Mission-Oriented Research and Innovation

Inventory and characterisation of initiatives

FINAL REPORT

A study prepared for the European Commission,
DG Research and Innovation, by:

The Joint Institute for Innovation Policy (JIIP), Joanneum Research, Tecnalia, TNO, VTT, and the Danish Technological Institute (DTI)
April 2018

Research and Innovation

Mission-oriented research and innovation: Inventory and characterisation of past initiatives. Final Report

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Mission-Oriented Research and Innovation: Inventory and characterisation of initiatives

Final Report

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EXECUTIVE SUMMARY

Context of the study

The European Commission, DG Research & Innovation, commissioned a study on "Mission-oriented Research and Innovation: Inventory and characterisation of past initiatives" to collect evidence, via a global mapping exercises and case studies, on current and past mission-oriented research and innovation (R&I) initiatives in the European Union, its Member States and its main trade partners. The purpose is to provide useful insights and practical guidance for the preparation of the future European R&I Framework Programme (FP9).

The main findings of the present Study are three-fold. Firstly, policymakers intending to move R&I policy towards mission orientation will need to take into account the fact that there is a plurality of mission-oriented R&I initiatives rather than a singular definition and that there are scales of mission orientation. Directionality and intentionality are core features differentiating them from other types of policy. However, they exist in different degrees on a scale between two ideal-types: the initiatives oriented towards (faster) scientific and technological advancement (accelerators) and those targeting societal challenges implying transformational changes (transformers), with varying components of both types.

The global mapping of mission-oriented R&I initiatives and the in-depth analysis reveal the importance of pre-conditions to their success. Existing institutions (including the political and cultural environment) and policies already in place will have an influence on the success of any new initiatives. Furthermore, mission-oriented R&I initiatives need to rely on existing capabilities and knowledge and often substantial historical trajectories as well as prior creation of R&I capacities. This means that a move towards mission orientation at the European level will have different impacts across the EU Members States, and that mission-oriented R&I initiatives may be designed in multiple phases with, for instance, the first ones focusing on research and the later ones on applied research, innovation and market introduction, or a mixed model. If the three-pillar structure of Horizon 2020 is maintained in FP9, the European Commission should therefore consider a comprehensive approach articulating the mission orientation to the scientific excellence pillar and the European Innovation Council and not limiting it to the societal challenges pillar or focus areas.

An important aspect is that (especially transformative) missions are supposed to address concrete societal or economic problems experienced by all stakeholders including citizens. Mission-oriented R&I initiatives require legitimacy and endorsement by the various stakeholders in order to be successful.

The preconditions that are considered here, are mostly at the national or regional level, which means that a mission-oriented approach at the European level may face a problem of shared policy competences and of collective ownership hampering their implementation and achievement. If the European Union decides to move its R&I policy towards mission orientation in the next Framework Programme, it should therefore steer away from seeking unanimous agreement, but look for 'variable geometry' and 'coalitions of the willing'.

The evidence collected clearly demonstrates clearly that there is no 'one-size-fits-all' mission-oriented approach but that successful mission-oriented R&I initiatives are designed to fit their specific purpose and context.

The key findings include:

- Most mission-oriented R&I initiatives are initiated by public organisations and designed in a top-down manner.

- New forms of governance must ensure vertical and horizontal coordination of stakeholders and break any existing silos. Such organisations might emerge from competition among (consortia of) existing national agencies to run mission-oriented R&I initiatives on the EU scale.

- Public organisations must set long-term direction towards and commitment to clearly identified missions. The direction setting is not however a question of 'picking winners' but rather a process of prioritising the societal targets and creating favourable conditions for the best solutions to merge, co-evolve and compete.

- In addition to public funding, novel and flexible ways of financing should be promoted including contributions from the private sector.

- Citizen engagement is a challenge for many of the mission-oriented R&I initiatives observed but remains of key importance. Their role should go beyond the mere buy-in of mission-oriented R&I initiatives and demand articulation. New forms of involvement must be found to ensure that mission-oriented R&I initiatives target what matters to the citizens.

- Mission-oriented R&I initiatives need coherent policy actions across a number of policy areas and levels. Policy mixes should be holistic and include demand-side policy instruments and put emphasis on a better match between demand and supply.

- Mission-oriented R&I initiatives must be reflexive and flexible enough, so that they can be reassessed and adapted to new developments and challenges, or possibly ceased. Evaluation and monitoring require criteria adapted to the mission, objectives and problems that they target.

The following sections detail the study findings.

Concepts and definitions

Mission-oriented R&I initiatives, be they private or public, typically are ambitious, exploratory and ground-breaking in nature, often cross-disciplinary, targeting a concrete problem/challenge, with a large impact and a well-defined timeframe. More specifically, they have a clearly defined (societal or technological) goal with preferably qualified and/or quantified targets and progress monitored along predefined milestones. Directionality and intentionality of these initiatives is what differentiate them from other types of initiatives, such as systemic or challenge-oriented policies.

Mission-oriented R&I initiatives tend to be sizeable (in relation to GDP or overall R&I investments by a country). Mission-oriented R&I initiatives are cross-disciplinary by nature and involve several types of stakeholders. They utilise a mix of policy instruments going beyond the mere realm of R&I policies and require horizontal policies cutting across governance levels. Finally, the results, which rely on different technologies, should be applicable to different industrial sectors and social contexts.

The collected empirical evidence sheds light on two additional features of mission-oriented R&I initiatives: they are managed by a clearly identified and empowered governance body which can be held responsible for the achievements of the missions, and they almost always emerge from a sense of urgency that is shared by a wide array of stakeholders.

Mission-oriented R&I initiatives are not a homogeneous group but vary along the aforementioned characteristics. They exist in different degrees on a scale between two ideal-types: the narrowly defined initiatives, aimed at single, well-defined and, the most often, scientific and/or technological objectives (the so-called 'accelerators'), on the one hand, and the more broadly defined initiatives addressing complex and often societal problems, requiring the transformation of systems (the so-called 'transformers'), on the other hand. Furthermore, mission-oriented initiatives may require a combination of several

projects, which can be mission-oriented but not necessarily all of them. In other words, policy interventions can be partly mission-oriented.

Global Mapping of ongoing MO R&I initiatives

The above definition served the mapping of mission-oriented R&I initiatives in the European Union, its Member States and its main trade partners (Australia, Brazil, India, Japan, Norway, Russia, Singapore, South Korea, Switzerland and United States), as well as in private organisations (charities and businesses). The mapping focusses on seven thematic areas (climate change, energy, circular economy, health security, food, and transport). After a quick scan that identified almost 200 initiatives globally, 44 representative ones were selected for deeper analysis. The resulting fiches give, for each of the 44 mission-oriented R&I initiatives, information on their background and objectives, elaboration process, technical and political feasibility, governance, resources, policy mix, relationship with other initiatives, and their strengths, weaknesses, threats and opportunities. These fiches were then clustered per country and per theme. Most of them are about public initiatives initiated by local, regional, national or international public government bodies, while a few have been implemented by private companies or charities (but still complying with the definition of mission-oriented R&I initiatives).

The missions pursued by many initiatives relate to country- or regional specific socio-economic contexts (e.g. ageing population in Japan) or risks (e.g. floods in the Netherlands due to the sea level rise, and *acqua alta* in the Venetian Lagoon). Despite such peculiarities, some mission themes and drivers are common to many countries, like climate change or health. Except for the influence of local priorities, the global mapping exercise did not provide many country specificities in terms of characteristics of mission-oriented R&I initiatives, although (national, regional or local) cultural and political factors have an influence on practices in the elaboration and design of mission-oriented R&I initiatives (e.g. the degree of openness of the process, evaluation culture etc.).

