Report of the Expert Group

"ERA Indicators and ERA Monitoring"

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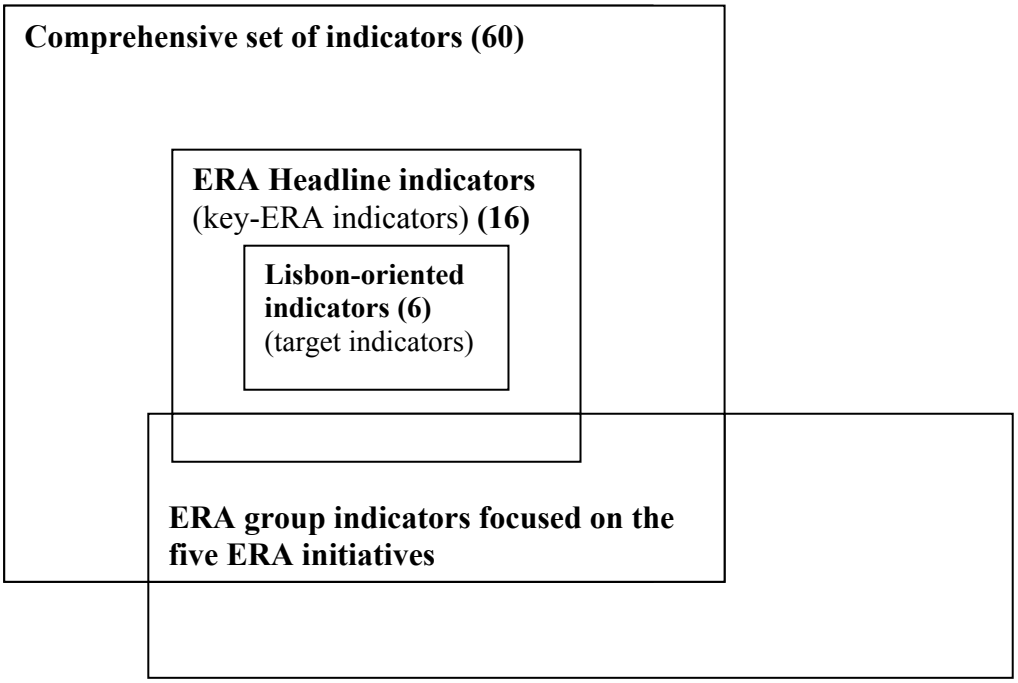
Executive Summary

The Mandate

The overall objective of the group is "to promote and contribute to the development of an evidence-based monitoring system on progress towards the ERA and a knowledge-based economy"[1]. It is an integral part of the "Ljubljana Process" that aims to define and build the ERA - which defines the European way to excellence in research and is a major driver of EU competitiveness in a globalised world.

Concretely, our group's mission is to define three subsets of indicators: a) a comprehensive set of indicators to fully understand progress towards the ERA and the European knowledge economy; b) a subset of key ERA indicators to monitor progress toward the ERA in a synthetic way linked to key ERA objectives derived from the ERA Vision 2020 ('ERA-Headline' indicators); c) an even smaller subset of indicators serving as references for targets of the contribution of the ERA in promoting a European knowledge society ('Lisbon-related indicators'). In addition to these three subsets, more focused indicators on the five ERA initiatives will be developed by the ERA groups.

Overall view of the sets of indicators



The group's mission is also, as specified in its terms of reference (page 2, 3, and 5), to address the issue of a monitoring system and make proposals in this respect.

The report is organised the following way: having proposed an ERA indicators framework (section 1), we present the three sets of proposed indicators (section 2), followed by a discussion of possible role of indicators in the monitoring (section 3); we then come to the conclusion.

[1] Terms of reference, page 1.

1. Methodology: The ERA indicators Framework

To ensure that this report is tightly related to the definition of ERA set up by Governments, we based our work of identifying relevant indicators on a detailed analysis of the ERA Vision 2020 document which expresses all the relevant facets of ERA – and on the other key document which is the Commission report on the five policy initiatives. We define our model of the ERA along two structural dimensions: the "components" of the ERA and the "types of concern" which its monitoring supposes.

The Five Components of the ERA

Component 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"

Component 2 - *Knowledge Triangle: Flows and dynamics*

"Strong interactions within the "knowledge triangle" (education, research and innovation) are promoted at all levels"

Component 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"

Component 4 - *The Societal Dimension*

"The ERA is firmly rooted in society and responsive to its needs and ambitions"

Component 5 – *Sustainable development and Grand challenges*

"The ERA is firmly rooted in society in pursuit of sustainable development"

The Four types of concern for the ERA monitoring

Type A1 – Member states (MS) level policy actions
Type A2 – EU level policy actions
Type B – ERA progress; state of the ERA
Type C – ERA effects; Lisbon objectives

Table 1: ERA monitoring indicators: the overall framework to build the indicators

Components of the system / Types of concern		*Component 1.* K activities in EU [volume & quality]	*Component 2.* Knowledge Δ [local, national, EU-wide]	*Component 3.* Fifth Freedom [conditions for EU-wide mobility and circulation single market for K]	*Component 4.* Societal Dimensions of ERA [Science in society]	*Component 5.* Sustainable Development and Grand Challenges
Type A Policy actions	*Type A1* Member States level	▪ Public RD investment ▪Attractiveness policies ▪ Incentives for private RD investment	▪ MS Knowledge Δ policies ▪ Coordination of Δ policies within MS	▪ Preparation of inter-operability of HE and R systems ▪ Opening public procurement, nat. programmes… ▪ Autonomous R. institutions ▪ Attractive working conditions for researchers	▪ Societal platforms ▪ involvement of stakeholders ▪ TA (Technology Assessment),, foresight	▪ SD policies and actions
	Type A2 EU-level and coordination across MS	▪ FP volume & structure ▪ ERC ▪ Joint programming. & instruments ▪ Speaking with one voice in international fora ▪ ESFRI & instruments	▪ Coordination of Δ policies within EU ▪ EIT (European Institute of Technology) ▪ EU innovation policy and public-private interactions	▪ Common market for knowledge and its production factors across *EU* ▪ High performance EU-wide info systems	▪ Societal platforms ▪ involvement of stakeholders ▪ TA (Technology Assessment), foresight ▪ Ethical principles ▪ Cohesion and equity concerns	▪ Strategic partnerships between community & MS SD policies and actions
Type B ERA progress state of the ERA as EU R-I system		▪ Integration – coordination among MS of public R funds	▪ Intra-MS and intra EU flows between HE-R-I ▪ Public-private interactions & flows	▪ Intra-EU collaboration ▪ Knowledge flows ▪ K production factors circulation intra ERA ▪ Level of competition in EU for K production factors ▪ Access to complementary K & capacities across EU ▪Accessible world class R infrast.	▪ Science society activities ▪ Common foresights ▪ Social, regional, geographic cohesion	▪ Joint SD activities
Type C ERA Effects – Lisbon objectives towards a K society		▪ K activities (Volume, quality) ▪ World class research ▪ Structural change: - K intensity - Specialisation (sectoral, geographic) - Dynamics of firms ▪ Revealed attractiveness of ERA ▪ Linkages – networks between ERA and the world; openness of ERA to the world			▪ Mutual trust & dialogue between society – S&T ▪ Public attitude to S&T ▪ equity: geographic, social, gender	▪ EU leadership in addressing global challenges and reaching SD goals

K: knowledge ; KΔ : knowledge triangle (higher education – research – innovation) ; Δ policies: triangle policies
MS: member state (and, when relevant, associated countries)
HE: Higher education; R: research; I : innovation; SD: sustainable development

2. The proposed indicators

All the indicators presented:

1. Should be computed at the level of each MS plus associated states and at EU level as well as ERA level (including associated states)[2]
2. For at least two dates for analysing trends
3. In relevant cases with comparisons with at least the US, Japan, China
4. With ratio to account for size, which can be GDP, but also population
5. For the financial indicators, growth rate in real terms is to be systematically considered
6. In relevant cases, the indicators should be computed at the level of sub-groups of countries, which have similar characteristics regarding their research base

For the Lisbon–oriented indicators list and the ERA-Headline indicators list, we present for each indicator, first the notion expressing what is needed for the monitoring of the ERA (*"Intention")* and then a proposed quantitative characterisation of the notion to be addressed (*"Indicator"),* indicating its source and availability[3]. While the list of "Intentions" is meant to have lasting significance, the relevant indicator for a given notion can (and should) change over time, when new data become available or new ideas of indicators emerge; in a sense, the indicators presented here can be seen as examples of what can be done since there are often several possible indicators for characterising an intention[4].

This list of indicators is a proposal which may be modified subject to the reflection on indicators inside the ERA groups

[2] in what follows, when referring to the ERA, the expressions EU or member states (MS) are meant to include associated States

[3] the proposed indicators are mostly either available or feasible in the short term

[4] to be relevant, an indicator needs not cover all the aspects of the notion it pretends to measure; it can measure only one aspect, provided one can make the hypothesis this aspect evolves in the same way as all the non measured (and non measurable) aspects.

Indicators Sets		
Lisbon-oriented indicators *Target indicators*	**ERA Headline indicators** *Key ERA indicators*	**Comprehensive set**
Public investments in knowledge	Idem	Idem
European integration of research Systems	Idem	Idem
Strength of the business research base of Europe	Idem	Idem
Transition towards a knowledge-based economy – structural change	Idem	Idem
Productivity of the economy	Idem	Idem
Contribution of research to address grand societal challenges	Idem	Idem
	ERA research actors cooperation and cohesion	Idem
	International cooperation in S&T and opening up to the world	Idem
	Mobility of researchers and research careers	Idem
	Knowledge transfer between public and private sector	Idem
	Pan-European research Infrastructures	Idem
	Excellence of the S&T base	Idem
	Human resource base of the ERA	Idem
	Knowledge-based innovation	Idem
	Firm dynamics – structural change	Idem
	International attractiveness of Europe for Business innovation and investment	Idem
	Confidence of society in science and the S&T community	Idem
		43 additional indicators on ERA

The Lisbon-oriented indicators

● PUBLIC INVESTMENTS IN KNOWLEDGE
Intention: Even though not sufficient, adequate funding levels are necessary for knowledge generation. In a knowledge society, public investment in R&D (both public and private), higher education and innovation is crucial.

Indicator: Public funding of R&D and higher education as a share of GDP

● EUROPEAN INTEGRATION OF RESEARCH SYSTEMS (policies)
Intention: The issue addressed is the "de-fragmentation" of the EU research systems and how it can be overcome by integrating (parts of) the national funding systems. This refers to National funds for trans-nationally coordinated Research. Joint Programming (ERA Initiative) is one part of this.

Indicator: Share of National Public Funds to Trans-nationally Coordinated Research.

● STRENGTH OF THE BUSINESS RESEARCH BASE OF EUROPE
Intention: This strength is measured by the business expenditures in R&D and represents an important aspect of the innovation potential.

Indicator: Business RD expenditure (BERD) / GDP (or population) and growth in real terms

● TRANSITION TOWARDS A KNOWLEDGE-BASED ECONOMY – STRUCTURAL CHANGE
Intention: The knowledge economy develops largely through the structural evolution of economic activities towards more knowledge-intensive ones; this can be monitored by observing the evolution of the relative weight of the most knowledge intensive activities.

Indicator: Evolution of the share of total value added contributed by sectors with higher proportions of tertiary educated employees in the work force

● PRODUCTIVITY OF THE ECONOMY
Intention: Productivity growth is the key factor behind competitive economies and sustainable long-term economic growth and living standards. The intention is to get a synthetic measure of the overall capacity of the economy to provide economic and social benefits to the people; of course distribution aspects would need to be considered to address the issue in a more complete way. This proposed indicator incorporates indirectly the impact of the knowledge economy on competitiveness through innovation.

Indicator: Growth rate of labour productivity per hour both for the whole economy and for the knowledge intensive part of it (as defined for indicator 4, above)

● CONTRIBUTION OF RESEARCH TO ADDRESS GRAND SOCIETAL CHALLENGES
Intention: Mobilising R&D to address Grand Societal Challenges and fostering the contribution of S&T to sustainable development and competitiveness are the overarching goals assigned to research policy in the ERA 2020 Vision. Optimally, a consistent methodology should be applied for all areas where EU-level agreements will be made for Grand Societal Challenges. Leadership and responsiveness of RD in the Grand Societal Challenges fields are aimed at.

Indicators:
(a) Leadership: World shares of scientific publications and European patent office (EPO) applications in the fields of the Grand Societal Challenges
(b) Responsiveness: World shares of scientific publications and EPO applications in the fields of the Grand Societal Challenges / World shares of scientific publications and EPO applications in all fields ('specialisation' in the fields of Grand Societal Challenges).

First area available: Climate change; data on environmentally related energy technology (SET-Plan themes)

The ERA Headline indicators

NATIONAL POLICY (Type A1)

● **Public investment in knowledge**
Indicator: Public funding of R&D and higher education as a share of GDP

JOINT/COORDINATED POLICIES (Type A2)

● **European integration of research systems (policies)**
Indicator: Share of National Public Funds for Trans-nationally Coordinated Research.

ERA MAKING (Type B)

● **ERA research actors cooperation and cohesion**
Indicator: Share of co-publications (as regard to publications and to co-publications) which are with EU partners, among which with the 10 Member States with the lowest R&D intensity

● **International cooperation in S & T and opening to the world (ERA Initiative)**
Indicator: Share of co-publications (as regard to publications and to co-publications) which are with non- EU partners

● **Mobility of researchers and research careers (ERA Initiative)**
Indicator: Percentage of Doctoral degree Holders who obtained their doctorate in another EU country and/or have worked in another EU country

● **Knowledge transfer between public and private sector (ERA Initiative)**
Indicator: Share of publicly-performed research which is financed by business

● **Pan-European research infrastructures**
Indicator: Amount of funding committed to new pan-European research infrastructures in the framework of ESFRI, ERIC or other transnational agreements

ERA EFFECTS (Type C)

● **Activity level in knowledge-producing activities**
Indicator: share of R&D expenditures in the Gross domestic product

● **Strength of the Business research base of Europe**
Indicator: Business expenditure in R&D (BERD) / GDP or population; growth in real terms

● **Excellence of the S&T Base**
Indicators:
a) World share in top 10% most cited publications divided by world share of publications
b) World share in top 250 most academic research intensive universities

● **The Human Resource Base of the ERA**
Indicator: Importance of tertiary education graduates in Europe

● **Transition towards a knowledge based economy - Structural change (1)**
Indicator: Evolution of the share of total value added contributed by sectors with higher proportions of tertiary educated employees

● **Knowledge based innovation**
Indicator: % of innovators as a percentage of all firms (Innovation of firms based on own research as well as adaptation of knowledge developed by others)

● **Firm Dynamics - Structural Change (2)**
Indicator: Percentage of high-growth firms.

● **International attractiveness of Europe for Business innovation and investment**
Indicator: Share of R&D expenditures by non-EU foreign affiliates in total business R&D expenditures and Share of R&D expenditures by non-EU foreign affiliates /their share of VA

● **Productivity of the economy**
Indicator: Growth rate of labour productivity per hour both for the whole economy and for the knowledge intensive part of it

● **Mobilising R&D to address Grand Challenges – Contribution of S&T to sustainable development and competitiveness**
Indicators:
(a) Leadership: World shares of scientific publications and EPO applications in the fields of the Grand Challenges
(b) Responsiveness: World shares of scientific publications and EPO applications in the fields of the Grand Challenges / World shares of scientific publications and EPO applications in all fields ('specialisation' in the fields of Grand challenges).

● **Confidence of society in science and the S&T community**
Indicator: responses in survey expressing interest and confidence of the citizens in S&T

The Comprehensive Set of Indicators

The purpose of this section is to propose a comprehensive set of indicators that covers in a systematic way the entries of the overall framework proposed above. This would facilitate, an understanding of the development of the various issues related to STI policies in the European context, but would also allow an analysis in terms of policy actions, ERA building and Lisbon objectives. This comprehensive set of indicators aims at contributing to the future versions of the STC report. In the main text of this report we only propose about 60 indicators that are readily available or quite easily obtainable.

3. The use of indicators for monitoring the ERA

Following our terms of reference we address now the issue of the monitoring system**.** In due time the appropriate mechanisms have to be chosen to execute that monitoring dependent on the results of the discussions regarding governance in CREST and the preferences of the Council in this respect.

In this context, the aim of this section is focussed on highlighting the elements which are important for indicators to play a meaningful role in the monitoring process.

The situation and challenges of the monitoring of the ERA

With the advent of ERA, the issue of monitoring is substantially changed for two reasons:

- the ERA is about the contribution of member states to realising it, with the Commission (and the FP) largely in a role of a catalyst for national systems and programmes. integration – coordination: the issue is to monitor national reforms and the integration of national programmes (policies) and systems
- the ERA is about integrating research into a "knowledge society" : "knowledge triangle" (higher education, research, innovation) and free circulation of knowledge ("5th freedom") are at the core of ERA and are related to policies beyond research policy.

The challenges presented by this situation have been widely recognised: the ERA monitoring and governance issues are prominent in the Ljubljana process. So, there is an on-going move towards a new scheme for monitoring.

But how could indicators fit into such a scheme and make a specific contribution? Such is the purpose of this report, which raises the question of how, in principle, such quantitative measurements can contribute to public policies.

The significance of indicators for the monitoring of public policies

If we seriously consider that indicators have a substantial role to play in such an eminently political process as the development of the ERA, then we need to clarify how indicators can be articulated to political processes.

We suggest the following understanding of the nature of indicators: that indicators are intrinsically dependent on a representation (or model or theory) of the topic at stake and are therefore debatable. The whole difficulty – and interest of the indicators for policy decisions – is to make explicit the underlying representation (or model or theory).

In this view, indicators are neither truth nor fallacy, but a common language with a high potential for collective deepening of issues with their underlying values, as long as certain methodological and procedural rules are respected. In this condition, they can be a powerful media for complex and high stakes policy monitoring – such as the ERA.

This understanding of the indicators makes them highly relevant for this task, provided the following conditions are fulfilled:

- the indicators are produced in a way which specifies the source data, treatments, approximations, the definition and rationale for the classifications used, the reasons for the proposed interpretation….
- possibilities are provided for the criticism of the indicators, for revealing the underlying assumptions and proxies, for questioning the classifications

- opportunities are given for alternative approaches, classifications, hierarchy of parameters and models of functioning of the system, leading to other indicators, or alternative interpretations or at least argued questioning of the interpretation of the indicators presented.

Towards using indicators for the monitoring of the ERA

Indicators are valuable in a monitoring process to the extent they enable the actors to reveal, express and discuss their representation of the issue at stake through their interpretation, criticism and eventually reconstruction of indicators.

Using indicators for the monitoring of the ERA would thus mean they are one of the vectors of the interaction among the actors, in tow possible contexts:

- a multi-actors assessment of the ERA-Headline indicators producing a thorough understanding of the building of ERA,
- key-issues ERA assessment (on ERA-Headline indicators) done by government representatives and the Commission, feeding into ministerial-level meetings (focussing on Lisbon oriented indicators).

Such ERA indicators assessment undoubtedly require significant preparation which takes time, resources and expertise in terms of the decision-making processes, the production of indicators and the collective learning methodologies. This point is crucial. Insufficient attention to it will lead to superficial work.

The large number of States involved, the objective complexity of the ERA making, its pluri-sectoral dimension (Knowledge triangle)…make the governance of the process and its monitoring a difficult task indeed. Indicators have a potential for addressing real issues in a universal language, but the condition for this potential to be realised is to have top-level and professional preparation. This requires a dedicated structure (body) with a significant operational capacity, as well as a high degree of legitimacy, both professional and political.

Conclusion: Towards a responsible and efficient use of indicators for the monitoring of ERA

Analyzing indicators with a systemic perspective

The suggestion is to interpret indicators not one by one but jointly, by subgroups of related indicators. The framework proposed for analyzing the ERA should be useful in clustering the indicators for such joint interpretation efforts.

A note of caution about using indicators to set targets

At least some of the Lisbon orientated indicators could be completed by the definition of a quantitative target of political significance. The risk is that since, by definition, an indicator measures a part (which is measurable) as a substitute or proxy to a larger picture (which is not measurable), setting a target based on the indicator leads to take care of the part (on which the indicator - target is set) and not of the larger picture (which is the real concern).

Setting targets and benchmarks for groups of countries

For the ERA monitoring process to be politically meaningful to all member states, it is suggested that interpretations, as well as targets and benchmarks be set up per groups of countries having similarities as regard to the ERA issues.

Linkage between the ERA and the national monitoring processes
Since the ERA is about the synergies between national policies articulated with EU level policies, it would be logical for monitoring processes at national level to be concerned with ERA monitoring, and reciprocally. This interaction would be greatly simplified if the National 'Lisbon documents' relied on similar and coherent methods, indicators and processes.

