Plant Science | Geo-surveys | Metro-logy | Marine | RTOs |
|---|---|---|---|---|---|---|
| **Convergence** | | X | X | | | X |
| **Increasing university links, up-skilling** | | X | X | X | X | X |
| **Globalisation** | X | | (varies) | | X | X |
| **Commercialisation, increasing role of markets** | X | (X) | X | | | |
| **Reorganisation** | | | X | X | X | X |
| **Increasing scale of institutes** | | | | | | X |
| **Affected by ERA policy drivers** | X | | | X | X | X |
| **Growing economic importance of the domain** | X | X | X | X | X | |
| **Shift from basic to more applied work** | X | | X | X | | |
| **National prestige** | X | | | | | |
| **New entrants in New Member States** | X | | X | X | | |
| **Climate change affects the research agenda** | X | X | X | | X | X |
| **Food production and safety affects agenda** | X | X | | | X | X |
| **Duplication of effort** | X | (X) | (X) | X | X | X |
| **Rationalisation opportunities** | X | | (X) | X | X | X |
| **Memo: European organisation** | ESA | EuropaBio | Eurogeo-surveys | EURAMET | EFARO, ESF | EUROTECH, EARTO |

**Note**: X = driver (X) = weak driver

As regards drivers **not** anticipated in our literature review, there is a movement towards applications discernible across three of the sectors. National prestige is a major determinant of behaviour in civil space, causing entry. Modernisation of New Member States is also leading to the creation or renewal of research institutions. Climate change and the (related) problems of food production and safety are affecting the research agenda and in some cases opening new opportunities. Eco-innovation is an example of such new opportunities. In the event of a more European approach being taken to some of the 'grad challenges' currently under discussion in European R&D policy debates, the research institutes could play a bigger part under some sort of European coordination.

The cases suggest that – even in plant science and geosurveys, where there is probably the least subject overlap among national players – there are opportunities to reduce duplication and fragmentation and to foster a division of labour that promotes critical mass and deepens institutes' specialist capabilities.

# 3. The Past and Future of Research Institutes in Six Fields

In this Chapter we first introduce the scenarios we use to structure thinking about the potential effects of the drivers identified both in the backwards-looking work and in the foresight seminars for each sector. We then summarise trends and developments in each field based on the full-length case studies (which are at be found in the Appendix to this report) and use both backwards and forwards looking drivers to set out scenarios for each field. The backwards drivers come from the literature review and case studies and are reported in Chapter 2, while the forwards-looking drivers emerged from the foresight workshops. We go on to present conclusions in Chapter 4 and to discuss potential policy implications in the final Chapter of the report.

## 3.1 Use of Scenarios

In order to structure the thinking in both the historical and the foresight aspects of this project, we constructed three **generic** scenarios, intended to provide a framework for the foresight exercise. The foresight workshops then produced more **specific** variants of these scenarios for the six fields considered.

At the overall, generic level, the scenarios were as follows

- An Alpha or 'alpha plus' scenario, intended to represent 'business as usual' in the sense that existing trajectories (eg gradually increasing European networking but also stagnation of funding at the overall level) would continue their course, within an overall pattern of improvement in the sector
- A Beta scenario, in which the financial crisis triggers significant cuts to the research institute sector
- A Delta or 'transforming' scenario, in which there is a significant step forward at the European level in progress towards the ERA

**Alpha Scenario – 'Business as Usual / Improvement'**

Under this scenario, there is continued diversity in the public research institutes, with some continued although not significant organisational change, such as quasi or full privatisation, some amalgamations with universities. The more fundamental science research institutes continue to have a European presence and some influence on European research policy, and they continue to collaborate with similar research institutions in other European countries and around the world. In some areas there is more joint programming on a variable geometry basis. The institutions in the newer member states remain less well resourced but take part in European networking and collaboration where possible. Links with universities and industry remain in place and in some areas increase. Stronger research institutes keep augmenting their international links and collaborations (beyond Europe). Support for industrial R&D remains uneven in Europe and there is little building up of capacity where it is weak. Reactions to societal and policy needs remain rooted in national-level institutes but there is in addition some measure of coordination. The sector remains in a steady state and the European research institute sector as a whole remains rather fragmented with unnecessary duplication.

**Beta Scenario – Negative**

In this scenario, many research institutes do not survive the downturn in public expenditure. They are either absorbed into teaching institutions (universities) or they are privatised. The institutes that become part of universities transform their research, as it needs to become more driven by scientific excellence and teaching needs. The volume and quality of research diminishes, as researchers are required to take on teaching commitments. Some research in support of policy remains due to continued government funding, and some industrial contract research remains, although at a lower level. The European networks are weakened as national or regional settings dominate.

The privatised institutes are forced to rationalise and take their research to very applied and needs oriented work, providing technical services and training. Many disappear, and the successful ones become much more internationalised, competing for work in a global market. Governments need to contract with either universities or private institutions to gain the necessary science and technology for policymaking and regulation. A "European" voice on such matters comes from those surviving and dominant institutions.

**Delta Scenario – Transforming**

Here, each type of public sector research institute becomes closely networked in coordinated research and joint programming. Mobility of researchers increases between them. Attention is paid to linkages with universities and industry and the networks are expanded. At a European level, there is attention to capacity building across the member states, but with reductions in duplication and increases in concentrations of specialisations. A virtuous circle is established of increasing intra-European trade in knowledge services and specialisation. New incentives are offered to the research institute system at the European Level. European research has a clearer identity to those outside Europe, and the networked organisations offer more critical mass and improved infrastructures for researchers. This improves the attractiveness of Europe to younger researchers. There are some mergers of national institute systems in terms of funding and organisation.

Not all the foresight groups were able to engage fully with the scenarios. (Workshop reports may be found in the Appendix to this volume.) We have therefore in some cases constructed scenarios based on their analyses of drivers and other comments during the foresight exercise.

## 3.2 Civil Space

### *3.2.1 Context*

European cooperation in space research is already in what may be thought of as a 'late' stage. The massive costs of launchers and platforms led to European cooperation already in 1964, with the creation of the European Launcher Development Organisation (ELDO), a precursor of the European Space Agency (ESA). The large risks associated with space R&D, coupled to a (probably declining) extent to which the specificity of science and engineering problems to the space environment, appear to have encouraged the focus on research institutes, with their potential for tight management and quality control, rather than other kinds of institutions in this sector.

Today, about 20 European countries have institutes active in civil space R&D, whose mission is to build instruments and observe, collect and analyse data from space. The way they approach this mission is somewhat dependent on their organisation and activities, but in general they undertake the same basic functions. The size and budget of each public research institute is dependent on history. Some countries (eg France, Germany and Sweden) have made space a national priority and prioritised space research to a greater extent and for a longer period than others.

The main elements characterising civil space studies are, as follows

- The **cost**, which is a strong driver to high level cooperation in a generic set of technologies
- The strong importance of **national prestige** in space research (influenced by the "space race" and the idea of the new frontier since the 60's)
- The **mission-orientated nature** of the research, leading to high level competition between research teams at international scale
- The high-level and **cutting-edge technologies** developed through space research
- The **long-term vision** needed in space research, given the long time required to develop instruments and to obtain data from instruments sent into space

- Last but not least, contrary to other research domains investigated in this public research institutes' analysis, civil space is **traditionally organised towards the institute sector** rather than universities.

This separation has probably been further encouraged by overlaps between civil and military space research and applications. Although our study deals with civilian applications of space research, civil and military space programmes are strongly interlinked.

*3.2.2 Trends*

Over the past 20 years European civil space research has grown, both in terms of activities conducted and budget, not least by drawing in new member states and smaller institutes. This has led to changes in organisation as well as in sources of income. Core funding is decreasing, whereas competitive funding (and to some extent third party income) is increasing.

Research priorities have in recent years to some degree shifted from basic research towards applied research and commercial applications. In particular, the European cooperation has moved on from launchers and platforms to large-scale applications such as Galileo (satellite position finding and navigation) and GMES (earth observation from space). Thus, space research applications increasingly concern sectors such as environment and telecommunications. There has therefore been a move away from "traditional" space activities inspired by national prestige (which was dominant during the so-called "space race"), towards more applied, competitive, research to tackle specific needs inspired by social demand. In parallel, however, there is continuing use of space for science, such as astronomy.

Civil space has not faced privatisation, although some institutes have become more independent from public decision-makers. The costs of space research and the long-term expected impacts could generally not be tackled by private organisations. Nowadays, the coordination of research teams within the institute is seen in some research institutes as an important challenge, which is mainly due to the expansion of institutes' activities.

Over the past 20 years, key drivers behind the changes experienced in the civil space sector are linked with internationalisation and Europeanisation. The needs for cooperation increase, along with the increasing complexity of the projects conducted and the missions involved. Politics and national prestige were among the main drivers of change in some countries (such as Austria), where national space programme were more recently launched.

Civil space research is increasingly based on global as well as European cooperation, due to the high cost and high-level competencies involved. In recent years, integration at European level has been strengthened, both on a bilateral (between countries) and multilateral (ESA and European space policy) basis. Some New Member States have joined ESA. New actors have also emerged on the global scene, such as China, Japan and India. International multi-author publications have also increased strongly, due to the increase of international missions and collaborators.

Given the internationally coordinated nature of space missions, specific duplication of work is minimal across Europe. The duplication that exists (dual sourcing) is seen as a way both to ensure reliable supply and to foster competition and excellence. Civil space research is organised through missions and competition between research teams at international level.

The future of Civil space research would appear to be moving towards increasing cooperation at European and global level. Space missions therefore involve more and more partners. New member states, namely the current cooperating states - Poland, Hungary and Romania - would join the ESA and other states such as Malta would cooperate further with the Agency. European space policy, and perhaps the European defence policy, would also act as key drivers of future changes.

Constraints to further cooperation and integration concern the survival of national prestige within space studies, the question of the governance for space policy at European level, as well as the national boundaries due to the difficulties to compete at international level and to contract with third parties (such as industrials), given the nature of space public research institutes, often integrated within national academy of sciences or under the umbrella of the government.

### *3.2.3 Backwards and Forwards Drivers*

Figure 9 summarises the drivers for civil space, identified in our case studies (see Appendix) and in the foresight exercise. The field has been dogged by a particular combination of high cost, which is an argument for international cooperation, and the role of space in maintaining national prestige. One traditional aspect of collaboration has been to pursue curiosity-driven scientific research. Both commercial opportunities and the growing opportunities to use space research in problem-driven research (climate, food) are shifting the emphasis towards more applied work – mostly in areas where collaboration is desirable. Increasing costs combined with resource limitations (especially following the recent financial crisis) mean that cooperation is increasingly necessary if space research is to continue. Economic pressures therefore point the same way as wider policy pressures: towards a further intensification of cooperation and the extension of European to global collaboration.

Figure 9 Civil Space: Backwards and Forwards Drivers

| Backwards Drivers | Forwards Drivers |
|---|---|
| Globalisation<br>Commercialisation, increasing role of markets<br>ERA Policy<br>Growing economic importance of the domain<br>Shift from basic to applied work<br>National prestige<br>New entrants in New Member States<br>Climate change research agenda<br>Food production and safety research agenda<br>Duplication of effort<br>Rationalisation opportunities | National space policies – national priorities<br>Innovation and industrial policy<br>Shift from blue sky to applied research<br>Europeanisation of space policy |

### *3.2.4 Scenarios and Policy Implications*

The Figures in this Section show how these drivers work out across the three scenarios. Alpha is inclusive, enabling EU institutes not only to satisfy national and European needs but also to play a larger role at the global level – something that will be necessary as the costs of some kinds of space research and exploration increase and as there is increasing need to enrol pace research into the process of tackling 'grand challenges'. The Beta scenario leads to retrenchment, fragmentation and the loss of knowledge, with the established major players surviving and reinforcing their positions at the cost of the wider use of space. Delta shifts the policy initiative to the EU and places the European level more firmly in the centre of implementing space policy and research, allowing a greater optimisation of resources and the strongest global position for Europe.

The participants in the foresight workshop felt overall that Alpha was the most likely scenario.

