Forward Visions on the European Research Area

VERA WP 1 – Task 1 (to Consortium and Commission Services only)

VERA Deliverable 1.2 Typology of RTDI directed towards Grand Societal Challenges

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1. Introduction and Task description

This document represents the integrated report of the stocktaking for the VERA project: Visions for the European Research Area. It is a substantial part of the project and for the work packages and deliverables to follow.

WP1 consists of three tasks:

T1: Scanning and Stocktaking of FLA with a focus on STI addressing the Grand challenges

In order to generate custom-made strategic intelligence for the future of ERA, the starting point was 1st the identification of Grand Challenges (GC) and 2ndly in relation to research sectors that are relevant for the ERA. The identification of GC was made on the basis of existing EU documents and of discussion papers that were published and discussed in related foresight and horizon scanning projects. These GC were classified into relevant research sectors, e.g. health, energy, environment, civil society. This approach allowed a thematic clustering of topics which then served as a basis for broadening the scanning of FLAs. We identified 10 sectors and more than 760 GC in total from a stock of 71 sources.

For the scanning of sources we took into consideration previous EU foresight and horizon scanning projects like EFMN, EFP, iKnow, ForSociety, ForLearn, ForWiki , SESTI etc. However, VERA stocktaking went beyond those activities, and we scanned also other international exercises such ESF's Forward Looks, similar activities by the Nordic Council, by energy organisations or other sectoral organisations, for example the WHO for comparison. In addition, the INCO networks, which VERA partners are affiliated with, will help with the stocktaking of FLA-like activities in various regions of the globe aside from the EU, for example, the Balkans, India, South-East Asia, etc. Since a lot of governmental institutions such as the US DOE or public research organisations such as the French Cemagref/IRSTEA, the German Max-Planck-Society and Fraunhofer-Society, the Finish VTT and many others have undertaken FLAs with relevance to the ERA in recent years, these exercises were taken into account with support of the excellent relations VERA partners entertain with the responsible actors.

Following the scanning of Task 1 created an inventory with a focus on science, society, technology and innovation issues which address the Grand Challenges.

For the purpose of the mapping we developed a tool which in part is compatible with existing ones (EFP, ETTIS) to transfer data more easily and to make use of projects that have already successfully created previous inventories. However, since we needed to create a new template for the mapping of the individual FLAs with additional or in part different categories, generic intellectual and design efforts were needed as well. According to the quality of information we were able to derive from the FLA stocktaking and dependent on the needs of the other work packages, especially WP 2, 3, 4 and 5,

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we had to define levels of granularity that make the comparison possible. What categories were eligible for the template and what level of granularity was considered feasible was determined in an internal workshop with the work package leaders. The results of the stocktaking are already presented on the VERA website in such a way that the project partners and the clients at the European Commission will be able to use it any time.

As part of this task, we conducted a serious of personal and phone interviews with experts on STI Foresight and FLAs to cover also countries which are not represented in the VERA consortium. The series of interviews took place during the first eight months after project start so that the results could be compared with the outcome of the mapping and integrated into this report.

T2: Development of Typology of STI themes directed at societal challenges

For a systematic overview of the inventory, we developed a typology that is representative for the FLAs mapped. This typology includes sector categories as well as STI categories but also categories that account for the engagement of civil society, level of participation, methodologies used, topics preferred by certain countries, regions, etc. This typology helps to identify major trends affecting the future of the ERA. This trend analysis will be explored further in WP 2. The typology further lays the ground for discussing which type of activity can serve which type of purpose for policy making; what are the key issues that need to be taken into account as potential building blocks of the ERA evolution.

T3: Assessment of usefulness for policy making of different types of FLAs through a cross-community workshop

Task 3 is still lying ahead of us. To assess the usefulness of the FLAs identified as relevant for the ERA, we will hold a workshop with EU and national policy makers. By help of the typology the FLAs will be introduced and their usefulness and relevance as a basis for further political action in the field of STI will be discussed. This format will also provide an opportunity to transfer results from the stocktaking to future Joint Programming Initiatives. Representatives of these fora will be invited to the assessment workshop. This workshop format can be a starting point for inspiring a new ERANET on Forward Looking Activities governed by the Member States and the European Commission.

The assessment workshop will take place between February and April 2013 and intends to feed relevant results into WP2 and to the scenario building in WP3 and 4, aside from giving input to external processes. In addition, if required, this task will provide room for ad-hoc requests from the European Commission on single topics. If needed, adjustments of the inventory can be made from the workshop inputs within one month after the workshop.

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2 Methodology

2.1 Definition of Grand Challenges

The “Grand Challenge” concept has been developed and refined by a range of individuals in specific organizational contexts over the past decades, becoming a more prominent term recently especially at EU Commission level.

There are very different understandings and definitions of this term. Some present already a technological solution to a problem that is only roughly sketched. Others imply devastating dystopias. Some are focusing on one sector only (for example defense, engineering, health), others point primarily to global developments such as climate change. In all cases, action orientation is implicit. Another point they have in common is that they want to “make the world a better place”, starting from the normative notion that some developments are going in the wrong direction and that concerted action is needed to change the path in order to improve the situation.

In the EU context, the concept of "Grand Challenges" was suggested by the ERA Expert Group "Rationales for the European Research Area", chaired by Luke Georghiou (University of Manchester). While there is a pressing need to improve the effectiveness of the public research system, the ultimate justification of the resources and commitment needed to achieve this lies in increasing the value of the contribution that public and private sector research makes, and is seen to make, to Europe’s economic, social and environmental goals.

> The rationale behind the project [ERA Expert Group, S. G.] is the fact that mankind is currently facing a number of severe global challenges, such as climate change, food and energy security, or (re-) emerging infectious diseases, which can only be dealt with on a multilateral or global level, since both the originating factors of the challenges and their consequences are global in nature. Institutional coordination and collective action are therefore required, in order to efficiently bundle the necessary resources. Science, technology and innovation (STI) play an important role in most strategic responses to global challenges. This coordination and regulation of international STI cooperation can be based on very different settings of global governance.
> http://www.era.gv.at/space/11442/directory/11767/message/19666.html

Against this background, our understanding of a grand challenge is a specific complex of problems that, our society has to face in the near, mid- or long-term future. The impact of this problem complex would be dramatic – even of global reach - and of high likelihood if no feasible solutions were found. Thus the concept of Grand Challenges implies three crucial aspects: **first it is problem driven, second a solution needs to found, and third a scenario of how society will change if this solution is found or not found.**

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We do not see new or emerging technologies as such as Grand Challenges. Rather, they can be part of problem complex or of the solution. To give one example: AIDS remains a severe and in some parts of the world an increasing problem. Many parts of the world fear that they have lost the battle against AIDS. A vaccine against AIDS would help to cure many ill persons and prevent new infections.

The Grand Challenges approach is originally an idea by US mathematician David Hilbert. His list of important unsolved problems more than 100 years ago has encouraged innovation in mathematics research ever since. Dr. David Hilbert first applied the concept of a Grand Challenge to the field of mathematics in which he identified 23 specific challenges. Especially in the US the concept has disseminated too many other academic disciplines and policy areas and was revitalized by the Bill & Melinda Gates Foundation which, in 2003, identified 14 Grand Challenges in Global Health. In 2008, they also launched a new $100M, five-year initiative called Grand Challenges Explorations, which is an extension of the Grand Challenges in Global Health initiative.

Similarly, Grand Challenges in Global Health is an approach in the US that focuses on 16 major global health challenges with the aim of engaging creative minds across scientific disciplines — including those who have not traditionally taken part in health research — to work on solutions that could lead to breakthrough advances for those in the developing world (http://www.grandchallenges.org/about/Pages/Overview.aspx)

GRAND CHALLENGE #1
Create Effective Single Dose Vaccines That Can Be Used Soon After Birth
GRAND CHALLENGE #2
Prepare Vaccines that Do Not Require Refrigeration
GRAND CHALLENGE #3
Develop Needle-Free Delivery Systems
GRAND CHALLENGE #4
Devise Reliable Tests in Model Systems to Evaluate Live Attenuated Vaccines
GRAND CHALLENGE #5
Solve How to Design Antigens for Effective, Protective Immunity
GRAND CHALLENGE #6
Learn Which Immunological Responses Provide Protective Immunity
GRAND CHALLENGE #7
Develop a Biological Strategy to Deplete or Incapacitate a Disease-transmitting Insect Population
GRAND CHALLENGE #8
Develop a Chemical Strategy to Deplete or Incapacitate a Disease-transmitting Insect Population
GRAND CHALLENGE #9
Create a Full Range of Optimal, Bioavailable Nutrients in a Single Staple Plant Species
GRAND CHALLENGE #10
Discover Drugs and Delivery Systems that Minimize the Likelihood of Drug Resistant Micro-organisms
GRAND CHALLENGE #11
Create Therapies that Can Cure Latent Infection
GRAND CHALLENGE #12
Create Immunological Methods that can Cure Chronic Infections
GRAND CHALLENGE #13
Develop Technologies that Permit Quantitative Assessment of Population Health Status
GRAND CHALLENGE #14
Develop Technologies that Allow Assessment of Multiple Conditions and Pathogens at Point-of-Care

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GRAND CHALLENGE #15
Discover Biomarkers of Health and Disease
GRAND CHALLENGE #16
Discover New Ways to Achieve Healthy Birth, Growth, and Development

In part as a reaction to globalization, there is also an economic competition aspect attached to Grand Challenges. USA policy used the terms to goals in the late 1980s for funding high-performance computing and communications research in part in response to the Japanese 5th Generation (or Next Generation) 10-year project.

"A grand challenge is a fundamental problem in science or engineering, with broad applications, whose solution would be enabled by the application of high performance computing resources that could become available in the near future. Examples of grand challenges are:

1. Computational fluid dynamics for
   - the design of hypersonic aircraft, efficient automobile bodies, and extremely quiet submarines,
   - weather forecasting for short and long term effects,
   - efficient recovery of oil, and for many other applications;
2. Electronic structure calculations for the design of new materials such as
   - chemical catalysts,
   - immunological agents, and
3. superconductors;Plasma dynamics for fusion energy technology and for safe and efficient military technology;
4. Calculations to understand the fundamental nature of matter, including quantum chromodynamics and condensed matter theory;
5. Symbolic computations including
   - speech recognition,
   - computer vision,
   - natural language understanding,
   - automated reasoning, and
   - tools for design, manufacturing, and simulation of complex systems."

"A Research and Development Strategy for High Performance Computing", Executive Office of the President, Office of Science and Technology Policy, November 20, 1987

Building on similar concepts, Grand Challenges Canada has developed its own definition of a Grand Challenge that reflects our specific use of the term in the context of global health:

A grand challenge is one or more specific critical barrier(s) that, if removed, would help solve an important health problem in the developing world with a high likelihood of global impact through widespread implementation.

In analyzing and comparing national Grand Challenges approaches for the European Area Research Board, the JIIP (2012) defines the concept as a “combination of major public and private interests, [that] are seen as key for realizing future economic growth and are concerned with important social and/or environmental problems” (p. 5).

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In the context of VERA, we take into account the different approaches and definitions for Grand Challenges but at the same time we also want to free ourselves from predefined patterns of thinking. Though we acknowledge that the "European approach" as defined by JIIP has a strong economic nexus, we do consider this as a fix characteristic of our Grand Challenges approach. Rather the VERA Grand Challenges approach looks for Grand Challenges driven by societal demand, implying a mission oriented action toward coping with the Grand Challenges. Thus, as mentioned above the first key characteristic of our Grand Challenges is that they are problem driven.