The cross-thematic analysis of the shortlisted mission-oriented R&I initiatives sheds further light on their characteristics:

- Many of the mission-oriented initiatives address multiple themes;
- Many of the initiatives related to circular economy, climate change and energy have a broad approach, whereas those within the themes transport, security, health and food tend to have a narrower focus.
- The themes seem to have an influence on the geographical scale of the mission-oriented initiatives: security initiatives being mostly at national or local levels, while circular economy, climate change, energy, health and transport are global and therefore need transnational initiatives;
- Mission-oriented R&I initiatives can be grouped into three categories based on their time span: initiatives with a very long-time span (more than 15 years) (health, security, transport, circular economy), initiatives with a duration of approximately 10-15 years (health, energy, circular economy, security, food, climate change, transport) and short-term initiatives with a duration of three to six years (health, energy, climate change, transport;
- The cross-thematic analysis reveals that the policy mix varies between the themes and between more technological and more societal missions and is largely dependent on the granularity and scope of the initiative. In case of more technologically oriented missions, there are often sector specific policy instruments (e.g. R&D funding programmes, tax credits, subsidies, etc.). For the more societal and broader umbrella missions, a more holistic policy mix is applied to support these types of missions. Some of the security-related initiatives include laws providing the legal framework for the mission.

Beyond these country-related and especially thematic differences, the mission-oriented R&I initiatives that were identified in the global mapping exercise have been mostly initiated by public bodies (governments or public agencies) with an early involvement of the industry, and developed in a top-down manner with high-level political support. The technical feasibility of most of them has been assessed ex ante. There is no single governance model, as the model depends on whether initiatives are publicly or privately led and the level of intervention. The following four governance models nevertheless seem to be the most common: governance by several ministries and subject to cross-governmental coordination; governance and coordinator by a single ministry, agency, or local government body; governance and coordination by a governance body created specifically for the mission; governance and coordination by a public-private partnership. Despite the efforts towards an active participation of stakeholders in the implementation and design of mission-oriented R&I initiatives, citizens are often left out or reduced to the role of end-users or consumers.

Public funding is the main source for the missions and vary significantly across the mission-oriented R&I initiatives depending on their timeframe, intervention level and scope. National government funding is often complemented with public funding from the European Union, regions, local authorities and special funds, with the addition of private investments.

The nature (especially the thematic focus) significantly defines the characteristics of the missions. It explains thereby their diversity with which the European Commission will need to cope, if it decides to introduce mission orientation in FP9.

In-depth case studies of mission-oriented initiatives

Seven case studies were conducted with a view of a better understanding of the implementation and management of mission-oriented R&I initiatives. Policy instruments mobilised, costs and benefits, and main success factors and other contextual enablers were assessed for that purpose.

Overall, all or most of the initiatives (with few specific exceptions):

- Demonstrate high levels of directionality and intentionality (specific and well-articulated goals and clearly set timeline and milestones), with varying degrees of ambitiousness;
- Mobilise both public funding and private investments;
- Are predominantly focused on knowledge application (TRLs 5-9), while some also declare targets related to new knowledge creation (TRLs 1-4);
- Barely involve demand-side measures (only the Japanese Hydrogen Society initiative implemented some while the German High-Tech Strategy shows some considerations for demand articulation), while paying attention to stakeholders' networks and engagement of citizens;
- Show an important degree of multidisciplinarity, involving many different science and technology fields;
- Have reflexivity mechanisms in place and show flexible policy design and timely monitoring activities;
- Show at least some connections to international agenda.

The case studies demonstrate the importance of long-term direction setting and the commitment of public governments as key success factors. Many of the initiatives show strong public leadership and centralised 'ownership' of the mission. The owners are in some cases prestigious individuals using their reputation to give the mission-oriented R&I initiatives and their results better visibility and public acceptance.

The analysis of the case studies also reveals that significant injections of public funding contribute to the success of the mission-oriented R&I initiatives selected. The governmental role can however vary significantly between the initiatives, and evolve over the course an initiative, e.g. from initial capacity building and infrastructure support towards supporting market creation and demand building.

Horizontal and vertical coordination of policies are important characteristics of the initiatives analysed. Regulation, (tax) incentives schemes, and demand-side policies are often necessary complements to R&I policy, and the policy mix needs to be coordinated in a cross-cutting and timely manner. Despite the recognized importance of demand articulation and, more broadly, of users and citizen engagement in mission-oriented R&I initiatives, they remain a challenge for most the cases analysed.

Beyond the importance of an appropriate design, a key success factor is the existence of capabilities and knowledge, upon which mission-oriented R&I initiatives can build. Those preconditions could additionally include infrastructures and a culture for knowledge, information and data sharing that facilitate the cross-disciplinary and cross-sector cooperation.

The success of mission-oriented R&I initiatives however does not depend exclusively on pre-conditions and on their design. During their implementation, they need to be rigorously monitored and periodically assessed, and have decision processes in place to decide how to deal with (changed) future directions of the initiative or even ceasing it. Such decisions must primarily take into consideration whether the initiatives are on the right track to achieve their mission and whether the mission or its objectives are still relevant. A transparent monitoring system is also considered to be an effective element for stakeholder and citizen engagement.

Although all the initiatives analysed in the case studies are ongoing missions, for which the final results and implications are still to be realised, it can be said that mission-orientation can serve as an effective tool for setting strategic orientation and priority of policies over a long period of time.

INTRODUCTION

This report constitutes the final delivery of the "Mission-oriented research and innovation: Inventory and characterisation of past initiatives" study PP-05542-2017, carried out for the European Commission, DG Research & Innovation. This Specific Contract is under the Multiple Framework Contract ENTR/172/PP/2012/FC for 'the procurement of studies and other supporting services on Impact Assessments and Evaluations'.

While the Horizon 2020 Framework Programme for Research and Technological Development is coming to an end, the European Commission, DG Research & Innovation (DG RTD) is preparing the future Framework Programme FP9. For that purpose, it needs evidence on mission-oriented research and innovation (R&I) in order to determine whether such orientation should be adopted and, if so, which approach should be pursued.

Increased attention is paid to the socio-economic impacts of R&I policies and not only to their direct R&I outputs. The idea behind is that these policies should not only stimulate R&I for the sole sake of R&I but should also help address and tackle socio-economic problems. Horizon 2020 has been already contributing to the ongoing policy trends towards challenge-oriented policies. Challenges are broadly defined like climate change or an ageing population. Mission-oriented policies aim similarly at tackling these "grand challenges," but they focus on specific problems, e.g. the reduction of CO2 emissions by a given percentage instead of the broad challenge of climate change.

Mission-oriented policies have gained a renewed interest, which means that they are not new. The most famous examples of such policies are the Apollo programme (the Man on the Moon) and the Manhattan project (the first nuclear weapon), which have been already widely documented and investigated. In Europe, the British and French governments collaborated for the development of Concorde, which must similarly be considered as a mission-oriented initiative, where the mission was to build a supersonic transport aircraft. For almost thirty years (from the 1960s to the late 1980s), the French industrial policy was articulated around the so-called *'grands programmes'* (e.g. the high-speed train TGV, Minitel) oriented towards the achievement of technological challenges. More recently, an increasing number of countries have implemented initiatives, like the German *Energiewende*, aimed at stimulating R&I for solving specific problems.