Figure 10 Civil Space Backwards and Forwards Scenarios: Alpha

| **Backwards Scenario - Alpha** | **Forwards Scenario – Alpha** |
|---|---|
| National funding dedicated to research and innovation remains flat but does not shrink, despite the economic crisis and budget downturn. In some less-advanced countries in the space domain (particularly new member state), no dedicated space policy programme is developed. Core funding continues to fall, increasing the need for contract work to offset the shortfall in budget. Institutions in the newer member states remain less well resourced but take part in ESA and collaboration where possible (with the eventual aim of joining ESA). Institutes innovate new commercial applications in order to find additional sources of income. Environmental work continues to increase in importance across Europe – under European programme pressure (GMES). The historical pattern of European and increasingly global cooperation continues. Research is increasingly mission-based and a growing share of resources comes from competitive funding. Projects within ESA continue. And there is still a moderate level of EU project participation. National prestige remains an important driver of civil space research. | The existence of new actors (ministries) enhances funding and research conditions. There is some consolidation among the funders but the number and size of research institutes are not affected. The work of the institutes become more interdisciplinary and increasingly tackles global issues. ESA evolves to have a stronger position as the 'European NASA' while attracting an increasing volume of private funds, in addition to income from the state. The image and attractiveness of space research improve. |

Figure 11 Civil Space Backwards and Forwards Scenarios: Beta

| **Backwards Scenario - Beta** | **Forwards Scenario – Beta** |
|---|---|
| Core funding declines rapidly because of budget downturn. Much more income therefore has to come from contracts and competitive funding. Smaller institutes (in new member states and recent space-tradition countries) face problems finding funding and fail to obtain the attention of industrials. There is rationalisation among institutes, which move to very applied and needs oriented work, providing technical and commercial services in telecommunications, environment, etc. Activity levels increase but work is fragmented among small research teams within institutes and at international level, with a lack of coordination.<br><br>Environmental concerns become the main source of income, displacing traditional scientific foci. The big institutes become more internationalised, competing for work in a global markets. Smaller institutes diversify their work outside space research to get funding. ESA remains the main actor but missions involve fewer players. Smaller institutes and new member state institutes are less involved. Space is not any more a focus of European policy, which fails to find coordination mechanisms. | Increased numbers of national stakeholders increase complexity and reduce coordination. National priorities over-rule the ESA tradition of cooperation so fewer players are involved in space missions. ESA ambitions to encompass more security work are not realised while economic uncertainties reduce funding availability. Human space flight is de-emphasised on cost grounds. |

Figure 12 Civil Space Backwards and Forwards Scenarios: Delta

| Backwards Scenario - Delta | Forwards Scenario – Delta |
|---|---|
| Governments recognise the importance of space in some issues such as environment, transport, societal issues, ICT… National space policy continues in long-tradition space countries (France) and expands in less-advanced space countries (Poland). New regulations and the promotion of competition and excellence in research lead to the development and enhancement of civil space research across Europe, especially through third party contracts with industries. New societal issues such as population ageing drive new applications, for example in telemedicine…. European priorities include more research as well as applications. Coordination between the various teams within institute helps in structuring activities and promoting effectiveness in research and knowledge transfer. National funding decreases, but international funding strongly increased, especially from European programmes. International collaboration depends and broadens to include more global partners. More EU countries join the cooperation. Competition and excellence are promoted through the development of competitive funding. European space policy becomes a focus of future research agendas. New governance mechanisms (both within Europe and with ESA) are set up. More funding comes from European projects and international cooperation becomes increasingly global, including with Japan, Russia and the major middle-income countries including China, India and Brazil. The emergence of EU defence policy encourages European space research in both military and civil sectors. | Non-EU players increasingly become involved in cooperations with the EU. The applied space research institutes become involved in more of the value chain, improving the economics of space applications and creating opportunities for more new players from smaller countries to enter. User-driven research becomes more important.<br>The strengthening of EU space policy, and perhaps even the creation of a DG-Space within the Commission, reinforces the European rather than the national level as the driving one in funding and policy.<br>With better funding, more breakthroughs are provided by EU space researchers. |

## 3.3 Plant Science

### *3.3.1 Context*

Plant science institutes are among the oldest in the institute sector. In most countries there have been several – often regionally based and with a network of field stations – though there is now increasingly a movement towards consolidation within individual countries. European Plant Science is currently a fast moving sector, spread out across a number of different disciplines, from molecular biology through agronomy to ecology. The main research areas may be divided into four groups: agricultural/food production; health and medicine; environmental sciences/bio-energy; and climate change studies. Historically a significant part of the plant science research has reflected national interests in agronomic crops. However, in current plant science globalisation and cross-natural interests play a major part.

### *3.3.2 Trends*

During the last decade or so several organisations have been founded with the goal of promoting the interests of various parts of the plant science sector. In 1996 EuropaBio (the European Association for Bioindustries) was created to provide a voice for the biotech industry at the EU level. Today EuropaBio is the political voice of the biotechnology industry in Europe. The association has some 81 corporate and 11 associate members operating worldwide, 5 Bioregions and 25 national biotechnology associations, representing 1800 small and medium sized biotech companies in Europe.[35] In 2000 EPSO, the European Plant Science Organisation was founded to represent the needs and interests of the European plant science community.

[35] http://www.europabio.org

National ministries own most of the plant science institutes. Most institutes have a relatively high share of core government funding; it normally varies between 50 and 90 per cent. The share of private funding is low in most institutes. Four forces drive changes among the institutes today.

- Political priorities
- Climate change
- Plant health and food safety
- Demographic changes, increasing population

A key challenge is the essentially national focus of the plant science institutes. While there are key differences among them driven by variety in geography, plant varieties, climate and so on, there are also substantial commonalities that are largely unexploited.

The degree to which this fragmentation continues depends largely upon the degree to which there is willingness at European level to intervene. Both the positive and negative scenarios suggest continued fragmentation in the sector in future. Closer integration with university research may be an element in increasing their capabilities, but this would also entail something of a change of role.

### *3.3.3 Backwards and Forwards Drivers*

Figure 13 summarises the drivers for plant science, identified in our case studies (see Appendix) and in the foresight exercise. The field has seen a process of institutional consolidation, making institutes larger and more multi-disciplinary within plant sciences but seems to have struggled to cope with the shift in the underlying intellectual models from a basis in applied to molecular science. The shift to a more basic research approach is a threat to applied research agendas. Continuing up-skilling and improved university links are needed in order to tackle this. Global competition is more threatening to the European institutes in these more fundamental areas, while local and regional variations were more likely to provide shelter from competition in more applied parts of plant science. The declining proportion of core funding and growing share of project-based funding in institutes' incomes provides concerns about funding longer-term projects and maintaining datasets over long periods.

The interlinked issues of climate change and renewed concerns about food safety and security are key drivers of future activity. The future of the sector will involve finding ways to combine global aspects of the research agenda with the intensely local and regional character of other aspects. The fact that problems are driven by geography and climate rather than administrative boundaries provides opportunities for trans-border regional cooperations. These cooperations should be needs driven, if they are to be effective.

Figure 13 Plant Science: Backwards and Forwards Drivers

| Backwards Drivers | Forwards Drivers |
|---|---|
| Convergence<br>University links, up-skilling<br>Commercialisation, increasing role of markets<br>Growing economic importance of the domain<br>Climate change research agenda<br>Food production and safety research agenda<br>Duplication of effort | Institutional convergence<br>Ascendancy of basic science models over applied science in funding<br>Reduced core funding<br>International cooperation – sometimes political rather than rational in nature<br>University links and up-skilling<br>Globalisation<br>Climate change, food production and safety<br>Need for long-term data collection and resource retention<br>Loss of industrial support<br>New technology platforms, eg systems biology<br>Communications |

### *3.3.4 Scenarios*

The Figures in this Section show how these drivers work out across the three scenarios. The shift in the intellectual basis of research in the field to encompass greater input from fundamental science is a challenge across all the scenarios. The Alpha scenario is the most optimistic about the future for the institutes, since it lets them find a *modus vivendi* with the universities while maintaining their practical focus, relevance and cooperation with knowledge users. Beta is a damaging scenario, because it leaves the institutes with no real way to solve the problems caused to them by the increasingly scientific style of research in their area. Unlike some of the other Delta scenarios, the plant science one does not involve a significant shift in European level policy and involvement in the field. Rather, it is based on the idea that needs are **so** geographically bounded that there is little to gain from stronger policy action at the EU level. It therefore concentrates on the threats posed to progress in research and society if the universities simply swallow the institutes. We could also imagine an alternative Delta scenario with a more proactive EU policy and greater common action on those grand challenges that relate to food production.

The participants in the foresight workshop felt overall that Alpha was the most likely scenario.

Figure 14 Plant Science Backwards and Forwards Scenarios: Alpha

| Backwards Scenario - Alpha | Forwards Scenario – Alpha |
|---|---|
| In this scenario, the national laboratories develop from a mainly national to more international research orientation. Stable (or perhaps even increased) state funding will enable the institutes to develop and to compete for international research funding. The institutes are active in building links with university research and industry, in order to keep at the cutting edge of science and industrial innovation and to maintain and improve staff competences. The institutes develop their roles both within and outside their national context. International organisations such as EPSO may contribute to this development. In addition to the structural and funding elements that must be present to ensure this positive development, the scenario also involves an optimistic view on the scientific growth in this field. Plant science plays an important role in solving today's global challenges – such as the climate changes and the need for more sustainable energy and food production. Technological progress will expand the research on use of plants for food in an environmental friendly and healthy manner. In the alpha scenario the plant science sector manages to retain and increase the political interests for contributing to the funding of these fields of research. | Improved integration with universities, including sharing equipment, leading to the development of stronger regional and national research centres. Improved communication of results feed back to increased funding. Increasingly acute food shortages and growing involvement by industry lead to increased core funding for the institutes. Greater interconnectedness with other sectors and more international collaboration arise from the comparatively generous funding regime in this scenario. Increasingly, advancing legislation and regulation creates a significant need for new, supporting R&D. The growing importance of applied problems reverses the trend of using basic science criteria in allocating funding. |

Figure 15 Plant Science Backwards and Forwards Scenarios: Beta

| Backwards Scenario - Beta | Forwards Scenario – Beta |
|---|---|
| In this scenario born from recession and low growth, plant research is subject to cuts, in common with other areas of public research. More reorganisations and quasi privatisations take place with the aim of increasing efficiency, but there is little or no pay-off in terms of effectiveness. Disparities among EU labs increase and cooperation declines, owing to lack of financial support and the need to maintain core national functions. Cooperation with business and government also reduces, making plant research less relevant. Contract research declines as industry investment in R&D and technical services declines. Plant science does not fade away completely but is gradually absorbed by universities, often as part of larger departments (biology, life sciences, etc). European industry is less well supported in terms of international trading and the US and Asia increase their comparative advantage as trading blocks as their plant science in the fields such as plants genetic and biomedicine becomes more effective and efficient than the European services. | Universities are affected by cuts and are therefore not good partners or institutional homes for the institutes. Lack of funds locks the institutes into existing research trajectories, so they become less innovative. The economic climate means company funding also declines. Research funds dry up more quickly at national than EU level; as a result, locally specific and more applied questions are neglected. Competition between applied and basic research funding proposals in the context of funding shortage drives a shift towards more basic research. |

Figure 16 Plant Science Backwards and Forwards Scenarios: Delta

| Backwards Scenario - Delta | Forwards Scenario – Delta |
|---|---|
| Here the plant science institutes are gradually absorbed by the universities, as a reaction to the increasing share of competitive public funding, leading to a shift from more applied to more basic work in order to improve their success when competing for project funding. This tendency is already observed in some EU member countries. The Delta scenario is driven by the competition for research funding and the ambition of becoming more internationally oriented. To do so, many plant science institutes form tight networks and co-operations with national universities. This could either be in the form of a separate university department or as part of an existing department. Reduced public funding could make it difficult for the plant science institutes to retain or improve their influence on the political agenda and draw on the benefits of being in a university setting in order to improve their scientific relevance. In this respect, this scenario resembles the Beta scenario. Alternatively, the plant science institutes continue to grow and develop even as part of the universities. In this respect, the Delta scenario mainly implies a change of ownership structure and a change of national role for the plant science institutes. As part of the universities, their function will no longer be to deliver services and policy-relevant information to government. | The shift in the intellectual basis of the field towards more fundamental scientific models is a major institutional threat to the institutes. They deal with this partly through an accommodation with the universities and partly by extending their cooperation with knowledge users, both policy users and industry. |

## 3.4 Geosurveys

### *3.4.1 Context*

There is a Geological Survey in each European state and its mission is to collect, document and make available geological data about its country. The way it approaches this mission is somewhat dependent on its supervising ministry, but in general it undertakes the same basic functions. Size and budget of Surveys is dependent on national context rather than population, GDP or country size.

### *3.4.2 Trends*

Over the past 20 years Surveys have been subjected to a raft of changes, mostly as a result of national economic and political shifts. These have resulted in changes in ownership, reductions in core budgets, and realignment of income streams towards national and international contract work.

Research priorities have in recent years shifted towards concerns for the environment. There has also been a move away from ‘traditional’ Survey activities such as basic research and mapping towards more applied, contract based, research to tackle specific needs for local authorities and private companies. Geological Surveys have not (in all but one case) faced privatisation. Instead, mergers with similar organisations and changes in ministry ownership typify the past 20 years.

Key drivers behind the changes experienced in the Geological Survey Sector in the most part are political and economic in nature. The increase in focus on the environment from the early 1990s has seen Surveys realign under the Ministry for the Environment in many countries. The emergence of ICT has also driven fundamental changes around collection, storage, access and presentation of data.

Work is ongoing to improve European integration (EuroGeoSurveys) and wider globalisation (OneGeology) of Survey work and data harmonisation brought about by the role of ICT in the Survey sector. Geological Surveys are internationally active, mostly with neighbouring states to improve harmonisation and tackle common problems, but also in the developing world through World Bank funded work in capacity building activities.

Given the national remits of the Surveys, specific duplication of work is minimal across Europe – however there are moves to tackle common issues such as geo-hazards, and carbon capture and storage in a more integrated and collaborative way. Harmonisation of existing data is now a key focus, with the ultimate aim to produce Europe-wide datasets to guide future European policy decisions.

The future of Surveys would appear to be moving towards better integration and collaboration in key themes relevant to Europe, but remaining relevant to national priorities and needs. Constraints to further cooperation and integration concern the survival of smaller Surveys in the face of diminishing budgets and a continued fragmented of policy (that impacts on Surveys) at the European level.