Secondly, the Grand Challenges we are identifying in VERA as relevant for the European Research Area should also comply with several additional criteria. One of them is that they point in a direction how to solve a societal problem. This solution should be compatible with public policy making. Grand Challenges we want to discuss in VERA should be of such kind as to be relevant for policy making and not of any nature that is out of scope for public policy. Further, the Grand Challenges should cease momentum and be of relevance for the mid- and long-term future. The content of the Grand Challenges should also be of relevance for the ERA governance in general and represent the awareness of (at least some of) the Member States that this issue needs political action. In addition, the solution implied should be a feasible innovative option (or several). This can be of incremental character or even of radical nature.

The 3rd key characteristic comprises scenarios what is going to happen, if an indicated alternative solution is implemented (positive) or if not (negative). Many Grand Challenges imply this scenario without further explanation. Some, however, in some FLA reports or policy papers where Grand Challenges are discussed, take great care of depicting future scenarios with reference to national, transnational and often even to global changes. The scenarios usually make clear that the Grand Challenges (and their solutions) are of high impact and of high likelihood.

References:

Joint Institute for Innovation Policy (2012): Investing in Research and Innovation for Grand Challenges. Study to assist the European Research Area Board. European Commission, Directorate General for Research and Innovation.

European Commission. Directorate General for Research (2008): Challenging Europe's Research: Rationales for the European Research Area (ERA). Report of the ERA Expert Group.

2.2 Screening of FLAs

Documents considered

In order to generate custom-made strategic intelligence for the future of ERA, the starting point was 1st the identification of Grand Challenges (GC) and 2ndly in relation to research sectors that are relevant for the ERA and for ERA governance.

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The identification of GC was made on the basis of existing EU documents and of discussion papers that have been published and discussed in relation to the future governance of ERA, and forward looking activities at national, EU and global level focusing on Grand Challenges that are relevant for the future governance of ERA, directly or indirectly. We took into consideration five different types of activities/documents to identify the Grand Challenges (not older than 2005):

A. ERA-governance related policy and strategy papers
B. European FLA addressing the Future of EU and ERA (directly or indirectly)
C. FLA on national R&I Priorities (not obviously ERA-related)
D. FLAs on important sectors for Europe
E. International Scope

As a resource, we took into consideration previous EU foresight and horizon scanning projects like EFMN, EFP, iKnow, ForSociety, ForLearn, ForWiki , SESTI etc. VERA stocktaking, however, went beyond those activities, and scanned also other international exercises such ESF's Forward Looks, similar activities by the Nordic Council, by energy organisations or other sectoral organisations, for example the WHO for comparison. In addition, the INCO networks, which VERA partners are affiliated with, will help with the stocktaking of FLA-like activities in various regions of the globe aside from the EU, for example, the Balkans, India, South-East Asia, etc. Since a lot of governmental institutions such as the US DOE or public research organisations such as the French Cemagref/IRSTEA, the German Max-Planck-Society and Fraunhofer-Society, the Finish VTT and many others have undertaken FLA with relevance to the ERA in recent years, these exercises will be taken into account with support of the excellent relations VERA partners entertain with the responsible actors.

In Task 1 we scanned these relevant Forward Looking Activities and created an inventory with a focus on the governance of science, technology and innovation issues which address the Grand Challenges. We had to assess to what degree they addressed science, technology and innovation matters as well as the different levels of granularity.

The section below points out the 5 different categories of activities covered in the VERA stocktaking (examples only):

A. ERA-governance related policy and strategy papers

EU strategic and long-term policies

- "Europe 2020 Strategy" and its flagship initiatives a.o. the Innovation Union – COM(2010)546
- A Budget for Europe 2020 (MFF) – COM(2011)500
- Horizon 2020, the future FP for R&I – COM(2011)808
- Single Market Act – COM(2011)206

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- Three 2050 EC "Roadmaps" for: Low carbon economy, Transport and Energy – COM(2011)112, COM(2011)144, COM(2011)885
- Green paper on ERA – COM(2007)161

B. European FLA addressing the Future of EU and ERA (directly or indirectly)

SSH Blue sky research projects

- EFP: European Foresight Platform
- SESTI: Scanning for Emerging S&T Issues
- FARHORIZON: Use of foresight to align research with longer term policy needs in EC
- INFU: Visions, scenarios and implications for policy and practice
- CIVISTI: Participative horizon scanning
- IKNOW: Wild cards and weak signals
- SANDERA: Security and defence

Current SSH projects

- PASHMINA: Paradigm shifts
- AUGUR: The world and Europe in 2030
- MEDPRO: Foresight in the Mediterranean area
- Expert Group: « Global Europe 2050 »

C. FLA on national R&I Priorities (not necessarily ERA-related at first glance)

- France : France2025 http://www.strategie.gouv.fr/article.php3?id_article=811
- Germany :BMBF-Foresight http://www.bmbf.de/en/12673.php
- UK: UK TIF Technology and Innovation Futures UK Growth Opportunities for the 2020s
- Spain: ENCYT2020 Estrategia Nacional de Ciencia y Tecnología (ENCYT) 2020. Ejercicio de Prospectiva a 2020
- Poland: Poland2020 Edwin Bendyk: Poland 2020. A Look from the Future. Alternative Visions of Poland's development based on the National Foresight Programme Poland 2020 scenarios
- Flanders: T&I Flanders Technology and Innovation in Flanders: Priorities. Summary report and recommendations. http://www.vrwi.be/en/publications/study-18a
- Finland: Foresight.fi http://www.foresight.fi/
- Ireland: Ireland2025 Sharing our Future: Ireland 2025 – Strategic Policy requirements for Enterprise Development

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D. FLAs on important sectors for Europe

Transport, Mobility & Aerospace

- Future of Super Intelligent Transport Systems
- FreightVision
- Transportation & Logistics 2030

Agriculture

- Agrimonde

Health & Nutrition

- SESTI

ICT

- Envisioning Digital Europe 2030: Scenarios for ICT in Future Governance and Policy Modelling

Energy

- Agriculture and the Challenges of Energy

Services

- INFU

Security

- FORESEC
- SANDERA

E. International Scope

- World Economic Forum 2012
- US National Intelligence Council: Global Trends 2025: A Transformed World[1]

[1] Since 2012 an updated version is available at: http://publicintelligence.net/global-trends-2030/

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Next to primary project and meta information the stocktaking focused on identifying

- Grand Challenges (at different levels of granularity)
- the connecting fields between the Grand Challenges (or overlapping categories; for example water shortage and draught as connectors between climate change and migration)
- the scenarios arising from the Grand Challenges
- the innovative solutions offered to cope with those challenges
- the aspects raised concerning the governance of ERA (for example top down, bottom up, multi-level), and also RTI governance (for example also at national or organizational level)

For the purpose of the mapping we created a new template with categories that address the specific aspects of ERA governance. It is presented in the Annex.

2.3 Regional Coverage

Geographically, the stocktaking had a focus on the EU and European countries but took a look beyond borders as well to get an outside view. While about one fourth of the reports focused on the EU in general, particular studies covered the UK, Finland, Germany, Czech Republic, Austria, Belgium, Greece, Denmark, France, Spain, the Netherlands, Ireland, Italy, Lithuania, Norway, Poland, Romania, Estonia, Slovenia, and Sweden. Beyond Europe, the US is covered in several reports, due to most of these reports having US origin. Other countries covered, though not prominently are Australia, Bahrain, Canada, China, and to lesser degree Malaysia, Turkey. One or two studies discussed national case for Ghana, Tunisia, Ethiopia, South Africa, Japan, Russia, India, Japan, BRIC, Iran, Israel, Turkey, Qatar, Saudi Arabia, Mexico, and Brazil. US studies we included discussed also the developments in Iraq, Afghanistan, and North. As regions beyond the EU some studies discussed trends in Latin America and the Sub-Saharan region.

2.4 Handling the template

The template was designed in a simple form, in excel, as this is compatible to most computer software programs and relatively simple to handle. Moreover, data could be compiled, changed, imported, and exported without complication. The WP1 team did not work, however, on one single document as this bore the danger of not being robust enough. Rather, each researcher worked on her/his files and in the end AIT will compiled them into one integrated database. The results are also stored and presented on the VERA website run by ZSI and are available to the public. For the purpose of integration and easy handling ZSI supported WP1 to create a common code file. Thus the data

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sheets, individual data and original documents can be retrieved easily by the project team. ZSI implemented this feature together with some user-friendly search and filtering options. This is an output oriented site. New inputs cannot be added by external users.

Two phases of stocktaking

The stocktaking template has was designed in such a way to collect information that will help to reach the objective of the work package, i.e. to answer questions such as

- What are the Grand Challenges the documents and projects we look at are concerned with in terms of economy, environment, geopolitics, society & ethics, Technology, and health?
- Do these documents and projects represent the discourse on Grand Challenges in the European Union and in other parts of the world?
- What conclusions can we draw from these documents concerning the future governance needs of the ERA? On RTI governance?

In order to deals with the masses of documents and projects somehow related to these questions we took an approach in two phases: the 1st phase served to identify a maximum of 100 documents/projects that are able to answer the questions posed above. In this phase we only filed the primary data to get an overview on the existing documents and projects. Once we had this overview we took a close look at the suitable documents and started phase II. The 2nd phase comprised the important content data on Grand Challenges, solutions, scenarios, etc. The first half of the cases was finished before the internal stocktaking WS in June 2012.

Before phase I could be started, however, the AIT VERA team launched a pilot phase to test the feasibility of the templates and discuss the results with the WP1 members. After phase II of the stocktaking, AIT started with a filtering mechanism in assigning the Grand Challenges to different STI or societal themes or research sectors (clustering). This process and findings were discussed among the WP1 members before being fed into the internal stocktaking workshop with the entire VERA consortium (June 2012 at AIT). The workshop served to reconfirm or change the clustering and develop a typology of STI themes related to Grand Challenges.

Before all data sheets were compiled into one master file, the AIT WP1 team took care of the quality control. If data were ambiguous or missing, the AIT team got in contact with the rapporteur to complete the data set.