Beyond the distinction between the man-on-the-moon type of mission-oriented initiatives and the initiatives targeting systemic transformations, it appears that these initiatives vary to a high degree in accordance with the policy instruments they mobilise, the governance they rely on, the context of their implementation, the sector(s) they target, the technological challenge(s) they must address, the stage of market development, and so on. In sum, there is no unique approach which the European Commission could adopt and pursue in FP9.

For the sake of an evidence-based decision as to whether FP9 should be oriented towards missions or not, and how such an orientation could be ensured, the Study consisted of a global mapping collecting evidence and data on mission-oriented R&I initiatives currently in place in the 28 EU Member States, in the European Union, and in major EU trade partners. In complement to this first data collection exercise, a series of in-depth case studies investigated how such initiatives have been implemented and managed.

The present Final Report presents the collected evidence and the analyses that had been performed on this basis. It is structured as follows. Section 1 provides with a definition of mission-oriented R&I which will then be used for the global mapping exercise and the selection of case studies. The methodology and outcomes of the global mapping exercise are presented in Section 2. Section 3 describes the case selection process and performs a cross-case analysis. Section 4 concludes.

1. DEFINING MISSION-ORIENTED RESEARCH AND INNOVATION

Based on the literature and our empirical findings, we define mission-oriented research and innovation initiatives as large-scale interventions aiming for a clearly defined mission (i.e. goal or solution) to be achieved. Missions have an important R&I component, however they are broader (sometimes much broader) than R&I alone and require also other measures to achieve the goals (e.g. regulation). Such initiatives are found predominantly in the public sector, but there are also ones driven by the private sector. Mission-oriented research and innovation initiatives typically are ambitious, exploratory and ground-breaking in nature, often cross-disciplinary, targeting a concrete problem / challenge, with a large impact and a well-defined timeframe.

The main characteristics of these initiatives are:

- A ***clearly defined (societal or technological) target, preferably qualified and/or quantified*** in terms of an x% reduction or a y% increase, or in more absolute terms (e.g., Malaria eradicated by e.g. 2050).

- The achievement of the mission is defined for a ***specific timeframe*** and progress should be monitored along ***predefined milestones***.

- A large scale. The initiatives mobilise significant public and/or private investments and other resources (infrastructures, human resources, etc.) and their expected societal and/or economic impact should be large. ***Large-scale*** is not absolute but ***dependent on the thematic area and the mission specified.*** Sometimes it is also sizeable in relation to GDP or overall R&I outlays by a country, a sector or a technology area.

- Mission-oriented research and innovation initiatives are ***often needed to drive a 'system' or 'transformative change'*** and are – due to their ambition – quite often of an explorative and ground-breaking nature either for policy or for markets. Initiatives may be divided into two broad categories depending on the nature of the mission:

    - ***Narrow*** mission-oriented R&I initiatives aim to achieve a ***single well-defined (often, but not exclusively in technological terms) objective*** like the Apollo project that aimed to send a man on the moon (not at developing the rocket that sent him).

    - ***Broader*** mission-oriented R&I initiatives aim at (or implying) the transformation of systems to address wicked (often societal) challenges like climate change and the ageing population.

- Mission-oriented research and innovation initiatives are often ***cross-disciplinary***. The initiatives should involve many different technologies (even if some are at the core of the initiative), involve many different actors (research sectors, companies, government, users, citizens inter alia). The solution that they target should be applicable in a variety of industrial sectors and social contexts, and their development requires horizontal policy cut across governance levels.

- The achievement of mission requires

    - the use of a ***mix of policy instruments*** (i.e. techniques employed by policy makers to complete a policy objective) ***that is adequately and accordingly coordinated and oriented.***

    - a strong commitment from the public institutions, with consistent decree of political approval making public institutions accountable for achieving the mission's objectives;

- *A clear and **empowered governance (structure)** that can held **accountable** for achieving the results*

- *A **sense of urgency** that is shared amongst a broad category of **stakeholders**, including citizens**.***

From the main characteristics that constitute mission-oriented R&I initiatives that we have identified in the proposal and the inception report, many are in common with 'systemic' policies in general (e.g. multi-actor/stakeholder involvement, multi-sector perspectives). ***The main differentiating feature, though, is the directionality and intentionality (with respect to specific targets) of the policy.*** This is what sets mission-oriented R&I initiatives aside from other policies (e.g. from those addressing societal challenges more broadly and as general orientations).

This working definition is used for screening and mapping mission-oriented R&I initiatives and for selecting relevant case studies.

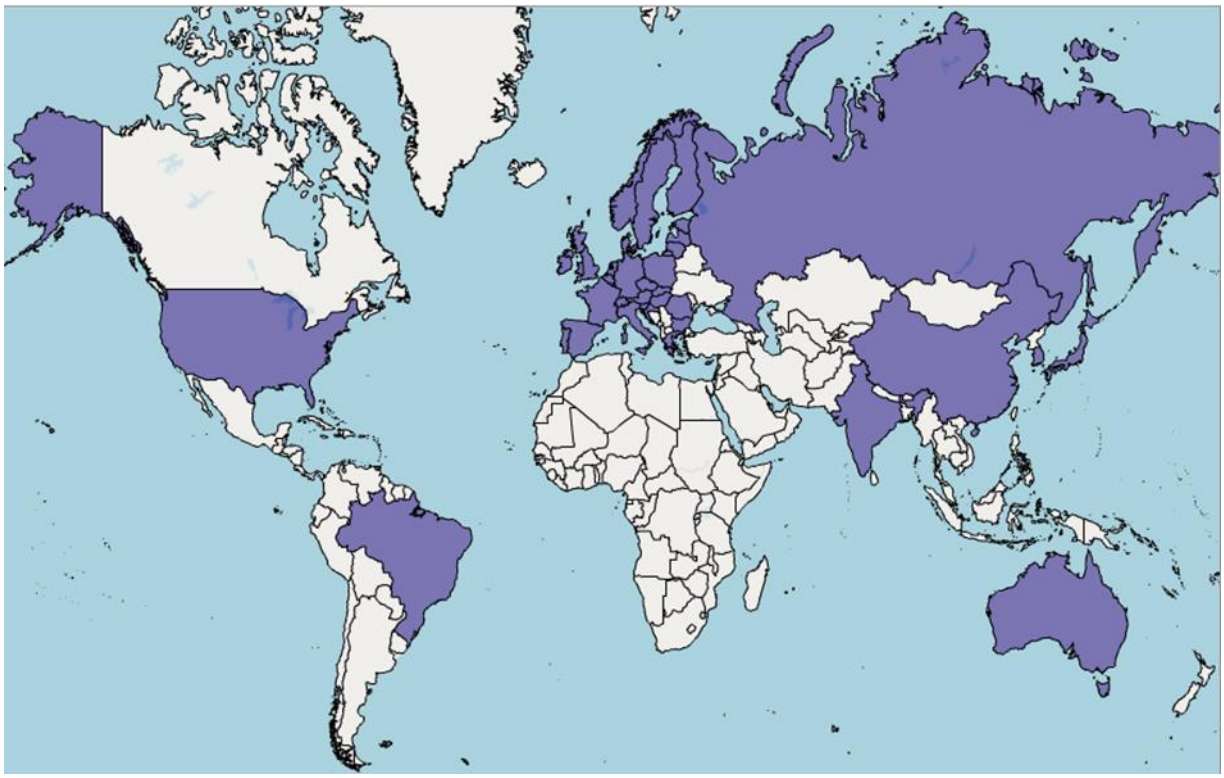
2. GLOBAL MAPPING OF ONGOING MISSION-ORIENTED RESEARCH AND INNOVATION INITIATIVES

2.1. Approach

The objective of the global mapping is to provide a global inventory of ongoing mission-oriented R&I initiatives for the European Union, its 28 Member States and a selection of third countries (Brazil, China, India, Japan, Norway, Russia, Singapore, South Korea, Switzerland and the United States). The mapping covers seven thematic areas and offers a concise and systematic overview of their background and origin, mission and ambition, formation, technical and political feasibility, resources (public and private), and actual implementation. Apart from government-led initiatives, the inventory includes also private-sector led and hybrid (public-private) initiatives with a mission-orientation.