### *3.4.3 Backwards and Forwards Drivers*

Figure 17 summarises the drivers for geosurveys, identified in our case studies (see Appendix) and in the foresight exercise. There is some degree of technology convergence with other fields, but perhaps the most notable is the increasing use of electronics and computing. Links to universities are established and improving. Globalisation affects the larger institutes (especially in countries with an imperial history) and those in small countries such as Denmark that traditionally are connected to the international development effort. Declining core funding in some cases means increasing emphasis on commercial activities such as the sale of services and consequent reorganisation but not all geosurveys are affected by this trend.

To a fair degree, the European geosurveys have finished their original task of geological mapping and are having to move into a phase of focusing on changes in geology, tackling the need for new and additional resources (not least water) and adding value to their existing knowledge. Climate change is an important driver here – not only in the search for new extractable resources but also to support activities such as Carbon Capture and Storage (CCS). Some geosurveys in the New Member States are very resource constrained and could benefit from being drawn further into the circle of European cooperation. The importance of geo-hazards varies greatly among countries but these are important activity drivers for some institutes.

Because the geosurveys’ remits are geographically determined, their tasks do not directly overlap but there are major opportunities for data integration and sharing facilities. The ‘footprint’ of individual institutes is administratively determined, so there is scope for rationalisation.

Figure 17 Geosurveys: Backwards and Forwards Drivers

| Backwards Drivers | Forwards Drivers |
|---|---|
| Convergence<br>University links, up-skilling<br>Globalisation<br>Commercialisation, increasing role of markets<br>Reorganisation<br>Growing economic importance of the domain<br>Shift from basic to applied work<br>New entrants in New Member States<br>Climate change research agenda<br>Duplication of effort<br>Rationalisation opportunities | Scarcity of sub-surface resources, including water<br>Use of ICT, interoperability, data harmonisation<br>Public and political perceptions of needs<br>Ownership and organisation<br>Climate change<br>Geo-hazards |

### *3.4.4 Scenarios*

The Figures in this Section show how these drivers work out across the three scenarios. Alpha involves continuing the trends towards applied and commercial activities with nationally focused institutes, but the background of gently declining basic activity combined with a continuing nationally-based division of labour under-utilises the opportunities for better, more integrated geological understanding and complicates the realisation of economies of scale and scope at the EU level even if these will partly be realised if current cooperation and funding trends continue. Beta leads to loss of capacity, fragmentation, potentially the disappearance of some smaller surveys and a considerable reduction in the coherence of the knowledge offered to the customer base – public and private. A Delta scenario in which the EU plays a more active role in coordinating and funding geosurveys activities offers significant increases in efficiency and customer service.

The participants in the foresight workshop felt overall that Alpha was the most likely scenario, but that there was a risk of something closer to Beta occurring, owing to expected reductions in state budgets as EU countries try to reduce their budget deficits.

Figure 18 Geosurveys Backwards and Forwards Scenarios: Alpha

| Backwards Scenario - Alpha | Forwards Scenario – Alpha |
|---|---|
| Given the historical trend, it is reasonable to expect that core funding will continue to fall even in the Alpha scenario, increasing the need for contract work to offset the shortfall in budget. The importance of surveys to national priorities remains variable across Europe so we should expect significant differences in capability among countries. We envisage that the slow increase in international cooperation of the past decades will continue. Environmental work continues to increase in importance across Europe, involving a greater role for Surveys in the fields of CCS and environmental protection. Contracts continue to be an important source of funding – increasing the need for multi-disciplinary staff. Correspondingly there will be a reduction in basic research across Surveys in Europe. The work of data harmonisation at the EU level and beyond continues. There is a low level of EU project participation and national priorities remain the most important for Surveys due to lack of common policy at the EU level. | In some countries, there may be regional devolution of the geosurveys function but in most places the shift from basic to more applied functions and reducing budgets favours a continued central model to maintain scale. Size otherwise depends upon national specificities. More interdisciplinary skills – in part obtained through collaborations with universities and other organisations – are needed to tackle the increasingly problem-orientated nature of the work. EU level coordination should increase. More of the funding will come from the EU, global state customers (for surveys and capacity building) and from non-traditional sources such as insurance companies. Stabilisation of core funding builds the basis for increased EU data sharing and interoperability. Here the EU needs to act as an enabler. There may be some part-privatisations or spin-offs to separate the provision of public goods from private services. |

Figure 19 Geosurveys Backwards and Forwards Scenarios: Beta

| Backwards Scenario - Beta | Forwards Scenario – Beta |
|---|---|
| In this scenario, core funding declines rapidly as the importance of nationally funded work in Surveys declines. Instead, there is increased reliance on contract work, bringing Surveys into direct competition with private consultancies. Some of the larger surveys could be privatised while smaller ones cease to operate or are subsumed into universities. Environmental work is placed into specialist organisations, without the need for Survey assistance. Basic research falls to inconsequential levels – applied work is increasingly given to private sector consultancies, reducing core income streams. International collaboration, coordination and harmonisation are abandoned. EU policy in the field of geology becomes more fragmented – offering no coherent EU level role or direction for Surveys, reliance on national priorities to direct work. | Regional devolution, where it happens, would put further pressure on geosurveys skills, given already declining budgets. Falling budgets imply increased fragmentation of geosurveys work and loss of specialist skills; smaller surveys will become sub-critical. Weakened governance implies reduced coherence of demand. Surveys become increasingly dependent upon commercial work, displacing public good research in favour of research for those who pay. Partnerships become increasingly random and EU coherence of data is lost. The EU level fails to provide coordination, so work loses continental coherence. Privatisation hollows out institute capabilities leaving an incoherent pattern of duplicative collaboration and an increasingly closed innovation model. |

Figure 20 Geosurveys Backwards and Forwards Scenarios: Delta

| Backwards Scenario - Delta | Forwards Scenario – Delta |
|---|---|
| This scenario involves an increase in core funding and budgets as governments recognise the central role and importance of Surveys in the fight to protect the environment. This enables greater international cooperation and integration. Surveys become the contractors of choice for applied work for both the public and private sectors. Availability of qualified staff increases and Surveys increase their revenues, producing a virtuous circle of growth. Initial European harmonisation of geosurvey data is completed, made accessible to all and a global data bank established that will form the basis of more global cooperation. An EC level body is formed to focus on the areas covered by Surveys – potentially a European Geological Survey with divisions in each (or many) Member State. | While regional or other forms of devolution would be destructive of capacities, the main transformative possibilities involve greater EU-level action and coordination. Sharing resources (servers, aircraft, ships, scarce expertise) at EU level strengthen the field and help it attract more multidisciplinary staff. This requires the creation of an EU-level umbrella organisation covering geological issues in the EU and connected into the Commission to enable policy coordination. Some funding would shift from the national to the EU level to support a rational division of labour and total interconnectedness of datasets. The creation of EU-level geological intelligence would provide uniform access to all in Europe and in turn strengthen EU policymaking and build towards en eventual global geosurveys. |

## 3.5 Metrology

### *3.5.1 Context*

The metrology public research institutions have an official status as National Metrology Institute, or NMI, which means that they are the official organisation responsible for metrology in the country and represent their countries in international organisations. They are all members of the European Association of National Metrology Institutes (EURAEMT) and the Western European Legal Metrology Collaboration WELMEC. They are nearly all government owned. We have included all the NMIs and some other public research institutes, which have significant metrology research which are not the NMI. The overall expenditure by European Union Member States on metrology research is taken to be €120 million, a figure announced in the official documents supporting the European Metrology Research Programme (EMRP) in metrology research. The metrology research institutes have as their research missions the support of metrology services, maintenance of standards, and the development of metrology in new areas.

### *3.5.2 Trends*

Over the last 20 years there have been several changes in organisational status, ownership and structure of metrology institutes and research in the field. There has been the creation and development of new institutes, for example in the Czech Republic. The overall landscape in terms of number of institutes and relative sizes and research probably has not changed dramatically, since there is still a strong rationale for having access to a national institute in each country, however small the country. What has changed and what makes the main story of this sector is the gradual increase in European research collaboration. Supported and stimulated by the Fifth Framework programme onwards, the European metrology institutes have built up networks and collaboration in research and now EURAMET operates a European Metrology Research Programme (EMRP) where joint projects are funded after calls for proposals and peer review, with EU support, based on the former Article 169 of the Treaty establishing the European Union. The institutes used the Framework projects, particularly the ERA-NETs, to assist in the preparation of this collaboration, including extensive mapping work, consultation, working out detailed implementation plans and looking to the future. Not all the European metrology laboratories are taking part in the EMRP, but it appears that it is allowing more long-term research to take place and more specialisation to develop among the population.

There remains a lot of duplication of metrology services and metrology research, but it seems that some duplication is needed for key areas and in order to deliver services to local industry. It is less clear that there is a need for significant duplication of research (as opposed to service delivery). Our interviews suggested that the EMRP cooperation is likely to grow in size and importance and that metrology itself will become more trans-nationally integrated. The drivers for this are a consensus that European institutes must cooperate in order to be able to cover the newly emerging metrology needs from high technology sectors and from public health and policy, and in order to provide the necessary infrastructure to allow European industry to innovate and be globally competitive. Centres of excellence will need to develop.

### *3.5.3 Backwards and Forwards Drivers*

Figure 21 summarises the drivers for metrology, identified in our case studies (see Appendix) and in the foresight exercise. Metrology institutes are increasingly linked to the academic system, providing needed access to additional disciplines, sometimes at the cost an increasingly academic set of incentives being employed in an applied context. European policy and reorganisation is a very substantial driver in metrology. EU-wide cooperation has evolved to the point where a Europe-wide Article 169 project is in place that funds a substantial proportion of Europe's metrology research and that therefore has the ability increasingly to structure that effort.

Metrology is seeing simultaneous needs to increase the amount of applied research done and to move into measurement in new fields, such as chemistry, biology and nanotechnology. Climate change also makes new demands of metrology. This involves creating new capabilities, offering the chance to optimise their location at the European rather than the national level and therefore to build globally competitive critical mass. Duplication of research and capabilities in the past means there is a clear case for rationalisation, an agenda that has for some time been pursued within the European cooperation, though more in making decisions about locating new capabilities than in deciding which existing capabilities can be eliminated.

The growth of the emerging economies means that Europe's past quasi-monopoly of metrology has disappeared, leaving a need for European metrology to tackle global competition.

Figure 21 Metrology: Backwards and Forwards Drivers

| Backwards Drivers | Forwards Drivers |
|---|---|
| University links, up-skilling<br>Reorganisation<br>ERA Policy<br>Growing economic importance of the domain<br>Shift from basic to applied work<br>New entrants in New Member States<br>Duplication of effort<br>Rationalisation opportunities | European Metrology Research Programme (EMRP)<br>Chemical, biological and other new fields for metrology<br>Climate change and environmental efficiency<br>New industrial needs, eg nanotechnologies<br>Metrology for healthcare<br>Opportunities for rationalisation within Europe<br>New entrants in the New Member States<br>Increasingly academic ethos, focus on science<br>New global competitors, eg India, China |

### *3.5.4 Scenarios*

The Figures in this Section show how these drivers work out across the three scenarios. The foresight group for metrology discussed drivers extensively but was unable to develop scenarios going beyond those already prepared for it, so we rely in this section largely on those backward-looking scenarios. We have inferred some aspects of Forwards scenarios from the group's discussion and included these in the Figures below. The group concluded, however, that an 'ideal' scenario would involve a greater European role in funding and organising metrology research. That would reduce dependence upon less stable national funding, increase collaboration and help make the system more useful to customers, private as well as public.

The Alpha scenario involves maintaining roughly the same level of cooperation and rationalisation as today. Rather than optimising the European system this promotes the Matthew principle: the strong get stronger and the weak get weaker. This tendency is greatly reinforced in the Beta scenario, where lack of funding undermines the gains that have so far been achieved in European cooperation, leaving the field increasingly fragmented, exposing European industry to increasingly competition from the emerging economies and eventually causing the *locus* of leading metrology research to shift from Europe to Asia. Delta offers an extreme version of Europeanisation of the metrology field, leading to increases in quality, competitive strength and efficiency and freeing resources to tackle new metrology challenges in ways that build advantage for both EU industry and EU metrology.

The participants in the foresight workshop felt overall that Alpha was the most likely scenario.