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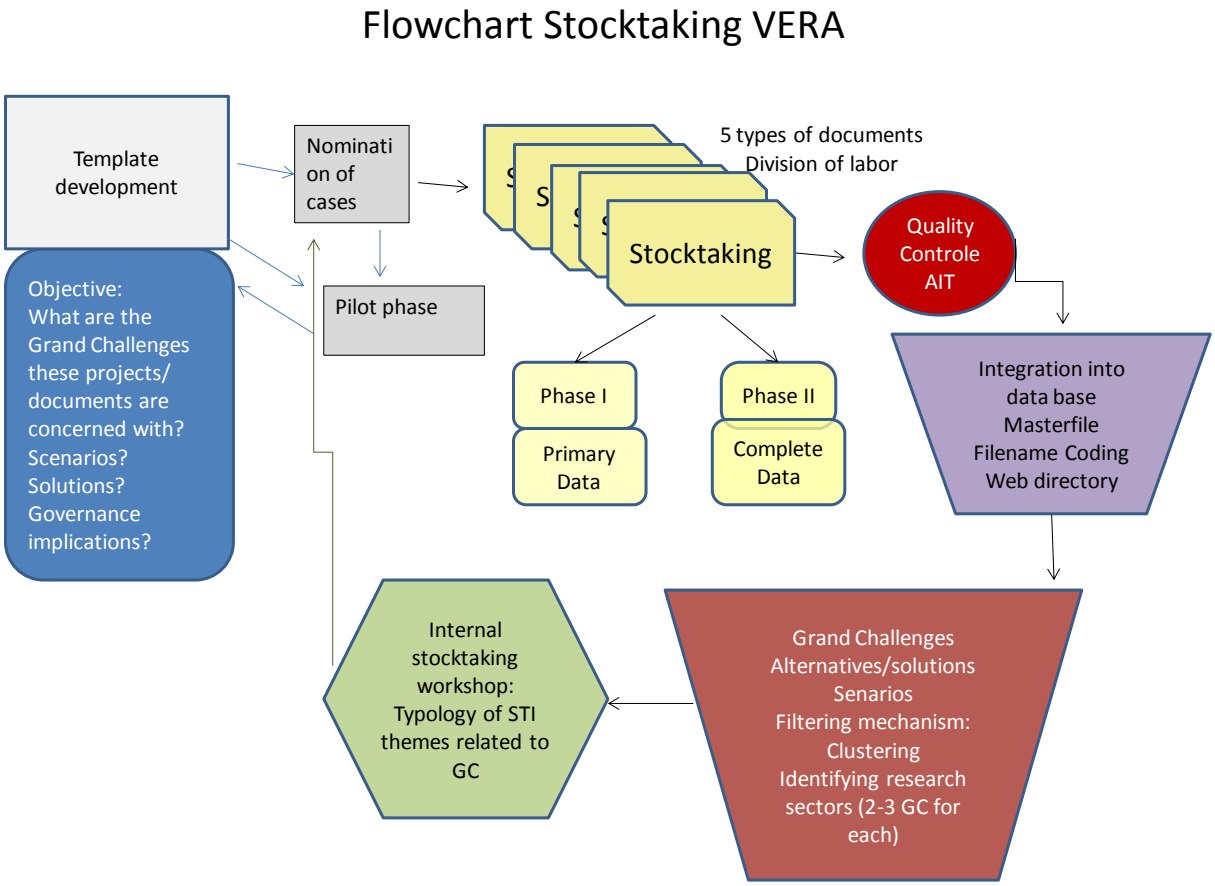
This process is described in the flow chart below:



Time frame for VERA stocktaking

March 22	Design of stocktaking draft finished
April 7	End pilot phase
April 10	Start nomination of cases (phase 1)
April 24	Distribute cases among WP1 team and start phase 2
June 1	Compile all finished data in one data base (at least 50% of the cases)
June 1	Start filtering mechanism and clustering
June 6	Discuss clustering results

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June 13	Revise clustering results
June 20	Stocktaking WS
June 21	Continue with the rest of the stocktaking
September 1	Finish stocktaking
September 21	Finish stocktaking file 1st draft
October 15	Finish stocktaking master file

Co-operation with other work packages

According to the quality of information we were able to derive from the FLA stocktaking and dependent on the needs of the other work packages, especially WP 2, 3, 4, 5 and 6 we had to define levels of granularity that make the comparison. What categories are eligible for the template and what level of granularity is considered feasible was determined in cooperation with the work package leaders. The result of the stocktaking is now presented at the VERA website in such a way that the project partners and the clients at the European Commission are able to use it any time.

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2.5 Screening of Country Cases

As part of this task, we conducted a serious of personal and phone interviews with experts on STI Foresight and FLAs to cover also countries which are not represented in the VERA consortium. The series of interviews took place during the first eight months after project start so that the results could be compared with the outcome of the mapping and integrated into this report.

As part of WP1 a workshop was foreseen with the central purpose to systematically engage those FP7 National Contact Points (NCPs) that could serve as mediators between EU and national research priorities in the stocktaking exercise not represented in the VERA consortium, including some relevant neighboring countries. Only those NCPs would be useful which are engaged in SSH topics with relation to VERA objectives. The NCPs taking part in ForSociety networking project would be an ideal group of actors. However, in the first six months of the VERA project this group of actors and the ForSociety project as a whole do not have any capacities to cooperate with the VERA project, nor do they have any event which would be useful for VERA to participate in to gather the required information.

The VERA coordinator and the WP leader thus decided to take alternative steps for generating the required information for the stocktaking. This alternative will be a number of interviews with national FLA actors in the respective countries. Actors in charge of national FLAs have also a much better overview and first hand information on national research priorities and Grand Challenges that were identified in the individual exercises. They usually also have a much better understanding of the task planned in VERA as they are familiar with the concept of FLA and RTI strategy papers.

Accordingly, WP1 start in April 2012 to identify the proper actors and important national FLAs and contacting those to set up appointments for interviews. Wherever possible, the interviews were be face to face, e.g. at conferences. Where this was not possible for reasons of time, logistics or costs, we undertook telephone interviews.

Countries and interviewer are listed below:

- Poland: Ewa Dönitz (FhG-ISI)
- Bulgaria: Philine Warnke (FhG-ISI/AIT)
- Greece: Effie Amanatidou(UniMan)
- Turkey: Oczan Saritas (UniMan)
- Israel: Susanne Giesecke (AIT)
- Switzerland: Susanne Giesecke (AIT)
- Russia: Susanne Giesecke (AIT)

The interviews were conducted between end of April and end of September 2012.

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The questionnaire was semi-structured and included questions like the following:

1. What projects were conducted to identify national RTI priorities?
2. Did these projects also discuss GC and/or (ERA/RTI) governance aspects?
3. Who did it?
4. With which partners?
5. When?
6. What documents resulted from these exercises?
7. Is there a project website?
8. Who is the project owner/sponsor?
9. What was the budget?
10. Which sectors were covered?
11. What were the GCs addressed?
12. What are the connecting fields?
13. Were there any aspects of ERA governance touched?
14. Were there any aspects of RTI governance touched, e.g. at national level?
15. Were there any other governance aspects touched?
16. Were there any surprising or remarkable issues?
17. What is the background/story behind the exercise(s)?
18. Were there any scenarios discussed?
19. What were the actions/solutions discussed to deal with the GC?
20. Who would potentially benefit from such actions taken?
21. What was the time horizon addressed?
22. What were the methods used in the exercise?
23. What was the target group for the exercise?
24. What were the objectives of the exercise?/what was the inspiration to conduct the exercise?
25. What was the geographic scope?
26. Were there any European issues discussed?

The interviews were documented in written form and transferred to the WP1 team. Here, the interview documents were fed into the stocktaking systems (see paper on stocktaking approach by Susanne Giesecke of April 2012). This procedure guaranteed a fair representation of EU countries and some neighboring countries in the stocktaking exercise. At the same token the procedure captured a broad scope of (national) RTI priorities and Grand Challenges. They were also considered in the typology of Grand Challenges (task 3 of WP1) and can later be considered in the scenario building (WP4).

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Timetable

April 16 - 21	Identify relevant FLA and contact persons
April 24	Start interviews
June 19	At least 4 interviews finished and results integrated into stocktaking database
September 20	Total of 7 interviews finished and results integrated into stocktaking database

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2.6 Clustering

The definition for a Grand Challenge was crucial for the clustering of the 761 Grand Challenges we identified. Even though the Grand Challenges we excerpted from the were not necessarily titled as such or had a different definition we need a definition of our own as a concept to work with in VERA in order to find headlines for the clustering of the findings. Our work so far for analyzing the stock-taking content concentrated on the GC. We did not take into consideration the scenarios, solutions, or any other categories. These will be used in the later work. For a better understanding of our approach and intention on clustering the GC we are describing the process of clustering here briefly:

The WP1 team wrote or printed every single CG of the pool of 761 on individual cards. In preparation of the internal WP1 workshop with the whole VERA team in June 2012 we started this work at a smaller scale, that is with the GC of the first 35 FLAs we had mapped to far at that time. First we collected and sorted all the Grand Challenges according to their field, e.g. environment, economy, mobility. Then we made ourselves acquainted with all the GC and started to cluster according to similarities and meta-topics. This was a lengthy process of several days and involved intense interactive discussion and continuous re-clustering. Where ever necessary we copied the cards of a GC to make it available to more than one cluster. Some cards however were so general and not able to indicate an useful CG that they were sorted out. The code system always helped to track the original source of each CG because each card carried the code, for example A2 for Europe 2020. The clusters resulting from this exercise were the following 28:

- (Gas)emissions and pollution
- Free choice of life style
- Fiscal management (instruments, prices, taxes)
- More sustainable competitive tourism
- Climate change mitigation
- Financial, ecological, political shocks call for new regulatory framework
- Long-term planning perspective for environmental sustainability
- Security (shortages) of basic resources (food, water, energy)
- Reduce use of non-renewable resources
- Decrease of energy consumption and increase of energy production efficiency
- Managing the societal dimensions of emerging technologies
- Reforming/improving education and training
- Progressing democratization and preservation of cultural heritage and diversity
- Crime prevention and security systems to tackle military threats
- New emerging powers & challenging the traditional global governance
- Global social and economic inequality
- Challenges of the European economy

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- Need for more balanced employment
- New dimensions of infections and diseases of human, animals and plants due to climate change
- Healthy food and sustainable agriculture that is adopting to climate change and improving the quality of life in rural areas
- Sustainable population growth and ageing in the European welfare state
- Copying with humanitarians challenges caused by migration
- Challenge in mobility and traffic
- Secure supply of resources for industry
- Sustainable manufacturing
- Creation of single European digital market
- Technical and societal innovation for data security
- Exploring new frontiers of technologies from the bottom to the orbit

These clusters were then discussed in the stocktaking workshop of June 2012. The group in part re-organized the clusters but all in all confirmed the approach. The alterations of the clusters during the interactive process are documented in the annex. With respect to the "usefulness for policy making" of the GC perspective the workshop participants discussed a few crucial points.

- GCs are a useful typology for thinking in STI themes, of which some may rather be related to social innovation. GCs are also useful to replace the "technology push" debate towards the question how to address GCs through technological innovation.
- Clearly, in order to address Grand Challenges a systemic view on socio-technical systems that allows for formulating problems in a more structured way and that is integrating both social and technological is required. However, when emphasizing the system's view there is a danger to fall back into classical "innovation systems" discourse which is not oriented towards societal challenges but towards the capability of innovation systems to create any kind of innovation.
- Alternative or complementary approaches to the systems approach could be thinking in "paradigms", "transition arenas" or "problem formulations".
- The analysis revealed a strong presence of established sectoral perspectives in the FLA studies. Accordingly, it seems useful to complement the systemic perspective required for Grand Challenges with sectoral approaches in order to link up to dominant policy arenas and discourses.
- The debate should not only focus on thematic priorities but also consider adequate STI policy instruments.

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3. Results

3.1 Inventory

The inventory contains 726 individual Grand Challenges named by the 67 screened FLAs. It has been submitted in an independent report and can be can be downloaded at http://vera.dev.zsi.at/stocktaking/list.

3.2 The 16 Grand Challenges

This chapter documents Grand Challengesageing that were identified through subsequent clustering of the more than 750 individual issues from inventory and interviews as described in the previous chapters.

3.2.1 Uncertainty is arising from a multipolar world

Increasing polarisation and regionalization are driving towards a multipolar world. Possible evolutions and implications or even solutions for this multi-aspect and multi-level challenge are still hardly understood.