The global inventory of ongoing mission-oriented R&I initiatives is not exhaustive across all countries and all themes, but includes the most relevant examples and broad variety of societal and technological projects, initiatives and broader policy approaches launched within the seven themes.

Figure 1. Country coverage global mapping



2.1.1. Three-step methodology

To build a global inventory of ongoing public and private mission-oriented R&I initiatives and cover the seven thematic areas, a three-step methodological approach for the global mapping has been applied.

Figure 2. Three-step methodology

2.1.2. Step 1: Quick scan global mapping

Based on the working definition of the mission-oriented R&I initiatives, a quick scan was carried out to identify potential mission-oriented R&I initiatives for the European Union, its 28 Member States, as well as important trade partners of the European Union. The objective of the mapping is not to make an exhaustive inventory of both public and private initiatives, but to have an exhaustive geographical coverage in order to identify the different approaches of mission-oriented R&I experienced in the selected countries. For this reason, the focus of the quick scan was limited to identifying those initiatives that fitted best to the working definition.

For the identification of ongoing mission-oriented R&I initiatives various sources were used, varying form international databases and policy and strategy documents, to interviews with policymakers and experts.

2.1.3. Step 2: Collection of information for the mission-oriented R&I fiches

Based on the results of the quick scan, initiatives that deserved further investigation were selected taking into account geographical and thematic coverage, granularity and type of the initiative, intervention level and scale (budget).

Out of the 137 initiatives, 44 mission-oriented R&I initiatives have been selected (see Table 1), including two cases that include a past initiative as well as its successor (US War on Cancer / Cancer Moonshot and the Dutch Delta Plan / Delta Programme).

2.1.4. Step 3: Reporting fiches and thematic reports

<u>Mission-oriented R&I initiative fiches</u>

The fiches provide detailed and comprehensive information on the selected individual ongoing mission-oriented R&I initiatives. Additional evidence on the initiatives was collected through desk research and interviews with policymakers. Each fiche includes a summary of the initiative and detailed description of 1) Background, origin, mission and ambition, 2) Formation, 3) Technical and political feasibility, 4) Governance: organisation, management and coordination, 5) Resources and budget needs/availability, 6) Policy mix and integral ('holistic') use to deploy mission-oriented R&I initiatives, 7) Embeddedness of and connectivity with related initiatives (regional, national, supranational, global) and 8) SWOT analysis. The fiches are included in Annex 1.

Table 1. Fiches mission-oriented R&I initiatives

Country	Mission-oriented R&I initiative	Country	Mission-oriented R&I initiative	Country	Mission-oriented R&I initiative	Country	Mission-oriented R&I initiative
Brazil	Inova Renewable Energy	**Finland**	Finnish Bioeconomy Strategy	**Netherlands**	Delta Plan/Delta Programme	**Sweden**	Fossil fuel free transportation
China	Water Programme	**France**	Agricultural-Innovation 2030	**Netherlands**	Portable artificial kidney	**Sweden**	Swedish Climate Policy Framework
China	New Energy Vehicles	**France**	Innovation 2030 Commission	**Netherlands**	Rotterdam Climate Initiative	**Switzerland**	Solar Impulse
China	Work station under deep sea	**Germany**	Energiewende	**Netherlands**	The Ocean Clean-up	**United Kingdom**	Alzheimer's Research UK
Denmark	Circular economy	**Germany**	The new High-Tech Strategy (HTS)	**Norway**	Zero-emission vehicles	**United Kingdom**	Cleaning up London's air
Estonia	E-Estonia	**Global**	Mission-Innovation	**Poland**	Electromobility Poland	**United States**	BRAIN
Estonia	Estonia E-Mobility Programme	**Italy**	MOSE	**Portugal**	Green Growth (GGC)	**United States**	War on Cancer / Cancer Moonshot
Global	E-Fan Electric aircraft	**India**	National Electric Mobility Mission Plan 2020	**Portugal**	Chronic Pain Initiative	**Global**	Computing Science
European Union	European Strategy for low-emission mobility	**Japan**	Hydrogen Society	**Singapore**	NEWater programme	**United States**	Health challenge
European Union	Common Agricultural Policy (CAP)	**Japan**	Strategy for robotic technology in elderly care	**South Korea**	Korea Brain Initiative	**United States**	Mission to Mars
European Union	Fuel Cells and Hydrogen JTI	**Luxembourg**	Third Industrial Revolution	**Spain**	Alternative Energy Vehicle	**United States**	SunShot Initiative

Thematic reports

Building upon the findings of the quick scan and the fiches containing in-depth information on the selected and most interesting mission-oriented R&I initiatives, the relevant initiatives were clustered to analyse, synthetize and present observations from a thematic perspective. The thematic reports describe the challenges, ambitions, content, scale/scope and outreach of the initiatives and identify similarities and lessons learned within the theme. The thematic reports are included in Annex 2.

Country fiches

In addition to the thematic reports, country fiches have been created to provide an overview of the mapped initiatives, including a brief summary and the lessons learned that could be derived. In addition, the country fiches include an overall description of national funding R&I systems. Comparable indicators were selected to assess to which degree these systems can or could support mission-oriented R&I policy and initiatives