The indicators lists and reports as "living documents"
There are technical (data availability) and political (for example new Grand challenges) reasons for the lists of indicators to evolve. This is why there is a need of a formalised decision process for adjusting (for example every year) the lists of indicators with their precise technical definition.

Broad issues not fit for direct qualitative measurements and the question of composite indicators
A major point is the need to address broad issues, which are central for the monitoring of ERA. At least three such issues can be identified:
- the framework conditions in each country, also influenced by EU-level decisions,
- the policy decisions and roadmaps for reforms,
- the efficiency of the research systems and related public expenditures.

Such meta-issues combine a large number of complex elements, the relevance of which is itself a matter of debate and even political vision.

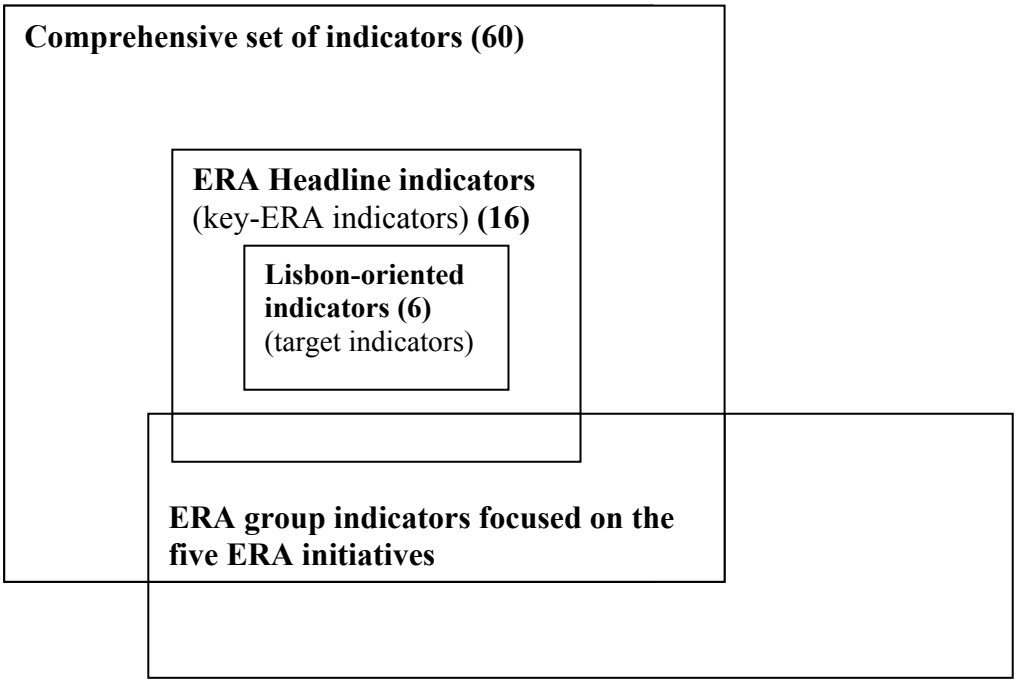
An approach sometimes proposed to monitor these broad issues is to build composite indicators, i.e. synthetic indicators based on the aggregation of as many indicators as there are elements to be considered. This is indeed a possibility and some composite indicators are widely used and well known (the Human development index of the United Nations for example). The difficulty in designing composite indicators lies both in the choice of the elements to be accounted for and in then their weighting for computing the aggregate synthetic indicator. In many cases, it seems easier to acknowledge the complex and qualitative nature of the issue, and to develop ad-hoc processes based on assessment studies or evaluations, expert advice and policy makers working groups.

The Mandate

The overall objective of the group is "to promote and contribute to the development of an evidence-based monitoring system on progress towards the ERA and a knowledge-based economy"[5]. It is an integral part of the "Ljubljana Process" that aims to define and build the ERA. Concretely, our group's mission is to define indicators to monitor progress toward the ERA ("ERA making") as well as indicators to assess the efficiency of the ERA in promoting a European knowledge society ("Lisbon objectives").

The ERA is being defined, and therefore is an evolving concept with correspondingly still fluid priorities and policies. Accordingly, our mandate itself has become more precise over the course of our work. In particular, we have had to take into account the ERA Vision 2020 document published in December 2008, the conclusions from the Competitiveness Council **(**reference**)** and the Lund Declaration. These further developments made it clear that we should put significant weight on the "Lisbon objectives" part of our brief as this aspect is under-represented in the set of indicators currently used in the Science Technology Competitiveness (STC) indicators Report. Those documents also reaffirmed the importance of the "knowledge triangle" and the need to appraise the ERA in a broad societal context.

Overall view of the sets of indicators



Concretely, our group's mission is to define three subsets of indicators: a) a comprehensive set of indicators to fully understand progress towards the ERA and the European knowledge economy; b) a subset of key ERA indicators to monitor progress toward the ERA in a synthetic way linked to key ERA objectives derived from the ERA Vision 2020 ('ERA-Headline' indicators); c) an even smaller subset of indicators serving as references for targets of the contribution of the ERA in promoting a European knowledge society ('Lisbon-related

[5] Terms of reference, page 1.

indicators'). In addition to these three subsets, more focused indicators on the five ERA initiatives will be developed by the ERA groups.

The group's mission is also, as specified in its terms of reference (page 2, 3, and 5), to address the issue of a monitoring system and make proposals in this respect.

The collective work of our group on "ERA indicators and ERA monitoring" presented in this final report, is backed up by six thematic reports. The first two reports consider two promising sources of indicators. Michael Tubbs examines indicators based on individual firms data, while Isidro Aguillo discusses the pros and cons of using data collected from the web. The next two reports focus on specific aspects of the ERA which have benefitted from recent work: the structure of public funding for Benedetto Lepori and International technology flows for Iulia Siedschlag**.** The two last thematic reports, written by Horst Soboll and Reinhilde Veugelers address the economic and innovation dimensions of the conceptual framework to interpret the sets of indicators we propose.

The purpose of this report is to provide a synthesis of our work. As such, it is both less and more than the sum of the individual reports mentioned above. Less because, given the space constraint, we cannot provide as detailed an analysis. The interested reader should therefore consult the underlying thematic reports for a more thorough discussion of the advantages or disadvantages of individual indicators or to get a more systematic presentation of our conceptual framework. On the other hand, the current report also goes beyond its individual components, in at least two respects. Firstly, we choose limited sets of indicators from the longer lists considered by each individual expert and present them in a coherent manner. Secondly, the report also reflects the contributions made by all members of the group during our numerous and intensive meetings. In particular, it includes some indicators that cover aspects of the ERA that would otherwise have fallen "between the cracks" of the areas covered by each specific report. Such indicators will therefore be discussed more extensively.

Our report should also be seen – and used – as one part of a larger collective reflection on research and ERA in the broader Lisbon process post 2010. Most obviously, our work is closely related to the task of the Expert group "The 3% objective: progress made and post-2010 policy scenarios". Recognising this close link, both groups have exchanged the minutes of their respective meetings and some members of both groups held a joint meeting on June 15th, 2009. We have also read the documents produced by expert group reports linked to the six areas of the ERA Green paper and to a more overall ERA rationale and monitoring.
The report is organised the following way: having proposed an ERA indicators framework (section 1), we present the three sets of proposed indicators (section 2), followed by a discussion of possible role of indicators in the monitoring (section 3); we then come to the conclusion.

1. Methodology: the ERA indicators framework

In this section, we propose a framework for the coherent presentation of indicators for ERA monitoring and discuss the desirable properties of such indicators.

1.1 The ERA indicators Framework

To ensure that this report is tightly related to the definition of ERA set up by Governments, we based our work on a detailed analysis of the ERA Vision 2020 document which expresses all the relevant facets of ERA – and on the other key document which is the Commission report on the five policy initiatives [REF].

These documents refer to a wide variety of issues and address simultaneously questions of policy along with objectives and longer term visions. The challenge for building indicators characterising such a complex reality is to set up a framework providing explicit categories for the indicators; this framework must be based on a simplified representation – a model – of the reality we want them to characterise.

In practice, there is no well-specified "model" of the ERA, where causes and effects are identified unambiguously, for two reasons. Firstly, the ERA relates to a complex system where even simple concepts like "inputs" and "outputs" are not well defined: what is an input for a given set of agents is often an output for another set of agents and causes and effects interact in endless feedback loops. Secondly any modelling of the ERA would be based on a specific understanding of what its main objectives and most essential aspects are. As political views of the ERA have evolved and are likely to continue evolving, specifying too tight an underlying "model" would only ensure that our analysis soon becomes obsolete.

In this context, we define our model of the ERA along two structural dimensions: the "components" of the ERA and the "types of concern" which its monitoring supposes. We base the model on the ERA Vision 2020 document and check that it addresses the policy initiatives.

1.1.1 The Five Components of the ERA

The question here is to identify and classify the key substantive aspects of the ERA and identify its features.

The June 11-12 meeting 2009 of CREST, identified eight 'individual components which make up the ERA Vision 2020' (our sub-components):

1. [1a] Mobilising R&D to address major societal challenges, respond to citizen needs and support policy development, [1b] building mutual trust and continuous dialogue between society and the S&T community.
2. [2a] Stimulate business to innovate and invest in Europe, [2b] promote strong interactions within the knowledge triangle and public/private partnerships in support of industrial competitiveness.
3. Enhance the effectiveness of knowledge transfer and circulation across ERA
4. Strengthen the excellence of the S&T base.
5. [5a] Ensure an adequate supply and mobility of human resources[5b] in an open and competitive single labour market for researchers.
6. Develop and ensure access to world class and globally integrated and networked research infrastructure.
7. Enhance science and technology capacity building in support of cohesion.
8. Stimulate international cooperation in science and technology and a wide opening to the world.

Like CREST, we chose to distinguish between the "societal" and "innovation system" aspects of the ERA. The "societal" dimension is divided into Grand challenges and science – society dialogue. The innovation system dimension is broken down into three components that can be organised around the knowledge triangle. We now present these five components in more detail, referring both to the 2020 vision for the ERA document and to the CREST typology.

Component 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"

Relevant quotes from the "2020 vision for the ERA" document:

►attractive conditions (…) for carrying out research and investing in RD intensive sectors in Europe
►business is stimulated to innovate and invest in Europe, in particular in RD
►significant support from the cohesion policy (…) to ensure optimum deployment across Europe of S&T capacities
►the supply of human resources is S&T is in line with the demand by public and private research players
►research institutions across the ERA have strategic, financial and managerial autonomy
►European research institutions provide attractive working conditions for researchers from all parts of the world, both men and women
►top-level scientific institutions (and) major research infrastructures in the ERA (…) are jointly funded at EU level when appropriate
►a significant share of public funding of research is provided through ERA-wide open competition thus gradually promoting the necessary specialisation and concentration of resources into units of excellence (…)
►top-level scientific institutions (and) major research infrastructures in the ERA promote excellence in science (…)
►the ERA is at the core of all major global networks of S&T knowledge producers, distributors and users
►the European publicly supported research and technology base plays a key-role (…) through world class cutting edge research

Reference to the CREST identification of components

2a. Stimulate business to innovate and invest in Europe
4. Strengthen the excellence of the S&T base.
5a. Ensure an adequate supply of human resources
6. Develop and ensure access to world class and globally integrated and networked research infrastructure.

The first component relates to the *Volume and Quality of Knowledge Activities* carried out within the EU. In accordance with the broad view conveyed in the ERA Vision document, such activities include research innovation and education. They should also, to the extent possible, capture all types of innovation (including organisational design, for example) and do so across all sectors of activities which are judged to be "knowledge-intensive".

Component 2 - *Knowledge Triangle: Flows and dynamics*

"strong interactions within the "knowledge triangle" (education, research and innovation) are promoted at all levels"

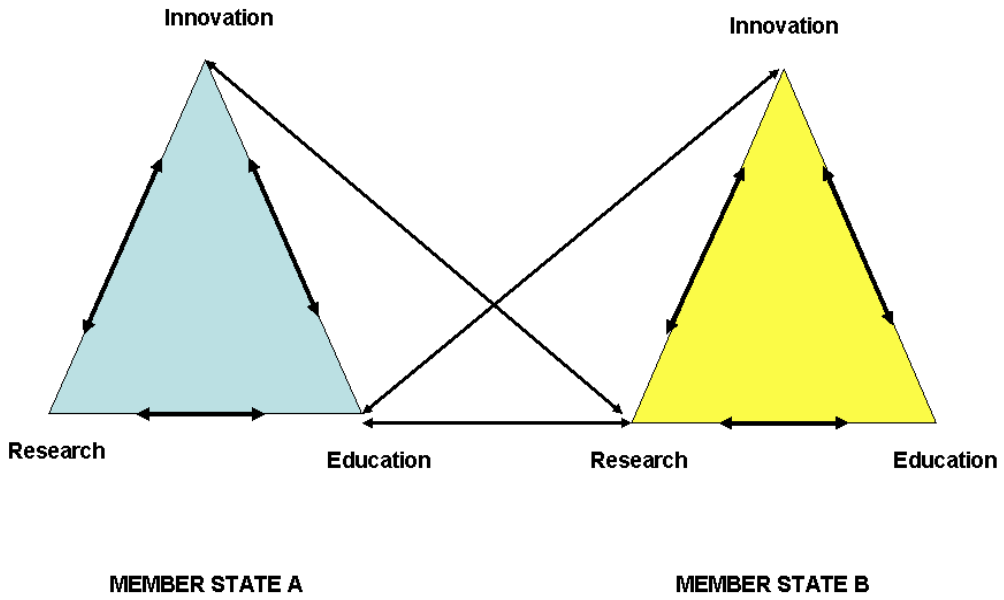
Relevant quotes from the "2020 vision for the ERA" document:

►(…) interactions within the "knowledge triangle" (education, research and innovation) are promoted at all levels, from individual researchers, funding organisations, universities, research institutions to SMEs and multinational companies and are supported by appropriate European mechanisms
►research, education and innovation policies and programmes are jointly designed among public authorities (…) with appropriate involvement of relevant stakeholders
►across the ERA firms (…) can easily engage in research partnerships with a European public research base

Reference to the CREST identification of components

2b. promote strong interactions within the knowledge triangle and public private partnerships in support of industrial competitiveness.

The second component relates to the "*Knowledge Triangle*", i.e. to the interactions and flows between research, innovation[6] and (higher) education, both within individual member states and across the ERA. The main emphasis is on links between research and education and on relationships between the public and the private sector. Knowledge triangle flows have both a national and an EU-wide dimension: they capture links within each national knowledge triangle as well as relationships between different poles of different "national" triangles.
This double dimension is illustrated on the following graph where, for simplicity, only three of the possible six cross-country flows between *different* types of poles are represented.



Component 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"

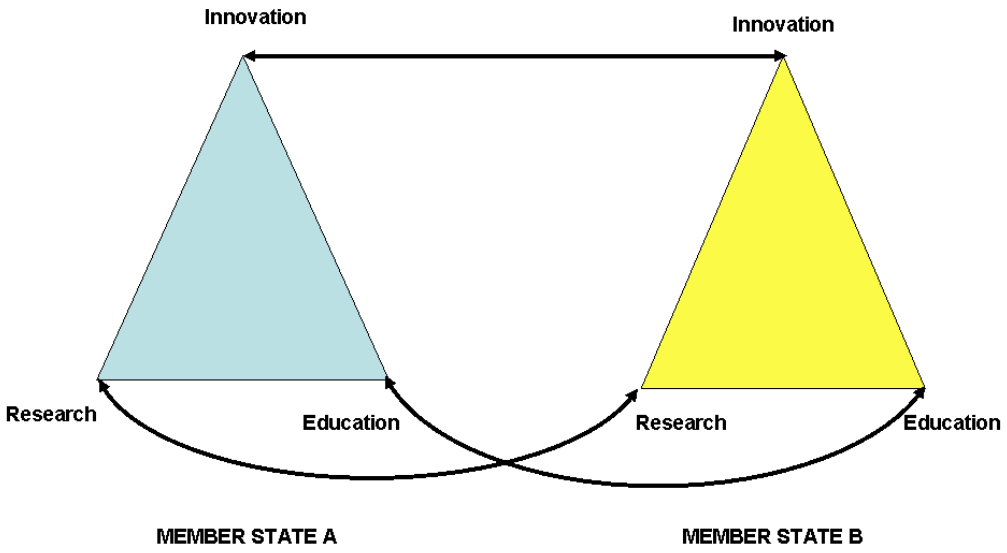
Relevant quotes from the "2020 vision for the ERA" document:
►all players will fully benefit from the "fifth freedom" across the ERA: free circulation of researchers, knowledge and technology
►the ERA provides for open circulation of knowledge across national borders
►establishment and functioning of the transnational markets and networks in which the ERA actors can interact with each other effectively and efficiently
►single labour market which enables mobility between countries and sectors with minimal financial or administrative obstacles
►the ERA contributes to the (…) balanced circulation of scientific talent
►fostering healthy Europe-wide scientific competition
►a significant share of public funding of research is provided through ERA-wide open competition
►fully open, non oriented research funded via the ERC and national funding organisations, which are open to direct applications within and across national borders in the EU
►firms operating in the ERA benefit from a single market for innovative goods and services
►across the ERA firms (…) benefit from attractive framework conditions based on (…) coordinated public procurement
►an open market for contract research

[6] *this includes* product, process, marketing *and* organisational innovation *(see Olso manual, OECD)*

► (firms) fully exploit the possibilities of open innovation through a single market to knowledge including an operational IPR framework
►major research infrastructures in the ERA (…) jointly funded at EU level when appropriate (…) offer equitable access to world class modern research facilities and technology demonstrators
►players are able to access, manage and share knowledge (..) across the ERA using interoperable high performance information systems
►the ERA enables Europe to speak with one voice in international for a with its main international partners;
► public authorities at all levels jointly promote consistency between their RD cooperation activities
►national and regional research systems (…) are developed in a simple and coherent manner

Reference to the CREST identification of components
3. Enhance the effectiveness of knowledge transfer and circulation across ERA
5b. Ensure an adequate mobility of human resources in an open and competitive single labour market for researchers
8. Stimulate international cooperation in science and technology and a wide opening to the world.

The third element of our ERA model concerns the *Fifth freedom* and the related circulation of knowledge across the ERA and with the world. An important concern here is the issue of the EU-wide circulation and allocation of resources (human and financial) for knowledge activities through various markets and coordination mechanisms. The main difference between these flows and those considered under the "knowledge triangle" components is that they are "horizontal", linking similar poles of the knowledge triangle across countries, as shown in the figure below.



Component 4 - *The Societal Dimension*

"the ERA is firmly rooted in society and responsive to its needs and ambitions"

Relevant quotes from the "2020 vision for the ERA" document:
►ERA builds on mutual trust and continuous dialogue between society and the scientific and technological community
► research carried out in the ERA respects the ethical principles of the EU and supports its democratic values as well as the cultures and identities of Member States
►the European publicly supported research and technology base plays a key-role in responding to the needs of citizens and businesses

Reference to the CREST identification of components
1b. Building mutual trust and continuous dialogue between society and the S&T community.
7. Enhance science and technology capacity building in support of cohesion.

The fourth component focuses on the *Societal Dimension* of the ERA, which includes the implication of stakeholders in the setting of policy options and priorities. It involves the development of a trusting relationship between S&T and society based on a permanent dialogue through interactive processes. Issues of equity, cohesion and ethics are central.

Component 5 – *Sustainable development and Grand challenges*

"the ERA is firmly rooted in society in pursuit of sustainable development"

Relevant quotes from the "2020 vision for the ERA" document:
► public authorities (…) develop joint initiatives that give Europe leadership in addressing global challenges and reaching sustainable development goals
►major challenges are addressed by (…) strategic partnerships involving the Community, Member States and Associated States in variable geometry, based on common foresight
►the ERA contributes effectively to the sustainable development and competitiveness of Europe
►major challenges are addressed by high level of public and private investments in research

Reference to the CREST identification of components
1a. Mobilising R&D to address major societal challenges, respond to citizen needs and support policy development,

The fifth and final component concerns the *Grand challenges*, the most prominent of which relating to the pursuit of *Sustainable Development*. The ERA is characterised by the fact that it addresses these Grand challenges at a scale which makes it a world leader in developing the science, the technologies and the innovations relevant for tackling them.

1.1.2 The Four types of concern for the ERA monitoring

The model addresses a second structural dimension of the ERA's complex system: the differentiation between policy action (national and EU-level), ERA making and the ERA effects, namely the attainment of Lisbon objectives. It is a distinction between four types of concern which relate to an input (national or EU-level policy actions)– intermediate outputs (ERA progress) – final outputs (knowledge society – Lisbon objectives) logic. However, as mentioned earlier, the model does not go beyond those structural elements, i.e. it does not specify the causal relationships between each individual element.