There is general acknowledgement that the current world order is changing. This is based on the emergence of new economic powers (BRICs, Latin America), and the rise of new economic models like state capitalism. This brings a change in the role of military power balance too. Alongside the shift of the centre of world economic growth to emerging markets in Asia, we may also be witnessing a diminishing decisive role of the EU and US in global affairs. At the same time difficult conditions are emerging in certain countries that call for attention (Afghan with drug trade, national security force development and governance challenges; Cuba, Mexico, Venezuela, Haiti with efforts to limit democratic freedoms). Emerging mega-cities around the world are expected to demand more power and autonomy. Uncertainties rise in terms of governance and the way of ruling (multi-lateralism, or rule-based) in the emerging world. International relations are expected to become less stable and consensus building even on urgent issues more difficult. States and international institutions may increasingly lose enforcing power when acting individually. Isolated conflicts such as the China – Vietnam conflict over disputed islands in the South China Sea may have global impact.

The implications of these phenomena span various areas. In relation to the economy a questioning appears of current democratic neo-liberal growth model with Chinese state capitalism and Islamic economic growth as alternatives. With regard to

Turkey considers space and defence among the five need oriented areas relevant for orienting its RTI strategy (the other three are energy, water and food). A country like Switzerland is anticipating challenges to its role in a multi-polar world and considered an increasingly insecure and conflict laden environment in its scenario work.

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science and technology, China and India are challenging Europe along their economic and scientific progress. The difficult conditions in some countries raise issues around democracy that lead to social pressures and turmoil (like in China) while the anti-globalisation movement is gaining power. Sources point out that this challenge calls at least for investing in long-term stability and prosperity in the EU neighbourhood as well as enhancing EU solidarity at time of crises.

3.2.2 Values and attitudes are changing globally

Attitudes and values are changing globally; societies and in particular policy need to respond to these changes.

Several studies point towards new attitudes with respect to environmental issues, well-being, economic growth, global justice, personal autonomy and social cohesion. As a result several arenas such as the judicial system, consumption patterns, political participation, pension systems and information systems are challenged to respond to changing demands. In particular consumption patterns are being challenged by sustainability oriented value systems. Several studies refer to changing consumer behaviour such as the turn towards value-oriented buying, ecological lifestyles, knowledge-based choice making or even frugality thinking. Traditional values such as appreciation of scarce resources and long-lasting care of products may experience a revival. New innovation patterns such as "cradle to cradle" and locally oriented production patterns may foster different values, competencies and infrastructures such as for instance a new appreciation of traditional and local craftsmanship. Adequately responding to this behavioural change at the nexus of consumption and sustainability is seen as a core challenge by several studies. They point out that a new type of interaction between the government, business and the communities is required to tackle this challenge. Media are expected to play a relevant role as well. On a global perspective, a change in values might also bring about more solidarity with the poorest in the EU Member States and in other regions of the world. Attached to a change in values is also the protection of pension rights. With the demographic change, a change is required towards a balanced social security system that enables life in dignity for all. Other value driven demands that will need to be addressed at political level are personal autonomy, individual empowerment and self-determination.

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3.2.3 The traditional role of the state is challenged

A number of developments are requiring new models of governance that are moving beyond the traditional model of the state.

The need for mediating between conflicting interests between the economy, environment and society and for reducing socioeconomic imbalances between geographic regions is challenging the traditional role of the state. New governance models with a new distribution of responsibilities and influences are required. Other factors that are challenging established governance models are the increasing demand for citizens' participation and transparency and the rise of non-state actors and the social divide in general, the erosion of trust in large institutions as well as in party politics and the call for personal responsibility and direct participation of civil society. Economic and cross-cutting issues concern ongoing crises and instabilities in the current (socio)economic situation, such as prosperity gaps, regional disparities, or fragile states. The role of the state might therefore need to evolve towards a more advanced and transparent governance model with limited bureaucracy, and move towards pluralism and more direct democracy.

3.2.4 The world is becoming more interconnected and thus more vulnerable

The more the world becomes interconnected and interdependent, the more new forms of crime and security threats are inter-linked and have far reaching consequences at all levels of society.

National sources underline this cluster of challenges: According to our interviews in Switzerland the change of values is considered a core driver of change for the future. Foresight in Switzerland emphasised a need to raise new awareness about common values as a key challenge for the Future. Scenarios were developed that describe how values could evolve differently within a scale from return to traditional values to complete loss of shared values within Switzerland. Similarly in Bulgaria the change of cultural identity is considered a highly relevant challenge. Polish Foresight identified the need to better understand popular culture and to conduct research in issues like psychological, social and cultural aspects of the use of modern communication technologies and the role of media.

Security threats may have more far reaching implications due to increasing interdependence between states and spread of new technologies. This applies to diverse types of threats such as threats to critical infrastructures and supply chains as well as threats to space systems such as interference of radiofrequencies. The growing dependence on complex high-technology infrastructures leads to new structural vulnerabilities. There are new forms of crime (like cybercrime) including incidents of data fraud or theft, sabotage and massive digital misinformation. The cyber world is becoming more important due to the changing role of individuals using ICT. Cyberattacks may have far reaching impacts due to increasing systems' interdependence.

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More 'conventional' threats continue to exist and intensify. There is proliferation of weapons of mass destruction, organised crime and growing nuclear risks in certain parts of the world (like the Middle East). The growth and integration of the S&T knowledge base also increases uncertainty and can lead to heightened techno-economic and techno-military rivalry. Terrorist attacks may span several fields from the cyber-space to drug or CBRN2 threats.

As an example, as emphasised in the Vera interview, Switzerland sees the improvement of the state's and affiliated institutions capacity to act as one of the core Challenges for the future, the Polish Foresight viewed the development of a civil society as one of the societal challenges of the Future and in particular highlighted the growing relevance of women both in policy and economy.

Economic security may be threatened by new forms of crime such as illicit trade, vulnerable supply chains, or pervasive entrenched corruption. Societal lives may be undermined by xenophobia, organised crime, terrorism, (on-line) abuse, restricted mobility, more 'introvert' life styles. Scientific and technological advancements (like in ICT, robotics, materials, nanotechnology, biotechnology and converging technologies) will increasingly put privacy and legal issues (e.g. on surveillance) on the agenda.

In finding solutions to this challenge, action is required in the field of organised crime, cyber-crime and terrorism. For example, experts suggest reviewing policies and practices in the field of terrorism. Sensitive technologies need to be protected from abuse or misuse. Action should also be taken in the direction of conflict management. At contest is the responsibility for security issues that is shared between the state and society. This shared responsibility seems to change more toward society.

At the policy level, however, steps should be taken to eliminate the fragmentation of national security and defence policies that have to deal with inter-connecting global threats, to adapt international regulatory architecture and to ensure more efficient communication in the society at large. The aim should be to reach inclusive, innovative and secure societies. While ICT is vulnerable to attacks it may also offer solutions to some security problems through developments such as advanced ICT interfaces and robotics, content technologies and information management, future internet, next generation computing,

In our interview it emerged that Foresight in Switzerland pointed at "monitoring of new threats" as one of the Grand Challenges.

[2] chemical, bio, radiological, nuclear

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storage technologies, safer internet for children, smart grid solutions for high and medium voltage electricity and finally large scale intelligent and interoperable technologies to optimise the capacity and use of infrastructure.

3.2.5 Health concerns of an ageing society are rising

The ageing of populations has diverse implications on science, technology, economy, and society that are proliferated in the context of new health risks and ineffective health systems.

Many Foresight studies among them the Polish national exercise call for better understanding of the socio-economic consequences of the ageing of the population in order to realise the potential of increasing life expectancies but also averting possible dangers such as shrinking of the workforce and subsequent decline of the economy.

Higher life expectancy, decrease in mortality rate and declining fertility are causing the rise of the average age of the population in Europe. Experts fear the increase of public spending on pensions and healthcare which is going to be unaffordable in many countries, spiralling costs of healthcare provision, and increasing costs for technology-related solutions. In societal terms, it may lead to increasing intergeneration gaps, and social inequality. The elderly, among others, are at risk of poverty if current financing models prevail. With regard to health terms, ageing brings an increase of chronic diseases, and mental disorders. Climate change and saturated lifestyles may intensify these implications and lead to more epidemics. Solutions are multi-fold and have to be inter-connected. Experts call for the redistribution of pensions and healthcare costs, and point to inequalities in health and medical care. Populations with increasing obesity, diabetes, heart and respiratory problems, and long-term conditions need guaranteed treatment.

The ageing workforce is valuable in terms of the knowledge and experiences gained. Promotion of healthier life-styles, preventive health measures and active aging as well as ensuring safer workplaces may improve the health of the population as a whole. A shift from acute to community care could be a first step to reform health systems. The aim should be towards an integrated health and social care service. The EU social and healthcare model should be preserved. Measures should also address education. Medical training should be reformed with stronger educational foundations and flexibility to respond to changing roles and service models. The quality of health care staff and professionals should be ensured to provide person-centred, compassionate care. Practices like horizon scanning should be used to influ-

The Swiss Foresight points to the challenge of stabilizing the costs of the health sector and to maintain quality at the same time. It also recommends taking action in order to secure human resources for the economy, research and military service by further anticipating demographic change, supporting young people and developing inclusive migration policies.

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ence long-term planning and decision making for the health and social care workforce. The need is also important to solve lacking of connectivity and interoperability across different health monitoring and assessment systems.

Certain S&T areas are promising in dealing with the challenge of ageing. These include for example robotics for health care; human enhancement; engineerable human, research on rare diseases, etc. Certain S&T advancements, however, bring a number of ethical, legal, or societal issues that have to be considered. Research should be intensified about the ethical issues arising for example from human enhancement, euthanasia, etc. There is also the need to regulate the use of cells, tissues and cell-based medical products and health data and information. The collection and transparency of health data should be improved.

3.2.6 A risk of financial system failure is emerging

In the financial sector the risk of systemic failures is increasing.

The economic system is at risk of ongoing stagnation, financial crises, and uneven recoveries. A challenge that is emerging strongly from economically oriented forward looking studies is the risk of a major systemic financial failure. This challenge is being recognized as a result of recent experience of the global financial crisis seen from various positions in the industrialised world. The studies mention several aspects such as the difficulties to rebalance financial markets due to uncoordinated action and the concern that liquidity crisis is not a singular issue but keeps recurring. The complex problem includes the chronic fiscal imbalance as well as unmanageable inflation or deflation, and all these factors lead to serious consequences of economic, societal and even environmental kind. Shocks of all kind create pressure for rebalancing with painful consequences and growing disparities between the rich and the poor. Persistent financial inequality in turn leads to social inequalities and social unrest. The lack of regulation results in extreme volatility in energy and agriculture prices. The multiple financial nodes all over the world make spill-overs into other areas of power likely. The volatility of financial systems is quite a complex phenomenon to handle. Furthermore, it puts the appropriateness of mainstream economic theories of development under question. This is turn makes efforts to find feasible solutions even harder and calls for radical thinking and transformation. Notwithstanding the complexity and uncertainty surrounding this challenge, a suggestion was mentioned in one of the sources in an effort to improve parts of the operation of the financial system through regulation. This is the introduction of a quality label for markets.3

[3] The **Markets in Financial Instruments Directive** 2004/39/EC (known as "MiFID") as subsequently amended is a European Union law that provides harmonised regulation for investment services across the 30 member states of the European Economic Area (the 27 Member States of the European Union plus Iceland, Norway and Liechtenstein). The main objectives of the Directive are to increase competition and consumer protection in

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3.2.7 Current non-sustainable economic model come under scrutiny

A growing unease with the current model of economic growth calls for alternative approaches to societal progress on a macro-level. At the same time eco-consistent business models are required in all sectors of economic activity.