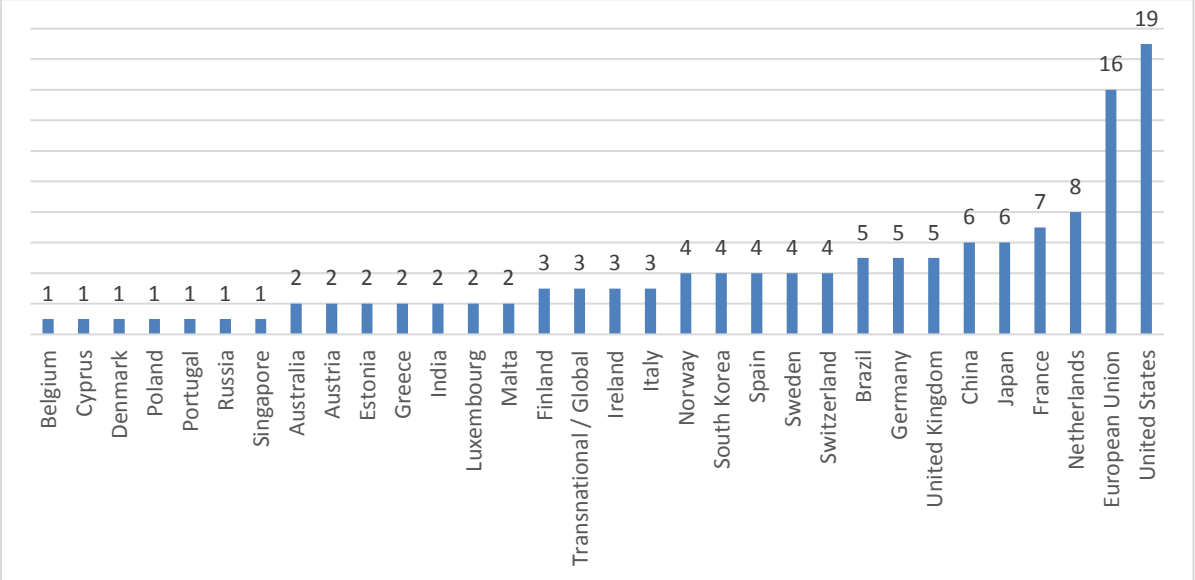
2.2. Outcomes of the global mapping

2.2.1. Country analysis

Countries with mission-oriented R&I initiatives

With the quick scan, 137 ongoing mission-oriented R&I initiatives in 32 countries (including the European Union and global initiatives) have been identified (see Figure 3). At the country level, many mission-oriented R&I initiatives have been identified in the United States (20) and European Union (17), Japan (9), The Netherlands (8), France (7), China (6), and Germany, United Kingdom and Brazil (5). On the contrary, for the EU Member States Bulgaria, Croatia, the Czech Republic, Hungary, the Slovak Republic, Slovenia and Romania, no initiatives could be found fitting the working definition. The number of initiatives identified does not necessarily imply that countries with many initiatives are more and countries without or only with a limited number of initiatives identified are less mission-oriented. However, the examples collected do suggest that some in countries, to a certain extent, the key aspects related to a mission-oriented approach seem to be more present than in other countries.

Figure 3. Number of identified ongoing mission-oriented R&I initiatives per country



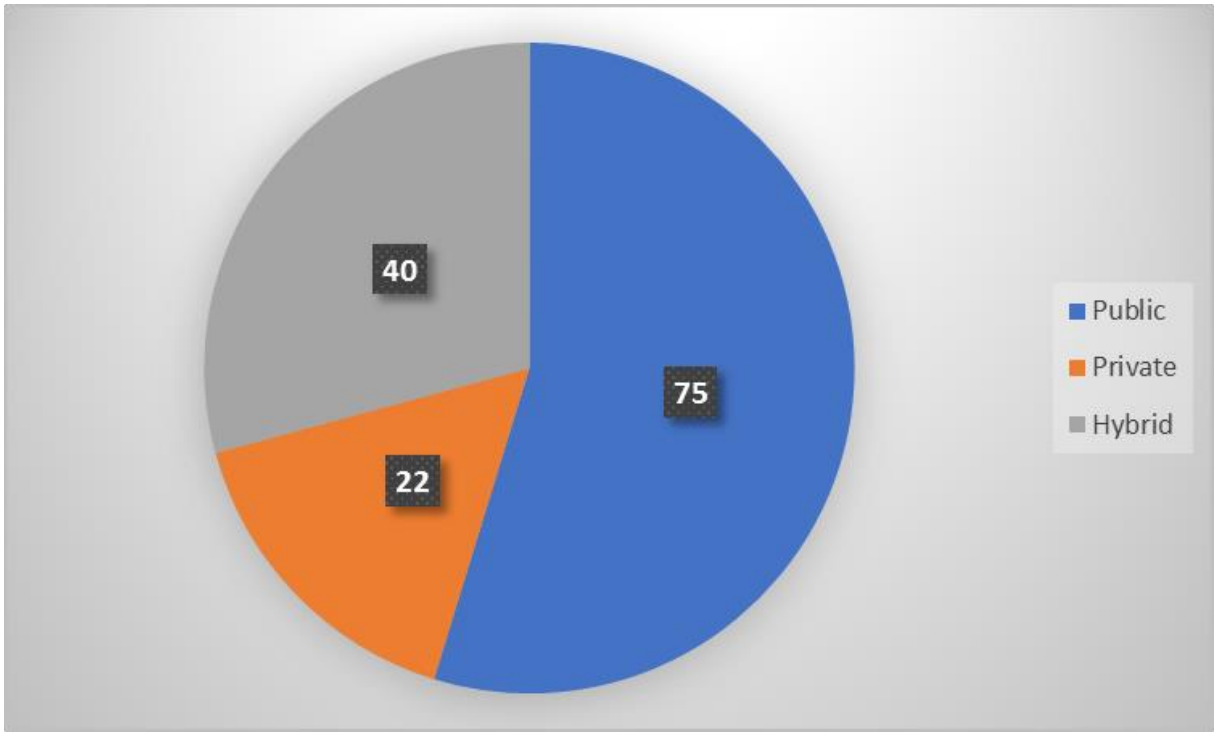
Granularity

With regard to the granularity of the initiatives identified, no country-specific conclusions can be drawn: in Western-European countries, as well as in American and Asian countries both narrow initiatives aiming to achieve a single objective and broader umbrella policy approaches that address multiple themes have been identified.

Initiators and type (public, private, hybrid)

A large part of the initiatives included are public initiatives initiated by local, regional (including the city level), national or international public government bodies (75 out of 137), followed by the hybrid initiatives (40). Also, 22 private initiatives are included. These initiatives are either initiated by large companies, (e.g. Google/Alphabet, Microsoft or Tesla), foundations (e.g. Clinton Foundation or the Bill & Melinda Gates Foundation), or private persons, such as Boyan Slat (Ocean Clean-up) or Bertrand Piccard (Solar Impulse). In many of the public initiated and run initiatives representatives of the business sector, knowledge and research institutes or other public bodies are involved. Also, here, no country-specific conclusions can be drawn, although in particular in the United States many cases initiated by private initiators (large companies and foundations) were identified.

Figure 4. Number of mission-oriented R&I initiatives per type



Intervention level (local, regional, national, international)

Also, from the perspective of the intervention level the country-specific conclusions appear too limited and more related to the thematic focus of the initiative. Not surprisingly, initiatives related to the country's specific geographical or socio-economic context (e.g. located in a delta, at the junction of tectonic plates or faced with a rapidly ageing) are nationally focused, whereas initiatives initiated by the European Commission are logically on the EU level.

Technical and political feasibility

With regard to assessment of the technical and political feasibility of initiatives, and whether cost-benefit analyses are regarded as an appropriate tool the outcomes indicate that this relates to the national political culture. In Anglo-Saxon countries, the use of 'hard'

cost-benefit analyses is more common than in Central and Northern European countries, where 'softer' and procedural approaches are more common.

Thematic focus

As mentioned above, the findings of the quick scan on the one hand show that many mission-oriented R&I initiatives relate to a country's specific geographical or socio-economic context or planned technologic pathways. Furthermore, some initiatives are related to regional or country specific, environmental problems or emerging risks (e.g. China's water pollution crisis, or expiration of Singapore's agreement with Malaysia on the supply of fresh water). On the other hand, climate change is the target of mission-oriented R&I initiatives in almost two third of the countries covered (either at the national – e.g. Swedish or Norwegian Climate Plans – or local levels – e.g. Rotterdam Climate Initiative), but also at the global (e.g. Mission Innovation) and EU (e.g. EU strategy for Low Emission Mobility) levels.