Figure 22 Metrology Backwards and Forwards Scenarios: Alpha

| **Backwards Scenario - Alpha** | **Forwards Scenario – Alpha** |
|---|---|
| In this scenario, the national laboratories remain in most member states. This is driven by the need to support statutory and regulatory functions and to support local firms in measurements and calibration in their own systems and language. The large and strong laboratories, which have a significant research effort compared to the small laboratories continue to develop their networks with other national laboratories and to drive more collaborative research within Europe. However, with present levels of funding this is still about exchange of views and meetings and joint communications. Joint research and joint research programming is small relative to national expenditure in total but growing. Some intergovernmental initiatives are built with variable geometry.<br><br>Countries with limited metrology capacity and little or no research remain small players. They start to increase their research through the EMRP, albeit from a low base. Metrology research is directed to challenges and needs for European industry, society and policy, but is primarily still nationally focused. There is still duplication and non-optimal use of research infrastructures, and in many countries there is little renewal of infrastructures. Metrology does not increase in attractiveness as a research area very much, but there is some extra involvement of university researchers and in the smaller countries there is a shift towards more R&D and engagement with the European community. Unless national pride demands, some smaller nations may cede their national measurement service to other countries, or short of this, a greater number of strategic formal partnerships emerge between NMIs. | Existing EU-level arrangements – especially EMRP – lead to a continuation of the trend towards Europe-wide collaboration and an increasingly rational division of labour in metrology. Progress is limited by the extent to which national metrology programmes' funding can be increased and the lack of trans-national customers for metrology. |

Figure 23 Metrology Backwards and Forwards Scenarios: Beta

| **Backwards Scenario - Beta** | **Forwards Scenario – Beta** |
|---|---|
| This scenario is born from recession and low growth, where metrology research, in common with some other areas of public research, is subject to cuts. More reorganisations and quasi privatisations take place with the aim of increasing efficiency, but there is little or no pay-off in terms of effectiveness. The disparity between the labs across the EU increases, and cooperation between the research institutions fades away due to lack of financial support and the need to keep core national functions. Cooperation with business and government also declines, making metrology research less relevant. Contract research declines as industry investment in R&D and technical services declines. However it does not fade away completely due to national and local needs. European industry is less well supported in terms of international trading and the US and Asia increase their comparative advantage as trading blocks as their metrology underpinning becomes more effective and efficient that the European services. US and Asian metrology research institutes become the contractors of choice for research and technical services. Most importantly perhaps, the innovative potential and performance of Europe declines as firms are left without metrology support and frameworks for measurement, testing etc in new domains. The health and welfare of citizens will also decline if metrology cannot support regulation and policy in key areas. | European metrology fails to take on the challenges of new metrology needs. As a result, EU industry is under-supported and loses competitive advantage. Advantage in metrology shifts towards Asia. |

Figure 24 Metrology Backwards and Forwards Scenarios: Delta

| Backwards Scenario - Delta | Forwards Scenario – Delta |
|---|---|
| Here we could imagine an extreme – a single networked organisation in effect performing metrology research and development across Europe and supporting local firms through quasi-national measurement systems. There is some rationalisation of research in particular and in supporting metrology services as well throughout the member states. Research is planned and executed at a European level but with attention to diverse needs within regions of Europe. This leads to a critical mass of research effort, sharing of infrastructures such as expensive or large scale equipment and more mobility of scientists, increasing the attractiveness of metrology as a science area. In policy terms, there is greater effectiveness of Europe in negotiating with WTO. Research is aligned to European policy needs and to growing and emerging industries in Europe. The organisation is also active in global markets for R&D and technical services concerning metrology. The organisation is active in building links with university research and industry, in order to keep at the cutting edge of science and industrial innovation. It is active in ensuring metrology expertise is available in member states where it has been less well supported and consequently is less well developed. | Shifting coordination and a greater proportion of funding to the European level increases efficiency and competitive strength in the metrology sector. Addressing metrology at the EU level allows the EU metrology system to address the challenges of the need for new types of measurement without a significant increase in resources. EU industry is strengthened by the availability of effective metrology, including critical masses of capability in new areas such as chemistry, biology and nanotechnology. EU standards become globally more influential because of their strong metrology backing. |

## 3.6 Marine

### *3.6.1 Context*

Joint research activities and communications among marine research institutes are long established and coordinated. Marine research responded to the need for European integration and globalisation decades before the EU was founded. In the marine science context it should be added that the cooperation is not limited to a European level; Canada, the USA and Russia are important partners, especially for the North Atlantic and Arctic Oceans. Not only the European and international challenges were met after the Second World War; in addition global challenges have been important. Several of the marine research institutes have worked in developing countries, mostly in Africa and Asia.

### *3.6.2 Trends*

The size of marine research institutes differs from one country to another in terms of employees, number of research vessels and funding. The dimension of a research unit does not necessarily reflect the size of the population in the country; it rather indicates the relative economic importance of the fisheries and marine environment; it is also a sign of the political, social and/or cultural significance of the coast.

The research units discussed in this report are all national advisory institutions, as the general aim of their scientific investigations is to offer up-to-data-expertise and policy-relevant information about the state of various stocks of fish and marine animals. Since 2000 several institutes have undergone restructuring processes, but no privatisation of research units has taken place. Despite reorganisation, the scientific content has not changed substantially. The research is to a large extent based on a core funding from the government, typically at least forty-fifty percent, but often higher. Part of the funding can be earmarked advisory contracts.

Although joint research and cooperation was established earlier, the 1980s saw intensified trans-national cooperation in the EU area. A number of organisations and committees with impact on the marine research units have been established; among them the Marine board of the European Science Foundation and the European Fisheries and Aquaculture Research Organisation.

The most important driver of a closer integration of research activities across national boundaries was the common fisheries policy (CFP) in EU from 1983. Connected to the CFP with its overall aim to reduce fishing pressure, came the establishment of the main measurement and a system to regulate the fishing effort: the total allowable catch (TAC) and yearly fishing quotas, based on scientific knowledge and advice. The CFP and the TAC has been a vital driver for change in the sector of marine research institutes. The impact of this change is that the workload connected to the scientific advisory process have gradually increased on the European level and is currently under constrains. No organisation today is in charge or controls the human and financial resources needed to fulfil the obligations for knowledge production and the scientific advisory process. There seems to be an immediate need for a better coordination between the EU, the national marine research institutes and the International Council for the Exploration of the Sea (ICES) to come to an agreement over the ways the scientific advisory processes are done, including also the factual costs linked to the processes. The expenses related to management measurements, especially the yearly TAC's should also be considered in relation to the priorities for research in fisheries science.

Another significant driver behind changes in the marine research sector is the growth of aquaculture (mariculture/marine fish farming). Aquaculture was established at significant scale in Europe during the 1970s, partly as a response to the decline of the commercial fish stocks. At first it was mainly a freshwater activity, but gradually aquaculture in the sea was developed. A relevant question to be raised is whether the development of aquaculture in Europe has stagnated and a renewal of a strategy for this branch of the fisheries is needed.

The need for scientific advice to establish TAC and regulate the fishing effort is a core activity at all marine research units in this report. One implication of this is that the theories and models on the populations of fish stocks do not differ substantially within Europe. When it comes to other knowledge fields and discipline there might be duplications of research effort across research institutes, which are a disadvantage from a European perspective.

### *3.6.3 Backwards and Forwards Drivers*

The marine institutes have been deeply embedded in national and international fisheries policy and its regulation for very many years and have a history of independence from other parts of the research system, based on their unique role and their ties to parent ministries of fisheries. These ties are now weakening and there is more convergence with the university sector. Both nationally and at EU level there is tension about whether fisheries research is best placed under the responsibility of the fisheries ministry or more centrally together with research.

Fisheries are of considerable – probably growing – economic importance, certainly in the context of increasing food shortages and the need to maintain sustainable fish stocks. The mobility of fishing fleets (and fish) and the need to maintain a coherent Common Fisheries Policy (CFP) combine with these pressures to increase the need for trans-national data collection, storage and manipulation. The interplay of fisheries with other concerns, such as environment and energy, also increased the need for more integrated intelligence about the marine.

Given a division of labour about data collection, there is not a clear issue of duplication among the institutes at the level of primary data, but the institutes rely on extremely expensive infrastructure that could probably be better shared and could more efficiently contribute to ocean-wide understanding and management of stocks.

Figure 25  Marine: Backwards and Forwards Drivers

| Backwards Drivers | Forwards Drivers |
|---|---|
| University links, up-skilling<br>Globalisation<br>Reorganisation<br>ERA Policy<br>Growing economic importance of the domain<br>Climate change research agenda<br>Food production and safety research agenda<br>Duplication of effort<br>Rationalisation opportunities | Needs for coherent data collection, storage and manipulation across national boundaries<br>Balance of power between DGs MARE and RTD<br>Globalisation of marine policymaking and industry<br>Technological developments affecting research<br>Balance between regional and national policies for the marine<br>Convergence with other fields<br>Growing importance of oil and gas, wind turbines, ethical issues, environmental disasters etc interacting with fisheries<br>EU policies for food production and safety<br>Duplication vs specialisation of research effort |

### *3.6.4 Scenarios*

The Figures in this Section show how these drivers work out across the three scenarios. The foresight group discussed drivers extensively but did not develop scenarios going beyond those already prepared for it, so we rely in this section largely on those backward-looking scenarios. We have inferred some aspects of Forwards scenarios from the group's discussion and included these in the Figures below. The group concluded, however, that an 'ideal' scenario would involve a greater European role in funding and organising research.

The Alpha scenario is sustainable in the medium term, but does not address the weaknesses of the CFP and TAC systems, which in their present political context produce sub-optimum resource management. Beta is a catastrophe not only for the institutes but also for the fishing industry, undermining fisheries policy while weakening the institutes, especially smaller and weaker ones whose potential is therefore not developed. Delta involves more EU/EFTA level cooperation and funding, refining the division of labour, improving efficiency of monitoring and creating opportunities for the institutes to do more science.

The participants in the foresight workshop felt overall that Alpha was the most likely scenario.

Figure 26 Marine Backwards and Forwards Scenarios: Alpha

| Backwards Scenario - Alpha | Forwards Scenario – Alpha |
|---|---|
| National laboratories (research units) remain in each member state. The scientific content largely remains the same and the level of funding is stable, but in many states there are renewals of the infrastructure. Fisheries science remains the same in terms of attractiveness as a research area, and has regular contact with the universities for education of trained candidates to enter the field and for research. There may be duplication and non-optimal use of research infrastructures. The research units, which have a significant research effort, continue to drive collaborative research, continue to develop their networks within Europe but also globally. With the present levels of funding, cooperation is also about joint research and research programming mainly financed through national means. Fisheries science is directed to challenges and needs for European industry, society and public needs. The field is partly driven by the need to support regulatory functions; the strains on the advisory-system are increasing on a European level. Research-based management does not give clear options for fisheries management strategies. Marine research also contributes to the economic support of the fisheries, especially the continuous development of a sustainable aquaculture. Environmental concerns and ecosystem perspectives are integrated in the scientific programmes. Broader socio-economic concerns, including social sciences are attempted to be included in the knowledge field of fisheries, hence economic and social aspects of the fisheries and the coastal communities are addressed. Scientists in the marine research sector are engaged in thinking about anticipatory work for future challenges. | The international coordination of the fisheries research effort is already quite advanced, especially in terms of data collection and analysis for fish stock management. This scenario represents continuity with that level of cooperation, but cannot address the shortcomings of the present situation, such as the crowding out of scientific research by the need to provide advice, sub-optimal sharing of infrastructure and division of labour and fragmentation of the effort on a national rather than a rational basis. An open question is whether and how the CFP and the wider system of TACs can improve under the current division of labour. |

Figure 27 Marine Backwards and Forwards Scenarios: Beta

| Backwards Scenario - Beta | Forwards Scenario – Beta |
|---|---|
| Owing to recession and low growth, marine research, in common with some other areas of public research, is subject to cuts. More reorganisation takes place with the aim of increasing efficiency, but there is little or no pay-neither off in terms of administrative effectiveness or in the development of scientific content. The disparity between the research units across the EU increases, and cooperation among the research institutions in the EFTA/EU-area weakens due to lack of incentives, financial support and the need to maintain core national functions. The assessment system with it needs for yearly scientific advice to set the yearly total allowable catches (TAC's) and quotas assessment system, demands large human and financial resources. Research-based institute management does not provide a choice for alternative management strategies. The workload of scientific advice becomes a severe hindrance to the further development of marine research. Environmental studies and the ecosystem perspective are weakened. The attractiveness of fisheries science as a research area declines. Contacts with the universities are kept at a low level. Economics and other social science disciplines are discouraged from the area. Economic and social aspects of the fisheries and the coastal communities are not addressed. Public investments in industrial R&D decline making further R&D, especially of sustainable aquaculture, less relevant. Frontline aquaculture however does not fade away completely due to national needs and the cooperation with (national/regional) business interests. | Funding reductions lead quite directly to increased fragmentation of effort, as national institutes have to prioritise their national needs over the greater common good. Increasing monitoring activities displace science, undermining the long-term capabilities of the institutes. Focus on national interests undermines the effectiveness of fisheries management and constrain cooperation. This is especially important for the resource-poorer institutes, whose development path needs to involve greater collaboration with EU partners. |

Figure 28 Marine Backwards and Forwards Scenarios: Delta

| Backwards Scenario - Delta | Forwards Scenario – Delta |
|---|---|
| Research is planned and executed at a coordinated national and European level but with greater attention to different needs in different seas, coastlines and regions of Europe. This leads to a larger mass of research effort, and an ability to share infrastructure such as expensive or large-scale equipment, increasing the attractiveness of fisheries science as a field of research. Research is aligned to defined European policy needs, to regulate the fisheries in order to develop sustainable fisheries. Strategies for more coordination and rationalisation of research in the supporting advisory services on a European level are realised. The management measurements set to regulate the exploitation of the fishing resources are regulated at a macro level and the TACs are long term based. Research-based management includes options for choices about management strategies. The load of scientific advice is managed to allow focus on the scientific content of marine research. Environmental studies and the ecosystem perspective are strengthened. The attractiveness of fisheries science as a research career increases. Economic and social aspects of the fisheries and the coastal communities are addressed and embedded in the management strategies. Economics and other social science disciplines are encouraged through EU programmes to participate in the knowledge field –fisheries and society. EU-investments in industrial R&D support further research and development of especially sustainable aquaculture, and contribute to renewal of aquaculture, and to keep the industry at the cutting edge of science and industrial innovation. The research units are active in building links with the universities for education and research purposes. | An increased European (EU/EFTA) role in funding and coordination provides improved strategic intelligence about marine resources, leading to better and more sustainable policies at the EU level. Europe maintains a strong voice in wider discussions about managing the marine environment and resources. Institutes may merge or develop closer alliances across borders, in the interests of efficient monitoring and increased scientific productivity, though the creation of a single European institute is neither necessary nor likely. A more specialised division of labour, with sharing of expensive infrastructure and better common acquisition, storage and manipulation of data, improves the quality of policy and the efficiency with which the institutes can collectively undertake their monitoring task. A result is that they can produce more science in addition to scientific advice and integrate perspectives from additional disciplines. |

## 3.7 Large RTOs

### *3.7.1 Context*

This part of the study focuses on ten large RTOs, including: the Austrian Institute of Technology, the Danish Technology Institute, VTT Technical Research Centre of Finland, the French Atomic Energy Commission, Fraunhofer Gesellschaft, the Industrieanlagen-Betriebsgesellschaft mbH, The Netherlands Organisation for Applied Scientific Research, The Foundation for Scientific and Industrial Research, Tecnalia Foundation and Rise Holding Ltd. The organisations are very different in terms of their size, varying between 800 and 16,000 employees, comprising of large number of research divisions, however they all share the common attribute of being polytechnic organisations and important nodes in the national and European landscape, with a mission to contribute to the countries competitiveness and to provide benefits to wider society.