The Polish Foresight exercise stresses the need to reconcile quality of life and growth and to achieve a fair distribution of wealth as one of the "Grand Challenges" for society and points to the need for social innovation.

This challenge points towards necessary paradigmatic changes towards a sustainable economic model. This includes socio-economic issues such as rise of income divides and increase of precarious working conditions as well as environmental effects such as the loss of biodiversity and the overexploitation of the earth's ecosystems services.

Several sources among them the Polish Foresight exercise call for acknowledgement of the limits to economic growth and more research into the nature of economic models and point out several dilemmas emerging from today's economic model.

Possible actions provided in this cluster include the application of environmental evaluation tools to induce businesses and public bodies to internalize environmental costs. In order to achieve transition to a new economic model, top down measures such as new indicators for measuring societal progress will need to be accompanied by changing consumption patterns and value changes in the society. Sources emphasise the high efforts required from societies to achieve this transition and warn of the danger to adopt sub-optimal tacks rather than systemic change.

investment services. As of the effective date, 1 November 2007, it replaced the Investment Services Directive (according to Wikipedia)

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Other studies point out how the uptake of sustainability oriented economic models could provide opportunities for novel endeavours. Diverse aspects such as the emergence of new sectors and opportunities for SMEs or businesses that profit from circular economy innovation patterns are mentioned. Positive effects may arise in all sectors and result from low-tech as much as from high-tech developments. 'Low-tech' may turn into a profitable business model in any kind of economic sector. Evolving ecological concerns are thus seen as potential business opportunities. One example for the urgent need to develop eco-innovation business models is tourism. The tourism industry is among important economic areas for many European countries and relates to many areas such as regional development or transport. At the same time climate change is affecting the sector through effects such as the decreasing snow cover in Alpine areas.

The Foresight exercise in Poland stressed the need to integrate environmental and sectoral policies.

In 2009 there were discussions in the former Greek government (socialist party) about the importance of the 'green economy' and the potential it could offer for the country's development. However, with the hit of the crises and the change of priorities that followed this idea was never operationalised.

3.2.8 Migration requires responses

The challenge of migration takes many forms as a consequence from other challenges like climate change, food and water shortages, natural disasters, pandemics, etc. each of which requires a specialized and coordinated response at various governance levels.

The FLA sources make clear that there are several causes for migration, i.e. extreme weather, natural disasters, conflicts, shortages in food and water quality and availability, or health issues like pandemics. At the same time there is increased mobility due to globalisation. Climate change will also lead to significant economic and social impacts with some regions and sectors likely to bear greater adverse effects. Outside Europe developing countries including island states will remain particularly vulnerable to climate change. Experts expect a significant number of environmental refugees in the next 20 years.

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These trends have implications in various areas: Migration causes urbanization. As an indication urbanisation and ethnic shifts are expected in 7 out of 8 mega-cities in the Sub-Saharan region. Migration also leads to severe income disparities between locals and immigrants. Other social implications include difficult relations with neighbouring countries; internal and cross-border tensions; social tensions, social pathologies and rising ethical issues; social exclusion, poverty; rising religious fanaticism; rise of radicalisation and nationalism due to refusal of rights to cultural and religious freedom. Further, consequences from environmental refugee movements remain ambiguous. More research is needed in relation to the implications of the different types of migration. The fragmented and uncoordinated EU action on migration issues deters clear policies with regard to illegal migration.

In Switzerland, recent Foresight activities point towards the need of inclusive migration policy whereas Polish Foresighters reflect on the consequences of more and more families with young children leaving the country.

Solutions are required on the one hand for a common migration and asylum EU policy to control the EU external borders. On the other hand, policies should work towards stability and prosperity in deprived regions, creating social and territorial cohesion to fight poverty and social exclusions. A third aspect toward a solution is to adjust existing policies to deal with implications of the specific challenge, i.e. shift focus of environmental policy from rural issues to urban areas as more urbanisation is expected due to migration.

3.2.9 Education is struggling to cope with new demands

For the EU countries several reports stress the increasing need for tertiary education and for reducing early school dropout. The necessity goes hand in hand with the emergence of new professions, some of which are characterized by highly skilled craftsmanship and thus need new forms and new content of training. Furthermore sources warn that the European education system is not performing well enough and that a region like Asia is catching up with the US and

The Polish Foresight exercise points to the need for ICT uptake in education.

Against strong resistance from the academia, Greece government undertook serious efforts in 2011 to reform the higher education system. The reform attempted radical changes in order to increase accountability, improve management and increase the autonomy of Higher Education Institutes, as well as to improve the quality of teaching and research. The reform also includes the involvement of non-academics in the management of the institutions, linking quality and performance with funding. The division however, remains between those advocating that efforts should focus on bridging the gap between research and innovation with the local economy, and those supporting that research should aim at more excellence and be better linked to education.

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EU. While on the one hand the education and training system in Europe needs to be modernized, a more specific demand defines the need for an education system capable of promoting sustainability, innovation and solidarity values. Some challenges reflect the fear that not enough financial resources are invested in education, the access to technologies and the recruitment of skilled personnel for science, education and training. With regard to the changing content or quality of skills in technical sectors more demand is envisioned in the workforce to respond to more consulting services; and the changing character of doing research implies more information sharing and joint activities, international and inter-agency cooperation as well as multi-disciplinarily in research. Finally Foresight studies are recognizing fundamental changes in the very notion of education from hierarchical teaching of predefined content and skills to a process of continuous self-refinement with everyday creativity at its core.

3.2.10 The health situation in deprived regions is deteriorating

Impoverished regions around the world struggle with acute and virulent health issues.

Along with increased global mobility and migration infectious diseases are on the rise worldwide. Major challenges are posed by the double burden of infectious and chronic diseases in less-developed countries. Outside the EU several deprived regions face precarious developments mostly rooted in poverty and adjunct to that mal- and undernourishment and the neglect of health provisions. Other causes for these developments are the increasing waste disposal in poor countries and unhealthy living conditions in increasingly densely populated urban regions urbanization. In many African regions child, infant and maternal mortality rates are stagnating on a high level. New lifestyle related and chronic diseases are on the rise. For instance in Sub-Saharan Africa diabetes cases are expected to double by 2030. Infectious and chronic diseases combined become a double burden. Dysfunctional health systems and the shortage of well-trained healthcare workers are adding up to the problem. From these trends arises the need to reduce poverty and to provide access to food, clean water and health provision. While prospects are that absolute poverty will diminish over the next two decades, areas of extreme poverty will remain, potentially entrenching existing gaps between rich and poor. In our analysis and projection we need to make a distinction between the growing middle class worldwide and sub-Saharan Africa which will not be able to enter the “globalisation game”. For HIV, for example, this implies that the infected population is climbing to 50 million by 2025, and 22 million in the sub-Saharan region.

3.2.11 Climate change is causing new diseases

New health problems are arising globally due to climate change

Global climate change has severe consequences on infections and diseases of humans and animals as well as plants and the entire flora. Infections, diseases and other profound effects on human and animal health grow hand in hand with increasingly frequent changes in weather. In some cases serious infections and migrant harmful organisms may spread between humans and animals and may do

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that also between flora and fauna. Accordingly, they may affect food chains and again be a threat to human and animal health. Via food chains in related industries the consequences may lead to disturbances in global trade and businesses. In conclusion, these impacts shall be explored by advanced risk and related science based assessments for creating robust action programs for avoiding arising problems. Ultimately infections and diseases of humans and animals can be avoided only by essential mitigation of global GHG emissions to the atmosphere.

3.2.12 Providing basic resources for increasing global demands becomes difficult

Without ecologically, economically and politically sustainable solutions scarcities of basic resources may lead to extensive and serious social and political problems in some areas of the globe.

In circumstances of growing global population the use and security of basic resources needed by humans such as food, water and energy becomes increasingly critical for all societies worldwide. As an example three billion people may lack clean water in 2025. The world's food and agricultural system is facing the challenge of properly feeding a population of nine billion individuals in 2050, while preserving the ecosystems from which other services such as bio-energies, biodiversity, carbon storage, climate regulation, are also expected. Without ecologically, economically and politically sustainable solutions these scarcities may lead to extensive and serious social and political problems in some areas of the globe. Moreover, many of these problems will culminate especially in densely populated urban areas as in developing economies that lack the human and material resources to apply sustainable and science based solutions. The lack of basic resources may lead to increasingly drastic consequences such as erosion with subsequently fatal effects on agriculture. Also, negative effects on the economy such as emerging shadow economies will harm markets, companies and consumers. To find robust solutions for these problems requires extensive research activities, such as searching for a balance between fuels and food based on utilization of biomass, finding new food production models, analysing long term

A line of action pointed out in several sources among them the Polish Foresight exercise is the adoption of circular economy concepts such as "cradle2cradle innovation patterns" and other advanced waste-free material engineering technologies and the use of biodegradable recyclable construction materials

Water shortage is a Grand Challenge for the Middle East, for example. Israel uses desalination technology to provide about a fourth of its domestic water needs. Modern desalination plants employ a method called reverse osmosis, which uses a membrane to separate the salt. More than 12,000 desalination plants now operate in the world. Desalination is extracting the salt from seawater. Desalination is used in many regions, particularly in the Middle East.

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global sustainable water strategy, looking for solutions to replace material based solutions by service and knowledge based solutions (de-materialization), balance between imported and home grown food, and so on.

One key element is in the transition towards sustainable material and resource future is the reduction of non-renewable resource use. Among the solutions proposed by the studies are a more intensive raw-material use in industries, recycling of material, circular economy concepts and miniaturization of products. Another relevant conceptual approach is the replacement of material solutions by intangible knowledge based solutions and services (De-materialisation). Naturally, a search for efficient and sustainable resource and material use raises a need of extensive science based solutions, as well as policy programs promoting the change towards more efficient non-renewable resource use. One aspect of particular relevance in this context is the design of the manufacturing of the future. Industrial processes, product development, construction industry or any other industrial activities are expected to be much more sustainable than we see today. These solutions are part of a strategic shift towards a green economy. This strategy, however, to be creditable for industrial communities, political decision-makers and all stakeholders, needs a robust science based analysis. Besides, a transition towards a sustainable manufacturing requires a carefully planned transitional period utilizing systemic innovation and transition management approaches.

On a national level the Foresight in Switzerland emphasises the need to sustain infrastructures and secure its finance on the one hand and seize the opportunities of urbanisation and limit the risks of development of settlements on the other.

On national level within the STI strategy of Turkey water and food are among the five need oriented approaches targeted by the STI strategy that were identified within an in depth stakeholder consultation process. Turkey considers energy, water and food as the three relevant Grand Challenges. Similarly Poland lists the access to resources and in particular food among its core challenges for the future. Bulgaria explored food and agriculture futures and identified conflicting resource uses as highly relevant future challenge.

Another core aspect is the creation of sustainable habitats across rural, urban and marine spaces. Reducing the ecological footprint of human settlements requires research based solutions such as effective water management, restoration of ecosystem, sustainable long term spatial and urban planning covering not only land but also the use of sea areas for human needs. Ultimately, there is an urgent need to change mindsets and behaviour of decision-makers responsible for spatial and especially urban planning as well as all humans with respect to their living environment towards a more sustainable direction.