Table 2. Thematic focus of mission-oriented initiatives per country

Theme / Country	Circular economy & Re-industriali sation	Climate Change & low carbon transition	Energy	Food & Bio-economy	Health	Security	Transport	Multiple themes
Australia			1		1			
Austria						1		1
Belgium	1							
Brazil			1		1	1		2
China					1	1		4
Cyprus			1					
Denmark	1							
Estonia								2
European Union			5	1	3		1	6
Finland	1						1	1
France		1		2	2			2
Germany		1			1		1	2
Greece			2					
India		1			2			3
Ireland		1			1			1
Italy								3
Japan	1		2		1	3	1	1
Luxembourg								2
Malta						1		1
Netherlands	1	2	1		2			2
Norway		1	1				1	1
Poland							1	
Portugal					1			1
Russia							1	
Singapore								1
South Korea	1				1			2
Spain		1		1		1	1	
Sweden		1					1	2
Switzerland					1		1	2
United Kingdom	1		1		2			1
United States		1	3	1	6	2	4	1
Transnational/ Global					1		1	1

Size (budget) and duration

From the perspective of size and duration of the mission-oriented R&I initiatives identified, no country-specific conclusions can be drawn. The budgets vary significantly in relation to the intervention level and range from several million (e.g. Dutch Ocean Clean-up, Finnish Arctic testing environment Aurora for intelligent transport and automated driving or the Maltese MARISOL project) to several billions (e.g. US SunShot Initiative, China's Major Science and Technology Programme for Water Pollution Control and Treatment, Norway's Zero-emission vehicles initiative or the Swiss Underground Cargo System). Also, the duration of the missions varies greatly and rather relates to the type of mission (technology-focused missions tend to have a timespan between five and ten years,

whereas long-term systemic transformative missions have a much longer horizon) rather than relating to the country.

Lessons learned

Because the focus of the global mapping is on ongoing mission-oriented R&I initiatives, it is too early to determine whether the initiatives have been successful in achieving their goals. However, the analysis shows that some of the initiatives serious budget issues (e.g. Dutch Delta Plan), delays and criticism on the solution developed (e.g. Italian MoSE) or were ceased (e.g. Airbus E-Fan). From the perspective of lessons learned the analysis provides many useful insights, but these are initiative-specific and therefore no country-specific conclusions can be drawn. The lessons vary from the importance of cross-sectoral coordination between ministries and wide-range of other actors to achieve large-scale system transitions (e.g. Chinese New Energy Vehicles) and a project-based approach allowing continuous improvement and updates, introducing new innovative tools and services (e.g. E-Estonia) to the combination of R&D push and market pull policy instruments to achieve systemic transformation (e.g. Japanese Hydrogen Society) and public private collaboration to push forward development and create concrete solutions (e.g. Dutch artificial kidney).

2.2.2. Cross-thematic analyses

Building upon the fiches containing in-depth information on the selected mission-oriented R&I initiatives and taking into account the findings of the global quick scan, the thematic experts clustered the relevant initiatives to analyse, synthetize and present observations from a thematic perspective (see Annex 2 for the thematic reports).

With regard to the thematic challenges, the overall outcomes of the thematic cross-comparison analysis show that:

- Many of the mission-oriented initiatives relate to more than one theme. In particular, the themes Energy, Climate and Transport (transition from fossil fuel-based towards low carbon renewable energy source driven systems) are strongly interrelated. Initiatives focused on circular economy missions relate to many of the other themes (Food, Energy, Climate and Security). An exception are the initiatives within the Health theme: out of the 30 health missions, 26 initiatives and approaches focus purely on health;

- The scope of the initiatives differs between the themes. Many of the initiatives within the themes Circular economy, Climate change and Energy are broader policy approaches contributing to paradigm shifts and systemic changes, whereas many initiatives within the themes Transport, Security, Health and Food have a narrower (technology or scientific) focus;

- The geographical scale of the challenges addressed ranges within the themes from local, regional or national specific challenges (Security) to national and international challenges (Food) and global challenges (Circular economy, Climate change, Energy, Health and Transport);

- With regard to the timespan the analysis shows that thematic missions differ and can be grouped into three categories: initiatives with a very long-time span (Health, Security, Transport, Circular economy), initiatives with a duration of approximately 10-15 years (Health, Energy, Circular economy, Security, Food, Climate change, Transport) and initiatives with a duration of three to six years (Health, Energy, Climate change, Transport).

Table 3. Cross-thematic comparison of mission-oriented R&I initiatives (1/7)

	Circular economy & Re-industrialisation	Climate Change & low carbon transition	Energy	Food & Bio-economy	Health	Security	Transport
Interrelatedness of initiatives to other themes	Food & Bio-economy, Energy, Security, Climate change	Energy, Transport, Circular economy	Climate change, Transport, Circular economy	Circular economy	-	Circular economy	Climate change, Energy
Scope	Broad	Broad	Broad / narrow (technology)	Narrow	Narrow (science)	Narrow	Narrow (technology)
Geographic scale of the thematic challenges	Global	Global	Global	National / international	Global	National, regional, local	Global
Duration	Long, 10-15 years	10-15 years, 3-6 years	10-15 years, 3-6 years	10-15 years	Long, 10-15 years, 3-6 years	Long, 10-15 years	Long, 10-15 years, 3-6 years

Background, origin, mission and ambition

- At the theme level, the missions differ in their backgrounds and origins. Some have their origins in concrete societal or economic problems, such as pollution, insecure energy or water supplies, flooding, security risks (terror, technology risk, natural hazard risks) or earthquakes, whereas others were launched due to lack in progress of already ongoing initiatives to develop a vaccine, or to strengthen industrial competitiveness. Furthermore, some of the initiatives build on existing national strengths and have strong historical trajectories of previous plans, whereas others do not have a history and were defined to meet a specific new "need".

- Despite the different origins and backgrounds of the missions, Climate change appears to an important driver for missions in all other themes (except for Health missions).

- With regard to the ambition level, the themes have in common that all the analysed initiatives are highly ambitious but differ when it comes to the targets they have set. Where the majority of the Circular economy, Climate change, Energy and Transport missions have comparatively concrete and quantifiable goals on a short, mid or long-term (e.g. Danish circular economy initiative aims for an 80% waste recycling by 2030), quite a number of the Food, Security and Health missions have set less clearly defined and measurable goals (e.g. US Global Health Program: "to eradicate ten neglected tropical diseases").

Table 4. Cross-thematic comparison of mission-oriented R&I initiatives (2/7)

	Circular economy & Re-industrialisation	Climate Change & low carbon transition	Energy	Food & Bio-economy	Health	Security	Transport
Drivers	Resource scarcity, climate change, demographic changes competitiveness, industrial leadership	Decarbonisation, frontrunner emerging technologies	Energy security, climate change, competitiveness	Secure food supply, climate change	Lack of funding, health challenges, lack of progress	Climate change and resilience, security and defence, industry competitiveness, secure energy and water supply	Climate change, energy security, pollution reduction, environment, leadership, sustainable energy, carbon emissions
Ambition level	Highly ambitious and clear defined targets	Highly ambitious and clear defined targets	Highly ambitious and clear defined targets	Highly ambitious, but some with more open defined targets	Highly ambitious, but some with more open defined targets	Highly ambitious, but some with more open defined targets	Highly ambitious and clear defined targets

				without timeline	without timeline	without timeline	

Formation

- In all themes, the initiator of missions are pre-dominantly public bodies (national government, ministry or agency), with in many cases early involvement of the industry. In many themes also private companies, foundations or individuals took the initiative for missions (Transport, Energy, Circular economy, Climate change and Health).

- The scope of the mission influences the mission formation process. Across the themes mission initiatives and policies are pre-dominantly developed top-down. In addition, some of the initiatives can be characterised as 'top-down- high-level', as they have been initiated at the highest level of government. Examples are the Mission-Innovation-initiative, the US War on Cancer (initiated by President Nixon) and the US Brain Initiative (launched by President Obama).