In short, then, the ERA monitoring implies the following up of policy actions, checking the evolution of the ERA and identifying the progress towards a knowledge society, i.e. the achievement of the Lisbon objectives. The overall underlying logic is that policies aim at building the ERA, considered as an intermediate objective for achieving the Lisbon objectives.

Type A1 – Member states (MS) level policy actions

This refers to the policies which each MS implements independently in order to have a better performing research and innovation system; this concerns the establishment of instruments, rules and regulations as well as the provision of public resources (orientations and programming, that is, financing functions). It is important to note that these national level policies and actions are also conceived in order to better contribute to the ERA by building institutions and rules which are *ex ante* compatible and 'inter-operable' with the other MS.

Type A2 – EU level policy actions

This refers to the policies which are decided and implemented in an integrated or coordinated way among all MS or some of them (variable geometry) with the purpose of building the ERA. This includes the instruments and budgets of the Commission, but also the instruments and budgets of the MS which are conceived and used jointly. In other words, we are concerned with the EU-level rules and regulations and public resources from Community or national budgets, which are integrated or coordinated at their orientation and programming phase, thus building joint policies. Clearly, there is a continuum between A1 and A2 types as the degree of coordination and joint implementation can differ across policies. The dividing line is therefore somewhat arbitrary.

Type B – ERA progress; state of the ERA

Here, the concern is about the extent to which there is progress in the building of the ERA, seen as an EU-level research and innovation system made of highly interconnected national systems. This type deals with the actual functioning of the knowledge production and innovation system, focussing on research, higher education and innovation activities performed by all actors, public as well as private.

Type C – ERA effects; Lisbon objectives

The concern is about the advent of a knowledge society as defined in the Lisbon objectives, which is the ultimate goal of the policies and of the ERA. We consider here the functioning of the broader societal system, of which the ERA is somehow the engine, but not the totality. In this sense, the ERA is an intermediate between policies (which aim at building it) and the Lisbon objectives (which are an outcome of the ERA).

1.1.3 The framework for the indicators design

From the two structural dimensions of this model, we set up a matrix combining the "components" of the ERA (rows) and the "types of concern" (column) (see table 1). The entries in the table define the various kinds of indicators enabling the characterisation and monitoring towards the ERA and the Lisbon objectives.

This table should not be read in a too mechanistic way. In particular, as noted earlier, the ERA is a system, without systematic one-to-one causality logic to be considered for each column of the matrix. Since ERA is a system, all policy actions contribute one way or another to ERA progress, and all aspects of ERA progress contribute one way or another to the ERA effects and the Lisbon objectives. This is why we cannot distinguish among the first three components – and have to merge them – when dealing with the ERA Effects – Lisbon objectives concern.

This framework will be used in the report not as a straightjacket (we acknowledge the continuum between the lines and, although to a lesser extent, between the columns) – but as a reference, allowing for a mapping to identify the various aspects of the complex system we want to characterise and monitor.

Table 1: ERA monitoring indicators: the overall framework to build the indicators

Components of the system / Types of concern		*Component 1.* K activities in EU [volume & quality]	*Component 2.* Knowledge Δ [local, national, EU-wide]	*Component 3.* Fifth Freedom [conditions for EU-wide mobility and circulation single market for K]	*Component 4.* Societal Dimensions of ERA [Science in society]	*Component 5.* Sustainable Development and Grand Challenges
Type A Policy actions	*Type A1* Member States level	▪ Public RD investment ▪Attractiveness policies ▪ Incentives for private RD investment	▪ MS Knowledge Δ policies ▪ Coordination of Δ policies within MS	▪ Preparation of inter-operability of HE and R systems ▪ Opening public procurement, nat. programmes… ▪ Autonomous R. institutions ▪ Attractive working conditions for researchers	▪ Societal platforms ▪ involvement of stakeholders ▪ TA (Technology Assessment),, foresight	▪ SD policies and actions
	Type A2 EU-level and coordination across MS	▪ FP volume & structure ▪ ERC ▪ Joint programming. & instruments ▪ Speaking with one voice in international fora ▪ ESFRI & instruments	▪ Coordination of Δ policies within EU ▪ EIT (European Institute of Technology) ▪ EU innovation policy and public-private interactions	▪ Common market for knowledge and its production factors across *EU* ▪ High performance EU-wide info systems	▪ Societal platforms ▪ involvement of stakeholders ▪ TA (Technology Assessment), foresight ▪ Ethical principles ▪ Cohesion and equity concerns	▪ Strategic partnerships between community & MS SD policies and actions
Type B ERA progress state of the ERA as EU R-I system		▪ Integration – coordination among MS of public R funds	▪ Intra-MS and intra EU flows between HE-R-I ▪ Public-private interactions & flows	▪ Intra-EU collaboration ▪ Knowledge flows ▪ K production factors circulation intra ERA ▪ Level of competition in EU for K production factors ▪ Access to complementary K & capacities across EU ▪Accessible world class R&D infrastructure.	▪ Science society activities ▪ Common foresights ▪ Social, regional, geographic cohesion	▪ Joint SD activities
Type C ERA Effects – Lisbon objectives towards a K society		▪ K activities (Volume, quality) ▪ World class research ▪ Structural change: - K intensity - Specialisation (sectoral, geographic) - Dynamics of firms ▪ Revealed attractiveness of ERA ▪ Linkages – networks between ERA and the world; openness of ERA to the world			▪ Mutual trust & dialogue between society – S&T ▪ Public attitude to S&T ▪ equity: geographic, social, gender	▪ EU leadership in addressing global challenges and reaching SD goals

K: knowledge ; KΔ : knowledge triangle (higher education – research – innovation) ; Δ policies: triangle policies
MS: member state (and, when relevant, associated countries)
HE: Higher education; R: research; I : innovation; SD: sustainable development

1.2. The three Subsets of Indicators

The comprehensive set of indicators
As specified in our mandate, we propose three sets of indicators. The *comprehensive* set of indicators is meant to provide the information required to foster a detailed understanding of the ERA: how it is evolving, how it is performing and how it responds to various policy initiatives. It also provides a catalogue of indicators that can be used to supplement or replace those that currently appear in the STC report.

The ERA – headline indicators
A second set of 15 to 20 *ERA-headline Indicators* is aimed at policy-makers involved in the post-Lubljana process, both at the level of the EU and at the level of the member states. It is therefore especially important that this section includes indicators for both national and EU-level aspects of the ERA.

The Lisbon-oriented indicators
Finally, an even more limited set of *Lisbon-oriented indicators* is designed for the use of the European Council of Ministers and the Competitiveness Council. These indicators have two main, non-exclusive functions: mobilise and help the Councils select meaningful ERA-related targets. Both the identification of these indicators and the numerical values to be set as targets are political decisions. We will therefore suggest a somewhat broader set of indicators from which 3 or 4 can eventually be chosen.

1.3 The desired properties of Indicators

The term "indicator" is used here in a broad sense.[7] Their usefulness for monitoring and policy-making's purpose, depends on the following characteristics:

• *Reliability/Accuracy*
We cannot rely on indicators that are likely to be affected by large measurement errors. In particular, indicators that might be available quickly but are typically subject to considerable "revisions" over time are not suitable for our purpose.

• *Explanatory power*
There is no point in measuring a variable, however precisely, if it does not have a clear interpretation in terms of "ERA-making", "ERA effects" or ERA-related policies. Ensuring that our proposed indicators are not misinterpreted is a main ambition of this report. This point is complex, since the interpretation of an indicator depends on an explicit or implicit model of the 'functioning' of the system – and there are legitimate disagreements and debates about such functioning (for example about the direction of causalities, the relative importance of various factors, the manner in which actors respond to incentives…). Moreover, the phenomenon addressed is often non measurable directly (for example industrial collaboration) and what is measured in practice is a parameter supposed to reflect the phenomenon, usually called a 'proxy' (for example intensity of patenting) ; the – sometimes limited -relevance of such proxies puts the explanatory power of an indicator at stake. A particular issue of interpretation arises in the case of *composite indicators*, which consist in a weighted sum of several indicators, addressing each an aspect of the phenomenon. For such indicators to be

[7] Note at the outset that we will not make the customary distinction between indicator, marker and descriptor See Benedetto Lepori's report for a definition and further discussion.

meaningful, the weight given to each of the components must reflect their relative impact on the phenomenon of interest. Determining these weights requires complex and data demanding statistical analysis which, in addition, involves opinions and subjective choices, one way or another.

• *Timeliness*
The greater the lag between the time when an indicator is available and the time when the facts/behaviour that it captures occurred, the less useful it is for monitoring purposes. For example, data on scientific publications, permanently updated for documentary purposes, is more "timely" than data on research funding, which results from national surveys..

• *Geographical coverage and comparability*
Comparable versions of the indicator should be available for all (or at least most) ERA countries as well as for countries against which the performance of the ERA might be benchmarked. ERA-wide coverage is important for three reasons. Firstly, we need reasonable coverage to ensure that the ERA-wide summary statistics, such as averages and variances, do not paint a misleading picture of the whole. Secondly, one needs to be able to compare the evolution of individual ERA members over time and to assess the characteristics of ERA-wide flows and networks. Finally, the ERA must be translated at the level of the member states, where many of the ERA-relevant policy decisions are eventually made. We also need reasonable international coverage both for benchmarking reasons and to be able to study the evolutions of the links between ERA and its major economic competitors/partners. It is therefore useful for comparable indicators to be available for the US, Canada, Japan, China, South Korea, India and Brazil. This group of countries will be collectively identified as Other World Regions (OWRs).

• *Time series*
The whole point of ERA monitoring is to assess the direction and pace of *change*. Such change can only be assessed if the indicators are available at reasonably frequent and regular intervals over time. We cannot therefore rely on one-time surveys, however interesting they might be.

• *Availability*
We make the following distinction in this respect. An indicator is *available* if it can be readily found in the desired form from a publicly accessible source (e.g. OECD, Eurostat). By contrast an indicator is said to be only *obtainable* if the underlying data is readily accessible but some work is required to construct the desired indicator from the data. This is often the case for patent-based indicators: the patents and patent applications can be found from the various patent office data bases but classifying this raw data according to the desired criterion (e.g. by nationality of assignee, field of research or gender of the inventors) requires the use of appropriate "search" tools to sift through the data. The label "obtainable" will only be granted to indicators for which this "sifting through" can be done both rapidly and cheaply.

Obviously, there will be trade-offs between those desirable properties. In particular, to cover essential aspects of the ERA we will often have to consider indicators that are not currently available for all member states.

1.4 The Data Sources

Our indicators are drawn from a variety of sources. Most of these are conventional sources providing systematic statistical information such as Eurostat or the OECD. However, these

sources mostly provide us with data at the national or regional levels. While such aggregate data is essential in giving an overall picture of the ERA and in helping assess the evolution of the performance of the member states, it often cuts across the relevant decision units (e.g. multinational corporations), or groups rather different types of activities under the same heading. To get a clear picture of the evolution of the ERA and of the impact of the ERA, aggregate data must therefore be combined with data collected at the level of the relevant decision units. Adding indicators that reflect the behaviour of economic agents such as firms, universities or funding agencies is a main theme of this report. This is one of the reasons why we also rely on company data and on the analysis of web-based data. Each of these two types of source presents advantages and drawbacks.

As an example of agent-based data, *Company data*[8] makes it easier to link inputs to outputs and, therefore, to obtain measures of efficiency. Company data is also available quickly and is generally characterised by a good level of accuracy (validated through auditing). On the other hand, this type of data only captures the *private* costs and benefits of ERA-related activities and policies. In particular, they are of limited help in capturing the "societal" dimension of the ERA. Moreover it is often difficult to map company data into any meaningful "geographical" pattern as the "location" of reported expenses is often dictated more by administrative (location of HQ) or tax considerations than by where the corresponding activities actually took place.

One of the innovations of this report is the introduction of more indicators that rely on data collected through w*ebmetrics*[9]. This approach is very flexible as the web-based data can be quite easily targeted at the agents of interest and filters (e.g. keyword searches) can be designed to capture the relevant aspects of their activities. Webmetrics also offers great potential in providing "softer" indicators to capture some of the ERA Vision's concerns with "societal" issues. The main drawbacks of the approach is the current scarcity of indicators that are collected repeatedly over time in a consistent manner and statistically uncontrollable nature of the information gathered (one never knows the proposition of the 'real world' this is captured in a web search). Because of this, we have stretched our definition of "obtainability" to include indicators based on data *that could be collected from the web at a reasonable cost*. One should also keep in mind that the virtual world reflected by webmetrics indicators has its own biases. For example older or less technology-oriented institutions or citizen will be underrepresented in this digital universe.

[8] See Michael Tubbs'report for an extensive discussion.
[9] See Isidro Aguillo's report for a definition.

2. The proposed indicators

All the indicators presented in this section:

1. Should be computed at the level of each MS plus associated states and at EU level as well as ERA level (including associated states)[10]
2. For at least two dates for analysing trends
3. In relevant cases with comparisons with the US, Japan, China
4. With ratio to account for size, which can be GDP, but also population
5. For the financial indicators, growth rate in real terms is to be systematically considered
6. In relevant cases, the indicators should be computed at the level of sub-groups of countries, which have similar characteristics regarding their research base

We present below the proposed three lists of indicators, from the more restricted (Lisbon related indicators) to the largest one (Comprehensive set).

These lists are inclusive: the Lisbon related list is included in the ERA Headline list, which is included in the Comprehensive set.

This list of indicators is a proposal which may be modified subject to the reflection on indicators inside the ERA groups.

The Lisbon-oriented indicators - OVERVIEW

1 ● PUBLIC INVESTMENTS IN KNOWLEDGE
Indicator: Public funding of R&D and higher education as a share of GDP

2 ● EUROPEAN INTEGRATION OF RESEARCH SYSTEMS (policies)
Indicator: Share of National Public Funds to Trans-nationally Coordinated Research.

3 ● STRENGTH OF THE BUSINESS RESEARCH BASE OF EUROPE
Indicator: Business RD expenditure (BERD) / GDP (or population) and growth in real terms

4 ● TRANSITION TOWARDS A KNOWLEDGE-BASED ECONOMY – STRUCTURAL CHANGE
Indicator: Evolution of the share of total value added contributed by sectors with higher proportions of tertiary educated employees work force

5 ● PRODUCTIVITY OF THE ECONOMY
Indicator: Growth rate of labour productivity per hour both for the whole economy and for the knowledge intensive part of it (as defined for indicator 4, above)

6 ● CONTRIBUTION OF RESEARCH TO ADDRESS GRAND SOCIETAL CHALLENGES
Indicators: (a) Leadership: World shares of scientific publications and European patent office (EPO) applications in the fields of the Grand Societal Challenges
(b) Responsiveness: World shares of scientific publications and EPO applications in the fields of the Grand Societal Challenges / World shares of scientific publications and EPO applications in all fields

[10] in what follows, when referring to the ERA, the expressions EU or member states (MS) are meant to include associated States

The ERA Headline indicators - OVERVIEW

1 ● Public investment in knowledge
Indicator: Public funding of R&D and higher education as a share of GDP

2 ● European integration of research systems (policies)
Indicator: Share of National Public Funds for Trans-nationally Coordinated Research.

3 ● ERA research actors cooperation and cohesion
Indicator: Share of co-publications (as regard to publications and to co-publications) which are with EU partners, among which with the the10 Member States with the lowest R&D intensity

4 ● International cooperation in S & T and opening to the world (ERA Initiative)
Indicator: Share of co-publications (as regard to publications and to co-publications) which are with non- EU partners

5 ● Mobility of researchers and research careers (ERA Initiative)
Indicator: Percentage of Doctoral degree Holders who obtained their doctorate in another EU country and/or have worked in another EU country

6 ● Knowledge transfer between public and private sector (ERA Initiative)
Indicator: Share of publicly-performed research which is financed by business

7 ● Pan-European research infrastructures
Indicator:Amount of funding committed to new pan-European research infrastructure in th framework of ESFRI, ERIC or other transnational agreements

8 ● Activity level in knowledge-producing activities
Indicator: share of R&D expenditures in the Gross domestic product

9 ● Strength of the Business research base of Europe
Indicator: Business expenditure in R&D (BERD) / GDP or population and growth in real terms

10 ● Excellence of the S&T Base
Indicators:
a) World share in top 10% most cited publications divided by world share of publications
b) World share in top 250 most academic research intensive universities

11 ● The Human Resource Base of the ERA
Indicator: Importance of tertiary education graduates in Europe

12 ● Transition towards a knowledge based economy - Structural change (1)
Indicator: Evolution of the share of total value added contributed by sectors with higher proportions of tertiary educated employees

13 ● Knowledge-based innovation
Indicator: Innovators as a percentage of all firms (Innovation of firm based on own research as well as adaptation of knowledge developed by others)

14 ● Firm Dynamics - Structural Change (2)
Indicator: Percentage of high-growth firms.

15 ● International attractiveness of Europe for Business innovation and investment
Indicator: Share of R&D expenditures by non-EU foreign affiliates in total business R&D expenditures and Share of R&D expenditures by non-EU foreign affiliates /their share of VA

16 ● Productivity of the economy
Indicator: Growth rate of labour productivity per hour both for the whole economy and for the knowledge intensive part of it

17 ● Mobilising R&D to address Grand Challenges – Contribution of S&T to sustainable development and competitiveness
Indicators:

(a) Leadership: World shares of scientific publications and EPO applications in the fields of the Grand Challenges
(b) Responsiveness: World shares of scientific publications and EPO applications in the fields of the Grand Challenges / World shares of scientific publications and EPO applications in all fields ('specialisation' in the fields of Grand challenges).

18 ● Confidence of society in science and the S&T community
Indicator: responses in survey expressing interest and confidence of the citizens in S&T

For the Lisbon–oriented indicators list and the ERA-Headline indicators list, we present for each indicator, first the notion expressing what is needed for the monitoring of the ERA ("*Intention")* and then a proposed quantitative characterisation of the notion to be addressed (*"Indicator"),* indicating its source and availability[11]. While the list of "Intentions" is meant to have lasting significance, the relevant indicator for a given notion can (and should) change over time, when new data become available or new ideas of indicators emerge; in a sense, the indicators presented here can be seen as examples of what can be done since there are often several possible indicators for characterising an Intention[12]. Also, for the Lisbon-oriented list we provide recent values of the indicator for both the EU and the USA.

2.1. The Lisbon-oriented indicators (ERA dimension of the Lisbon objectives)

The restricted set of **Lisbon-Oriented indicators** is designed for the use of the European Council of Ministers and the Competitiveness Council. These indicators have two main, non-exclusive functions: mobilise and help the Councils select meaningful ERA-related targets.

We propose six indicators. The first two indicators capture policy actions, at the level of the member states for indicator 1 and through joint programming for indicator 2. As the overarching purpose of the ERA is to foster the development of a knowledge-based economy, our third, fourth and fifth indicators track the strength of ERA in business RD, the relative importance of knowledge-intensive sectors in the economy and the productivity of the economy. Structural change and productivity can be seen as the joint effect of the policies reflected in the first two indicators and other policy levers. The sixth indicator echoes the concerns of both the ERA Vision and the Lund declaration about the ERA's ability to respond to Grand Challenges. Table 8 relates the indicators to the framework presented in section 3.

1 ● PUBLIC INVESTMENTS IN KNOWLEDGE

Intention: Even though not sufficient, adequate funding levels are necessary for knowledge generation. In a knowledge society, public investment in RD (both public and private), higher education and innovation is crucial.

Indicator: Public funding of R&D and higher education as a share of GDP
Computed as: publicly funded GERD (excluding HERD) + public expenditures at tertiary level of education as a share of GDP

Source: OECD, Eurostat

[11] the proposed indicators are mostly either available or feasible in the short term
[12] to be relevant, an indicator needs not cover all the aspects of the notion it pretends to measure; it can measure only one aspect, provided one can make the hypothesis this aspect evolves in the same way as all the non measured (and non measurable) aspects.

Status: Available

Value (2006) EU-27: 1,57 % (Value USA: 2,02 %)

Comments: This indicator is a measure of public investment in the knowledge-based economy. It differs from the traditional measure of GERD/GDP – on which the "3% target" was based – in two respects. Firstly, our indicator only includes R&D expenditures that are under the direct control of policy-makers. The advantage of this approach is that it increases accountability. The drawback is that it does not capture the effect that other policies – such as tax credits or the lowering of administrative costs of innovation – might have on the R&D expenditures of the private sector. We feel that, for Lisbon-oriented indicators, accountability is a greater concern than completeness. The second difference with respect to the "3% target% is that, because of the importance of the knowledge triangle in the current thinking about ERA, we include public expenditure on both research and tertiary education. Ideally, one would also want to include public expenditures on innovation that are not directly related to research (e.g. training), in order to fully account for the third component of the knowledge triangle. Unfortunately reliable data for this element are not currently available. It is worth noting that our proposed indicator corresponds to the publicly financed portion of the 5% target for investment in R&D, Education and Innovation proposed by the Expert Group on the 3% Objective, , but in this case with the inclusion of BERD.