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3.2.13 Scarcities in material resources are emerging

Demand for metals and minerals is growing dramatically especially due to fast growth of emerging economies, and increasing strategic demand of minerals in industrialized economies (in aerospace, defence, related ICT, energy, health, water supply, etc.) as well. Science based solutions to replace traditional minerals and e.g. refined metals based on them, seem not enough to satisfy all this increasing global demand. Moreover resource dependencies such as the dependence of Europe on natural gas delivery of Russia seem to be a serious issue. Even more that 50% of major ore reserves are located in poor countries and, even more seriously, a bulk of the critical mines and related strategic materials (e.g. for ICT industry) are located in emerging economies. These facts may create problems and related vulnerability for the access of industrial economies to these sources which may raise possibilities to political and economic challenges. Accordingly diverse science based analysis and solutions are needed of producing basic data and understanding of the current and future oriented state-of-the-art of supply of availability of resources for industry in EU, and related possible needed European worldwide policy initiatives on a worldwide level. Establishing a holistic approach to sustainable natural resources management at international level is seen as absolutely critical.

3.2.14 Our modes of energy supply and use are threatening the survival of humankind

Adopting sustainable forms of energy production and consumption is one of the key means for mitigating climate change.

CO2 and other GhG4 emissions have caused the climate change phenomenon, with rising temperature of the atmosphere and related problems like vulnerability in nature, serious infections and other health effects, increasing natural disasters such as tropical cyclones, diminishing clean water resources, as well as the rise of environmental refugees due to increasing drought. GHG emissions are mainly consequences of

The Greece foresight acknowledged the importance to tackle the negative consequences from climate change is explicitly mentioned as a justification of the selected priorities in the energy sector. Renewable energy sources or clean coal technologies and energy efficiency are promoted as key areas to focus. Protection of the environment and biodiversity became another key priority.

This challenge was underlined in the VERA interviews with specific EU member states. Turkey, Poland and Bulgaria and were emphasising energy transition as key challenge targeted by their STI strategies. In addition to renewable and alternative energy sources the Polish Foresight found the need for technologies for generating electricity and heat in dispersed systems. Turkey considers energy along with water and food as core grand challenge with transition to green and renewable sources as well as efficiency in production and consumption at the core. Switzerland emphasises also the need to secure long-term energy resources along similar lines Polish Foresight is emphasising the growing relevance of resource related politics in particular with respect to oil (petropolitics).

[4] „Greenhouse Gas“

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unsustainable energy production and consumption patterns especially in industrialised economies due to wrong pricing in the use of environmental resources.

GHG emissions can be reduced by substantial changes of current energy production and consumption structures, especially by global transition from non-renewable energy sources to renewables and higher energy and material efficiency. Therefore, reducing energy consumption and increasing the efficiency of energy production are among the key means in the shift towards sustainable low carbon economy, following EU´s 20:20:20 targets. Public actions and regulation and voluntary private initiatives as well as intensive public-private partnerships are necessary in realizing this shift.

Of special importance is the development of entire energy systems towards sustainable direction in large emerging economies. The toolbox of sustainable energy consumption and energy production consists of a wide variety of solutions: cross-cutting transitions to sustainable, secure and low carbon energy system, energy efficiency in a wide sense in economic and industrial activities (manufacturing, transportation, buildings, etc.), decentralized energy systems, ICT driven in smart grids integrating also effectively production, transmission, distribution, natural gas use as temporary solution, storage and consumption of energy, new ways of managing electricity, etc. The development of effective solutions in all these fields requires well focused and effective research, development and piloting activities. After development of robust solutions of special importance in policy actions is scaling-up of energy-efficient and energy-saving solutions which can be accelerated e.g. by public procurement and related policy measures. Transition to and diffusion of sustainable solutions may be accelerated by smart policies, for example by diversification of prices of traditional and new sustainable energy sources and hence promoting the demand of sustainable sources.

The transition process however requires an effective common private and public strategy including a concrete policy action plan. The implementation and enforcement of such an action plan can be supported by policies based on systemic innovation and a multi-level transition framework. The action plan will require careful ex-ante assessment, parallel supporting studies as well as ex-post evaluation of impacts. In parallel measures for adapting to the changing climate need to be defined and implemented.

3.2.15 Transportation systems come under strain

Environmental and health impacts from emissions, mitigation of climate change, urbanization, the need for traffic safety and security and avoidance of traffic jams are among drivers towards re-inventing mobility and full-scale transition of existing transportation systems.

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Accordingly, profound transportation system level research and development activities are needed in searching for economically and ecologically sustainable solutions for European and global transportation. Systemic changes of all transportation forms, logistics and infrastructure, by utilizing advanced ICT based solutions, enable integration and optimization of various transportation technologies in smart and innovative ways. Especially in urban passenger traffic a strong move towards public transportation is necessary. Moreover, change towards lighter material solutions, advanced design, sustainable energy solutions and innovations based on friction research and development of all transportation forms are of importance as is real time traffic management. Democratizing transportation relates e.g. to special needs of physically disabled passengers and development of transportation systems in developing economies.

In the Federal Republic of Russia the Grand Challenges problem is going to shape the S&T policy agenda in the next 15-20 years. These issues were actively discussed at the recent Foresight. One major issue is the switch from traditional thematic priorities to a complex analysis of problems engendered by the emergence of grand challenges. This issue is especially important to Russia, since the R&D sphere in this country has traditionally followed the inertial development scenario: most of the financial support is channeled into the established areas, while future-oriented steps — development of responses to new challenges based on S&T solutions, and creating a potential for entering newly emerging market niches — are almost never taken. The technology paradigm is dominant and will be in future policy making, providing support to markets connected with the new wave of technological development. Main technological areas include nano-systems, efficient environment management, ICT, transport and space systems, energy-efficient and energy saving technologies, life sciences.

3.2.16 EU Competitiveness is endangered

Many aspects in this cluster reflect the fear of Europe or the EU falling behind other world regions in terms of competitiveness on the global market. These studies issue warnings that Europe may lose competitiveness due to poor education and skills as well as rising costs and declining labour force participation caused by demographic change. Another challenge is the fragmentation of Europe that may prevent effective exploitation of the research and innovation potential. Finally in a globalised world Europe will have to compete for the best brains with China, India, Turkey and Iran and may experience brain drain.

New technologies are seen and discussed with regard to competitiveness, such as the potential of space research or human enhancement, with the limitation that citizens want to be involved where it is not (yet) commercial. With regard to new or emerging technologies, one suggestion is to install clearing houses and 'national IP shop windows' in early stage technology areas where we find a wide diversity of efforts, players and technologies to encourage a 'critical mass'.

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The brain drain from leading European regions Europe to more attractive regions cannot be compensated by the new immigration flows from impoverished regions within EU countries. One way out of the economic downturn is to create growth in regional and local economies and to promote the regional quality and brand names, as well as a more competitive service-based society. A further remedy would be the provision of good IT infrastructures, which might also attract high-quality researchers. In spite of the economic plight there is a lot of conviction that the "European production model" is excellent and that its advantages should be promoted more in the rest of the world.

Another line of action towards enhancing EU competitiveness is the creation of a single European digital market. On the one hand substantial economic benefits are expected from such a digital single market for households and firms. Secondly, a digital agenda for Europe could also imply access to digital resources of Europe's cultural heritage, foster political action to overcome the digital divide within Europe and ensure electronic interoperability across countries and across languages (e.g. for health services).

3.2 The Typology of Grand Challenges

Grand Challenges can be characterized in several respects. When setting up the inventory of forward looking studies the challenging issues mentioned in the studies were assigned to nine categories as shown in figure 1.

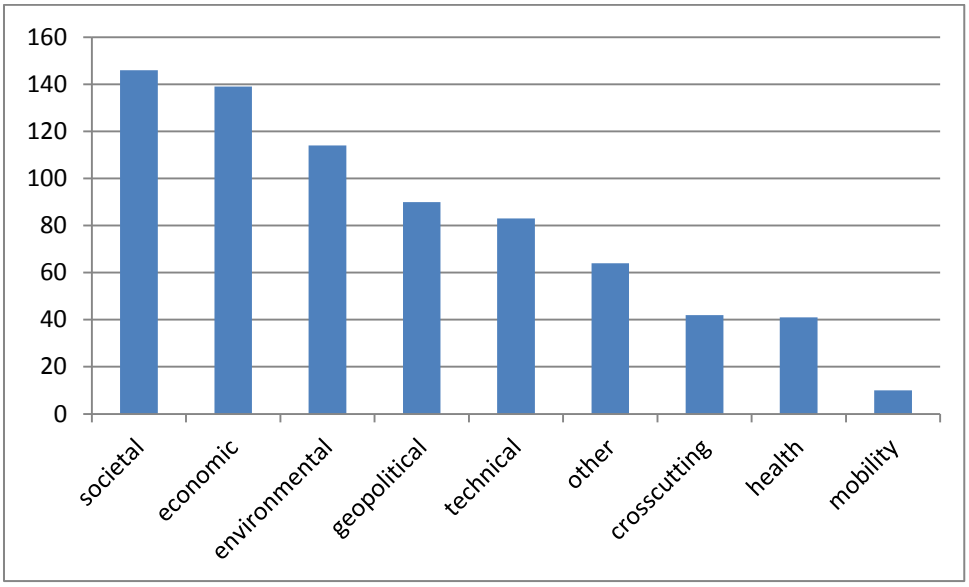

Fig. 1: *Number of challenges listed in the 67 FLAs screened by VERA per GC category, n=726*

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The majority of challenging issues listed by the FLAs was assigned to the category "societal" (146) closely followed by "economic" issues (139) and slightly less environmental ones. Around 90 challenges were assigned to the realms "geopolitical" and "technical". Only 10 challenges are located in the area of mobility which is not surprising as purely sectoral studies were not investigated. Health related challenges are more often identified in general FLA studies (40) and 42 challenges were explicitly cross-cutting.

This type of typology can be applied to individual issues. For Grand Challenges however, that are by definition complex and multi-disciplinary, such a classification is no longer adequate. Each of the 16 challenges identified is cutting across several of these categories.

In VERA two different approaches to classifying the grand challenges were applied

1. Analysis of interdependencies and dynamics between the grand challenges in order to distinguish different levels of challenges.
2. Analysis of characteristics relevant for policies addressing these challenges in order to provide relevant distinctions for VERA WP4.

Both classifications were based on the assessments made within the original FLA sources and on joint assessment of the WP1 team.

In the following section we present the outcomes of both these classifications.

3.2.1 Typology emerging from analysis of the interdependencies between the challenges

Two clusters of are central to all other ones and are driving developments in several other realms:

- The cluster of providing basic resources for a population of nine billion individuals while preserving the ecosystem and balance with all other services expected from the ecosystem (12)
- The cluster of adopting a sustainable economic model which underpins long term sustainable forms of production and consumption (7)

They could therefore be termed: **1st order or primary challenges**. Other challenges such as sustainable modes of energy production and consumption (12), transportation systems (15), climate related diseases (11) are heavily depending on the success in addressing the primary challenges and could therefore be termed **2nd order or secondary challenges**. The primary challenges however depend on **normative agreements** and thereby ultimately on the emergence of new values and attitudes (2) and success in education struggles (9) and material scarcities (13). Figure x visualizes the typology emerging from this analysis.