- An exception is some of the privately-initiated health missions that tend to be more bottom-up. For instance, the Alzheimer Research UK is run as a charity and originally was set up by a few individuals. Also, the Computing Science initiative can be categorised as bottom-up, as it was initially initiated by researchers but then later taken up by the top management of Microsoft.

- Furthermore, across the themes the openness of the formation process appears to depend on cultural and political factors, the scope of the mission and if a mission aims at a controversial goal. An example of the influence of cultural and political factors is the closed top-down process followed in China versus the more open and transparent process to seek consensus among stakeholders in several European countries. The scope of the mission also appears to influence the openness of the process: the process of formulating umbrella policy approaches tends to be rooted in previous policy cycles (e.g. Brazil Inova Renewable Energy), and shows a gradual process of policy development over long period of time involving a large pool of stakeholders. Another example is the Luxembourg Third Industrial Revolution for which public consultations were organised to identify the most relevant goals, needs and priorities to more engaging tools such as selection of best practices from a short list. Finally, the openness of the formation process tends to be more open to secure societal and industry acceptance of the mission. To ensure acceptance of its NEWater programme, Singapore's government set up a wide public communication programme and engaged with different stakeholders.

Table 5. Cross-thematic comparison of mission-oriented R&I initiatives (3/7)

	Circular economy & Re-industrialisation	Climate Change & low carbon transition	Energy	Food & Bio-economy	Health	Security	Transport
Initiator	Public (and private)	Public (and private)	Public (and private)	Public	Public and private	Public	Public (and private)
Approach	Top-down, public and expert consultation	Top-down, stakeholder involvement	Top-down, stakeholder involvement	Top-down	Top-down (high-level) / bottom-up	Top-down, closed / external consultation	Top-down, varying industry and research involvement

Technical and political feasibility

- For most of the themes, the technical feasibility of the initiative has been assessed prior to the launch of a mission. The analysis shows that in particular for the technological focussed and privately-led initiatives technical feasibility assessments were carried out, either on mission (e.g. Energiewende, US Brain, Dutch artificial kidney), sub-programme (e.g. Dutch Delta Programme) or on the project-level (e.g. E-Estonia,

Alzheimer Research UK and Japan's strategy for robotic technology for elderly care). Industry-led initiatives appear to assess the feasibility and risk issues more frequently during the initiative and carry out a structured cost-benefit analysis (e.g. Mission to Mars in the United States, or E-Fan Electric Aircraft initiatives). For more societal-focused circular economy and climate change missions and publicly-led transport missions, these assessments appear to be less important, although there are exceptions such as the Cleaning the London Air initiative, Indian and Estonian electric mobility plans and the fuel cell and hydrogen initiatives of both EU and Japan that included technical feasibility studies.

- Across the themes, high-level political support is the starting condition for the publicly-led initiatives: missions are adopted only in case the political feasibility is warranted. Initiatives such as the Energiewende, the Brazilian Inova Renewable Energy, Luxembourg's Third Industrial Revolution and Japanese Hydrogen Society are backed-up by high-level political decisions. Furthermore, the analysis of climate change initiatives shows that cooperation and communication efforts at national, European (EC climate package) and international level (Clinton Climate initiative) strengthen the political feasibility. Despite its importance, the political and societal feasibility appears to be the least formally studied one.

- In case of private missions, such as the Global Health Program (Gates Foundation) or Computing Science (Microsoft), political assessment may not be particularly relevant as they are not dependent on public funding.

Table 6. Cross-thematic comparison of mission-oriented R&I initiatives (4/7)

	Circular economy & Re-industrialisation	Climate Change & low carbon transition	Energy	Food & Bio-economy	Health	Security	Transport
Technical feasibility	Technological-focused missions assessed on technical feasibility, assessment less common for societal-focused missions	Technological-focused missions assessed on technical feasibility, assessment less common for societal-focused missions	Assessed with semi-formal technical feasibility studies	n.a.	Technical feasibility assessment seems not to be common prior to the start	Assessed on mission, sub-programme or project-level	Privately-led missions assessed on technical feasibility, assessment less common for publicly-led missions
Political and societal feasibility	By exception assessed, but political support is a starting condition	Most missions are adopted only in case the political feasibility is warranted	Most missions backed-up by high-level political decisions	n.a.	Publicly-led missions backed-up by high-level political decisions	By exception assessed, but political support is a starting condition	High-level political support is a starting condition for many of the initiatives

Governance: organisation, management and coordination

- Across the themes, governance models to organise, manage and coordinate missions vary considerably depending in particular on whether the initiative is publicly or privately driven. The most straightforward governance model can be found in private initiatives such as the Microsoft's Computing Science where the initiative is managed by a company's vice president, or the Solar Impulse where the initiative is managed by the two founders.

- The governance and coordination of (large) public initiatives also varies. The following four governance models seem to be common:

    - Governance by several ministries and subject to cross-governmental coordination (e.g. Cancer Moonshot, Japan's strategy for robotic technology for elderly care, Korean Brain Initiative, Brazilian Inova Renewable Energy, German HTS). Broader umbrella policy approaches (e.g. Energiewende,

HTS, Third Industrial Revolution, Innovation 2030 Commission, etc.) have more complex governance structures to manage and coordinate cooperation between various public and private actors. For example, the Energiewende is coordinated by the Federal Ministry for Economic Affairs and Energy. For the implementation, not only are many other ministries involved, also cooperation and coordination with various other public and private actors is required. Furthermore, the governance also comprises diverse political levels and jurisdictions – global, European, federal, state, and municipal – as well as interest groups, cooperatives, alliances, banks, and individuals;

- Governance and coordinator by a single ministry, agency, or local government body, such as thematic ministries in the field of energy, environment, health, public works, or industry (e.g. the National Programme for Pain Management in Portugal, Delta Plan and the NEWater);

- Governance and coordination by new mission-created governance bodies. Examples are the Delta Programme that is managed and coordinated by the Delta Commissioner and MoSE that is managed by the Committee for Policy, Coordination and Control, the so-called *'Comitatone'.* Other examples are the Swedish Climate Policy Council that assists the government by providing an independent assessment of how the overall policy presented by the government is compatible with the climate goals. In India, a National Council for Electric Mobility (NCEM) acts as the decision-making body for the National Electric Mobility Mission Plan 2020. It approves the long-term objectives, the targeted outcomes and milestones, the role of the various stakeholders, the projects and incentives to be implementation. The NCEM consists of representatives of the ministries, the Planning Commission, the National Manufacturing Competitive Council, and the Principal Scientific Advisor to the Prime Minister, plus experts from the automobile industry and academia;

- Governance and coordination by a public-private partnership. In many of the initiatives also other public and private actors are involved. Energy missions, such as Brazilian Inova Renewable Energy and German Energiewende, are characterised by strong involvement of state-owned investment banks, similarly the Chinese Deep-Sea Workstation is a public-private partnership involving state-owned enterprises.

- Despite the different governance models, many initiatives include active participation of stakeholders. Examples are Circular economy missions with advisory groups or panels that assist or form part of the governance structure of the initiatives, or supervisory groups that conduct independent evaluations to ensure transparency, confidence and relevance of the initiative.

- In most missions there is no citizen involvement. A few city initiatives such as Clean Air London are notable examples. In Clean Air London, citizens have been engaged through different consultation rounds regarding air quality strategies and actions, and in the case of EV rollout in Estonia at least an information campaign was carried out to communicate the benefits of EV and details of the programme.