2 ● EUROPEAN INTEGRATION OF RESEARCH SYSTEMS (policies)

Intention: The issue addressed is the "de-fragmentation" of the EU research systems, that is, the coordination or integration and opening-up of the funding of research, which may or may not include integration of performing the research. This refers to National funds for transnationally coordinated Research. Joint Programming (ERA Initiative) is one part of this.

Indicator: Share of National Public Funds to Trans-nationally Coordinated Research.

Source: Eurostat
Status: Under development (2-years time perspective)

Approximate value EU-27: 12 – 15% (approximate value USA: > 50%)

Notes:
- a more comprehensive indicator would be "the share of public funds to transnationally coordinated research", which would then include also FP and RD-related structural funds (for the latter, caution should be exercised to avoid for double counting).
- the opening of national programmes should be accounted for in the future, as well as the differentiation between 'light' joint funding (without transborder financial flows) and 'full' joint funding (with transborder financial flows)
- This indicator may be slightly modified subject to the reflection on indicators inside the ERA group on Joint programming.

Eurostat is working on new sub-categories of the GBAORD (Governments Budget Appropriations or Outlays for R&D). Eurostat and Member States' statistical authorities have tested the widening of GBAORD details in the joint programming area. The new breakdown tested is the total budget funded by the government (state, federal, provincial), as measured by GBAORD directed to trans-national public R&D performers and trans-national public R&D programmes and it has three following sub-categories:

a/ National contributions to trans-national public R&D performers (CERN, ILL, ERSF, EMBL, EMBO, ESO, JRC)

b/ National contributions to Europe-wide trans-national public R&D programmes, with and without cross-border flows of funds (ERA-NETs, ERA-NETs +, ESA, EFDA EUREKA, COST, EUROCORES, Article 169 initiatives)

c/ National contributions to bi- or multi-lateral public R&D programmes established between MSs governments, with and without cross-border flows of funds
The pilot data collection covering 8 countries in May 2009 showed that, although not without extra efforts, these details can be produced within national administrations. Therefore the piloting will be extended covering all EU Member States in autumn 2009. Should it prove to be generally feasible the extended categorisation could be proposed to make mandatory within ESS.
Should the wide implementation of the new sub-categories be successful, a firm and determined commitment of Eurostat and Member States' statistical authorities is called for.

3 ● STRENGTH OF THE BUSINESS RESEARCH BASE OF EUROPE

Intention: This strength is measured by the business expenditures in R&D and represents an important aspect of the innovation potential.

Indicator: Business expenditure in R&D (BERD) / GDP or population and its growth in real terms

Source: OECD, Eurostat
Status: Available

Value (2007) EU-27: 1,18 % (Value USA: 1,92 %)
Growth 2006-2007 EU-27: 3,9% (Growth USA: 4,3%)

note: we use the term 'business' in reference to the OECD / Frascati manual terminology

Comment: It should be noted that business R&D intensity reflects industrial specialisation patterns. Country rankings of business R&D intensity might be misleading if account is not made of industrial structures.

4 ● TRANSITION TOWARDS A KNOWLEDGE-BASED ECONOMY – STRUCTURAL CHANGE

Intention: The knowledge economy develops largely through the structural evolution of economic activities towards more knowledge-intensive ones; this can be monitored by observing the evolution of the relative weight of the set of most knowledge intensive activities in the economy

Indicator: Evolution of the share of total value added contributed by sectors with higher proportions of tertiary educated employees

Source: Eurostat [see annex 6]
Status: Under development (for 2010)

Comments: Since the main goal is to accelerate the transformation of the ERA into the leading knowledge-based economic area, some measure of structural change is appropriate. To share of value added captures the notion that an increasing share of EU "wealth" should come from the "knowledge economy". The traditional "High-tech/Low Tech" classification of activities does not fit our purpose since it would not reflect the spread of knowledge to a broader range of sectors, including services and more traditional manufacturing sectors. Instead, the proposed indicator relies on a new classification that will be computed by *Eurostat.* It is obtained by ranking sectors of activity by the intensity of their use of personnel with tertiary education. This ranking is done at the level of the EU as a whole. Based on the ranking, sectors will be grouped into three categories (high, medium

and low) that can then be applied to every Member State. Two sets of numbers would be reported from each Member state: the proportion of activities found in each of the three categories and the actual "tertiary education" intensity of each of the three categories in the member State. The first set of number give us a good picture of structural change as defined above. The second set of number allows us to track over time any knowledge-deepening of knowledge within each of the EU-wide categories.

note: the building of the categories of sectors could also be done through analysis at firm level (characterisation of the sectors by the average % of the employees having tertiary education at firm level statistics).

New sectoral classification based on the intensity of the tertiary educated employed

The necessary data could be extracted from Eurostat data base (Labour Force Survey data) for compiling a new classification using knowledge intensity. It would be measured in terms of 'Number of persons employed, aged between 25 and 64, with tertiary education as a share of total number of employed in the same age group (between 25 and 64)' by economic activity (likely at 3 digit of NACE)'.

Availability of the sectoral value added data

Data on value added are readily available in Eurostat data base (Business Statistics data) at 3 digit and/or 4 digit level of NACE Rev. 1.1 (for NACE Sections C to K). I.e. this could be used in the context of the new classification (above) or old classification (high-tech manufacturing / knowledge intensive services) as far as these classifications being overlapping.

Availability of the sectoral business demography data

5 ● PRODUCTIVITY OF THE ECONOMY

Intention: The Intention is to get a synthetic measure of the overall capacity of the economy to provide economic and social benefits to the people; of course distribution aspects would need to be considered to address the issue in a more complete way. This proposed indicator incorporates indirectly the impact of the knowledge economy on competitiveness through innovation.

Indicator: Growth rate of labour productivity per hour both for the whole economy and for the knowledge intensive part of it

Source: Eurostat
Status: available

Value	*EU-27: 32.9*	*(Value USA: 43.8)*	*(2007)*
Growth real terms	*EU-27: 1.3%*	*(Value USA: 1.7%)*	*(2006-2007)*

Comment: The ultimate goal of the ERA is to contribute to the improvement of the welfare of its citizens. In a world of global competition, this welfare is significantly affected by the overall competitiveness of the EU and its Member States. Labour productivity is a broad measure of competitiveness, the relevance of which is supported by a strong body of theoretical and empirical work.
It would be fruitful to compute labour productivity both in terms of hours worked and in terms of persons employed. The first measure takes into account the fact that EU workers might take a portion of their increased productivity as extra leisure, while the second helps assess the evolution of the overall production potential of a country or region. This indicator should of course be used to compare the EU and its Member States to other regions of the world.
The knowledge intensive part of the economy would be determined based on intensity in tertiary educated workers, as defined for the previous Lisbon-oriented indicator.

6 • CONTRIBUTION OF RESEARCH TO ADDRESS GRAND SOCIETAL CHALLENGES

Intention: Mobilising R&D to address Grand Societal Challenges and fostering the contribution of S&T to sustainable development and competitiveness are the overarching goals assigned to research policy in the ERA 2020 Vision. Optimally, a consistent methodology should be applied for all areas where EU-level agreements will be made for Grand Societal Challenges. Leadership and responsiveness of RD in the fields of the Grand Societal Challenges are aimed at.

Indicators:

(a) Leadership: World shares of scientific publications and European patent office (EPO) applications in the fields of the Grand Societal Challenges

(b) Responsiveness: World shares of scientific publications and EPO applications in the fields of the Grand Societal Challenges / World shares of scientific publications and EPO applications in all fields ('specialisation' in the fields of Grand Societal Challenges).

Source: Bibliometric indicators (WoS) + Eurostat
First area available: Climate change; data on environmentally related energy technology (SET-Plan themes)
Status: Under development (short term) by Eurostat

Comments:
- The proposed indicator has been recently established by *Eurostat*. The indicator should be obtained in two forms. Under the first form, one would divide the share of publications among the total number of EPO applications *in the same field*. This makes it possible to gauge the EU's *leadership* in responding to Grand Societal Challenges. Under the second form, the share of environmental-related patent applications would be in terms of the total number of EPO applications filed by agents from the EU or from a given Member State ('specialisation' indicator). By showing how readily innovative effort is re-directed, this provides a measure of *responsiveness* of research to the emergence of Grand Societal Challenges.
- In practice, the definition of the boundaries of the themes in terms of publication and patent classifications should be made by an expert group including S&T specialists, bibliometric classification experts and participants in the definition of the themes of the Grand Societal Challenge under study
- The Grand Societal Challenges to be considered are those chosen as such by the Council and which should benefit from Joint Programming and coordination of efforts. The indicators proposed can fairly easily be computed for the Grand Societal Challenges as they are identified

Note: a key-issue in addressing Grand Societal Challenges is the ability to perform multidisciplinary research; this should be accounted for in the future.

EPO applications and Grand Societal Challenges
Areas of investigation covering 'Patents in Nuclear Technology', 'Patents in Wind Energy', 'Patents in Environmental related Energy' are examples of areas to be investigated based on the identification and allocation of relevant International patent classification (IPC) codes to each selected technological field.
The test extractions and setting up the regular production flow would be rather straightforward for these (type of) areas as long as the defined area fits into the International patent classification and the selection of IPC codes is validated at appropriate fora.

table 2 – mapping of the Lisbon-oriented indicators

Components of the system / Types of concern		*Component 1.* K activities in EU [volume & quality]	*Component 2.* Knowledge Δ [local, national, EU-wide]	*Component 3.* Fifth Freedom	*Component 4.* Societal Dimensions of ERA[Science in society]	*Component 5.* Sustainable Development and Grand Challenges
Type A Policy actions	*Type A1* Member States level	**1 ● Public investment in knowledge**				
	Type A2 EU-level and coord.across MS	**2 ● Integration of research systems**				
Type B ERA progress state of the ERA as EU R-I system						
Type C ERA Effects – Lisbon objectives towards a K society		**3 ● Strength of the business research base in Europe** **4 ● Transition towards a knowledge based economy Structural change** **5. Productivity of the economy**			**6 ● Mobilising RD to address Grand Societal Challenges - Contribution to sustainable development and competitiveness**	

2.2. The ERA Headline indicators

The set of **ERA-headline *Indicators*** is aimed at policy-makers involved in the post-Ljubljana process, both at the level of the EU and at the level of the member states.

Particular attention is therefore given to indicators that help track the implementation of the ERA policy initiatives and their direct effects. Therefore, a significant number of the proposed indicators respond to the following questions: Do researchers move across the ERA? Is knowledge being effectively transferred between the public and the private sector? Is the relative importance of joint programming increasing and is there evidence of an increase in cooperative research? Do we observe an increase in joint infrastructure programming? Is the ERA proving to be increasingly attractive to foreign researchers and foreign innovative firms? Our proposals here also serve as input to the specific working groups on each ERA initiative set up in the framework of CREST.

In building our list, we used each of the four types of indicators that we defined above. Type A1 indicators refer to national policy levers, while type A2 indicators reflect policies that are jointly determined or coordinated across Member States. Type B indicators that help monitor "ERA making", i.e. the increased integration of the European research system. Finally type C indicators capture "ERA Effects", understood as the impact of the ERA on the Lisbon objectives. The idea is that an integrated assessment of all the 16 proposed indicator provides a good synthesis of progress towards the European Research Area.

Note: in what follows the notation EU includes States which are associated to the Ljubljana process.

NATIONAL POLICY (Type A1)

1 ● Public Investment in knowledge

Intention: Even though not sufficient, adequate funding levels are necessary for knowledge generation. In a knowledge society, public investment in R&D (both public and private), higher education and innovation is crucial.

Indicator: Public funding of R&D and higher education as a share of GDP
Computed as: publicly funded GERD (excluding HERD) + public expenditures at tertiary level of education as a share of GDP

Source: OECD, Eurostat
Status: Available

Comment: See section 4.1 on Lisbon-oriented indicators.

JOINT/COORDINATED POLICIES (Type A2)

2 ● European integration of research systems (policies)

Intention: The issue addressed is the "de-fragmentation" of the EU research systems, that is, the coordination or integration and opening-up of the funding of research, which may or may not include integration of performing the research. This refers to National funds to transnationally coordinated Research. Joint Programming (ERA Initiative) is one part of this.

Indicator: Share of National Public Funds for Trans-nationally Coordinated Research.
Source: Eurostat
Status: Under development (2-years time perspective)

Comment: See section 4.1. on Lisbon-oriented indicators. This indicator may be slightly modified subject to the reflection on indicators inside the ERA group on Joint programming.

ERA MAKING (Type B)

3 ● ERA research actors cooperation and cohesion

Intention: ERA implies a high degree of interaction and cooperation of research actors across the borders of the MSs but also in a cohesive way, i.e. involving all MSs

Indicator: Share of co-publications (as regard to publications and to co-publications) which are with EU partners, among which with the the10 Member States with the lowest R&D intensity
Source: Bibliometric indicator
Status: Available

Comments: A core notion of the ERA project is that increased cooperation across the ERA would significantly improve the performance of the European research system. Because of this, even though the ERA also encourages greater opening to the rest of the world, one would still want to see – initially at least – a greater growth of interaction within the ERA than between the ERA and the outside world.
A limitation of the indicator is that it is looks mostly at the interaction within public research. In this respect, indicators built on patents co-invention and co-ownership would be interesting, although their interpretation

would raise other difficulties. It should also be noted that, the indicator will tend to be larger for smaller countries since, for them, there are relatively more opportunities to find collaborators outside their frontiers than within.[13] As a result the emphasis should mostly be on *changes* in the value of these indicators.

Note: Interesting indicators are in development at IPTS, such as homogeneity in the international distribution of co-publications or cross-countries knowledge spillovers

4 ● International cooperation in S & T and opening to the world (ERA Initiative)

Intention: The ERA is a major partner for researchers worldwide and its further opening to the world is a major goal. All aspects of international cooperation are relevant, including mobility of knowledge embodied in researchers, scientific cooperation and technological cooperation.

Indicator: Share of co-publications (as regard to publications and to co-publications) which are with non- EU partners
Source: Bibliometric indicator
Status: Available

Comment: This indicator is a proposal which may be modified subject to the reflection on indicators inside the ERA group on this ERA initiative. This indicator is related to the previous one. This time, we capture increased cooperation with researchers from non-EU countries.

5 ● Mobility of researchers and research careers (ERA Initiative)

Intention: A central feature of the ERA and its "fifth freedom"dimension, is the opening of the borders of MSs to the ERA-wide mobility and also to the international mobility of researchers. There are two aspects therefore: the intra-EU mobility and the extra-ERA flows. Optimally, we would also like to know how mobility is linked to the career paths of the researchers. However, no data is currently available on this.

Indicator: Percentage of Doctoral degree Holders who obtained their doctorate in another EU country and/or have worked in another EU country
Source: OECD - Eurostat
Status: Under development (progressively available for 2010 and 2011)

Back-up: Share of Doctoral candidates from other EU and extra-EU countries (as % of total number of doctoral candidates)

Comment: This indicator is a proposal which may be modified subject to the reflection on indicators inside the ERA group on this ERA initiative. The proposed indicator is currently available for the subset of countries that fully implement the CDH project (*OECD – Eurostat*). If an indicator that is immediately available for all States is required then one can fall back onto our back up indicator. Even in this case, we would recommend that both indicators be presented for the countries for which they both exist. Like the two previous indicators, this indicator can be affected by the relative size of the ERA countries. However, as explained for the ERA indicator 3, this bias is not be very large.

[13] In the case of ERA countries, the bias is likely to be relatively small. If x_{min} is the population share of the smallest economy and x_{max} the population share of the largest economy, the maximum bias, in a benchmark where researchers choose their partners randomly, would be $(1-x_{min})/(1-x_{max})$. Even taking $x_{min} = 0$ and using the $x_{max} = 0.165$, which theweight of germany in the EU's pop[ulation, the maximum bias in any pairwise comparison of countries would be less than 20%.

Notes:
- administrative data (i.e. university employment files for example) contains detailed data, but is inaccessible because of privacy protection laws. An interesting solution would be to aggregate the data sufficiently to protect privacy. The use of such 'micro-aggregated' data, at the level of the research institution would improve our knowledge of mobility and career patterns
- mobility between public research and industry is an important aspect to measure. Again the CDH project would make this possible.
- interpretation must be careful, since increased mobility may also mean increased proportion of precarious jobs
- work is starting on the feasibility of having data on mobility and the careers of researchers as opposed to the doctorate holders covered by the CDH project (see annex on the MORE project)
- as shown by the report on ERA monitoring of Mobility schemes of IPTS, it is useful to distinguish between ERA integration through intra EU mobility, openness of national institutions and the attractiveness of a country or institution.

CDH - Careers of Doctorate Holders Survey

Careers of Doctorate Holders (CDH) is a project of Eurostat and Member States' statistical authorities, the OECD and UIS. The statistics on Careers of Doctorate Holders is intended to measure demographic, employment and career characteristics of these persons, as well as their international mobility and driving forces behind this mobility.

The Careers of Doctorate Holders survey for the reference year 2006 (CDH 2006) was the first coordinated round of this data collection, and thus had a certain element of 'pilot exercise'. CDH 2006 covered 23 countries, among which 18 Member States. The target population for the CDH survey consists of persons who, in the reference year, fulfill the following criteria:
- Have an education at ISCED 6 level, obtained anywhere in the world (i.e. research qualification holders, mainly doctorate holders);
- Live (permanently or non-permanently) in the survey country, and;
- Are not older than 69 years in the reference year.

The CDH statistics try to answer questions about the international mobility of highly skilled workers, as frequently discussed under the headings of 'brain drain' / 'brain gain' / 'brain circulation'. In addition, these statistics address whether the quality and the number of research qualification holders educated correspond to the needs of the labour market. Furthermore, the issue of whether the national labour markets remain the main frame for this highly skilled group is addressed. Other issues are how well the skills of the highest educated are used by the society, as well as how attractive different careers are to the research qualification holders.

The work for collecting the CDH data for reference year 2009 has started. The common questionnaire, methodological guidelines and the model for the output tabulations have been widely reviewed and discussed between the three institutions (Eurostat, OECD and UIS) and within the group of countries involved.

Should the wide implementation of the CDH 2009 (and beyond) be successful, a firm commitment of Eurostat and Member States' statistical authorities is called for. Should the data prove to be generally feasible and solid for the policy need the CDH statistics could be proposed to make mandatory within ESS.

6 ● Knowledge transfer between public and private sector (ERA Initiative)

Intention: The "knowledge triangle" is largely about integration and articulation between the knowledge-based activities of the public and the private sector. This is a broad area comprising many elements such as cooperation, patenting and licensing, mobility of human resources and funding actions between public (universities and PROs) and private research.

Indicator: Share of publicly-performed research which is financed by business
Computed as: HERD financed by business + GOVERD financed by business / BERD
Source: OECD, Eurostat

Status: Available

Comment: This indicator is a proposal which may be modified subject to the reflection on indicators inside the ERA group on this ERA initiative. [14] Although straightforward, one should note that this indicator does not include publicly-performed research financed by entities that are not classified as "business". Comparisons among member states will be relevant here.

Alternative 1:
Indicator: share of innovative firms collaborating with public research
Source: CIS (Community innovation Survey)
Status: available

Alternative 2:
Indicator: mobility of people between public and private sector
Source: CDH (Careers of doctorate holders survey)
Status: not available (in development)

7 ● Pan-European research infrastructures (ERA initiative)

Intention: Express the progress made in implementing the roadmap for research infrastructures built jointly by the Commission and the member states in the context of ESFRI.

Indicator: *Amount of funding committed to new pan-European research infrastructures in the framework of ESFRI, ERIC or other transnational agreements*
Source: *Commission, Eurostat*
Status: *Basic data available in principle but the indicator needs to be better specified (referred to either the overall roadmap or to the amount spent on research infrastructures by member-states…) and actually computed*

ERA EFFECTS (Type C)

8 ● Activity level in knowledge-producing activities

Intention: Monitor the overall level of R&D activities; this refers to the objective of investing 3 % of GDP in R&D

Indicator: share of R&D expenditures in the Gross domestic product
Computed as: GERD/GDP (or population, or in growth in real terms)
Source: OCDE, Eurostat
Status: Available

Comment: When presenting our first indicator (in section 4.1), we mentioned that it was not meant to capture private R&D. By contrast, this indicator captures all R&D expenditures irrespective of the source of funding or of the type of agent carrying out the research,.

9 ● Strength of the Business research base of Europe

[14] A specific Expert group focused on Knowledge transfer recommends core performance indicators for the PROs in areas such as: research agreements, invention disclosures, patent applications, patent grants, licenses executed, license income earned and spin-offs established.(see "Metrics for knowledge transfer from Public Research Organisations in Europe", Expert group to the European Commission, 2009.