### *3.7.2 Trends*

There are significant differences in the history of the organisations, mostly in line with the changes in national business environments and shifts in national policy intentions. The changes are reflected in the altering composition of the organisations, such as number of divisions and research institutes. Although most of the organisations seem to stagnate in terms of number of employees or have even had some reduction during the last twenty years, Fraunhofer Gesellschaft shows significant growth.

All of the organisations have undergone restructuring, due to privatisation (e.g. IABG, DTI), modernisation (e.g RISE, TNO, DTI), divesting commercial activities (e.g. CEA), or loss of the core mission (e.g. AIT). In other cases the reorganisations were due to organic growth (e.g. Fraunhofer), mergers of institutes (Tecnalia, SINTEF) or the changing needs of customers (VTT). The varying organisational set ups have resulted in changing research portfolios, with increasing emphasis on the multidisciplinary exploitation of knowledge created across the various research areas.

Further to country specific drivers, the development of information and communication tools and the increased consciousness regarding environment issues and climate change, globalisation and internationalisation of the client base formulated the strategies and affected the direction of the RTO's activities in a significant way during the last two decades.

The RTOs of the EUROTECH group have functioned as major nodes in Framework Programme networks already (Fraunhofer and CEA occupying the second and third position in FP7 so far), playing crucial role in building the ERA. They have extensive international activities and presence, and their future strategies reveal that further expansion can be expected in terms of their international activities. Transnational cooperation of the RTOs is mostly focused on the overlapping thematic areas where they can provide complementary knowledge and services with the joint objective of pursuing research excellence and to provide better services to their client.

In contract research, keeping ideas secure and confidential has high importance. Duplication of activities may occur at organisational level, and may be necessary in order to provide the industrial support that is the RTOs' mission.

The development of the RTO sector appears highly dependent upon the policy environment. As long as funding incentives are essentially national in character there will be little effective reason to expect change in the essentially fragmented and national character of the RTO infrastructure. The institutes have an innovation model that relies on subsidy to establish technology platforms or capabilities that in turn allow them to act in a developmental role with their clients, rather than as a simple consulting deliverer of services that could be obtained elsewhere in the market. Preserving their current role depends upon maintaining some level of subsidy.

### *3.7.3 Backwards and Forwards Drivers*

The drivers affecting the large RTOs are better documented in the literature than those for other fields. They include convergence of technologies and problems providing reasons for the institutes to become more polytechnic, so as to be able to solve their customers' increasingly wide-ranging problems. Sometimes referred to as the 'knowledge explosion', this is pushing industry in some cases towards a more 'open' innovation model (in the sense of greater use of external sources of knowledge). It has in some cases led institutes to reorganise. And provided an incentive to build scale. University links are generally increasing, so that institutes can tackle the increasingly 'scientific' nature of technologies and upgrade their own skills in order to stay ahead of the capabilities of their customers. It is not clear that the 'third mission' of the universities presents a significant threat to the role of the RTOs, which have different research foci and capabilities. EU policies have yet to provide significant incentives for the RTOs to extend their bases beyond their home countries and the lack of such trans-national incentives appears to be a major block to their geographic diversification. Climate change, food production and other new technologically related challenges provide significant new opportunities for the RTOs.

Unlike in the government laboratories, duplication of effort is not automatically a problem, since the institutes need to compete, to provide competing solutions and to work with competing companies. Historically, however, the national RTOs have tended to aim collectively to provide a complete set of technologies and services to their customers. More specialisation may help the European RTO sector collectively maintain presence at the leading edge of global research by defragmenting the European effort.

Figure 29 Large RTOs: Backwards and Forwards Drivers

| Backwards Drivers | Forwards Drivers |
|---|---|
| Convergence<br>University links, up-skilling<br>Globalisation<br>Reorganisation<br>Increasing scale of institutes<br>ERA Policy<br>Climate change research agenda<br>Food production and safety research agenda<br>Duplication of effort<br>Rationalisation opportunities | Political desire for clear return on state investments in R&D<br>Industry R&D is becoming more short term in nature<br>Pressures on state budget available for funding RTOs<br>Need to satisfy both local and global demands<br>ERA policies<br>University 'third mission' generating competition<br>The 'knowledge explosion' |

### *3.7.4 Scenarios*

The Figures in this Section show how these drivers work out across the three scenarios. The Alpha scenario allows the RTO sector to continue much as at present but fails to move its contributions to the European project much beyond networking. Lack of change in the structure of the RTO system may impede the take-up of new technologies, leading to a risk of lock-in to old sectors and under-support of emerging ones. Beta leads largely to stagnation, though there may be scope for entry in new areas. However, it brings the progress of European cooperation and consolidation to a halt. Delta shifts some funding responsibility to the European level, enabling rationalisation and restructuring that improves customer service and positions the EU RTO sector better in global competition.

The participants in the foresight workshop felt overall that Alpha was the most likely scenario, but aimed to lobby for EU-level intervention in the RTO sector in the hope of realising a scenario closer to Delta. .

Figure 30 Large RTOs Backwards and Forwards Scenarios: Alpha

| Backwards Scenario - Alpha | Forwards Scenario – Alpha |
|---|---|
| In this scenario, relatively stable national funding continues to be available to the RTOs, with some minor reductions due to the current economic downturn. They therefore remain major nodes in the national innovation system creating benefits for society, primarily by reducing the risks of industrial innovation. RTOs can also fulfil an advisory role for national policymaking in specific thematic areas. Under this scenario. The RTOs present an early first step in the career path of young researchers as part of the RTOs' training and educational role in the national innovation system. Collaboration with the university sector remains a high and growing priority.<br>The large RTOs we studied continue to participate in international programmes and initiatives, occupying very high rankings. There is already a cooperation trajectory in place (for example, though an ERA-NET), so even under a 'business as usual' scenario we must expect some joint initiatives to take place in order to coordinate activities and highlight common interest areas. At the same time, the RTOs are likely to continue their slow pace of opening new, overseas subsidiaries and liaison offices abroad. In some cases this will provide increased revenue and profit, since these activities focus on customer-facing activities rather than building technology platforms. The RTOs will continue to restructure in order to exploit their multidisciplinary nature, to provide better services to their customers and to increase efficiency | Traditional RTOs will continue to consolidate – and to abandon some mature fields – but there is likely to be entry in new fields. Internationalisation of the large RTOs will continue at the current modest pace. The main contributions to Europeanisation of the RTO sector will be through networking actions of the EU, such as the KICs of the European Institute of Technology. The lack of real change in the funding system will mean that existing de facto oligopolies among the large RTOs (eg in energy research) will go unchallenged, which may not provide the optimal research inputs for addressing some of the 'grand challenges' ahead. |

Figure 31 Large RTOs Backwards and Forwards Scenarios: Beta

| Backwards Scenario - Beta | Forwards Scenario – Beta |
|---|---|
| Under the negative scenario with strong pressure on budgets, there is a considerable risk of significant decrease in the core funding for the RTOs, forcing them to increase private sources of income. This reduces their focus on their social and economic mission as they have to struggle for sales and their profile becomes less and less distinct from that of consultancies. Smaller organisations appear with very niched foci, weakening the positions of the national RTOs and fragmenting the sector. The development of the university sector (increased focus on applied research activities and enlarged level of services provided to industry) will lead policymakers to question the necessity of having RTOs, even though the universities have neither the skill sets nor the incentives to take over the RTOs' function. Under budgetary pressure, the RTOs are likely to retrench and refocus at the national level, reinforcing the fragmentation of the ERA and reducing their usefulness as importers of knowledge from the world. This knocks on to a loss of the ability to exploit the advantages of being multidisciplinary organisations. The organisations become very fragmented with high level of intramural competition for funding. | Traditional RTOs will continue to consolidate – and be especially willing to abandon some mature fields – but there is likely to be entry in new fields. There will be pressures to rationalise in the sector, but in the absence of funding cross-border solutions will not be taken up. Against the background of reduced state funding, the RTOs will increasingly seek commercial money. Over time this will erode their ability to renew their technologies, making them ineffective. General lack of funds will lead the structure of the RTO sector to stagnate – a lack of entry in new fields may be a particular problem. |

Figure 32 Large RTOs Backwards and Forwards Scenarios: Delta

| Backwards Scenario - Delta | Forwards Scenario – Delta |
|---|---|
| Under a transformative scenario, governments increase their emphasis on the role and development of the national RTOs, tending to create one central organisation in each country through the merger of other research institutes. Increased core funding enables the RTOs to grow significantly without being forced to be over-dependent on customers from the private sector. The RTOs become more engaged in supporting industry through training and preparing researchers. The division of labour among the university and RTO sector is based on the organisation's main strengths: universities – creation of abstract or basic knowledge and education; RTOs – technologies, applications, understanding the context of use and industrial realities such as deadlines. Some of the national RTOs grow very large; national RTOs may be replaced by large international organisations, if adequate incentive systems can be found, allowing greater specialisation and improved customer support. Europe turns into more of a common market for knowledge and knowledge services with collaboration over national boundaries becoming even more important. Global actions take place in order to tackle international challenges such as climate change. | In this scenario, the major RTOs have an increasing influence at the EU level. Funding and policy willingness both become available to support the creation of multinational RTOs, under pressure from the smaller countries, which need to specialise and build scale but lack the size to do this nationally. The institutes tend to become more global actors and find a growing rage of sources of funds – both to support their internal research and their company-facing activities. They become increasingly interconnected, forming partnerships not only in Europe but also more widely in the emerging economies. |

# 4. Implications for the research institute sector in the ERA

The institutes have many challenges in common and face customers whose needs are constantly becoming more sophisticated. Each sector also has its own characteristics and is at a different stage in terms of the degree to which it is organised at the European level. EU-level organisation plays strong role in Space and Metrology but has so far had little influence over the Plant Science sector. Others are in between these positions. Analysis at the sector level shows in each case scope for adding value to the sector and to the ERA more broadly through greater coordination at EU level.

Foresight workshop participants generally thought Alpha was the most likely scenario, though some were anxious that the need in many countries to reduce the state budget could make Beta more likely. But there was also broad agreement that Delta was a more **desirable** scenario, and we were able to identify at least some of the policy actions needed.

This Chapter considers first what the common challenges are among the institute sectors, some of which can be addressed at European level. Next, we discuss the sectors and their potential contributions to ERA one by one. Finally, we analyse the six sectors under alternative scenarios and look case by case at the triggers that would lead them to adopt a more European approach and potentially organisation.

## 4.1 Common challenges among the institutes

There are obvious differences among the six sectors but they also face many common challenges, a number of which can be addressed through improved coordination and eventually restructuring at the European level.

The institutes and sectors considered are all rather mature. Institutes have long histories and there are few new entrants. Organisational changes tend to be rationalising rather than expansionary and have mostly affected the RTOs. There has been little privatisation since the burst of activity in the UK during the 1980s, except in some of the New Member States, which have closed or privatised applied institutes during the course of transition. Employment in the sector is not generally growing.

All the sectors are increasingly PhD-intensive and links with the university sector in the form of joint appointments, publications and sharing of PhD students are increasing. Core funding is in most cases declining gently so that industry is growing in importance as a customer. With the exception of the plant science institutes, which are increasing their more fundamental research capabilities in response to changes in the scientific basis of the field, the institutes are all doing more applied work. The RTO participants in the foresight workshop particularly identified what they called a 'knowledge explosion' as a key issue facing them. By this they meant a combination of factors

- The increased use of 'open' innovation models and processes, in which knowledge may not be freely available but where organisations increasingly seek and use knowledge generated by others
- The increased technological sophistication of their customers, with a corresponding increase in the complexity and interdisciplinarity of the solutions the RTOs need to provide
- The wider spread across society of the ability to do knowledge-intensive work and to deal at some level with research, implied by the Mode 2 discussion in section 2.4.1 above

The various change drivers identified in the literature survey, case studies and foresight workshops also show additional common patterns (Figure 33). All the sectors view climate change as a challenge they will be involved in addressing and most also see food production in a similar way.