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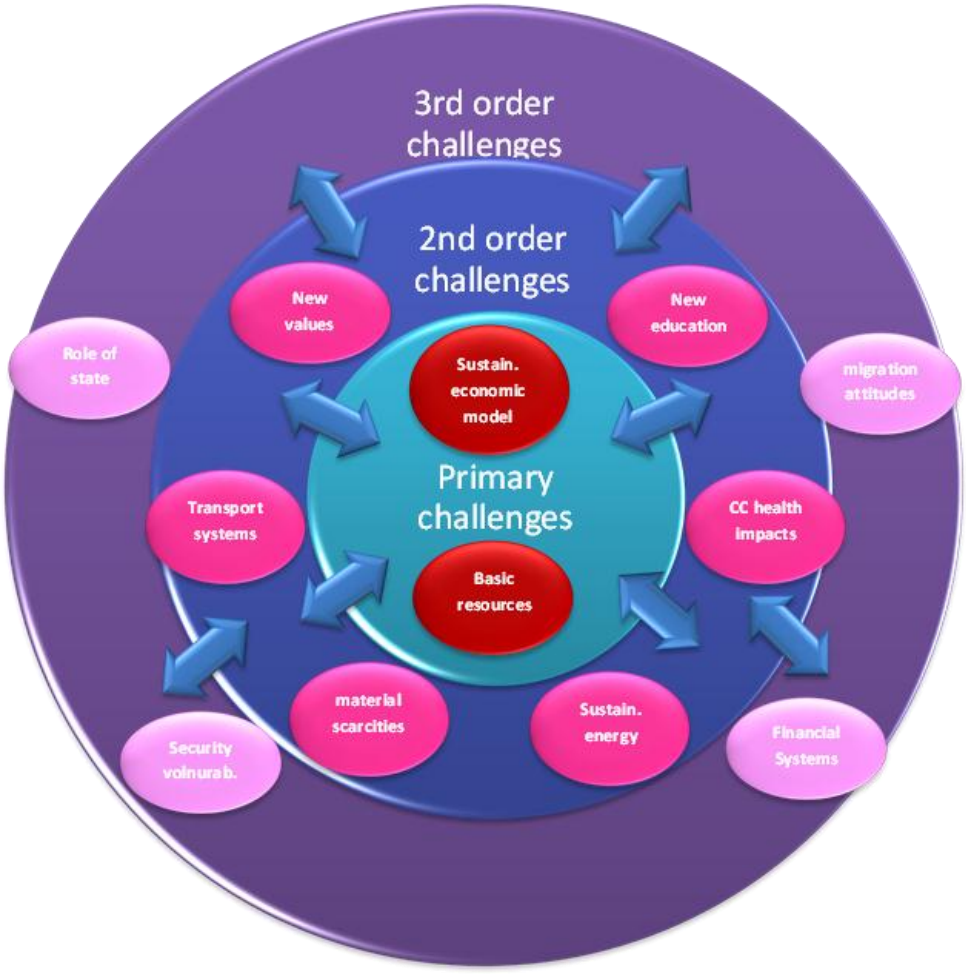

Fig. 1: *Towards a Typology of Grand Challenges based on internal dynamics*

3.2.2 Typology emerging from policy relevant characteristics

A first rough classification revealed the following distinctions:

Several of the 16 challenges are directly dealing with **new modes of global governance of complex systems**:

The changing role of the state (3), increased vulnerability (4), uncertainty in a multipolar world (1), financial system failure (6) and migration all of which are very much driven by multifold factors such as poverty, global tensions and diseases and could therefore be seen as **3rd** order or tertiary challenges. Also for this cluster the emergence of different values and attitudes in societies around the

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world is decisive. Whether the world turns towards global governance or competitive structures depends largely on whether attitudes such as global empathy prevail.

Three challenges are related to **large scale infrastructure transitions**: energy patterns (12), transportation systems (15) and increased vulnerability (4) which is very much related to ICT infrastructures. Also health concerns in poor regions (10) and ageing societies (5) points towards infrastructure transitions albeit primarily on a national level.

The vast majority of the challenges are truly **global**. Some however such as health systems, ageing patterns (5, 10) and education systems (9) transport patterns (15) and energy modes (14) are also depending on national systems. Competitiveness of the EU (16) stands out as a challenge which is primarily driven by the interest of a specific group of countries that will not be adopted by other parts of the world.

Furthermore, a distinction can be made between **immaterial challenges** involving values, attitudes and our ways of governing such as (2), (1), (4), (8) and those that involve **redirecting flows of material and energy** like (12), (14), (11).

Finally, challenges that require **large scale systemic change** such as energy patterns (14) transportation systems (15) but also sustainable economic models (7) can be singled out.

The VERA team developed a set of characteristics with relevance for policies addressing the challenges (cf. Annex IV). All clusters were assessed with respect to these characteristics. In the following paragraphs we discuss those categories that proved most suitable to form a policy relevant typology:

- Need for societal participation
- Multidisciplinarity
- Implications for infrastructure
- Need for business involvement
- Need for knowledge
- Required policy strategies
- Kind of policy action required

"**Need for societal participation**", is a category that is of very high importance. In fact more than half of the challenges we have defined are prone for a high degree of societal participation, these are: *The world is becoming more interconnected and thus more vulnerable (4), Values and attitudes are changing globally (2), The traditional role of the state is challenged (3), Health concerns of an ageing society are rising (5), Migration requires responses (8), Providing basic resources for increasing global*

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demands becomes difficult (12), Our modes of energy supply and use are threatening the survival of humankind (14), and *The current non-sustainable economic model comes under scrutiny (7)*. The importance of this feature for the specific challenges reflects the increasing desire for empowerment of citizens in a global world, the increasing concerns over security, health and migration issues, as well as the pivotal role of society in changing habits and attitudes about life-styles and modes of consumption.

"**Multidisciplinarity"** is required especially for the clusters: *The health situation in deprived regions is deteriorating (10), Providing basic resources for increasing global demands becomes difficult (12),* and *Our modes of energy supply and use are threatening the survival of humankind (14)*. This signifies the need for all scientific and technological disciplines to joint forces in studying these phenomena as well as in exploring possible solutions.

With respect to **infrastructure implications** the need for "Improvement of existing existing infrastructure" applies to the following Grand Challenges: *The world is becoming more interconnected and thus more vulnerable (4), Health concerns of an ageing society are rising (5),* and *Providing basic resources for increasing global demands becomes difficult (12).* Going a step ahead "create new infrastructure" is required for *The health situation in deprived regions is deteriorating (10), Our modes of energy supply and use are threatening the survival of humankind (14), The current non-sustainable economic model come under scrutiny (7),* and *Transportation systems come under strain* (15) in order to solve the Grand Challenges better. New infrastructure is seen to be needed in certain sectors like energy or related ones like transportation mainly referring to new modes of energy. At the same time, new infrastructure may also refer to international structures to deal with EU wide issues like the financial crises or specific problems in certain areas of the world through international aid.

The **"Need for business involvement"** is highest for *Providing basic resources for increasing global demands becomes difficult (12),* at second degree also for the energy and transportation challenges as well as the health/ageing one. This shows that indeed some of the challenges also provide great business opportunities. At the same time it also indicates that business practices may have been part of the problem and thus need to be involved in order to change in favour of sustainability.

"Need for knowledge" in order to cope better with Grand Challenges applies to those subsumed in *Providing basic resources for increasing global demands becomes difficult (12),* and *Our modes of energy supply and use are threatening the survival of humankind (14).* This relates to the great difficulty in finding viable solutions as this implies changing our life-styles to a new mode.

With regard to "**required policy strategies**" the appropriate strategy for *Uncertainty is arising from a multipolar world (1)* would be to ***overcome fragmentation***. Other clusters require different policy strategies***. Transformation***, would need to be applied to several: *Health concerns of an ageing society are rising (5), Education is struggling to cope with new demands (9), Our modes of energy supply*

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and use are threatening the survival of humankind (14), and *Transportation systems come under strain (15).*

Health concerns of an ageing society are rising (5) would also be distended for further policy actions such as budgetary ones.

The world is becoming more interconnected and thus more vulnerable (4) would fit best to policy actions that raise awareness.

Coordination of policy areas seems the appropriate strategy for several challenges again: *The world is becoming more interconnected and thus more vulnerable (4), The current non-sustainable economic model come under scrutiny (7), Transportation systems come under strain (15),* and *EU Competitiveness is endangered (16)*

International action is required for *Uncertainty is arising from a multipolar world (1),* and *Scarcities in material resources are emerging (13)*.

A ***high need for new regulation*** applies to the Grand Challenges: *The world is becoming more interconnected and thus more vulnerable (4),* and *The traditional role of the state is challenged (3).*

To move towards a solution of the problems described in the individual clusters of Grand Challenges at a political level, we identified a couple or categories to describe what is **most important to recognize for policy action**:

- Degree of complexity (which shows that the issue is very difficult to handle)
- Degree of public concern (which indices that society is concerned with this issue)
- Need for new regulation (needs top-down policy action and new laws or rules)
- requirement of innovation activities for solutions (not only at policy level)
- Interdependencies with other GC/clusters (indices the connectedness to the other topics)

A **high** degree **of complexity** signifies that it is very difficult to deal with such Grand Challenges and that a holistic policy approach is required. This applies to *Uncertainty is arising from a multipolar world (1), The world is becoming more interconnected and thus more vulnerable (4),* and *Providing basic resources for increasing global demands becomes difficult (12).*

A **high** degree of **public concern** would be attached to several of Grand Challenges: *The world is becoming more interconnected and thus more vulnerable (4), Values and attitudes are changing globally (2), The traditional role of the state is challenged (3), Health concerns of an ageing society are rising (5),* and *Our modes of energy supply and use are threatening the survival of humankind (14).*

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A **high** degree of **interdependencies** with other GCs can be found in: *Values and attitudes are changing globally (2), The traditional role of the state is challenged (3), Migration requires responses (8), Providing basic resources for increasing global demands becomes difficult (12),* and *Our modes of energy supply and use are threatening the survival of humankind (14)*.

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4. Conclusion

From the analysis of a broad range of sources on Grand Challenges it becomes clear that we cannot take a European perspective only. Especially not when attempting to identify ways of dealing with the Grand Challenges, or at least some of them. The most pressing challenges are globally interconnected and require global action. *Our modes of energy supply and use are threatening the survival of humankind (14), Providing basic resources for increasing global demands becomes difficult (12) and The world is becoming more interconnected and thus more vulnerable (4)* are the ones most frequently discussed on the last pages of this document. They also show the requirement of shared common responsibility at a global scale which does not imply that the EU countries can lay back and point to the other countries. On the contrary, from a European perspective, European countries are among the major drivers of Grand Challenges, and among the major affected countries as well, although the effects of Grand Challenges are more widely spread at global scale than the drivers.

These cluster that we have identified and that are discussed on the previous four pages also seem to be the ones that need policy actions most immediate and where policy action is able to make a difference if planned and executed in a systemic way.

To face the Grand Challenges of the future of Europe, most of all we need to cope with the global ones. If we can make a major contribution to those we will better be able to cope with the challenges that lie ahead for Europe.