Intention: This strength is measured by the business expenditures in RD and represents an important aspect of the innovation potential.

Indicator: Business expenditure in RD (BERD) / GDP or population and its growth in real terms
Source: OECD, Eurostat
Status: Available

10 ● Excellence of the S&T Base

Intention: Scientific excellence is the basis for both attractiveness and technological breakthroughs. Excellence should be monitored both in terms of (national and EU) averages and in terms of research and HE institutions.

Indicators:
a) World share in top 10% most cited publications divided by world share of publications
Source: Bibliometric indicator
Status: Available

Comment: The indicator measures the share in the top 10 % publications worldwide as compared to the share in all publications; it is a measure of the 'specialisation' in the most cited publications set.

b) World share in top 250 most academic research intensive universities and, if possible, PROs; at MS level this world share should be normalised by population and/or GERD
Source: Several private databases are available ranking universities and public research organisations. The Leiden ranking is preferred.
Status: Available

Comment: The Leiden ranking is preferred because of its methodological rigour. In particular it controls effectively for the different patterns of specialisations of universities. On the other hand, it only includes research universities, ignoring PROs and technical universities: more inclusive, yet methodologically sound rankings should be checked, such as for example the Scimago institutions ranking
.

11 ● The Human Resource Base of the ERA

Intention: A full picture of the size of the knowledge triangle in Europe requires data on the population in Europe which has a high knowledge level. This includes both research and knowledge-based potential or active work force in private and public sectors.

Indicator: Importance of tertiary education graduates in Europe
Computed as: Percentage of population aged 25 – 34 with tertiary education.
Source: Eurostat, OECD
Status: Available

Alternative: indicators focusing on the change in tertiary educated graduayes most likely to take part in research activities.
Indicator: new doctoral graduates in % of population
Status: Available

Comment: This indicator provides a measure of the top-end "output" of the educational systems of the EU and its Member States. It also covers an important aspect of absorption capacity and is a significant element of the attractiveness of the EU and Member States.

12 ● Transition towards a knowledge based economy - Structural change (1)

Intention: The knowledge economy consists largely in the structural evolution of the activities towards more knowledge intensive ones; this can be apprehended in observing the evolution of the relative weight of the most knowledge intensive activities in the economy

Indicator: Evolution of the share of total value added contributed by sectors with higher proportions of tertiary educated employees
Source: Eurostat [see annex 6]
Status: Under development (for 2010)

Comment: See section 4.1 on Lisbon-oriented indicators.

13 ● Knowledge-based innovation

Intention: Characterize and compare the countries in terms of their % of innovative firms in various modes of innovation.

Indicator: *innovators as a percentage of all firms (Innovation by firms based on own research as well as adaptation of knowledge developed by others)*
Source: *CIS – developed by OECD ('"output-based innovation modes")*
Status: *Available*

Note:
Composite indicator (combining different questions of the CIS-survey). It combines source of knowledge and the degree of novelty of the products. It tries to capture to what degree firms in the countries are either :
- new to market international innovators (= innovations based on own research and new to the international market)
- new to market domestic innovators (= innovations based on own research but only new to the domestic market);
- international modifiers (= innovations based on own research already existing on the international market);
- domestic modifiers (= innovators only operating on domestic markets; products exist already on international research)
- adopters (innovations being developed by others).

14 ● Firm Dynamics - Structural Change (2)

Intention: Capturing the process of "creative destruction" whereby innovating firms progress at a quicker pace than the average. To understand structural change through firm dynamics we would optimally need to integrate or cross-analyse in one indicator firm demography with knowledge-intensity variables. This is not currently feasible.

Indicator: Percentage of high-growth firms.
Source: Eurostat.
Status: Available

Comment: According to a widespread view, small firms are an important source of innovation. Their ability to gain access to capital and quickly develop to bring innovations to market is therefore an important aspect of a knowledge society. A related view is that much of the perceived gap between the innovation performance of the US and that of the EU can be accounted for by the fact that small innovative US firms grow faster than their EU counterparts. The purpose of this indicator is to keep track of such firm dynamics. In the absence of reliable indicators of the specific progress of younger or more innovative firm, the best proxy available is the percentage of firms that has grown by more than a given percentage threshold. One advantage of this broader indicator is precisely that it is not tied too narrowly to one specific view of the innovation process. In particular, the

indicator would also paint a positive picture for a system which is also quite innovative, but where innovations keep occurring within well established companies.

Notes:

- an indication of the size of the firms concerned would be important. In fact firms that are below some minimum size should not be included. The Eurostat data excludes firms with fewer than 10 employees.
- We do not restrict to firms in knowledge-intensive sectors. There are three reasons for this. Firstly, there is currently no breakdown of high growth firm according to the knowledge intensity of its main sector of activity. Secondly, allocating a given firm to a specific sector activity is a notoriously perilous exercise. Finally, by not choosing a set of sectors a priori, we are in a better position to notice where dynamic behaviour is emerging.

Business demography data by economic activity are available for Industry only at sub-Section level (two letters) of NACE Rev. 1.1 (Business Statistics data) thus it is not possible to produce aggregates for the new classification (above) or old classification (high-tech manufacturing). For Services data are available at 2 and/or 3 digits of NACE Rev.1.1., so there situation is better for the new classification (above) or old classification (knowledge intensive services). Data on business demography indicators are available only at country level but are not available for the aggregate EU-27.

15 ● International attractiveness of Europe for Business innovation and investment

Intention: The ERA should be an attractive place for firms to invest in R&D. For a comprehensive understanding of the attractiveness of Europe for business knowledge investments we would need to have data on inflows and outflows not only for US firms but also for firms from larger Asian countries and other major economies of the world.

Indicator: Share of R&D expenditures by non-EU foreign affiliates in total business R&D expenditures and Share of R&D expenditures by non-EU foreign affiliates / their share of VA
Source: Eurostat
Status: Available

Comments: The split between EU and Non-EU affiliates is not currently computed. However, we understand that member States would be readily able to compute such a split if asked by Eurostat, The same comment applies to the alternative indicator below.

Alternative:
Indicator: BERD financed by abroad (non-EU)
Source: Eurostat
Status: Under development (2 years perspective)

Back-up: R&D expenditures of affiliates of US parent companies abroad for EU, Canada, Japan and China.

Comment: The EU/Non EU split is currently not available for the proposed indicator or its alternative. While this is being developed, we propose to use the behaviour of US companies as a benchmark. Besides its availability, this back up indicator offers one significant advantage: it show how one set of firms facing fairly homogenous conditions chooses between their main alternatives for foreign R&D investment. On the other hand, it only gives us information about the attractiveness of the EU as a whole, since there is no breakdown by Member State.

16 ● Productivity of the economy

Intention: to get a synthetic measure of the overall capacity of the economy to provide economic and social benefits to the people; of course distribution aspects would need to be considered to address the issue in a more complete way. This proposed

indicator incorporates indirectly the impact of the knowledge economy on competitiveness through innovation.

Indicator: Growth rate of labour productivity per hour both for the whole economy and for the knowledge intensive part of it

Source: Eurostat
Status: available

Comments: see section 4.1 on Lisbon-oriented indicators

17 ● Mobilising R&D to address Grand Challenges – Contribution of S&T to sustainable development and competitiveness

Intention: Mobilising R&D to address Grand Societal Challenges and fostering the contribution of S&T to sustainable development and competitiveness are the overarching goals assigned to research policy in the ERA 2020 Vision. Optimally, a consistent methodology should be applied for all areas where EU-level agreements will be made for Grand Societal Challenges. Leadership and responsiveness of RD in the fields of the Grand Societal Challenges are aimed at.

Indicators:

(a) Leadership: World shares of scientific publications and European patent office (EPO) applications in the fields of the Grand Societal Challenges

(b) Responsiveness: World shares of scientific publications and EPO applications in the fields of the Grand Societal Challenges / World shares of scientific publications and EPO applications in all fields ('specialisation' in the fields of Grand Societal Challenges).

Source: Bibliometric indicators (WoS) + Eurostat

First area available: Climate change; data on environmentally related energy technology (SET-Plan themes)
Status: Under development (short term) by Eurostat

Comment: See section 4.1 on Lisbon-oriented indicators.

18 ● Confidence of society in science and the S&T community

Intention: Apprehending the state of the opinion of citizens regarding science and scientists, which also implies a good knowledge of the needs and expectations of Europe's citizens in science.

Indicator: responses in survey expressing interest and confidence of the citizens in S&T
Source: Eurobarometer
Status: Feasible; periodic repetition of survey to be agreed.

Comment: The following survey by Eurobarometer, published in 2001, addresses quite well the issue at stake here: 'Europeans, science and technology', Eurobarometer 55.2, Dec. 2001.
The questions in the survey have the following headings: Information, interest, knowledge; Values, science, technology ; Responsibilities and accountability of scientists ; Levels of confidence ; Young people and the scientific vocation crisis ; European scientific research.
The suggestion here is to perform a yearly survey for a short selection of questions.

Note: This could be an area where web-based analysis and indicators could be relevant, in particular to address specific "hot topics"

Table 3 organises the ERA-Headline indicators according to the systemic framework that we developed in section 3. This framework combines the four types of indicators mentioned above with the five main components of the ERA "system". The reader who is interested on the rationale beyond this approach is referred to section 3.

table 3 – mapping of the ERA headline indicators

Components of the system / Types of concern		*Component 1.* K activities in EU [volume & quality]	*Component 2.* Knowledge Δ [local, national, EU-wide]	*Component 3.* Fifth Freedom	*Component 4.* Societal Dimensions of ERA [Science in society]	*Component 5.* Sustainable Development and Grand Societal Challenges
Type A Policy actions	*Type A1* Member States level	**1 ► Public investment in knowledge** **4 ► Excellence of the S&T base**				
	Type A2 EU-level and coord. across MS	**2 ► European integration of research systems (policies)**				
Type B ERA progress state of the ERA as EU R-I system			**6 ►Knowledge transfer between public and private sector**	**3 ► ERA actors cooperation and cohesion** **4 ►International cooperation in S&T and wide opening to the world.** **5 ►Mobility of researchers and research careers.** **7 ► Pan-European research infrastructures**		
Type C ERA Effects – Lisbon objectives towards a K society		**8 ► Activity level in knowledge – production activities** **9 ► Strength of the business research base in Europe** **10 ►Excellence of the S&T base** **11 ►Human resource base of the ERA** **12 ►Structural change 1: Transition towards a knowledge-based economy** **13 ► Knowledge based innovation** **14 ► Structural change 2: Firms dynamics** **15 ►International attractiveness of Europe for Business innovation and investment.** **16 ►Productivity of the Economy**			**18 ►Confidence of society in science and the S&T community**	**17 ► Mobilising RD to address major societal challenges. Contribution of S&T to sustainable development & competitiveness (Grand Societal Challenges)**

2.3 The Comprehensive Set of Indicators

The purpose of this section is to propose a comprehensive set of indicators, that is, covering in a systematic way the entries of the overall framework proposed above. This would allow, in principle, an understanding of the development of the various issues related to the STI policies in the European context, but also an analysis in terms policy actions, ERA building and Lisbon objectives. This comprehensive set of indicators aims at contributing to the future

versions of the STC report. In the main text of this report we only propose about 60 indicators that are readily available or quite easily obtainable.

Remarks:
- Many potentially useful indicators can be found in the expert reports which accompany this report. They also include a more thorough discussion of the proposed indicators.
- A more systematic discussion of how ERA monitoring would benefit from investments in additional data collection appears in annex 1.
- A longer list of useful indicators – including some more tentative ones – can be found in annex 5.

In any case, the set of indicators proposed here should not be seen as a stabilised or closed list, but as possibilities and examples.

Component 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"

Table 4: Knowledge Activities in the EU

Components of the system / Types of concern		*Component 1.* K activities in EU [volume & quality]
Type A Policy levers/ actions	*Type A1* Member States level	• GERD Financed by Government as % of GDP. *Eurostat, OECD* * • Tertiary education expenditures as % of GDP. *OECD* * • Assessment of public financial support and tax incentives for private R&D**, *0ECD*
	Type A2 EU-level and coordination across MS	• National Public Funding to Trans-nationally Coordinated Research**, Eurostat • ***Amount of funding committed to nw pan-European research infrastructures in the framework of ESFRI, ERIC or other transnational agreements*** • Cost of obtaining and maintaining a patent (EPO, JPO, USPTO)*
Type B ERA progress state of the ERA as EU R-I system		• Number of participations in European programmes per thousand researchers (106)* • Network statistics for FP6 collaborations (based on data for map p.100 of STC report 2008).*
Type C ERA Effects – Lisbon objectives towards a K society		see table 2

Indicators that are already found in the 2008 STC report are noted with the corresponding page number in brackets
* new indicators already available or easily obtainable
** new indicators likely to be available soon or are currently obtainable but with some work

Table 4 displays the indicators related to knowledge activities in the EU. A first set of A1 indicators measures the intensity of governmental investment into public R&D and higher education. Including spending on higher education is helpful, for two reasons. Firstly higher education is a crucial source of skilled personnel for both the public and the private sector. Secondly, with currently available data, it is hard to separate the part of education HE funding that is related to research from the part that finances teaching activities so that GERD data does not capture the resources spent on R&D in the HE sector very well. These indicators of public investment are complemented by a measure of the quality of the innovation environment provided by a broad set of other government policies such as tax incentives.

Ideally, we would also like to capture the manner according to which such funding is allocated. Finding indicators that capture various aspects of funding would be useful for two reasons. Firstly, the competitive allocation of research resources is one of the basic ERA mechanism identified in the ERA Vision. Secondly, member states differ widely in the way they distribute research funds. Over time, such diversity of funding models should make it possible to identify the approaches that work well so that some "best practices" can be shared. Unfortunately, good measures of these aspects of national funding systems are not currently widely available. The prospects for the development of such indicators are discussed in annex 1, as well as in Benedetto Lepori's report.

Our first A2 indicator reflects the level of EU or coordinated research funding. This indicator is under development by *Eurostat* and should be available soon. Investments in the context of the ESFRI (European strategic forum for research infrastructures) are added since they correspond to an ERA initiative and the related funding are not necessarily included in the above category of "transnationally coordinated research". We also include the international comparison of patenting costs since the much greater cost of obtaining and maintaining EPO patents is often seen as a significant barrier to innovation. One should however keep in mind that making patents more expensive is also a manner of reducing the number of patent granted, limiting the emergence of the "patent thickets" that may hamper the commercial exploitation of intellectual property. Type B indicators capture the actual involvement of national research institutions in jointly designed projects". More information about the "network statistics" referred to in one of the indicators can be found in our discussion of Table 3 and in the annex 3. To reflect the fact that the economic effects of ERA are jointly determined by the first three components of our ERA "system", type C indicators relating to these three components are presented together later on, in table 7.

Component 2 - *Knowledge Triangle: Flows and dynamics*

"strong interactions within the "knowledge triangle" (education, research and innovation) are promoted at all levels"

Table 5: Knowledge Triangle

Components of the system / Types of concern		*Component 2*. Knowledge Δ [local, national, EU-wide]
Type A Policy levers/ actions	*Type A1* Member States level	• Publicly financed BERD as % of publicly financed R&D.* • Share of BERD financed by government*
	Type A2 EU-level and coordination across MS	
Type B ERA progress state of the ERA as EU R-I system		• Share of public sector expenditures on R&D (GOVERD + HERD) financed by business enterprises (37)* • Share of doctoral degree holders working in the private sector (Physical, math and engineering + Life Sciences but not health and nursing).*CDH: OECD /Eurostat/UIS surveys* ** • Percentage of innovative firms collaborating with public research organisation*, CIS • Membership of science research parks ** • Share of the scientific articles referenced in EPO applications*. *DG RTD*
Type C ERA Effects – Lisbon objectives towards a K society		see table 2

Indicators that are already found in the 2008 STC report are noted with the corresponding page number in brackets
* new indicators already available or easily obtainable
** new indicators likely to be available soon or are currently obtainable but with some work,
*** important indicators requiring significant development efforts

Table 5 presents indicators that capture several aspects of the Knowledge Triangle. We do not have integrated many policy indicators for the moment. However, some indicators can be found in the reports on industry-science links from OECD (NESTI/TIP/...). This makes it important to encourage the OECD/NESTI project and to ensure that the current projects on university data gives reliable information on research parks or on the private financing of HEIs activities.

Type B indicators attempt to capture the relationship between Education and Scientific Research, as well as the links between the private and public sectors. While we do have reasonable data on the funding of research activities carried out in both the private and public sector, it is also crucial to track the relevant flows of human capital. To achieve this, the full implementation of the OECD-Eurostat CDH project, on which our second indicator is based, is required. It would, for example enable us to determine the proportion of doctorate holders working in the private sector or to evaluate the number of researchers who move back to academia after accumulating significant experience in the private sector. Finally, we do have data on public-private partnerships (and all other collaborations by innovative firms) in the CIS. A weakness however of this indicator is that it does not say much about the importance (marginal or very important) of these collaborations. New indicators based on the CIS are under construction at the OECD. A measure of the importance of scientific research parks is not readily available but could be constructed at a reasonable cost.

Component 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"

Table 6: Fifth Freedom and Knowledge Flows

Components of the system / Types of concern		*Component 3.* Fifth Freedom [conditions for EU-wide mobility and circulation single market for K]
Type A Policy levers/ actions	*Type A1* Member States level	• Number of publicly funded open access repositories. **
	Type A2 EU-level and coordination across MS	• Funding of "mobility" programmes such as Erasmus (faculty only) and MarieCurie * •Potential qualitative indicators** : Progress of the Bologna process Progress on harmonisation of employment, social security & pension statute of researchers, faculty, students Progress on opening of national programme Progress on opening of public procurement related to research Progress on a European market for innovative goods and services
Type B ERA progress state of the ERA as EU R-I system		**EMBODIED KNOWLEDGE FLOWS IN PEOPLE** • Erasmus (faculty) and Marie Curie Flows: incoming and outgoing per country. Breakdown science/business -econ/others ** • Percentage of Doctoral degree Holders who obtained their doctorate in another EU country and/or have worked in another EU country**, *CDH-Eurostat/OECD.* • Share of Doctoral candidates from other EU countries (as % of total number of doctoral candidates)*, OECD. **DISEMBODIED KNOWLEDGE FLOWS** • Evolution of scientific publications and co-publications intra- EU (127) and by field (136-137) • Evolution of patenting and co-patenting intra-EU. • Number of participations in European programmes per thousand researchers (106) • Network statistics for FP6 collaborations (based on data for map p.100 of STC report 2008) * programmes *
Type C ERA Effects – Lisbon objectives towards a K society		see table 2

Indicators that are already found in the 2008 STC report are noted with the corresponding page number in brackets
* new indicators already available or easily obtainable
** new indicators likely to be available soon or are currently obtainable but with some work,
*** important indicators requiring significant development efforts

Our third component, presented in Table 6 is mostly concerned with openness and the fifth freedom. Implementing the "fifth freedom" is supposed to lead to the creation of a "common market for knowledge". However, since knowledge is also embodied in people, the emergence of such a common market also depends on the ability to effectively exploit existing freedoms in terms of free movement of research personnel. This component also includes an appraisal of the ERA's "openness to the world" as this is a natural companion of "internal" openness.

The proposed A1 indicator is a measure of the accessibility of knowledge (open access repositories). We would also have liked to include indicators of policies designed to open public research funding to non-nationals. However, as discussed in Benedetto Lepori's report, such indicators are not currently available. Given the importance of public markets in the EU economy, one would also like to be able to monitor the openness of national

procurement for knowledge-intensive goods. Ideally, one would have an indicator based on the proportion of such sales obtained by non-national ERA actors but one would also want to assess other aspects of the procurement system. In particular, it is important to encourage – and therefore monitor – an increased reliance on performance-based specification rather than on design-based specifications. Unfortunately, no reliable indicator is currently available.

Our type A2 indicator draws on the observed faculty flows within the Erasmus and Marie Curie programmes. We also point out that, in order to get a more complete picture, the progress of a number of policy processes and programmes needs to be assessed qualitatively.

The type B indicators for this component reflect flows of knowledge. As the actual openness of member state policies is hard to assess directly, increases in these flows should be seen as prima facie evidence that policies are indeed moving in a direction that fosters the development of an integrated "internal market" for research and knowledge.[15]

Embodied flows or knowledge should be measured by the migration of research/HE personnel both in the economy at large and within the confines of EU-backed programmes such as Erasmus and Marie Curie. Type B indicators should also include other signs of openness both in terms of HE/research employment and procurement programmes. Ideally, the indicators concerning HE employment would capture both openness to foreign experts and openness to foreign knowledge (foreign Ph.D, irrespective of nationality). Given the prevalence of in-breeding in many EU HEIs, it also seemed important to also include a measure of institutional openness in the form of the, for example, the "% of academic staff with highest degrees from the HEI where they work. Unfortunately, good indicators of openness to foreign knowledge or in-breeding are not currently obtainable. Still, there are reasons to believe that they might be in the near future (see annex 1).