Duplication of effort and the need for rationalisation appeared among the commonest drivers as did research and innovation policy at various levels, especially the European level.

All the institute sectors studied are organised in international – usually European – networks or associations.

- Space: ESA
- Plant Science: EPSO
- Geosurveys: Eurogeosurveys
- Metrology: EURAMET
- Marine: ICES
- RTOs: EARTO / EUROTECH

The big RTO systems such as Fraunhofer, TNO and VTT are major nodes in the Framework Programme, frequently partnering with other RTOs. Unlike in industry, however, the Framework does not appear to provide incentives for the RTOs to build cross-border alliances or to enter each other's markets.

Figure 33 Summary of Change Drivers in Institute Sectors

| | Space | Plants | Geo-surveys | Metro-logy | Marine | RTOs |
|---|---|---|---|---|---|---|
| Climate change research agenda | X | X | X | X | X | X |
| Duplication of effort | X | X | X | X | X | X |
| Globalisation | X | | X | X | X | X |
| Growing economic importance of the domain | X | X | X | X | X | |
| Rationalisation opportunities | X | | X | X | X | X |
| University links, up-skilling | | X | X | X | X | X |
| ERA policy | X | | | X | X | X |
| Food production and safety research agenda | X | X | | | X | X |
| Reorganisation | | | X | X | X | X |
| EU, national and global policies | X | | | X | X | X |
| Convergence, new technology platforms | | X | X | | X | X |
| Shift from basic to applied work | X | | X | X | | |
| New problems and user needs | | | X | X | | X |
| New entrants in New Member States | X | | | X | | |
| Commercialisation, increasing role of markets | | X | X | | | |
| Growing overlap with universities | | X | | | | X |
| Funding refocused on basic research/science | | X | | X | | |
| Public and political perceptions of need | | | X | | | X |
| Knowledge explosion'/'Open Innovation' | | X | | | | X |

**Source**: Compilation and consolidation of forwards and backwards drivers from previous tables. Only drivers shared by two or more sectors are shown

## 4.2 Individual sectors in European context

This study shows that the six institute sectors are in important respects diverse.

**Space** projects and missions last a long time, so despite being a 'high tech' sector, change happens slowly. They involve a large measure of national prestige but also a great deal of expense, which long ago drove national agencies into international cooperation, especially through ESA and its predecessors. Space is the only one of the six sectors where there can be said to be a European policy, with the EU level actively coordinating events. Some of the most expensive space missions are beginning to involve elements of global cooperation, so Europe needs to position itself in relation not only to the USA but also the BRICs and other fast-growing countries.

Civil space already exhibits the highest level of European cooperation of all the fields we explore, as a result of which Europe is an established player in space at the global level. The scenarios suggest that clustering more of EU space policy at the European rather than the national level can further strengthen the European position. This will build stronger civil space research institutes within Europe that operate on the global arena, as well as strengthening the positions of newer and smaller players. The high cost of space work means that customers and beneficiaries are well served by building the large-scale research organisations and infrastructure needed to provide a wide range of types of basic and applied research and services, allowing the sector not only to pursue traditional space research issues but increasingly to engage with the need to incorporate space research into tackling the coming 'grand challenges'.

On a project-by-project level, there is little duplication of effort even today, as there is a carefully managed division of labour, though there is significant duplication of capacity and therefore scope for competition within Europe. A more extensive role for the European level in space research policy implies both the benefits of critical mass and specialisation amongst the larger players and the opportunity to bring in a greater number of smaller institutes by enabling them to applied work, in part exploiting the strength of the larger institutions to provide capabilities and services. The scale and scope of the larger institutions' work therefore help to generate the more open knowledge market that is central to the ERA vision. A strengthened set of European institutes in civil space research positions the EU to be a yet more active partner in opening ERA to the world than is already possible on the basis of the European cooperation so far.

**Plant science** is in important respects more spatially tied to the national level than are the other fields, owing to differences of climate and geography that drive differences among flora, fauna and ecosystems. There have been rationalisations in plant sciences within many countries but the diversity has tended to keep cross-border rationalisation off the agenda. Unlike the other sectors, where the balance of work is becoming more applied, the growing importance of molecular biology in this sector means that fundamental science is becoming more important. Arguably, that is leading to increased commonalities in methods and infrastructures, which in turn increase the opportunities to find synergies between different institutes. The plant scientists believe they should play a significant role in tackling some of the grand challenges linked to food production. In the past, this sector has not played a significant role in the EU Framework Programme but its involvement is increasing, which supports the idea that it is increasingly relevant for the sector to operate at the European as well as the national level.

Plant science is in the course of a transformation, where fundamental disciplines such as molecular biology combine with other scientific innovations such as systems biology to change the skill set needed. The scenarios suggest that continuing evolution and tightening of the relationship between the institutes and the universities is the most effective way to tackle this change. Simply merging the two groups of organisations would lead to the loss of the applied agenda, with consequent damage for industry and policymaking as well as the rump of the institutes themselves. European strength in plant science and its application would better be served by exploiting the common areas of problem and interest among the institutes and building mass by networking these together. (In the long term it could even be advantageous to encourage the formation of institutes that tackle the problems of geographically defined supra-national regions with similar plant patterns.)

However, while a measure of independence between institutes and universities is required, links are also needed that reinforce and upgrade institutes' scientific capabilities and that provide 'focusing devices' for the universities: clear signals about what areas of more fundamental research are likely to be useful in solving problems, for example by highlighting missing understanding and/or human capital. A symbiotic relationship between strong universities having international reach and institutes with critical mass seems therefore the best way to reinforce European strength and global competitiveness in plant sciences. Despite the very nationally organised past history, there is little reason why such a symbiosis should be organised at either national or EU scale – it clearly requires variable geometry. One reason for keeping the institutes separate from the universities is that they will then be better able to understand and meet the needs of their knowledge users, not only in industry and agriculture but also in government. Spatial variations in plant varieties and their interactions with their environments imply that there are limits to rationalisation within the plant science institute sector, though at the same time there are clear opportunities to build larger entities with wider geographic scope than we have today, because today's institutes are based on administrative rather than scientific or geographic logic. Enabling cross-border institutes to establish themselves would provide an important contribution to more open knowledge markets within the ERA. The resulting institutes with increased scientific depth and at the same time a greater 'contact surface' to applications would be able better to contribute to a globally engaged ERA.

The **geosurveys** are by definition linked to the territory they survey and are linked also to the national level by their role in identifying and exploiting national resources. Economic pressures on them reflect the wider need to constrain state expenditures, so while states want to keep control of their own geosurveys they also have incentives to cooperate. Their 'basic' work of mapping the national geology is – at least in Europe – largely drying up and they are increasingly engaged in putting that knowledge to use and detailing it, for example via resource exploration. EU-15 geosurveys tend to be strong and increasingly reliant on applications while surveys in the New Member States tend to have few resources and to lag behind. However, the changing nature of the work is accompanied by a shift from core to project-based (sometimes commercial) funding. While national boundaries determine the division of labour and prevent spatial duplication of effort, the current pattern of gentle decline in basic activity will tend further to fragment the field. The surveys are themselves organising – through Eurogeosurveys – to coordinate their efforts but the extent of efficiency improvement possible through coordination is limited. Common funding, for example of infrastructural capabilities, and the emergence of trans-national customers will probably be needed to make the field more efficient. There may also be opportunities to cooperate in global markets. Current work outside Europe tends to be related to development, funded in a fragmented way by different aid agencies and to be a somewhat peripheral activity of the surveys.

In recent years, the geosurveys have tended to focus increasingly on environmental questions rather than resource identification and use. This shift underlines the irrationality of a division of labour based on administrative lines. Neither rock nor water pays attention to national boundaries. The new problem focus speaks for a more European form of organisation and division of labour, in which the automatic tie to individual countries is broken. Unlike in some of the other fields considered in this study, it is difficult to have a very open market in geological data, since individual geosurveys effectively have monopolies in their own countries. The more open markets in knowledge envisaged in the ERA must therefore rely on greater cooperation and to some degree on the separation of data collection and processing. A transforming approach to integrating the European geological surveys is likely to provide the strongest, most rational and customer-useful approach to this field. This will depend upon the economic arguments for such improvement defeating national pride.

**Metrology** is also under budget pressure, in the sense that there is an increasing number of areas where measurement is economically important but where there is little scope to increase institute budgets in ways that would allow them to do more research. This is an important force driving cooperation. Some duplication of facilities is needed so that institutes can deliver metrology services to local industry and government but the underlying knowledge is not spatially specific and metrology is widely seen as one of the most obvious areas for rationalisation of European activity.

Metrology has in fact moved considerably further towards European organisation than many other sectors. Historically, European metrology has been at the leading edge and many other parts of the world have relied upon it. However, the field faces a range of new measurement challenges that must be met in order to provide adequate support to EU industry and in order to help meet some of the 'grand challenges' we face in the coming years. The best way to meet the new measurement challenges is to build closer links with researchers in relevant disciplines and to create critical masses of metrology capability is the needed areas. This implies a division of labour rather than the traditional strategy of pursuing all areas of metrology in all countries. The EMRP shows the way, providing both a coordination mechanism and a competitive arena in which such specialist capabilities can develop scale and excellence. Reaping the benefits of this specialisation will pose a new challenge: 'distribution' of new metrology services. Over time, this – together with the clear opportunities for rationalisation in the field –may lead to a specialisation among institutes where some largely 'retail' knowledge while other do a mixture of production and retailing. Without some such arrangement it will be hard to offer a comprehensive set of measurement services across Europe. At the same time, more sophisticated customers ware likely to be able to access advanced metrology services across large distances. This ability provides a competitive check on the European metrology sector: if it fails to perform competitively, the advanced customers will go to the USA and Asia to meet their needs.

The **marine** institutes similarly have a mixture of peculiarities some of which promote working separately at national level and others of which tend towards cooperation. Clearly, coasts and coastal ecosystems are nationally specific but fish do not respect national borders. The rise of aquaculture also brings new research issues that tend to be generic rather than spatially specific. While national interests in access to marine resources are strong and depend upon obtaining reliable and objective information, these interests can in the longer term only be secured through negotiation and cooperation. Research ships are extremely expensive to buy and to operate, making capacity sharing attractive.

The marine institutes have arrangements for international cooperation that considerably antedate the EU, which therefore provides a potential supplement to their international activities rather than a replacement. The growing involvement of the universities together with a shift in some of the funding towards a European level would provide important impulses to renewal of the institutes, broadening their brief and capabilities towards current and future regulatory and scientific needs. While institutes' data collection tasks overlap little, they need expensive common infrastructures as well data storage and manipulation activities and they collectively need to prevent the monitoring workload from swamping their scientific activities. As a result, there should be strong incentives to find more European funding solutions. At the same time, institutes are likely to be pulled in a national direction by their role in negotiating catches within the CFP. From the European perspective, increasingly common and open data storage and analysis is strongly in the common interest, providing the free flow of information envisaged in the ERA.

The **RTOs'** mission of supporting innovation among their industrial customers induces them to behave much more like businesses than institutes in the other sectors. Successful privatised RTOs (eg Pera, Qinetiq) and those with very low core funding (GTS, SINTEF) can be driven to internationalise by setting up offices abroad, exporting or both. Large European RTOs with higher levels of core funding are increasingly exporting but tend not to establish offices abroad beyond a minimal level.

The large RTOs have to a degree become trapped in their national markets, unable to follow the globalisation patterns of their major customers or to compete effectively with each other because of their nationally-based incentive (funding) systems. They make extensive use of the Framework Programme in order to extend their geographic reach and they also increasingly export contract research and other services; but they are not able to exercise their developmental role across borders within the EU owing to the national nature of their funding. Increasing European strength (scale, critical mass, quality) among the RTOs and enabling them to take on the rest of the world depends upon loosening these ties to the national level. In doing so, they will provide leverage to, and exploit the knowledge of, the European universities with which they increasingly partner. (This should entail not only helping exploit new knowledge from the universities but also providing signals about global research needs and developments of interest, especially in the applied sciences.)

Moving beyond Europe would let the RTOs serve their customers better – both through physical presence outside their home countries and by accessing more of the world's technology. Increased scale coupled with competition-based specialisation would also improve their competitiveness and their ability to serve their customers. This would depend upon – and reinforce – the opening of knowledge markets within Europe.

## 4.3 The institute sectors under different scenarios

Figure 34 to Figure 36 analyse the way the scenarios are expected to affect a number of policy-relevant dimensions of the European institute system. The first two rows in each table – the level of core funding and the existence (or not) of trans-national or EU-level customers – influence the other dimensions. The symbols in each table show whether the expected trend is up, down or unchanged, compared with the situation today.