What we as Europeans have to face is that our lifestyle and the underlying economic model can be considered the roots of a fundamental problems with devastating global effects. Many studies and independent resources have pointed this out before. It is of course not only the European lifestyle but that of all developed economies. At the same time, the global interconnectedness that seems to make this lifestyle transferable to emerging, lagging, and in the long term even to undeveloped economies, makes societies vulnerable to shocks in many respects.

Facing the Grand Challenges means to introduce fundamental changes in many areas of our lives and activities and thereby affecting global liaisons as well. Even if it is unrealistic to introduce radical changes, the changes required if we take the Grand Challenges ahead will be felt by every European citizen. Policy makers are in a crucial role as the changes required will not occur without fundamental policy measures in almost any policy area and in a way that coordinates these areas.

Furthermore it becomes clear that the scope of these Grand Challenges is in essence societal. We need to take this into account when we talk about policy actions, for example in the area of research, technology and innovation policy – in the respective work packages of the VERA project and beyond. We especially need to consider what the impact of that societal scope is with regard to the systemic character of handling the Grand Challenges.

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In sum, the Grand Challenges discussed here call for more intense collaboration globally, for a change in our way of living and doing things that we need – but aren't these two more challenges to deal with!

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5. Annexes

Annex I

Draft template and categories of VERA Stocktaking

Code	Every FLA or document has a code according to a predefined code system
Primary Project Information	
Title	Name of the document/project
Lead	name of the organisation in charge
Additional project partners	government, other organisations etc.
Type of activity /Type of document	FLA, strategy project, survey, etc. / What type of document is this analysis based on (e.g. report, strategy paper, slide presentation, etc.)
Date conducted	from … to …
Date of Publication	When was the document published?
Duration	how long did it last?
Summary	brief summery of the main idea and results
Web link	link web address in function
Financed by	Government, organzation, private stakeholder, etc.
Budget	how much did the excercise cost?
Research area/market/industry/sector	Name all research ares, markets, industry secotors covered in this report/document (for example production, energy, transport, building, environmantal engineering, convercence, biotechnology, services, ICT, robots, health, education, nanotechnology, material sciences, life sciences)
Main report (full title)	What is the title of the main report? (sometimes they differ from the title of the project)
Content	
Overall Perception of Grand Challenges	What are the Grand Challenges discussed in this project/document with regard to the following sectors?
Economic Challenges	Long version (for public inventory on website)
Economic Challenges Shortlist	For clustering the GC
Environmental Challenges	Long version (for public inventory on website)
Environmental Challenges Shortlist	For clustering the GC
Geopolitical Challenges	Long version (for public inventory on website)
Geopolitical Challenges Shortlist	For clustering the GC
Societal Challenges	Long version (for public inventory on website)

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Societal Challenges Shortlist	For clustering the GC
Technical Challenges	Long version (for public inventory on website)
Technical Challenges Shortlist	For clustering the GC
Health Challenges	Long version (for public inventory on website)
Health Challenges Shortlist	For clustering the GC
Mobility Challenges	Long version (for public inventory on website)
Mobility Challenges Shortlist	For clustering the GC
Cross-cutting Challenges	Long version (for public inventory on website)
Cross-cutting Challenges Short-list	For clustering the GC
Other Challenges	What other challenges did you come across that do not fit in the given categories? Long version (for public inventory on website)
Other Challenges Shortlist	For clustering the GC
Connecting fields	what are the important areas related to the Grand Challenges or their sectors?
Aspects of ERA Governance	What are the ERA governance aspacts expicitly or explicitly discussed with relation to the Grand Challenges?
Aspects of RTI Governance	What are RTI governance aspects explicitly or implicitly discussed with relation to the Grand Challenges?
Other Aspects of Governance	What other aspects of governance are explicitly or implicitly discussed with relation to the Grand Challenges?
Surprising Issues	What did you encounter, learn or find out that you did not expect in this document/project?
Background information	What is the context of this project? The (hi)story behind it? (this kind of information is not always in the text itself)
SCENARIOS (if applicable)	With regard to the Grand Challenges, what are the scenarios that were developed in the project/document, implicit or explicit?
Scenario 1	
Scenario 2	
Scenario 3	
Scenario 4	
Actions/solutions implied	What actions and/or solutions with regard to the Grand Challenges are discussed in the project/document? Or with regard to the scenarios?
Who benefits from the actions taken?	Name groups of persons, organisations, sectors, regions
Meta Information	

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Time horizon	What is the future time frame this project/document is looking at?
Methods	What methods were used in this project to undertake the exercise (e.g. interviews, Delphi survey, desk research, focus groups, scenarios, simulation, gaming, world café, etc.)
Target group	Who is the audience/target group for this document/project (e.g. high-level policy makers, the general public, industry CEOs, desision makers in the health sector, higher education management, etc.)
Keywords	Identify key words which capture the discussion of the document/project best.
Objectives	How much can you find our about the objectives of this document/project (ecxplic or implicit)?
Geographical scope	What is the geographic scope of this document/project? (E.g. national, regional, local, global, international, etc.)
Countries covered	What countries/regions are concerned?
ERA actors/stakeholders mentioned	Name all actors/stakeholder either individually by name or/and their organisation. This question concerns all actors/stakeholders and their organizations named in the document or in relation to the project.
Entry details	
Rapporteur	put in your name
Rapporteur's organization	put in your organization's abbreviation
Entry Date	When did you finish this stocktaking sheet?

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Annex II

Documents/Cases used in the 1st round (yellow)
Additional Documents/Cases used in the 2nd round (green)

A	ERA governance related policy..
A1	Horizon 2020
A2	Europe 2020
A3	A Budget for Europe 2020 (Part I)
A4	A Budget for Europe 2020 (Part II)
A5	Single Market Act
A6	ERA: New Perspectives
A7	A Roadmap for moving to a competitive low carbon economy in 2050
A8	Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system
A9	Energy Roadmap 2050
A11	European strategy for promoting the tastes of Europe
A12	Adapting to climate change
A13	EU Agenda for Adequate, Safe and Sustainable Pensions
A14	Rare Diseases: Europe's challenges
A16	Together for Health: A Strategic Approach for the EU 2008-2013

B	Europ. FLAs addr. ERA Future
B1	iKNOW
B2	FARHORIZON - Use of foresight to align research with longer term policy needs in Europe
B3	Innovation futures in Europe: a foresight exercise on emerging patterns of innovation. Visions, scenarios and implications for policy and practice
B4	Citizen Visions on Science, Technology and Innovation
B5	AUGUR - Challenges for Europe in the world of 2030
B6	Global Europe 2030/2050
B8	Research Infrastructures: foresight and impact
B9	TECHNOLIFE - A Transdisciplinary approach to the emerging challenges of novel technologies: Lifeworld and imaginaries in foresight and ethics
B10	Changing Multilateralism: the EU as a Global-regional Actor in Security and Peace

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B11	Study into European research and education networking as targeted by eEurope

C	FLAs on natl. R&I priorities
C1	France 2025
C2	The BMBF Foresight Process
C3	Sustainable development scenarios Spain
C4	Horizon Scan Report 2007 - Towards a Future Oriented Policy and Knowledge Agenda
C5	Technology and Innovation Futures: UK Growth Opportunities for the 2020s
C6	An Environment Research Funders' Forum Report: Horizon Scanning Study
C7	FinnSight 2015
C13	Nordic Hydrogen Energy Foresight
C20	The Millennium Project
C30	Ireland 2025

D	FLAs on important Europ.sectors
D1	Super intelligent Transport Systems (NL)
D2	Agrimonde: Scenarios and Challenges for Feeding the World in 2050 (F)
D3	SANDERA (The Future Impact of Security and Defence Policies on the European Research Area)
D4	Envisioning Digital Europe 2030: Scenarios for ICT in Future Governance and Policy Modelling
D5	SESTI (Scanning for Emerging Science and Technology Issues)
D6	Transportation and Logistics 2030
D7	Breakthrough technologies: For the security of supply of critical minerals and metals in the EU
D8	CReATE - Creating a joint Research Agenda for ICT Innovation in the Creative Industries across Europe
D9	Shell Energy Scenarios to 2050
D10	EFONET: Assessment of Energy Foresight in the EU
D12	FORESEC
D13	FESTOS instead of SECURENV due to unavailability of SECURENV reports
D14	TECHNOLIFE a Transdisciplinary approach to the emerging challenges of novel technologies: Lifeworld and imaginaries in foresight and ethics
D15	Crisis Response and Disaster Resilience 2030: Forging Strategic Action in an Age of Uncertainty (FEMA - USA)
D17	Prospects of Quantum Key Distribution: Making Data Communication Secure for the Future
D18	Roadmap Robotics for Healthcare

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D19	SWAMI Dark Scenarios
D20	FreightVision
D21	CfWI Public Health Futures: Horizon Scanning on developing the specialist public health work-force and the public health skills of the wider healthcare workforce in England by 2030.
D22	The Future of Pensions and Healthcare in a Rapidly Ageing World Scenarios to 2030 (WEF)
D23	2009 Ageing Report (EC DG ECFIN)
D24	The future of healthcare in Africa (Janssen)
D25	The Ageing society 2030 (Danish Research Agency)
D26	Human health and climate change (IPCC)
D27	The future of healthcare in Europe (Janssen)

E	**FLAs with intl. Scope**
E1	Global Risks 2012
E2	Global Trends 2025: A Transformed World
E4	Facing the Future: Time for the EU to Meet Global Challenges
E5	"The World in 2025"
E6	VISIONS FOR HORIZON 2020 - from Copenhagen Research Forum
E9	Annual Threat Assessment DNI
E16	Citizens in an Interconnected and Polycentric World. Global Trends 2030 (ESPAS - EUISS)

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Annex III

New clusters as of September 6/7

- technical and societal innovation for data security
- (gas)emissions and pollution
- exploring new frontiers from the bottom to the orbit
- lacking response to deal with acute and virulent challenges in deprived regions outside the EU
- sustainable habitats
- new emerging powers are challenging the traditional global governance
- decrease energy consumption and increase energy production efficiency
- managing the societal dimension of emerging technologies
- healthy food and sustainable agriculture that is adapting to climate change and improving the quality of life in rural areas
- reduce use of non-renewable resources
- reforming /improving education and training
- financial, ecological and political shocks call for new regulatory frameworks
- challenges to democracy in broader Europe
- pressure for demands based on new social values
- climate change mitigation
- challenges of the European Economy
- technology abuse and threats to infrastructure
- creation of single European digital market
- ageing of society and challenges
- more sustainable and competitive tourism
- crime prevention and security systems to tackle military threats
- emergence of new business opportunities
- a new economic model
- secure supply of resources for industry
- extending lives
- financial instability constraints
- challenges in mobility and traffic
- sustainable manufacturing
- sustainability and security of basic resources: food, water, energy
- new dimensions of infections and diseases of humans, animals, plants due to climate change
- coping with humanitarian challenges caused by migration

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Annex IV: Typology for VERA clusters of Grand Challenges:

In the June WS the VERA team started to discuss the categories for creating a typology and assessing the clusters. Those categories can be classified into two meta-categories:

1. Categories to describe the clusters
2. Most important for policy action

In the first meta-category we find the following sub-categories:

- Multidisciplinarity
- Implications for infrastructure
- Need for business involvement
- Need for knowledge
- Need for Societal participation
- required policy strategies
- Kind of policy action required

For the second meta-category we defined the following sub-categories:

- Degree of complexity
- Degree of public concern
- Need for new regulation
- requirement of innovation activities for solutions
- Interdependencies with other GC/clusters

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