Disembodied flows of knowledge are captured through patterns of citation for both patents and scientific articles and collaborations across national borders.

Type C indicators related to components 1, 2 and 3

The type C indicators presented in table 7 jointly relate to the first three components of the system, not just to "knowledge activities in the EU". This reflects the fact that the innovation performance of ERA is jointly determined by all components of the innovation system. These indicators can be broken down into four groups.

[15] While indicators of *information* flows can be obtained through webmetrics, we feel that such indicators are not yet reliable and stable enough to be retained. We also decided not to include an indicator of knowledge flows embodied in goods: as the free flows of such goods should be sufficiently ensured by existing freedoms, they are not a focus of the ERA.

table 7 - for components 1, 2,3 - *Type C indicators* - ERA Effects – Lisbon objectives

Type C ERA Effects – Lisbon objectives towards a K society	QUALITY / EXCELLENCE • EU / MS world share of 10% most cited scientific publications per field (64) • EU/MS share of highly cited Triadic and EPO patents * • Leiden ranking of top research universities*. STRUCTURAL CHANGE I: KNOWLEDGE INTENSITY OF THE ECONOMY (comparison to the US, Japan and China) • GERD as % of GDP • BERD as % of GDP • Number of Triadic patents per million population (71). • Number of scientific publications per million population* • Share of population aged 25 – 34 with tertiary education. *Eurostat* • Doctoral graduates per thousand population aged 20 –29: all fields and "Science, Mathematics and Computing". *Eurostat* * • R&D personnel in the business enterprise sector as % of total employment. *Eurostat* * • ***innovators as a percentage of all firms (Inovation by firms based on own research as well as adaptation of knowledge developed by others)**** STRUCTURAL CHANGE II: SPECIALISATION IN HIGH GROWTH- HIGH TECH (comparison to the US, Japan and China) • EU-US-Japan specialisation in high-growth scientific fields (66).* • *Value added of sectors intensive in tertiary education as % of total value added***. Eurostat.* • High-Tech exports as % of total national exports (79) STRUCTURAL CHANGE III: FIRM S DYNAMICS (comparison to the US, Japan and China) • % of fast-growing firms*. *OECD.* • Venture capital at early stage and at expansion/ replacement stage as of GDP. *Eurostat* * • Entrepreneurial activity index, Eurobarometer on Entrepreneurship * STRUCTURAL CHANGE IV: GEOGRAPHIC CONCENTRATION (comparison to the US, Japan and China) • Concentration (e.g. Gini coefficient) of inventors listed in EPO applications per field at the NUTS 2 level for EU-27 countries. *Obtainable EPO* ** • Top NUTS 2 regions in terms of R&D personnel as % of total employment * *Eurostat* REVEALED ATTRACTIVENESS • Share of the ERA in the total number of students (from US, Japan, China, India,..) pursuing doctoral degree s outside of their own country/area. Breakdown by S&E/B&Ec/Others ** • Intended destination of US citizen with doctoral degrees wishing to leave the US, share of Europe CDH:*OECD/ Eurostat/UIS survey* * • Share of business R&D expenditures by non-EU foreign affiliates in private R&D expenditures**, Eurostat. • R&D expenditure of affiliates of US parent companies abroad in EU, Canada, Japan and China (85)*. *OECD* • Foreign S&E doctorate recipients who choose to stay in the US (EU)*, *OECD* LINKAGES BETWEEN ERA AND THE WORLD • Co-publications with non- EU partners as share of total pubications* • Co-patenting with non-EU partners, as share of totl patenting**. • Number of EU doctorate holders in the US** (*CDH, Eurostat/OECD)* • Number of S&E doctorates earned in the US per thousand S&E doctorates awarded at home*. *OECD*

The first group of C indicators captures the quality of research and HE activities with a focus on achieving "excellence". The concern for excellence is reflected in the fact that we only look at the top end of the distribution of patents and publications. The proposed measures are largely traditional. Still, let us notice that we report patent output both at the EPO and at the "triadic" level. This is an indirect manner of distinguishing between the patenting output of smaller companies, which tend to limit themselves to the EPO, and the output of larger companies who are active at both levels. The pros and cons of the Leiden ranking of research universities have already been discussed in section 4.2.

The second group of type C indicators attempts to measure several aspects of "structural change". The first aspect is the changing knowledge intensity of the economy. We look at knowledge-intensity from both the input (BERD, GERD, R&D personnel) and the output (patents, publications, graduates) side. Notice that the shares of population with tertiary or graduate education can also be seen as an important aspect of the ERA "absorption capacity". The age group for this indicator has been chosen to ensure that both Masters and doctoral degrees are captured. It is also narrow enough for the measure to show some non-negligible change over time.

The second aspect of structural change concerns the balance between various areas of economic activity and research. In particular we are interested in the evolving share of knowledge-intensive sectors and the relative importance of sciences and engineering in higher education. While we use the traditional "high-tech" classification when looking at exports, we propose a new classification – based on a sector's intensive use of workers with tertiary education, to determine the share of valued added generated by "knowledge-intensive" sectors. This classification is discussed in more details in section 4.1. The indicators in this group are recorded both at the level of the EU as a whole and at the level of the member states.

A third aspect of structural change relates to the performance and life-cycle of innovative firms: how many are born, how fast they grow and how quickly this process of creation and growth adapts as new fields of innovation emerge. This is a crucial feature of the ERA as a lack of entrepreneurial spirit and the failure of new firms to grow sufficiently fast are often cited as drawbacks of the EU compared to the US economy. As discussed in more depth in annex 1 of this report, we are somewhat hampered by the lack of data on the behaviour of new and small firms beyond the OECD indicator on fast-growing firms. We try to find a way around this obstacle by including an indicator of venture capital activity. Since venture capital investments are mostly used to finance start-up and fast-growing enterprises, they can be used to track the health of such dynamic firms. Finally, entrepreneurial spirit is also assessed more directly through the Eurobarometer.

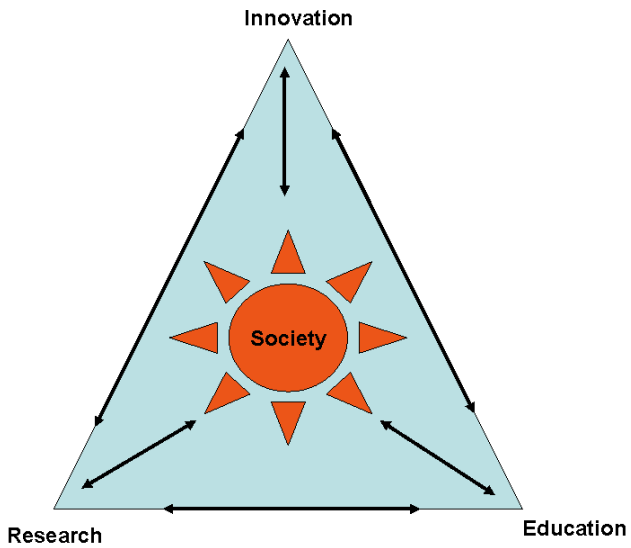
The changing pattern of specialisation across member states is another important dimension of structural change. This geographical dimension could in principle be approached through measures of patenting and measures of employment of R&D personnel. The first type of indicator has the advantage of being an output measure, but personnel data gives us a better idea of where innovation activities actually take place. Patents will be allocated to the region where the assignee is located. For companies, this usually means the location of the HQ, which might be very different from the location where the corresponding research was performed. Because each type of measure has strengths and weaknesses, both types of indicators are retained.

The third group of type C indicators assesses whether the ERA is indeed an attractive place to study, work in research, invest in research and patent. Such attractiveness is not only a sign of the ERA's success, it also contributes to its continuing development. It is only if the ERA is increasingly chosen over other available alternatives that its "attractiveness" can be judged to improve. Accordingly, whenever possible, we propose indicators that explicitly consider the choices open to foreign agents that might or might not decide to participate in ERA. For example we consider the "share of the ERA in the total number of students (from US, Japan, China, India,..) pursuing doctoral degrees outside of their own country". However, since the

data for such an approach is not often available, we also consider the absolute and relative participation of foreign agents in the ERA.

The final group of type C indicators for the three components that make up the innovation economy explores the links between ERA and the world. These links are captured through co-authorships and the presence of EU doctoral holders in the US. We also include the share of citizens earning their S&E doctorates in the US rather than at home. This should be read together with the indicator on the number of EU citizen with US doctorates who choose to stay in the US. An increasingly open but attractive ERA would likely be characterised by higher levels of the first indicator and lower levels of the second.

The next two dimensions are very prominent in the ERA Vision 2020and the Lund Declaration. These are also the dimensions that have received the least attention in the STC reports. We do therefore propose a number of new indicators of all types. Not surprisingly, finding indicators that capture such "softer" aspects of the ERA well is challenging. The indicators that we propose are therefore somewhat more speculative than for the other three components.



As illustrated in the figure above, each of the poles of the knowledge triangle has a societal dimension. Some themes, such as gender equality, apply to all three "corners" of the triangle, Other themes are more specific. For example, research tends to raise fundamental issues as to the treatment of the subjects of experiments, human or animal. Many innovations, such as DNA mapping, call for a broad social debate as to their acceptable use and the proper balance between a higher education system that caters to the needs of business and one that aims at forming informed citizens is hotly debated.

The indicators for the societal dimension of ERA are listed in Table 8.The two indicators of type A1 capture the idea that a "knowledge society" requires that there is a broad interest in and familiarity with science/knowledge within society at large.[16]

[16] The average number of hours of science and mathematics in the secondary school curriculum is not strictly an instrument since it is the joint result of a policy decision on the various "tracks" offered to secondary school students and of the students' choice between these tracks. Still, given that governments have significant control

We use data from the Erasmus programme as the basis for both A2 and B indicators. One could of course argue that, since the programme encourages intra-ERA flows of persons, this type of indicator should appear under our third component. However, as we restrict our attention to undergraduate exchanges, we believe that these flows contribute more to the general spread of knowledge than to the development of the ERA's innovation capacity.

Our type B indicators measure the public interest in sciences as well as a webmetrics indicator that tries to capture the grounding of research in broad societal concerns.

Type C indicators reflect the actual mastery of basic science within the population and the actual degree of integration of women within the innovation community. In particular we include two indicators of woman's current participation in higher education as these would reflect changes more rapidly than traditional "stock" measures. We also differentiate between the proportion of women employed in research in the public and in the business sectors as promoting gender equality in the private sector might require the use of somewhat different policy tools. Finally, a survey-based measure of trust between society and the S&T community seems to be the best way to capture this important dimension of the ERA Vision.

Component 4 - *The Societal Dimension of ERA*

"the ERA is firmly rooted in society and responsive to its needs and ambitions"

Table 8: Societal Dimensions of ERA (10 indicators)

Components of the system / Types of concern		*Component 4*. Societal Dimensions of ERA [Science in society]
Type A Policy levers/ actions	*Type A1* Member States level	• Public expenditure on museums, Zoos and herbaria per million population * Source • Average number of hours of sciences and mathematics in the secondary school Curriculum **
	Type A2 EU-level and coordination across MS	• Expenditures on Erasmus Programme (Undergraduates)*
Type B ERA progress state of the ERA as EU R-I system		• Erasmus (students) incoming and outgoing per country as % of total number of students Breakdown science/business -econ/others * • Sales of popular science books and/or magazines per million population * • Share of science programming on main TV channels* • Webmetric indicator on societal and problem-oriented research articles and conferences*
Type C ERA Effects – Lisbon objectives towards a K society		• World ranking of secondary school students in science and math*, *PISA.* • % of female among doctoral students in science, mathematics and computing *Eurostat* * • % of female researchers in all sectors and in the business sector. *Eurostat* * • Mutual trust between society and S&T community **. *Eurobarometer.*

Indicators that are already found in the 2008 STC report are noted with the corresponding page number in brackets
* new indicators already available or easily obtainable
** new indicators likely to be available soon or are currently obtainable but with some work,
*** important indicators requiring significant development efforts

as to how attractive the various options are, we decided to place this indicator in the A1 columns rather than in the b column.

The Lund Declaration states that "European research must focus on the Grand Challenges of our time, breaking with current thematic approaches. This calls for a new deal between member states and the European Commission in which European and national instruments are well aligned and cooperation builds on transparency and trust. Identifying grand challenges should involve all stakeholders in transparent processes". This text contains several important elements. Firstly, "Grand Challenges of our time" will, by definition, change over time. We will therefore limit ourselves to providing examples of indicators for one of the current challenges, namely the issue of climate change. Secondly, as for other aspects of the ERA, Grand Challenges are addressed by EU institutions and by the member states. This calls for both type A1 and A2 indicators. Thirdly, the identification of challenges should not be a top-down process.

"Grand Challenge" indicators are presented in Table 9. We do not have any type A1 indicator. This is due to the fact that governments do not currently keep track of resources allocated to meeting "challenge" that cut across traditional sectors and disciplines. Moreover, even if governments did produce the required data, ensuring the consistency of such an indicator might be tricky as governments might "increase" their perceived levels of investment simply by re-labelling various types of expenditures. The same caveat also applies to our single "A2" indicator.

We propose two related type B indicators. The first one measures the spread of concern and discussion about grand challenges within the university community. This could of course be extended to include other relevant agents such as PROs and large multinational companies. The indicator relies on webmetrics and is focussed on agents that are involved in research in order to get an early measure of what is starting to be done to address the challenge. Actual research output will only appear much later and will be measured by type C indicators. One should of course keep in mind that keywords can be misleading. In particular, there is a tendency for institutions – both private and public – to simply "re-label" current activities to give the impression that they are at the forefront on the currently fashionable issues. It is for example clear that the explosion of sections on "Corporate Social Responsibility" on company websites over the last 10 years does not correspond to an equivalent increase in actually socially responsible practice. Still, to the extent that the propensity for mostly cosmetic use of keywords is no more widespread in the EU than abroad, a comparison of keyword frequency between different geographic area should still be useful.

The second of our B indicators exploits the same type of web-based data but for a difference purpose. This time the target is broadened to include other types of agents such as governments, NGOs and popular chat rooms in order to track down if not the birth at least the early emergence of concerns. This seems to be the best approach to appraise the extent to which grand challenges are indeed identified by all stakeholders and do not simply originate from a single sector of society. The network statistics that are discussed in annex 3 would of course also be useful to study the flows underlying these two B indicators in more details. In particular they would provide measures of the EU's leadership or "centrality" in the global response to grand challenges.

Component 5 – *Sustainable development and Grand challenges*

"the ERA is firmly rooted in society in pursuit of sustainable development"

Table 9: Sustainable Development and Grand Challenges (5 indicators)

Components of the system / Types of concern		*Component 5.* Sustainable Development and Grand Challenges
Type A Policy levers/ actions	*Type A1* Member States level	
	Type A2 EU-level and coordination across MS	• Proportion of FP funds allocated to research on Grand Challenges **
Type B ERA progress state of the ERA as EU R-I system		• Frequency of keywords related to the "grand challenge"(e.g. climate change) on the websites of top universities for the EU and other world regions/countries. *Obtainable, webmetrics* ** • Frequency of keywords related to the "grand challenge"(e.g. climate change) on popular Social networking websites. *Obtainable webmetrics* **
Type C ERA Effects – Lisbon objectives towards a K society		• scientific specialisation and leadership in climate change (and other challenge): EU/MS share of worldwide top cited scientific publications on climate change (or other challenge) *Obtainable* ** • technological specialisation: share of EPO / PCT applications)in "Environmental- related energy". *Eurostat* *

Indicators that are already found in the 2008 STC report are noted with the corresponding page number in brackets
* new indicators already available or easily obtainable
** new indicators likely to be available soon or are currently obtainable but with some work,
*** important indicators requiring significant development efforts

The type C indicators are all straightforward measures of scientific output related to the grand challenges.

3. The use of indicators for monitoring the ERA

The overall objective of the Group is to "promote and contribute to the development of an evidence-based monitoring system at European level on progress towards the ERA and a knowledge-based economy" and in this perspective, it must "propose a European level monitoring system and relevant indicators".

The issue of the monitoring of progress towards the ERA and a knowledge-based economy is central in the Ljubljana process and form a part of the ERA governance issue: it is indeed high in the agenda and has already been addressed in several occasions these last months by CREST and the Competitiveness councils.

3.1 The situation and challenges of the monitoring of the ERA

The concept of the ERA is a child of the research dimension of the EU and its central instrument is the FP, under the responsibility of the Commissioner for Research and of DG Research. Hence, at start, the monitoring of the ERA is the same as the monitoring of the FP, with, broadly speaking, at political level, the interplay between the Competitiveness Council (research ministers meetings), the Commissioner for Research and the EP, with a formalised consultative role of several advisory bodies and an operational role for DG Research. The monitoring processes are mediated by a variety of assessment reports, produced internally (reporting type) or externally (evaluative type) with different mixes of management, scientific and strategic focus.

Although complex and regularly adjusted, this scheme has worked for many years in this overall format. With the advent of ERA, the issue of monitoring is substantially changed for two fundamental reasons:

- the ERA is about the contribution of member states to realising it, with the Commission (and the FP) largely in a role of a catalyst for national systems and programmes integration – coordination: the issue is to monitor national reforms and the integration of national programmes (policies) and systems,

- the ERA is about integrating research into a "knowledge society" : the "knowledge triangle" (higher education, research, innovation) and the free circulation of knowledge ("5th freedom") are at the core of the ERA and directly related to policies far beyond research policy: the issue is to monitor the complementarities and synergies between a variety Community policies and instruments (FP, CIP, Structural Funds, Ljubljana process, framework Education & training, Bologna process…) – involving the Education, Youth and Culture (EYC), the Economic and Financial Affairs (Ecofin) and the Employment, Social Policy, Health and Consumer Affairs Council (EPSCO) councils.

The monitoring issues are further complicated by two major evolutions:

- the increasing number of member states and associated states to the FP, which now amount to 35.

- the increasing number and sophistication of the ERA instruments and tools: FP, integration coordination instruments (JITI, ERANETs…), soft tools (platforms, foresight, joint programming, OMC, guidelines, codes of conduct…), legislation (IPR, competition..).

The challenges presented by this situation have been widely recognised: the ERA monitoring and governance issues are prominent in the Ljubljana process and a central point for the Swedish presidency. In practice, the new monitoring and governance issues ERA faces, have started to be addressed with the launch of the Lisbon process, which also involves member states policies and also demands strong policy coordination. This is why a number of decisions related to these monitoring and governance issues have already been made. The most important are the following:

a) better analytical tools:
   - development of systematic databases, studies and benchmarking capabilities about national research, higher education and innovation system and their articulation into the ERA (Eurostat, ERAWATCH, innovation scoreboard, STC report…).
   - the evolution of evaluation activities towards "impact assessment" processes, focussing more on the contribution to policy and societal goals.

b) new and more diversified interactive processes:
   - the development of the open Method of Coordination (OMC) as a 'soft tool' for CREST to address national policies convergence – coordination – integration.
   - the creation of specific configurations of CREST (Group for Joint programming, Strategic forum for international S&T cooperation, Steering group on human resources and mobility) – which report directly to the competitiveness council.

c) the mandate given to CREST to establish a roadmap for the implementation of the ERA vision 2020.

In addition, it has been proposed that an informal ERA ministerial meeting could be convened on a regular basis to discuss the progress of ERA. Such meeting would address issues of research, innovation and higher education, in order to:

- take a coherent overview of progress towards the ERA vision, in particular in the specific initiatives designed to achieve it.
- provide strategic orientations.

So, there is an on-going move towards a new scheme for monitoring. But how could indicators fit into such a scheme and make a specific contribution?

Such is the purpose of this report, which raises the question of how, in principle, such quantitative measurements can contribute to public policies.

3.2. The significance of indicators for the monitoring of public policies

S&T indicators have a long history and an important record in contributing to research, higher education and innovation policies, their preparation, monitoring and evaluation. The development and general adoption of the 'New public management' framework along with advances in communication technologies have generalised the use of S&T indicators – at all levels of the research system. Yet, the exact role and legitimacy of such indicators in their relation to policy decisions still resurfaces regularly as a hot and unresolved issue.

Therefore, if we seriously consider that indicators have a substantial role to play in such an eminently political process as the development of the ERA, then we need to clarify how indicators can be articulated to political processes.

a) The traditional view: the great separation between science and society

Presented with the traditional concepts of the radical separation between the realm of science (supposedly neutral and objective) and politics (supposedly values laden and subjective), the issue is the following: scientifically and professionally produced indicators provide undisputable knowledge (in the realm of science) – but since politics and decision-making refer to a different framework, those indicators are not a legitimate basis for decisions which are in the realm of politics. This - admittedly simplified but widespread - view of both science and politics - leads to an (at best) ambiguous role of indicators vis a vis policy since they are both true and illegitimate….