Figure 34 shows expected effects of the **Alpha** scenario. The effects on core funding are mixed. Plant science core funding is expected to rise, given a shift towards or into the university sector and increased fundamental research activity. In the other sectors, existing flat or declining trends were expected to continue. The existing trend towards increased European networking among existing institutes is expected to continue, indicating that a degree of progress is already in rain towards ERA but the Alpha scenario does not produce rationalisation or a restructuring at EU level. Nor does it lead to much increase in the openness of knowledge markets in Europe – another key ERA objective. Existing trends for some of the institutes to increase their global reach beyond Europe continue and those likely to work in the areas of the grand challenges continue to do so. There is no change in the extent to which the institute sector addresses EU policy priorities or improves customer service under this scenario. The existing trend towards doing more work for industry continues. The Alpha scenario therefore continues the slow progress in the institute sector towards ERA but – as one would expect of a 'business as usual' scenario – it does not involve a step-change in the development of ERA.

Figure 34 Expected changes under the Alpha scenario

| | Space | Plants | Geo-surveys | Metro-logy | Marine | RTOs |
|---|---|---|---|---|---|---|
| **Core funding** | ↓ | ↑ | ↓ | – | – | – |
| **Trans-national / EU customers** | – | – | – | – | – | – |
| **European restructuring / rationalisation** | – | – | – | – | – | – |
| **European networking** | – | ↑ | ↑ | ↑ | ↑ | ↑ |
| **Rationalisation within the national level** | – | – | – | – | – | – |
| **More open knowledge markets in Europe** | – | ↑ | – | – | – | ↑ |
| **Global reach of the research institutes** | ↑ | ↑ | – | – | – | ↑ |
| **Institutes address EU policy priorities** | – | – | – | – | – | – |
| **Institutes address the grand challenges** | ↑ | ↑ | ↑ | – | – | – |
| **Value for money from the subsidy** | – | – | – | – | – | – |
| **Production of new research-based knowledge** | – | ↑ | – | – | ↓ | – |
| **Customer service** | – | – | – | – | – | ↑ |
| **Work done for industry** | ↑ | – | ↑ | – | – | – |

State budget cuts are at the heart of the **Beta** scenario (Figure 35)and are immediately translated into reductions in core funding. The institutes 'withdraw' back into their national contexts, further accentuating nationally based fragmentation and in the majority of cases rationalising within their country of origin. The opportunities for exploiting synergies among the institutes in different countries are not taken and they network less and less among themselves. European knowledge markets become more fragmented and the global reach of the institutes is limited. With increased focus on national needs, the institutes pay less attention to EU policy goals. The amount of new knowledge produced declines along with the core funding, except in plant science, which is expected to be integrated to a greater extent with the universities, resulting in a shift from applied to more fundamental research. Under the strain of shortage of funds, the institutes' customers tend to receive declining levels of service. Some sectors are able to increase their work with industry as a way to make up for the loss of core funding; others are not. This scenario represents a big leap backwards, in relation to the ERA objectives.

Figure 35 Expected changes under the Beta scenario

| | Space | Plants | Geo-surveys | Metro-logy | Marine | RTOs |
|---|---|---|---|---|---|---|
| **Core funding** | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| **Trans-national / EU customers** | – | – | – | – | – | – |
| **European restructuring / rationalisation** | – | – | – | – | – | ↓ |
| **European networking** | ↓ | ↓ | ↓ | ↓ | ↓ | ↓ |
| **Rationalisation within the national level** | ↑ | ↑ | ↑ | ↑ | – | – |
| **More open knowledge markets in Europe** | – | ↓ | ↓ | ↓ | ↓ | ↓ |
| **Global reach of the research institutes** | ↓ | ↓ | ↓ | ↓ | – | – |
| **Institutes address EU policy priorities** | ↓ | – | ↓ | ↓ | ↓ | – |
| **Institutes address the grand challenges** | – | – | – | – | – | – |
| **Value for money from the subsidy** | – | – | – | – | – | – |
| **Production of new research-based knowledge** | ↓ | ↑ | ↓ | ↓ | ↓ | ↓ |
| **Customer service** | – | ↓ | ↓ | ↓ | – | ↓ |
| **Work done for industry** | ↑ | ↓ | ↑ | ↓ | – | ↑ |

The **Delta** scenario (Figure 36) is intended to be disruptive and centres on the idea of greater European integration with strengthened policy measures in place to promote achievement of the ERA objectives. Under this scenario, the EU is expected to strengthen – or encourage Member States to strengthen – institute core funding, with the European level itself emerging as a new category of **customer** for the institutes. Sectors varied in the degree to which they saw the creation of new EU-level institutions as likely, but most expect a strengthening of European structures, which creates opportunities to exploit synergies across Europe's internal borders and to rationalise the number of institutes and the division of labour among them. This could also involve some rationalisation at national level. From this strengthened position, institutes can then trade more effectively within European knowledge markets and extend their reach beyond Europe more effectively. The increased strength of the institutes, in the presence of a European level that acts more coherently as a customer, spills over into increased efforts to achieve EU policy priorities including tackling the grand challenges. Overall, performance improves in terms of value for money, knowledge production, and to a lesser degree customer service and work for industry.

Figure 36 Expected changes under the Delta scenario

| | Space | Plants | Geo-surveys | Metro-logy | Marine | RTOs |
|---|---|---|---|---|---|---|
| **Core funding** | ↑ | – | ↑ | ↑ | ↑ | ↑ |
| **Trans-national / EU customers** | ↑ | – | ↑ | ↑ | ↑ | ↑ |
| **European restructuring / rationalisation** | – | – | ↑ | ↑ | ↑ | ↑ |
| **European networking** | ↑ | – | ↑ | ↑ | ↑ | |
| **Rationalisation within the national level** | – | ↑ | – | ↑ | – | ↑ |
| **More open knowledge markets in Europe** | – | – | ↑ | ↑ | ↑ | ↑ |
| **Global reach of the research institutes** | ↑ | – | ↑ | ↑ | ↑ | ↑ |
| **Institutes address EU policy priorities** | ↑ | – | ↑ | ↑ | ↑ | – |
| **Institutes address the grand challenges** | ↑ | – | ↑ | – | ↑ | – |
| **Value for money from the subsidy** | – | – | ↑ | ↑ | ↑ | ↑ |
| **Production of new research-based knowledge** | ↑ | ↑ | ↑ | ↑ | ↑ | – |
| **Customer service** | ↑ | ↓ | ↑ | – | – | ↑ |
| **Work done for industry** | ↑ | ↓ | ↑ | ↑ | – | ↑ |

While the foresight workshop participants generally regarded the Alpha scenario as the most likely, their accounts also indicated what could trigger the Delta, transformative scenario

- In Space, participants saw the degree of policy initiative taken at the EU level as determining the outcome between Alpha and Delta. Participants preferred the Delta scenario no only because it increased the importance of space activities but also because it provided a platform from which several of the grand challenges could be tackled at European level
- The Plant Science participants saw the degree of funding squeeze that the sector will experience in the next few years as determining events. A serious effort at EU level to tackle the grand challenges relevant to food production would create the additional income and the common agenda needed to strengthen and de-fragment the sector
- Similarly, the Geosurveys saw the degree to which the EU level takes on aspects of geology and the environment in relation to the grand challenges as determining whether the Delta scenario would be realised. An initial step would be to bring the data already collected by the geosurveys together in order to create EU-wide strategic intelligence, laying the basis for a continent-wide approach to geology, water as well as mineral resources
- The Metrology sector is already particularly advanced in Europe-wide cooperation. Participants saw Member States' willingness to cede national positions in some areas of metrology so as to create a more European knowledge base as the key factor in determining whether closer European cooperation (and eventually mergers of some institutes) would resolve the 'metrology dilemma' – increasing the breadth of metrological knowledge and techniques while lowering costs at the level of the continent as a whole in order to pay for the new knowledge
- Similarly, in the Marine sector the willingness of Member States to cede insight into, and possibly some degree of control over, Total Allowable Catches under the Common Fisheries Policy was seen as crucial to realising the Delta scenario. There is growing pressure for more collective solutions to issues of resources and quality in the food chain, so it seemed plausible and reasonable for the EU

centrally to play a greater role, notably in generating the strategic intelligence about fish and fish stocks needed

- RTO participants saw removal of the incentives that lock them into their national markets as the main requirement for realising the Delta scenario

Thus, there are sector-specific requirements for achieving the Delta scenario, but they rest primarily on the creation or reinforcement of strategic or policy intelligence at the European level and the degree to which sector policies have a European component, creating a European-level customer. The RTOs appear to be different. Government is their main sponsor but not their primary customer. However, for them too the major constraint on Europeanisation is customer access.

A note of caution should perhaps be introduced in relation to these scenario analyses. The institutes do not see competition as a major factor in their development and tend to assume that outcomes will be determined in a rational, technocratic manner on the basis of policy decisions. In our discussion of policy options, we will also explore competition-based options that could prove more disruptive to the present order.

# 5. Policy Implications

The idea of ERA has been evolving since it was introduced in 2000. Today it is, in effect, to build a globally competitive research and innovation system optimised at the European level. It is clear that tackling the grand challenges at EU level will become part of the agenda. Recent expert group reports have begun to identify the potential of the institutes to contribute and the importance of actually creating the common market in knowledge and knowledge services envisaged from the first ERA Communication but that is not yet in place.

The ways in which the institutes are funded today tends to lock them to the national level and fails to encourage the cross-border competition needed to improve the quality and performance of the sector as a whole. We conclude that the institute sector plays important roles in the European innovation system. It needs its own policy measures and should not be conflated with the universities. Increasing Europe's share in the funding of the institutes and its ability to operate as a trans-national customer will be key to triggering needed rationalisation and improvement in the institute sector. Article 169 has been used in a constructive way to coordinate and rationalise institute activity in metrology.

The Commission needs to adopt policy objectives for the RTOs in the ERA relating to: building a real common market in knowledge and knowledge services; removing barriers to institutes building global scale; involving them in the grand challenges; ensuring they have adequate infrastructure; supporting their self organisation at the European level; and above all supporting disequilibrating developments in the sector that enable improvement through competition.

Our policy recommendations focus on: integrating the institutes into other policies; providing tiered planning and investment support to institute sectors aiming to improve their European-level performance; study and address the barriers to the operation of a common market in knowledge and knowledge services.

In this Chapter we use the results of the historical studies and foresight exercises to explore European policy options for the research institute sector. While aiming to respect the evidence and the views collected during those exercises, this prospective chapter does not rely solely upon them but connects them to policy issues involved in the building of the ERA.

## 5.1 The ERA Context

The 2000 Communication on the ERA[36] argued that Europe lagged the USA and Japan in industrial competitiveness and the ability to make social and economic use of research. Complaining that there was no European policy on research, it proposed a unified research area, comparable with the idea of the EU as a common market for goods and services. "De-compartmentalisation and better integration of Europe's scientific and technological area is an indispensable condition for invigorating research in Europe."

This meant breaking down borders between the Member States in order to 'optimise at the European level' features such as policy coordination, overall investment in RTD, networking and the building of critical mass in RTD. Also targeted were increased human mobility and the bringing together of the scientific communities of the new Member States with those of the EU-15, the creation of more opportunities for female and young researchers and steps to make Europe a highly-attractive place to do

[36] COM 2000 (6) Final

research based on common ethical values. Two months later, the Lisbon Declaration[i] set Europe "a new strategic goal to become the most competitive and dynamic knowledge-based economy in the world, capable of sustained economic growth with more and better jobs and greater social cohesion". Research and innovation actions building on the idea of the ERA were to be pursued but broader policies were also involved that included improved policies for the Information Society, modernising the 'European social model' and macroeconomic policies. Not long afterwards, the Council set the Barcelona target of spending 3% of EU GDP on R&D.

In 2007, the Green Paper that 'relaunched' the ERA[37] described its key features as

- **An adequate flow of competent researchers** with high levels of mobility between institutions, disciplines, sectors and countries
- **World-class research infrastructures**, integrated, networked and accessible to research teams from across Europe and the world, notably thanks to new generations of electronic communication infrastructures
- **Excellent research institutions** engaged in effective public-private cooperation and partnerships, forming the core of research and innovation 'clusters' including 'virtual research communities', mostly specialised in interdisciplinary areas and attracting a critical mass of human and financial resources
- **Effective knowledge-sharing** notably between public research and industry, as well as with the public at large
- **Well-coordinated research programmes and priorities**, including a significant volume of jointly-programmed public research investment at European level involving common priorities, coordinated implementation and joint evaluation
- **A wide opening of the European Research Area to the world** with special emphasis on neighbouring countries and a strong commitment to addressing global challenges with Europe's partners

Today, the idea of ERA is even more ambitious – in effect to build a globally competitive Research and Innovation System **optimised at the European level**, aligning regional and national policies and institutions to this new scale. The EU ERA 2020 Vision therefore has five major components[38]

1. Knowledge Activities: Volume and Quality - "The ERA defines the European way to excellence in research and is a major driver of EU competitiveness in a globalised world"
2. Knowledge Triangle: Flows and dynamics - "Strong interactions within the "knowledge triangle" (education, research and innovation) are promoted at all levels"
3. Fifth freedom: intra and extra-EU openness and circulation - "The ERA provides a seamless area of freedom and opportunities for dialogue, exchange and interaction, open to the world"
4. The Societal Dimension - "The ERA is firmly rooted in society and responsive to its needs and ambitions"
5. Sustainable development and Grand challenges - "The ERA is firmly rooted in society in pursuit of sustainable development"

While the current research and innovation policy discussion in the EU focuses increasingly on 'grand challenges', it is not yet agreed what these are. Challenges often

[37] Commission of the European Communities, *Green Paper, European Research Area: New Perspectives,* COM(2007) 161 final, Brussels 4.4.2007

[38] *2020 Vision for the European Research Area*, Brussels: European Council Conclusions, December 2008

mentioned include: climate change and the need for clean energy; sustainable transport; sustainable consumption and production; improved public health; food, water and energy security. However, there is no definitive list.