In this paradigm of the radical separation, the use of indicators for the monitoring of the ERA would be logically considered by policy-makers either irrelevant or dangerous for democracy – leading to a suspicion of manipulation through the use of indicators, crystallising and locking-in the positions of the various stakeholders and/or countries involved.

In this view, indicators are clearly counter-productive for the decision-making and monitoring processes.

b) The proposed view: indicators as a representation and a language for expressing issues

We suggest another understanding of the nature of indicators: that indicators are intrinsically dependent on a representation (or model or theory) of the topic at stake and therefore debatable. The whole difficulty – and interest of the indicators for policy decisions – is to make explicit the underlying representation (or model or theory).

There are three aspects in the linkage between indicators and the representation (or model or theory) of the topic at stake:

- any indicator refers to classifications and categories (scientific disciplines, types of institutions, industrial sectors, publications…) which are, strictly speaking, based on a representation (or model or theory),
- an indicator is usually interpreted not for what it is directly, but for what it is supposed to 'indicate' – which is the notion of 'proxy' (a classical proxy for the industrial relevance of public research is the number of patents it produces; another one, for the excellence of a researcher, is its h-index…); but the validity of a proxy is in itself depending on a representation (or model or theory),
- the conception and interpretation of indicators always relies on implicit models of how the system works – for example about the relationship between research and innovation, innovation and growth, mode of funding and efficiency… , about the definition of the parameters that drive the system (definition of RD…).

In this view, indicators are neither truth nor fallacy, but a common language with a high potential for collective deepening of issues with their underlying values, as long as certain methodological and procedural rules are respected. In this condition, they can be a powerful media for complex and high stakes policy monitoring – such as the ERA.

This is the perspective we propose for using indicators for the monitoring of the ERA, which supposes certain conditions to be fulfilled.

c) The conditions for indicators to be relevant for decision-making and monitoring

If indicators are linked to representations of the world, then – beyond questions of data and computation accuracy – the definition and the interpretation of any indicator is eminently debatable ; the indicator can be considered a language – the universal language of numbers – but which express a specific representation (or model or theory) of the topic at stake. This representation depends on the culture, the position, the interest, the history of the actor which produces the indicator.

Far from disqualifying indicators for policy monitoring, this understanding of the indicators makes them highly relevant for this task, provided the following conditions are fulfilled:

- the indicators are produced in a way which specifies the source data, treatments, approximations, the definition and rationale for the classifications used, the reasons for the proposed interpretation….
- possibilities are provided for the criticism of the indicators, for revealing the underlying assumptions and proxies, for questioning the classifications,
- opportunities are given for alternative approaches, classifications, hierarchy of parameters and models of functioning of the system, leading to other indicators, or alternative interpretations or at least argued questioning of the interpretation of those presented.

We consider that in such a context, indicators can be highly favourable for mutual learning and deepening of the issues in substantive, policy and even political terms; in other words, if those conditions are satisfied, indicators are highly relevant for complex and potentially conflictual monitoring, such as ERA policies monitoring.

3.3 Towards using indicators for the monitoring of the ERA

Indicators are valuable in a monitoring process to the extent they enable the actors to reveal, express and discuss their representation of the issue at stake through their interpretation, criticism and eventually reconstruction of indicators.

Using indicators for the monitoring of the ERA would thus mean they are one of the vectors of the interaction among the actors, in tow possible contexts:

- a multi-actors assessment of the ERA-Headline indicators producing a thorough understanding of the building of ERA,
- key-issues ERA assessment (on ERA-Headline indicators) done by government representatives and the Commission, feeding into ministerial-level meetings (focussing on Lisbon oriented indicators).

Such ERA indicators assessment undoubtedly require significant preparation which takes time, resources and expertise in terms of the decision-making processes, the production of indicators and the collective learning methodologies. This point is crucial. Insufficient attention to it will lead to superficial work.

The large number of States involved, the objective complexity of the ERA making, its pluri-sectoral dimension (Knowledge triangle)…make the governance of the process and its

monitoring a difficult task indeed. Indicators have a potential for addressing real issues in a universal language, but the condition for this potential to be realised is to have top-level and professional preparation. This requires a dedicated structure (body) with a significant operational capacity, as well as a high degree of legitimacy, both professional and political.

4. Conclusion: Towards a responsible and efficient use of indicators for the monitoring of ERA

► Analyzing indicators with a systemic perspective

A great concern with indicators is misinterpretation, since they measure only bits and parts of a complex reality – and their labelling often gives the impression they cover more than what they do in reality. A way to overcome at least partially this risk is to interpret indicators not one by one but jointly, but subgroups of related indicators. This idea is that of 'triangulation', that is giving meaning to an indicator under the constraint that it is coherent with the image given by the other indicators; if impossible, this leads to the invalidation of the interpretation given previously.

The framework proposed for analyzing the ERA should be useful in clustering the indicators for such joint interpretation efforts.

► Being cautious with the issue of indicators becoming targets

As said earlier, at least some of the Lisbon orientated indicators could be completed by the definition of a quantitative target of political significance. The risk with this is the following: since, by definition, an indicator measures a part (which is measurable) as a substitute or proxy to a larger picture (which is not measurable), setting a target based on the indicator leads, for the rational policy maker, to take care of the part (on which the indicator - target is set) and not of the larger picture (which is the real concern).

This is a well documented risk, but still a very real one, and which can be extremely costly in terms of flawed strategic decisions and investments. There is a need to assess very carefully the targets and the associated risks, on a case by case basis, possibly complementing the numerical targets with qualitative assessments to prevent such unwelcome distortions.

► Setting targets and benchmarks for groups of countries

ERA is for making a strong and highly interconnected Europe, but it is also recognizing differences among members states, and in particular the differences of their initial position – for example in S&T production - in the making of the ERA. Hence, for the ERA monitoring process to be politically meaningful to all member states, it is suggested that interpretations, as well as targets and benchmarks to be set up per groups of countries having similarities as regard to the ERA issues.

A way to start the analytical process for identifying those groups would be to perform a typology (clusterisation) of the countries on their characteristics as measured on all the ERA-Headline indicators. The issue is to understand the structural differences in terms of the innovation systems of the countries, and not to have even implicit hierarchy. The point is that differing systems call for differing policies and priorities, with different benchmarks and targets.

This would not be an easy process, but if it succeeded, it would be both a proof of the quality of functioning of the policy indicators assessment forum and a sign of its capability to monitor the ERA in a meaningful way.

► Linkage between the ERA and the national monitoring processes

Since the ERA is about the synergies between national policies articulated with EU level policies, it would be logical that monitoring processes at national level be concerned with ERA monitoring, and reciprocally. This calls for some coherence and even partial overlapping, between indicators lists at national and ERA levels. It also calls for an articulation between the ERA level assessment of progress in the various member states and the purely national assessment process.

Of course, this depends on the countries willingness, but following the promising steps made in this direction by the recent OMC exercises, one can be reasonably optimistic. This would give more depth and significance to the policy assessment forum.

This is linked also to the preparation of the National 'Lisbon documents'. The complementarity and coherence in the methods, indicators and processes is to be realised.

► The indicators lists and reports as "living documents"

There are technical (data availability) and political (for example new Grand challenges) reasons for the lists of indicators to evolve; this has to be recognized from the start. Therefore it must be considered a task of the policy assessment forum and of its staff, to prepare such evolutions, based on feed-back from the users and actors of the processes.

One must also stress the dynamics of the field of indicators design and production; a small but lively scientific and professional community, well connected at EU level, makes it a vibrant area of activity. From this side also, new indicators will be proposed.

This is why there is a need of a formalised decision process for adjusting (for example every year) the lists of indicators with their precise technical definition.

► The broad issues not fit for direct qualitative measurements and the question of composite indicators

A major point is the need to address broad issues, which are central for the monitoring of ERA; at least three can be outlined:

- the framework conditions in each country, and also set up by EU-level decisions, and their evolution
- the policy decisions and roadmaps for reforms
- the efficiency of the research systems and of public expenditures in research and innovation policies.

Such meta-issues combine a large number of complex elements, which identification is in itself a matter of debate and even political vision.

A possibility sometimes advocated, is to build composite indicators, i.e. a synthetic indicator based on the aggregation of as many indicators as there are elements to be considered. This is indeed a possibility and some composite indicators are used and well known (the Human development index of the United Nations for example).

The difficulty is the choice of the elements to be accounted for and then their weighting for computing the aggregate synthetic indicator. In many cases, it seems easier to acknowledge the complex and qualitative nature of the issue, and to develop ad-hoc assessment processes based on studies, expert advice and policy makers working group.

Annex 1
Executive summary of the technical reports of the experts of the Group

Knowledge Flows in the ERA

Report prepared by

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Executive summary

This report have three objectives: The most important is to provide a list of feasible and meaningful indicators for describing and monitoring the Knowledge Flows in the ERA for the next decade (Vision 2020). Apart from other quantitative indicators, the report makes emphasis in the webometrics tools as they can provide additional information and uncover relationships not previously recognized.

The second contribution is on the building of composite indicators that combine different variables in complex scenarios. Current proposals have been heavily criticized from a methodological point of view, but they can be useful for measuring the so called Fifth Freedom and for monitoring ERA making at institutional level.

The third task performed was a review of the current edition of the STC Report. Main suggestions for improving include major use of visualization tools specially for describing networks; consider groupings of countries for disaggregating data both in ERA but also out of ERA (North America, Asia-Pacific, BRIC countries, Latin America) and add a new level of descriptions including individual organizations, specially but not only universities.

Taxonomy was proposed for the indicators, that are classified in three large groups: Those related with information flows focusing on the availability, geographical topology and actual usage of academic electronic networks (big science, e-science, grid or P2P networks) The second group are the most important describing the (disembodied) knowledge flows according to three main sources: publications (collaboration and co-authorship), patents (co-inventors) and websites (co-linking, networks). The third group consisting of embodied knowledge flows is only briefly described as they overlaps with human resources indicators targeted in other report.

REPORT ON INDICATORS AND DATA DEVELOPMENT ON INTERNATIONAL TECHNOLOGY AND INDUSTRIAL SPILLOVERS

Dr Iulia Siedschlag*

EXECUTIVE SUMMARY

The objective of this Report is to contribute to the development of an evidence-based system to monitor progress towards the European Research Area (ERA) and a knowledge-based economy in the area of international technology and industrial spillovers. We start with an overview of existing theory and empirical evidence on the role of international technology spillovers on economic growth. Further, we discuss the transmission channels of international technology spillovers and barriers to international technology diffusion. Next we turn to measuring specialisation in knowledge-based sectors and geographical concentration patterns of these sectors. The remainder of this Report proposes three sets of indicators to monitor progress towards the ERA and a knowledge-based economy in the area of international technology diffusion.

Modern growth theory has established the importance of knowledge and international knowledge spillovers as sources of economic growth. Existing empirical evidence at firm and industry levels suggests that social rates of return to R&D/technology investment are higher than the private rates of return. In many countries foreign sources of technology account to a large extent for technology adoption.

International technology diffusion can take place through a number of channels: *embodied technology* can be transmitted through international trade with goods and services; capital flows; and mobility of scientists; *disembodied technology* is diffused via international trade of technology.

Barriers to international technology diffusion. However, international technology diffusion is neither inevitable nor automatic. Empirical evidence suggests that international technology spillovers are conditioned by domestic R&D expenditure, human capital and the quality of institutions. Thus, domestic R&D expenditure has the potential to generate total factor productivity growth from both innovation and technology transfer.

Measuring and monitoring specialisation in R&D intensive industries is important and policy relevant. Country rankings of R&D intensity might be misleading if account is not made of their industrial structure.

R&D intensive industries and knowledge-intensive services tend to concentrate in space reflecting the geographical concentration of investment, infrastructure, physical and human capital.

The remainder of this Report proposes **three sets of indicators to monitor progress towards the ERA and a knowledge-based economy in the area of international technology diffusion**: Lisbon-Oriented Indicators, ERA Headline Indicators and a Comprehensive Set of Indicators for the analysis of developments in science, technology and competitiveness in the ERA.

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Corporate Datasets and Measures Derived from them as indicators forERA

By Dr Michael Tubbs

Director, Innovomantex Ltd and Professor of innovation and Strategic management, Ashcroft International Business School, Cambridge

The paper explains how large sets of corporate data taken from audited company accounts can be used to develop indicators and efficiency measures for ERA. Corporate data has many advantages over the usual national statistics and is the primary data used by businesses, analysts, investors and the financial markets. Its advantages include accuracy, immediacy and the ability to compare inputs and outputs. Corporate data enables a detailed insight into the health of individual companies and how they create wealth and allows a direct connection to be made between management decisions and company performance. It also reveals the company sector strengths of different countries and allows performance comparisons between companies in the same sector but based in different countries.

Two particular datasets are discussed in this paper - a Value Added Scoreboard and a R&D Scoreboard although others are possible (e.g. a Capex Scoreboard). It is proposed that a 2000 company European Value Added Scoreboard should be prepared to enable company wealth and wealth creation efficiency (WCE) to be analysed together with the dynamics of companies – the way in which middle-sized companies grow and flourish (or the reverse).

There are many indicators that can be developed from VA and R&D Scoreboards and similar datasets but the principal ones proposed in this paper are:

- Monitoring of structural change via the value added/WCE vs. time for the group of knowledge intensive companies amongst the top 2000 European companies by VA.
- Monitoring of the attractiveness of Europe as a location for R&D. This is done by monitoring the % of total worldwide R&D chosen to be performed in Europe vs. other locations by the European subsidiaries of non-European companies.
- The growth characteristics of middle-sized companies, particularly those in knowledge-intensive sectors. This is to be done via the second 1000 companies in a VA Scoreboard. The proportion of companies in a given size range that show sustainable profitable growth above a set level is monitored. The EU can be compared to other economies in this respect, particularly the US..
- Monitoring framework conditions that encourage research, wealth creation and entrepreneurship in Europe. One particular issue is R&D tax credits but there are others concerned with regulation, infrastructure and skills that emerge from interviews with company CEOs.
- A league table (effectively a scoreboard) of top world universities, preferably constructed with a bias towards research aspects, to see how many European universities (and from which European countries) make the upper ranks (say top 200) and whether this proportion increases with time. This is important since European R&D companies need to have a good selection of world-class universities to work with in Europe. To be world class, a university needs to rank highly or it will find difficulty in attracting world class faculty, the brightest students or in partnering with the very best companies and gaining their sponsorship. There is thus a virtuous circle in operation.

There are a number of other indicators that can be developed from corporate datasets but those listed above give a flavour of what can be done. The object of these indicators based on corporate data is to ensure that company-based measures are central to ERA since it is companies which are the knowledge intensive wealth creators and job providers that will ensure Europe is competitive in this century. We cannot rely on the more straightforward products and services since developing and emerging countries are mastering these and will be able to use lower labour costs to provide them more competitively. Success with knowledge intensive products and services and continued reinvestment of added value into yet more knowledge based R&D will ensure that European companies can continue to enjoy success in a globalised and competitive world and that European citizens can continue to enjoy a high standard of living.

The contribution of indicators on public funding of research activities to the ERA monitoring

Benedetto Lepori,
Centre for Organisational Research, Faculty of Economics, University of Lugano,

The report on "The contribution of indicators on public funding of research activities to the ERA monitoring" provides a comprehensive framework on the development of indicators on public funding, then systematically the different categories of indicators which could be development for the purposes of ERA monitoring, based also on the available data sources, and then provides recommendations on the priority indicators, as well on actions to improve the statistical basis.

The conceptual framework is rooted in the notion of position indicators, meant to characterize the position of individual actors in the (different layers of the) research system, beyond the focus on national aggregates which characterize most of the current indicators in this area. This drives to the identification of four distinct layers in public research funding, i.e. State, funding agencies, research organizations and research groups, as well as of two main allocation channels, namely core allocation to research organizations (including higher education institutions) and project funding to individual research groups. This allows to devise specific indicators to characterize each of these layers; two relevant example for the purposes of ERA monitoring are:

- indicators analysing the composition of funding by allocation modes, like the share of project funding in total funding and its composition by instruments and funding agencies.
- indicators looking to the volume and composition of funding of higher education institutions (for example share of third-party funds) to characterize the position in different funding "markets".

Beyond this horizontal view, a major area of development in the future is likely to be "market-space" indicators mapping funding flows between agencies and performers and addressing issues of market structure and segmentation, as well as of dynamic competition between performers.

These new approaches to indicators on public funding have however to take into account the limitations of existing statistics, which has been by large design in view of national comparisons. The report identifies then at least for areas of improvement: data on transnational research funding, being a well-known limitation of current R&D statistics and being to some extent addressed by new EUROSTAT initiatives; the characterization of funding portfolios both at the quantitative level (OECD-NESTI project on GBAORD) and at the qualitative level (ERAWATCH Research inventory); finally, the systematic provision of data on funding sources of individual higher education institutions.

In terms of indicators for ERA monitoring, based on currently available data, the report proposes two headline indicators, namely *total public expenditures for tertiary education (including research expenditures) as a % of GDP* and the *share of funding from public international programs (including joint programs) in national research expenditures in the public sector* (higher education and government sector), as well as a more comprehensive set of core indicators summarized in the table below.

Indicator	Type	Geogr. Level	Status
GERD financed by the State	Policies	Country	Available
Tertiary education expenditures	Policies	Country	Not available
Share of project funding	Policies	Country	Not available
Characterization of public funding systems	Policies	Country	Not available
Research expenditures of international organizations	ERA making	EU	Available (partially)
Funding from international research programmes	Policies	EU	Available (partially)
Funding for joint research programmes	Policies	Country	Available (partially)
Share of national GBAORD devoted to international and joint research initiatives	Policies	Country	Not available
Share of funding from international and joint public initiatives in national GERD	ERA making	EU	Not available
Opening of national programmes	Policies	Country	Not available
Composition of funding for HEI	ERA making	Country	Available (partially)
Allocation modes for HEI core funding	Policies	Country	Not available
Share of third-party funding in HEI budget	ERA making	Country	Not available
Participation to EU FP	ERA making	Individual institution	Not available
Recipients of ERC grants	ERA making	Individual institution	Not available
Funding schemes for individual researchers (grant)	Policies	Country	Not available

A report on cross-analysis of indicators on public research and on industry research

Horst Soboll

Summary

The common **European Research Area ERA** is seen as a key element for a new step forward for Europes development in a competitive international world - aiming to become the leading knowledge based economy and society. For ERA indicators in general, several different aspects need to be taken into account, at least, if they are used not only by statistical experts, but as well by the decision makers to assess, shape and monitor the European Research Area ERA.

Most important is the **communication aspect** – meaning a clear and easy to understand indicator, guiding the decision makers in an intended direction. Special emphasis is needed to avoid unintended (or even intended) misunderstandings or misinterpretations.
Besides an easy availability and transparent generation of indicator data, there is a need to get a complete picture reflecting the real situation across Europe and sectors.

This includes **soft data based on surveys, questionnaires** etc., which are - up to a certain extent – not comparable with hard statistical data, but nevertheless are very useful to describe the overall situation and perceptions. Most investment decisions are as well based on similar personal assessments and perceptions, therefore the traditional statistical hard data should be complemented by soft data.

It is suggested to offer towards politicians and media 3 headline indicators esp. in respect to easy understanding and being illustrative and avoid misinterpretation, first an input indicator for **investments in R&D**. Another indicator should reflect the **ERA integration** and productivity aspects, e.g. a Joint Programming measure as number of common projects, joint programs or similar common activities by all Member States compared to all across Europe.
A third indicator may describe the environment needed for **ERA change**, which is often described in surveys as responses by decision makers or perceptions of management out of a survey like IMD.

Whereas the headline indicators aim more for press and politics (executives) some additional clear indicators are needed for detailed discussion and preparation of innovation strategies and decisions.

A complete picture needs to cover the input / output side, the integration of ERA and some effects / impact of ERA for following areas
- education as a cornerstone of innovative capacity,
- research and development as the major activity and
- all additional aspects for a successful innovation such as regulations, financing, demand / procurement etc.

Annex 2
Indicators to be Developed or under Development

In this section, we point out the dimensions for which the need for new indicators is keenest and identify current data-gathering efforts that might prove useful in the near future.

i. Universities

Given the crucial role of universities within the knowledge triangle and the widely perceived need to modernise European institutions of higher learning**,** it is important to make sure that these projects yield appropriate data regarding their funding, their governance, their performance, their links to the private sector and their openness to ERA and the world. More specifically, we would hope to get the following information:

1. Funding How much public funding is just a lump sum and how much is linked to student numbers (with breakdown between undergraduates and postgraduates)? How is research financed? What is the share of project funding in total public funding of universities? How much comes directly from the government and how much comes from other public funding agencies? Is the quality of university research independently assessed and how much of the funding is tied to the results of this assessment? How much of the public funding for research is obtained on a competitive basis? How much funding is received from the private sector and on what terms? How is research funding allocated across fields? How much goes to interdisciplinary research (e.g. are there interdisciplinary research centres at the university)? Concrete suggestions along these lines can be found in Benedetto Lepori's report.

2. Which universities have formal IP/technology transfer offices? How many deals have they struck and what is the total revenue generated? Who is the technology licensed to (EU firms? Non-EU firms?)? How many universities have research parks or business incubators?

3. What the university procedures for hiring? How are jobs advertised. Does the university have final say in academic appointments or (as in Germany and Belgium, for example) does the choice need to confirmed by the relevant ministry? What is the proportion of permanent faculty members with foreign citizenship (with EU/non-EU breakdown)?

4. Where do the university's graduates go? To the public sector or the private sector? In which country? What kind of jobs do they get, in which sectors? How many graduates get back into academia after working in the business sector?

5. What is the profile of academics? What is their gender? Their nationality? Where (country + institution) did they get their highest degrees from? In which field(s) do they do research? Are they involved in interdisciplinary research?

This is not a gratuitous wish list. All the points mentioned above are closely related to concerns expressed in the ERA Vision or in the Lund Declaration and for which we currently have insufficient indicators. For example we currently do not have any acceptable indicator of the volume and quality of interdisciplinary or multidisciplinary research. How then can we track the formation of "broad areas of issue-oriented research in relevant field". Similarly,

point 5 and information on technology transfer and financing would allow us to "beef" up our table of indicators for the "Knowledge Triangle" component.

There are a number of current ventures with the potential to address many of the issues raised above. Three of those aim at collecting data about universities themselves: the EUMIDA project, which is a feasibility study on large-scale data collection on HEIs (coordinated by the University of Pisa), CHEPS, which is a long term project to develop multidimensional classification schemes for the top 200 research-intensives European Universities and ERAWATCH's own attempt to collect data from 200 European universities.

Two other projects attempt to track the mobility of researchers. Most prominently, the CDH survey tracks the careers of doctoral degree holders. It is intended to measure demographic, employment and career characteristics of these persons, as well as their international mobility and the driving forces behind this mobility. The first round of this survey, carried out in 2006, involved 23 countries, including 18 member states. The work for collecting the CDH data for 2009 has started. The common questionnaire, methodological guidelines and the model for output tabulations have been widely reviewed and discussed between the three institutions (Eurostat, OECD and UIS) and within the group of countries involved. Should the wide implementation of the CDH 2009 (and beyond) be successful, a firm and determined commitment of Eurostat and Member States authorities is called for. As such this survey would enable us to capture many of the important policy aspects mentioned above. We therefore see its further development and full implementation as crucial to the effective monitoring of the ERA. Making CDH statistics mandatory within ESS should therefore be seriously considered.

DG RTD is also conducting its own pilot project (MORE) to collect data about the mobility and careers of researchers. This project relates to a broader set of researchers since it is not limited to the sole doctoral degree holders. The Member States are not officially involved in the MORE project but they are informed via the SGHRM. Eurostat is associated with the project as a member of the Advisory Board. The project included a large survey of researchers in academia across the EU in June/July 2009. Data across Member States are expected by the end of 2009 while the final report incorporating other indicators and pilot surveys is due end June 2010. Depending on the results of the study, the Commission will consider whether or not to carry out further surveys in future.

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ii. Webmetrics

Because of its relative novelty, the webmetrics approach is a particularly fecund source of future indicators. It holds particular promise for better capturing the place of ERA agents in international networks or the relationships between education science and society at large. It might also be uniquely useful in tracking the mechanisms through which grand challenged are both identified (where are such issues first discussed and by whom?) and addressed. Although significant amounts of data can be collected from the webs at relatively low cost, very few web-based indicators are currently compiled in a systematic, reliable manner. A moderate investment to ensure that a few web-based ERA indicators are available might therefore be worthwhile. The following table presents a few of the more interesting indicators with an estimate of the man-days involved.

Indicator	Component and Type	Man-Days
Co-linking and inter-linking of top HEIs	Component 3, type B	10
Topological situation of ERA academic webspace compared to other regions	Component 3, type B	5
Links academia/top 100 ERA innovative companies	Component 2, type B	5
Identification of "hot topics" or social concerns	Components 4 and 5, type B	10

iii. Firm Dynamics

Our current set of indicators still does not reflect the birth and evolution of innovative firms very well. Expanding the VA and R&D scoreboards to cover the top 2000 European-based firms would give us data on medium-sized firms. We could therefore identify and track innovative firms at an earlier stage of their growth. Adding the *age* of the firm (however imperfect this metric might be) to both scoreboard would also be useful. These developments are important as the failure of new European firms to grow as fast as their US counterparts seems to be a significant factor in explaining the poorer performance of the EU. In this sense, a further development of the VA scoreboard to include companies from other parts of the world (notably the US and Japan) would provide useful benchmarks.

iv. Legal Frameworks

Our type A1 and A2 indicators are biased towards the policy instruments that can be measured quantitatively. This means that we mostly capture the resources (financial or human) invested in knowledge production and their allocation. However, government also crucially influence the evolution and success of ERA through other tools, ranging from fiscal incentives to legal frameworks. These are often impossible to capture with the available data. Consider for example the fiscal treatment of private R&D expenditures. In order to provide a meaningful indicator, one would first have to understand the local rules of each member state before expressing them in some common form that would need to aggregate not only different instruments (tax credits, depreciation rules,…) but would also need to reconcile definitions that can differ quite widely. The implementation and effect of the policy initiative on providing a legal framework for the joint financing and development of research infrastructure are even harder to measure. Overall, then, there is a need for reflection as to how such information might be obtained in the future.

v. Public Attitude toward Science

Both the ERA vision and the Lund Declaration insist on the need for a true knowledge *society* where all stakeholders are involved in the design of policies and where the public at large trusts the scientific community and feels that ERA is responsive to its needs and concerns. We have tried to measure such aspect of ERA indirectly, by relying, for example, on indicators of the public's involvement in scientific activities. However, a periodic survey that would examine the public's attitude towards science and some specific "grand challenges" would be a worthwhile addition[17]. Since *Eurobarometer* published such a survey in 2005, ensuring the periodic replication a small part of this work would seem to be the best approach.

[17] Eurobarometer provided such a study in 2004 but, as far as we know, it has not been repeated.

vi. Government: Procurement and Policy-Making

Two further aspects of governmental policies are not well measured by our current set of indicators: procurement and the notion that policy should be "knowledge based" (as stated in the ERA Vision 2020 document). On the procurement front, one needs to know the proportion of expenditures that concern knowledge intensive goods or services, the proportion that is allocated through open bidding or tender, the proportion of these auctions or tender that are broadly advertised throughout the EU and the proportion of total knowledge-intensive procurement that is allocated to non-national bidders. One would also like to monitor the extent to which tenders are specified in terms of performance rather than in terms of a specific design. The notion of knowledge-based policy making could be approached by tracking the field and level of education of government employees (globally or in some more precise areas of decision making). The number, size and composition of scientific advisory groups could also be recorded. While part of this information might be obtained relatively easily at the level of the European Commission (type A2), it is not currently available for member states in any broadly comparable form.

vii. New sub-categories of the GBAORD

Developing new categories of the GBAORD would give us a better understanding of two aspects of the ERA. Firstly, new categories could be designed to capture national contributions to jointly designed and/or financed projects. Secondly, a further breakdown of the government's contribution to research performed in higher education institutions would give us a better idea of the variety of HE financing "models" that prevail across member states. There is important ongoing work on the first of these two aspects.

Eurostat is currently working on new sub-categories of the GBAORD. Together with the member States' statistical authorities, Eurostat has tested the widening of GBAORD details in the joint programming area. The new breakdown tested is the total budget funded by the government (state, federal, provincial) as measured by GBAORD directed to trans-national public R&D performers and trans-national public R&D programmes. The new breakdown has the following sub-categories:

a. National contributions to trans-national public R&D performers (CERN, ILL, ERSF, EMBO, ESO, JRC).
b. National contributions to Europe-wide trans-national public R&D programmes, with and without cross-border flows of funds (ERA-NETS, ERA-NETS +,ESA, EFDA, EUREKA, COST, EUROCORES, Article 169 initiatives).
c. National contributions to bi- or multi-lateral public R&D programmes established between Member States governments, with and without cross-border funds.

The pilot conducted in May 2009 covered 8 countries. It showed that these details can be produced within national administrations with reasonable effort. Hence, the pilot will be extended to cover all EU Member States in the Autumn of 2009. Should it prove to be generally feasible, the extended categorisation could be proposed to be made mandatory within ESS.

Annex 3

A Note on Network Statistics

As the ERA is about integration, it necessarily involves the creation of a variety of networks. These can be networks of infrastructure, network of collaborations or even flows of knowledge. Flows of knowledge *between* countries can be easily captured by the inflows and outflows between pairs of countries or between countries and regions. Networks of collaborations can be represented in a similar manner. However, this approach is ill suited for capturing such flows and links at the level of numerous individual institutions (such as HEIs). It also fails to adequately represent the resulting patterns of specialisation. Other manners of presenting such data are therefore called for.

Maps of network links and specialisation patterns are a first approach. Such maps make it possible to show directly the linkages (and their intensity) between institutions without imposing some ad hoc geographical partition (such as by member states or NUTS regions). While quite useful, such maps do not always tell us enough about how patterns of specialisation and the structure of networks evolve over time or about how these patterns and structures compare to those observed in other regions of the world such as the US. To do this, we need a number of summary statistics that capture the main aspects of the networks that are represented on such maps. We need to be able to assess the range extent density and other topographical features of these networks, both to track their evolution and to compare ERA networks with networks based in other regions of the world.

Fortunately, such statistics are readily available and can be computed quite easily from the underlying data by using a variety of software packages that are freely available (e.g. UCINET)

Formally, a network is a set of nodes (e.g, countries, individual institutions,) connected through a set of links. Such links can be directed if a link from A to B does not have the same meaning as a link from B to A (e.g. a licensing relationship) or undirected if the fact that A and B are connected is all that matters (e.g. collaborations between universities).

Useful measures include the number of nodes with at least k links (the "degree distribution" of the network) as well as measures of average connectivity (e.g. network density) and variance[18]. These statistics give us a good idea of how "dense" and well connected a network is, which is clearly relevant to the ERA. There are also various measures of the degree of "clustering" within a network and measures of the "centrality" of a given node in the network. Such measures get directly at the idea of the emergence of "poles of excellence".

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[18] For a more complete and formal description of these statistics, see M. O. Jackson, 2008, *Social and Economic Networks*, Princeton University Press, pages 30 to 43. For extensions of these indicators to cases where the links between two nodes can vary in intensity (e.g. number of cooperations between two universities), see S. Wasserman and K. Faust, 1994, *Social Network Analysis*, Cambridge university Press.

Annex 4
Monitoring the ERA initiatives: a methodological note

A centrepiece of ERA monitoring must be tracking the implementation, progress and effects of the five policy initiatives to which ERA has so far given birth. For each policy it is therefore useful to identify the cells of Table 1 where the relevant indicators are most likely to be found.

The first ERA policy aims at creating a European Partnership for Research to provide an environment where researchers can develop attractive careers. In particular, this involves facilitating the mobility of researchers across the ERA by fostering the openness of research institutions, ensuring the "portability" of grants and encouraging the formation of centres of excellence. As such many aspects of this initiative will be captured within our "fifth freedom" component. However some indicators of investment into first-class research infrastructure and of the level of funding of both research and higher education – found under our first component – would also be relevant. By contrast, the initiative on knowledge sharing – which emphasises the effective management of intellectual property in knowledge transfers from public research organisations to industry – is clearly linked to indicators grouped under our second "Research Triangle" component.

The initiative on joint programming closely corresponds to our type A2 indicators. As such it would cut "vertically" through table 1. However, given the initiative's focus on the coordination of research efforts, it is more closely related to our first component. Within this component indicators of type B and C will only be relevant if we can tie some intermediate and final effects fairly precisely to joint programming. An example would be a measure of publications or patents resulting from specific programmes designed in a joint programming framework.

Researchers

	A1	A2	A3	A4
Knowledge activities				
Knowledge Triangle				
Fifth Freedom				
Societal				
Grand Challenges				

Knowledge Sharing

	A1	A2	A3	A4
Knowledge activities				
Knowledge Triangle				
Fifth Freedom				
Societal				
Grand Challenges				

Joint Programming

	A1	A2	A3	A4
Knowledge activities				
Knowledge Triangle				
Fifth Freedom				
Societal				
Grand Challenges				

International S&T Cooperation

	A1	A2	A3	A4
Knowledge activities				
Knowledge Triangle				
Fifth Freedom				
Societal				
Grand Challenges				

The initiative on International Science and Technology Cooperation also involves the close coordination of member state policies. As such it will tend to be associated with policy levers indicators of type A2 1 rather than A1, indicators of type B and C capturing the resulting links between the ERA and the rest of the world. Relevant indicators will appear mostly under our third component – where the ERA's attractiveness to outsiders and its links to international networks are captured.

The initiative on Research Infrastructures aims at setting up a legal framework to facilitate the development and funding of pan-European research infrastructures. As such it belongs firmly within our first component, with an emphasis on type A2 indicators. However, as we will see in section IV, finding actual indicators corresponding to this initiative is extremely challenging.

Annex 5: Additional Indicators

We quickly lost a few additional indicators that could be considered to capture important aspects of the ERA. Compared to those included in section 4.3., the indicators found here tend to be more speculative, more controversial and harder to obtain – but maybe more original.

Knowledge Activities: Volume and Quality

Type A1

• Funding models for universities (STC report p. 97). *Erawatch*

• Independent evaluation of university research: % of funding linked to evaluation.

• Composite regulation indicator. *OECD*

Knowledge Triangle

Type A2

• Investment in EIT

Type B

• Proportion of HEIs with research parks and/or business incubators

• R&D Personnel by sector (Business, Government, HE).*Eurostat*

• % of inventors with tertiary education and % with PhD degree, *PatVal*

• % of EPO applications with at least one business and one HEI or governmental assignee

• Assessment of Collaboration between academia and business. *WEF*

Fifth Freedom and Knowledge Flows

Type A1

Bursaries for doctoral studies in the US, Japan, China, and other relevant regions S&E/bus-econ/others

• % of government procurement for knowledge-intensive goods advertised on a (at least) EU-wide basis.

• Proportion of "portable" research grants.

Type B

•. Cross-EU flows of Research infrastructure users: summary statistics for successive framework programmes

• Countries with the most central participants in FP5 and FP6 (STC report, p.99)

• % of academic staff with doctoral degrees from top 100 (Shanghai) HEIs from outside ERA

• % of academic staff with highest degrees from the HEI where they work.

• Network statistics for web-based hyperlinks between universities in EU-27 at NUTS 2 level.

• Network Statistics for ICT networks. *Obtainable, webmetrics*

• % of government procurement allocated to foreign EU-based supplier

ERA Effects(Type C)

• Quality assessment of education system. *WEF*

• Summary Innovation Index. *European Innovation Scoreboard*

• Concentration of employment in high-tech knowledge-based services and manufacturing relative to (world and) ERA average. *Eurostat..*

• R&D Personnel (HC) in the business enterprise sector as % of total employment. *Eurostat*

• % of High-Tech start ups .*OECD,*

• % of patent applications not originating from top 750 EU-based firms, per field. *Obtainable, EPO + UK VA Scoreboard.*

• Shares of EU/US in # of scientific publications cited in patents within 5 technology fields (STC, p.133). *DG Research*

Societal Dimensions of ERA

Type B

• Percentage of Households with Access to Broadband Internet

• Share of females in doctoral degrees with doctorates, by field

• Number/pattern of "hits" on the Athena website. *Obtainable from DG RTD*

Type C

• % of EPO applications with at least one female inventor. *Obtainable EPO.*

Grand Challenges

Type A1

• Proportion of staff with masters/doctoral degrees in Sciences – Math – Bus/Econ in ministerial departments. *This is meant to capture the idea of "knowledge-based policy-making"*

Type A2

• Proportion of staff with masters/ doctoral degrees in Sciences – Math – Bus/Econ in European Commission DGs.

Annex 6
Computing the indicator: Transition towards a knowledge based economy – Structural change (1)

Note by EUROSTAT

a) new classification requested

The EU Labour Force Survey (EU-LFS) contains data for economic activities and educational achievements and is the best available source for creating this classification. The Statistical Classification of Economic Activities in the European Community (NACE) has recently undergone a revision from Rev. 1.1 to Rev. 2, meaning EU-LFS data according NACE Rev. 2 is only available for 2008. It would still be too risky to base this classification on only one year of new data so NACE Rev. 1.1 has been used as a transitional solution.

In the test classification using EU-LFS data, out of 62 economic activities the share of employed persons with tertiary education was over 30% for 22 activities*. Situation is relatively stable while looking at the years separately. First activity below the line of 30% counts for share 29.0% and first activity above the line counts 30.5% share. This threshold is fully subjective; it splits the activities in shares of 1/3. The lower threshold could be 15 with 22 activities below and this leaves 18 activities in the middle group. Other thresholds are possible as well.

The highest category consists of:

activity	ISCED 5&6 share
Research and development	69.6%
Education	65.8%
Computer and related activities	59.9%
Extra-territorial organizations and bodies	51.8%
Manufacture of office machinery and computers	46.1%
Activities of membership organizations n.e.c.	46.0%
Financial intermediation, except insurance and pension funding	44.6%
Other business activities	42.3%
Recreational, cultural and sporting activities	41.6%
Health and social work	40.9%
Insurance and pension funding, except compulsory social security	40.7%
Activities auxiliary to financial intermediation	37.7%
Air transport	36.8%
Manufacture of chemicals and chemical products	36.5%
Public administration and defence; compulsory social security	35.9%
Manufacture of coke, refined petroleum products and nuclear fuel	34.2%
Manufacture of radio, television and communication equipment and apparatus	34.2%
Mining of uranium and thorium ores	33.4%
Manufacture of medical, precision and optical instruments, watches and clocks	33.3%
Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying	32.5%
Real estate activities	31.9%
Publishing, printing and reproduction of recorded media	30.5%

*(EU-LFS data for the average 2006-2008; economic activities were according to 2 digit level of NACE 1.1; tertiary education consists of ISCED 5 and 6. The data from 2008 data is partial and data is missing for BG, PL, SE, SI, but it only affects the 2006-2008 average slightly.)

This knowledge-based activity classification test produces a relatively mixed set of activities. It covers industry and services, public administration some of them being relative small or totally 'new' activities in STI measurement context.

The method used has the advantages of being very easy to make and update and is very user-friendly due to its transparency.

If the classification would be widely used it could be discussed whether this approach is sufficient. The alternative would be, as done for the existing Knowledge-Intensive Services (KIS), to combine with subjective input. The subjective approach has the advantage of "trimming" the core group (high knowledge) from "problematic" activities.

Some examples of problematic activities with high knowledge intensity:

- Mining of uranium and ore: The low number of employees makes the share unreliable and the share of tertiary educated fluctuates between 16 and 45% from 2006 to 2008.
- Real estate: Contains a high share highly educated but the work does not demand highly educated employees. It further creates an extremely high value added per employed person due to the high sums of money flowing through this sector and the low number of employees.
- Public administration: Its knowledge intensity has been debated and varies between countries, but now there is support of it being knowledge-intensive. However, this activity is not covered by all surveys (like Structural Business Survey (SBS), Structure of Earnings Survey (SES), etc).
- Education: Undoubtedly knowledge-intensive, however, the share of tertiary educated varies strongly between countries. In Sweden kitchen and cleaning staff often belong to the school staff while in countries like Greece they are outsourced, leading to a much higher share.

The examples above are given only to reflect whether the chosen method is sufficient or not. There are ongoing discussions about an overview of the high-tech manufacturing and KIS classifications, when R&D intensity data according NACE Rev. 2 will be available in 2011, and when additional years will be available for EU LFS, so using the easy approach is thought to be sufficient for now and then the classification can be included in the coming overview, in possibly 2011.

If there is need for this classification to already now be in NACE Rev. 2 as well, work could be undertaken to create at least a transitional classification according NACE Rev. 2.

Notice that this experiment used only 2 digit level of NACE classification. The situation would become more complex (but at the same time potentially more relevant) if using 3 digit level. Also many primary statistics whose data and variables would be shown through this classification does not necessary provide breakdowns beyond 2 digit level.

b) calculating the indicator

Taking the experimental nature of the classification so far calculations have not been executed.

Using the new classification the calculation of the indicator proposed 'Evolution of the share of the value added of sectors intensive in tertiary education work force' is possible only for the activities where Value Added data is available i.e. business sector activities. Alike the nominator would have to be reduced to the business sector activities.

The Value Added itself is an obligatory variable in business statistics transmission plan and the data are available, in particular at two digit level, for all MS.