Recent expert group reflections on the ERA are beginning to suggest policy aims at the EU level, which relate to RTOs and not just to universities. The Georghiou group[39] emphasised the need to develop "a true European market for applied research services in the RTO sector". The Soete group pointed to the need for Community-based policies for merit-based competition schemes among universities and RTOs at EU level.

> *RTOs turn out to be crucial for the success of the ERA because of their fundamental role for both research and innovation. In particular their role in national innovation systems is important. The competition of RTOs in the benchmarking with peers among others would benefit highly from a better integration into the ERA.*
>
> *The Commission should be more cogniscent of the importance of RTOs in the innovation system. Therefore, incentives to RTO-RTO cooperation and RTO-University cooperation are strongly recommended. This will reduce fragmentation and reduce overlap, and stimulate cross border cooperation in projects and research facilities. At the same time RTOs would benefit from continuity of funding programmes on collaborative research with emphasis on knowledge transfer that already in place. RTOs are well equipped to respond to such challenges.*[40]

The group argued that ERA policy should have a focus on **institutions**. Critical mass, it argued, is easy to achieve at the level of research groups (in most subjects this requires only 5-8 people – in some subjects even ewer). But the research literature shows that institutional quality and efficiency improves when research organisations become large and broad. Building 'critical mass' in the ERA should focus on this dimension (which is why competition – so there are winners and losers – and not just networking is important in future ERA policy).

The institutes make significant contributions to all five dimensions of ERA outlined in *Europe 2020*. First, they are major knowledge generators and providers, supporting EU policy and competitiveness. Second, they are strong components of the 'knowledge triangle' by virtue of their intense cooperation on the one hand with universities and other research institutes and on the other with the innovation processes of producers in industry and the state. Third, they provide public as well as traded knowledge goods within and beyond the EU. Fourth, they already have strong societal missions and are well positioned to tackle many of the 'grand challenges' ahead, such as climate change, environment, ageing, health and food supply. Responding to these is typically a societal task that will also suck in economic actors on a large scale. Fifth, sustainable development is part of this societal mission and is universally recognised by the institutes not only as a duty but also as a major opportunity for them.

It is clear from the fields studied that there is scope further to increase the contribution of the institutes on each of these dimensions if the European dimension of their activities is reinforced.

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[39] Luke Georghiou et al, Report of the ERA Expert Group, *Challenging Europe's Research: Rationales for the European Research Area (ERA)*, Brussels: DG Research, 2008

[40] Luc Soete et al, Expert Group Report, *The Role of Community Research Policy in the Knowledge-Based Economy*, Brussels: DG-Research, 2009

## 5.2 Conclusions relevant to ERA policy

While the scenario exercise shows that there would be benefits to 're-optimising' European institute sectors at the European rather than the national level, there are significant barriers to change built into the structure of the system. In the government labs sectors, there is an assumption that there is a natural monopoly at the national level and institutes are dimensioned in order to meet governments' views of how much research capacity they need. In effect they have been sheltered from competition and increasingly exposing these institutes to a need to generate additional income is therefore an important check that their quality and efficiency overall can match external standards. The significant role of core funding for the RTOs means that these, too, effectively operate in sheltered markets – albeit usually ones that afford a lot less shelter than that seen in government labs. Meeting the standards required to participate in the Framework Programme is an important test in this respect but the Framework serves essentially to **network** the national positions of the institutes rather than to impose additional competition among them. Unlike industrial FP participants, institutes do not tend to use the Programme to develop positions that they can then leverage into other countries. Rather, they respect each other's nationally based positions and move on to the next project on the same network basis.

These arrangements encourage structural inertia in the research institute sector. A key, missing element is a (trans-national) customer who is willing to put the institutes within a sector in competition with each other in order to reduce the importance of the existing lock-ins in preventing structural changes.

This study shows that the research institutes play important societal and economic roles in the European innovation system. Their missions are quite distinct from (and not substitutable by) that of the universities and, indeed, from each other.

The six fields studied were chosen to be in various ways representative of parts of the institute sector. They are all facing change, both in the content of their work (involving new disciplines, changing the balance between more fundamental and more applied work, adjusting their customer bases to increase the proportion of their income that is competitive and driven by applications and innovation). The origins of the institutes are national, tackling needs at national level, generally at a time well before the EU was established in anything like its current form. Naturally, creating the Union opens opportunities not available when the institutes were originally conceived – in particular, opportunities to share resources, build scale and strength at a supra-national level. An emergent theme across the cases was the importance of globalisation and the resulting emergence of organisations in the emerging economies as viable competitors to the EU institutes. If the EU institutes are to compete with these in future, they will need already now to build scale and global capacity.

The cases and scenarios suggest that in all cases benefits are available to the institutes and their users from adding a European dimension to the way the field is organised. Space is already in some senses a demonstrator for this; it has been forced into that position by the massive costs of space exploration and research, although it is strongly steered by coalitions of national interest and the strict 'juste retour' principles employed by ESA simultaneously perpetuate fragmentation and undermine the opportunities to build greater global scale. The arrangements for cooperation on civil space antedate the EU, building on a principle of aggregating national needs and funding an à la carte compromise across national ambitions. European space policy is largely the sum of the national policies rather than being a European construct. The fact that this is a self-limiting mode of organisation is evident from the institutes' desire for a stronger European policy component.

The plant science, geosurveys, metrology and marine institute studies showed varying degrees of activity towards optimising structures at the European level. Metrology is the most advanced, having launched an Article 169 project that is beginning to set common European agendas in metrology research. Plant science and marine institutes lag behind: they still belong strongly to older regimes that antedate the Union and they have close links with national agriculture and fisheries policies, as opposed to research policies. An important distinction between the way civil space is organised and the way these other four fields could be organised at European level is that using Article 169 (or something like it) provides a mix of national and European money – and therefore a 'space' within which the power of self-organisation by the institutes can be harnessed to building a trans-national, European agenda.

All these five cases are of institutes that essentially work for the government, even if they are increasingly encouraged to work for the rest of society as well. The benefits they would reap from a stronger European dimension include the ability to create collective agendas that help them tackle the change needs of their respective fields, rationalisation and increased effectiveness freeing up resources, infrastructure sharing, increased specialisation and therefore scale within those specialised areas and potentially extension of their customer base to include the European level as well as reaching cross-border demand within the EU.

The RTO case is different. RTOs are subsidised to support national industrial development and increase the rate of industrial innovation. There is an element of competition with other EU RTOs and – especially – other EU countries' industry built into their role. But they are trapped by the national subsidy logic so that they struggle to serve their globalising customers – who instead build links with other knowledge organisations outside Europe – and they are constrained from building the scale that would help them operate more effectively at a global level. The way to escape this logic is to attract new funding at European or trans-national level, for example by taking on the RTO role in more than one country, thereby changing the RTOs' incentives better to match their customers' needs and RTOs' opportunities.

The cases identified no strong barriers to the trading of knowledge by institutes within the EU. Because they already work with private industry, the RTOs have gone furthest in serving industry across intra-EU borders, though their cross-border customers tend to be the more technologically sophisticated ones. The limitations on such intra-EU knowledge flows are primarily

- Customers' perceived needs for comparatively local supply
- State funding of institutes, so that the main supply of knowledge is part of a contract with the state and therefore not exposed to competition from alternative suppliers

Little can – or should – be done about the first. However, a more rational relationship between funders and institutes that takes account both of needs at the national level and at the European level is not hard to imagine. The institutes themselves suggest that elements could include: mechanisms that rationalise infrastructures and selectively develop capacities so as to share costs and to build specialisation; and projects that define pubic goods at the European level and organise their procurement (such as the work of Eurogeosurveys on maintaining and visualising geological data for Europe as a whole). These goals are attainable using existing instruments such as Article 169 that at once build on participants' self-organisation and involve the Member States as co-funders. The metrology example has already shown that this is possible and it would seem not unreasonable that the geosurveys could soon follow.

At the first step, it is unlikely that Member States will be prepared to rationalise away their nationally owned institutes, even if this is ultimately rational in some cases. In no event could this be imposed. However,

Our policy conclusions are therefore as follows

- The institute sector plays important roles in the European innovation system, both at the national level and in support of ERA. It requires separate policy consideration and should not be conflated with other sectors, notably the university sector

- Increasing the component of institute funding and demand that has a European character will strengthen the institute sector and the ERA

- Overly top-down arrangements, including arrangements driven by compromise among Member State policies, will only have limited effects on genuine Europeanisation of the institute sector. Rather, that Europeanisation needs to be based on the needs of the institutes' funders or customers and on the self-organisation of the institutes themselves. Article 169 provides a practical way to achieve this although given the notorious complexity of establishing Article 169 arrangements the Commission could usefully study the possibility of setting up a simpler instrument with the same objectives
- It is however also desirable to move beyond a process of more closely networking existing institutes and to create opportunities for rationalisation. Only the institutes and their owners themselves can take these opportunities. The most useful contribution the Commission and others can make is to support the analysis that would have to precede such decisions – making it clear that decisions which historically might have been unthinkable are, in the current context and in the context of the ERA, rational

## 5.3 Policy recommendations at the EU level

In the light of the ERA objectives, which are ultimately to build a healthy 'research ecology' at European level, objectives for EU-level policy for the research institute sector should be to optimise the research institute sector towards European needs by

- Integrating European knowledge markets to create a common market for knowledge and knowledge services
- Removing barriers to research institutes building globally competitive and naturally viable scale[41] through competition and specialisation
- Exploiting the capabilities of the RTOs to tackle the grand challenges, once these are defined and integrated into EU research and innovation policy
- Ensuring that Community provision of research infrastructure addresses not only the needs of basic research (ESFRI) but also of the institute sector
- Supporting the self-organisation of research institute sectors at the European level via organisations such as Eurogeosurveys and their connection to areas of developing policy need at European level
- Supporting developments in the institute sector that are **disequilibrating**, ie that combat existing lock-ins and enable new and existing institutes or groups of institutes to build positions in competition with others that overall strengthen the 'offer' of the European institute sector and its global competitiveness

Some of these objectives will be promoted by the manner of implementation of measures that are not specific to research institutes, notably the way in which particular instruments are used to tackle the grand challenges. Specific consideration should be given to the role of research institutes in designing these interventions.

An urgent need is proper statistics about the institute sector. The Commission should ask Eurostat to establish definitions and collect statistics about the institutes, as is done for the university sector, and should encourage the OECD to act in a similar way.

Owing to the lock-ins and impediments to structural change that persist in the institute system – and which are less present in universities or industry – moving towards ERA requires some institute-specific measures or use of existing instruments.

The Commission should adopt a tiered approach to supporting integration and structural change, in order to address the different stages of development at which individual institute sectors find themselves. In some sectors it will be important for

[41] Comparisons with the USA are often made in defining the aims of EU research and innovation policies. However, it is not self-evident that the scale or monolithic structure of key US government laboratories would be optima for Europe. Rather, an evolutionary approach is needed to discover the scale and degree of competition that is appropriate in each European sector

these actions to be inclusive; in others, it may be preferable for institutes themselves to select those whom they see as key to building and delivering an 'offer' to the European level.

One level is to offer support through planning or exploratory actions, enabling groups of institutes to develop common research agendas and strategies addressing needs at the European level. Key to this action is the development of a strategy and the creation of a connection to a European-level, transnational customer, in order to initiate a set of dynamics that encourage the development of market relations that tend to structure the research institute sector towards European needs. Planning grants could encourage rationalisation as well as wider improvements in strategy: small projects to undertake feasibility and impact analyses of institute mergers or expansions[42]. Examples are powerful. Once one or two cross-border mergers or alliances in place – probably between small neighbouring countries – the idea will no longer be so unthinkable.

A second level is to invite groups of institutes collectively to develop new intellectual capital (technology platforms or capabilities) at the European level that they subsequently can exploit in their wider operations. In effect, this means injecting European funding into the first stage of the innovation process depicted in Figure 7, creating shared public goods that can then be exploited in the institutes' wider operations.

A third level is to provide competitive funding for shared infrastructure, enabling specialisation and division of labour while reducing unnecessary duplication in the sector. Some such infrastructures may be shareable with universities. Others may be provided only to a sub-set of institutes

As EURAMET has demonstrated, Article 169 provides a good opportunity to begin to implement a reorganisation of an institute sector, based not only on a common strategic plan but also competition. Where the Commission can identify institute sectors that link to EU policy needs, it should actively solicit them to establish Article 169 arrangements.

Perhaps most fundamentally, however, the Commission should tackle the fact that there is not really a functioning cross-border market for institute research and services in the EU. In particular, there is no cross-border competition for 'competitive' government projects, so that the degree of competition is nationally limited and the institutes to not receive adequate market signals or incentives to encourage specialisation or improved performance. At the detailed level, it is not clear what all the obstacles are to opening up such markets. The Commission should ensure that these obstacles are studied and then aim to institute a reform to overcome them.

[42] There is a precedent in UK funding for RTOs in the 1990s, when the Department of Trade and Industry offered strategy support to RTOs aiming to improve their services to SMEs

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