Table 7. Cross-thematic comparison of mission-oriented R&I initiatives (5/7)

	Circular economy & Re-industrialisation	Climate Change & low carbon transition	Energy	Food & Bio-economy	Health	Security	Transport
Governance and coordination	Varies between the initiatives: 1) single Ministry or agency 2) new created	Varies between the initiatives: 1) several ministries and subject to cross-	Varies between the initiatives: 1) several ministries and subject to cross-	Management via committees seems to be a preferred coordination mechanism	Varies between the public and private initiatives: 1) several ministries	Varies between the initiatives: 1) several ministries and subject to cross-	Varies between the initiatives: 1) several ministries and subject to cross-

	governance body, 3) public-private partnership	governmental coordination 2) single Ministry or local government 3) new created governance body	governmental coordination 2) single Ministry or agency 3) new created governance body, 4) public-private partnership		and subject to cross-governmental coordination 2) single Ministry or agency and 3) company management board	governmental coordination 2) single Ministry or agency and 3) new created governance body	governmental coordination 2) single Ministry or agency

Resources and budget needs/availability

- Since most of the initiatives are public, the cross-thematic analysis shows that public funding sources are the main source for the missions and range from several million for smaller local or national missions up to several billion euro (the US War on Cancer has the largest budget: USD 118 billion for 1971-2016). The size of the budgets is directly related to the timescale, intervention level and scope of the initiative – for example the Danish circular economy initiative affects only three regions, while the French Innovation 2030 Contest and the German HTS have allocated funding for projects in different fields.

- The initiatives are mainly funded by central government, but also regional, local and EU public funding play an important role in some the initiatives (e.g. MoSE and Delta Programme).

- For some of the missions, special funds have been established to secure sufficient resources (e.g. the Delta Fund for the Dutch Delta Programme and the Energy and Climate Fund for the German Energiewende).

- Although the main funding sources are public, across the themes private investments play an important role in some of the initiatives. For example, in the Polish and Indian electric mobility plans the private sector is expected to contribute significantly to the overall investments needed. Similarly, industry sector investments on fuel cell and hydrogen technological development have a significant role in both Japanese and European initiatives. Also, in the case of the Delta Programme, private partners are involved and contribute financially to the National Water and Climate Knowledge and Innovation Programme that stimulates collaboration between government authorities, knowledge institutes and industry partners in pilot projects, thematic issues and long-term developments.

- With respect to budget and resources, the Global Health Program (Gates Foundation) provides an interesting example in terms of potential financial 'power' and significance of such missions in the health-care sector. Within a relatively short period of time since its establishment, the Gates Foundation with the GHP has become the largest financier of research on Third World diseases, such as malaria, largely neglected by pharmaceutical industry with little incentive to invest in R&D on diseases prevalent in developing countries.

Table 8. Cross-thematic comparison of mission-oriented R&I initiatives (6/7)

	Circular economy & Re-industrialisation	Climate Change & low carbon transition	Energy	Food & Bio-economy	Health	Security	Transport
Public funding	Budgets vary significantly and ranges from several million (local initiatives) to several	Budget varies between several million to several billion euro	Large scale policy approaches have total budgets varying from EUR 200-	No comprehensive information available, but budget	Large variation in the budgets of the initiative, largest budget is	Budget varies between several hundreds of million to	Budgets vary significantly and ranges from several million to

	billion euro (for broader national strategies)	and is directly related to the timescale and scope of the initiative	400 million up to EUR 5 billion	sizes are substantial	USD 118 billion (War on Cancer for 1971-2016)	several billion euro	several billion euro
Private funding	Most initiatives are publicly funded	Significant private investments	n.a.	n.a.	Most initiatives are either publicly or privately funded, but there are also initiatives that combine public and private funding	Limited private funding	Significant private investments

Policy mix and integral (holistic) use and deploy of mission-oriented R&I initiatives

- The cross-thematic analysis reveals that the policy mix varies between the themes and between more technological and more societal missions and is largely dependent on the granularity and scope of the initiative. For instance, the purely scientific health-related initiatives and some of the energy-related missions (e.g. EU Fuel Cells and Hydrogen JTI, US SunShot, Chinese Deep-Sea Workstation, German HTS and Brazil Inova Renewable Energy), are large-scale R&D focused initiatives. There are only two health missions where there is evidence of broader policy mix used to support the mission. In case of Cancer Moonshot, regulation (anti-tobacco laws) and education have been central for the mission. Similarly, in Japan's strategy for robotic technology for elderly care, standardisation and regulation have had a key position in the mission in addition to R&D support.

- In case of accelerator missions, there are often sector specific policy instruments (e.g. R&D funding programmes, tax credits, subsidies, etc.).

- For the more societal and broader umbrella missions, a more holistic policy mix is applied to support the missions. For instance, the German Energiewende, Japanese Hydrogen Society, Dutch Delta Programme and Portuguese Green Growth initiative have a holistic policy mix where research and innovation support forms only a part of the policy mix. The other policies include demand-side measures such as investment subsidies, taxation measures or low-cost loans. Typical policy instruments mentioned include R&D programmes, investment subsidies for the industry, tax incentives for consumers, public procurement measures, demonstration projects, industrial standards setting, infrastructure investment subsidies and public awareness measures.

- Some of the security-related initiatives include laws providing the legal framework for the mission (MoSE, Delta Plan and Delta Programme).

Table 9. Cross-thematic comparison of mission-oriented R&I initiatives (7/7)

	Circular economy & Re-industrialisation	Climate Change & low carbon transition	Energy	Food & Bio-economy	Health	Security	Transport
Policy mix	Broad mix, often connected and supported by other policy instruments (e.g. reduction of	Different instruments, for technological mission sector specific policy instruments	Different policy-mixes, ranging from holistic policy-mixes where research and innovation	Broad policy mix and holistic approach (including regulatory measures)	Pre-dominantly R&D programmes, in some cases a broader policy mix is used to	Broad variety of policy instruments, including laws to provide the legal framework,	Broad variety of policy mixes, including R&D programmes, investment subsidies, tax

	administrative burden of investments, energy and environmental and innovation policies) as well as contests and demonstration and pilot projects	(e.g. R&D funding programmes, tax credits, subsidies, etc.), societal missions are linked to more technology specific policy instruments (e.g. regulation)	support forms only a part of the policy-mix to large-scale only R&D focused initiatives		support the mission (regulation (anti-tobacco laws), education and standardisation)	R&D programmes, public procurement, demonstration projects, cross-project explorative studies and public awareness measures	incentives for consumers, public procurement, demonstration projects, industrial standard setting, infrastructure investment subsidies and public awareness measures

3. IMPLEMENTATION AND MANAGEMENT OF ONGOING MISSION-ORIENTED RESEARCH AND INNOVATION INITIATIVES: CASE STUDIES

3.1. Case study selection and approach

Case studies of mission-oriented R&I initiatives were conducted with the overall aim to have more in-depth understanding of the definition, implementation and the implications of such initiatives. The case selection was based on the quick-scan and the mapping fiches of the initiatives. The objective was to analyse at least **ten case studies** that could be considered as good examples of mission-oriented R&I, and from which policy lessons for the European Commission (in the context of the preparations of FP9) could be drawn. The following describes briefly the activities conducted.

3.1.1. Case study selection

The case studies assess **ongoing R&I policies and initiatives that can have a different degree of mission-orientation**. The contemporary mission-oriented innovation programmes can range from national to international, varying often substantially in terms of scale. A balance selection was made, based on:

- Covering the **diversity of mission-oriented R&I** (from the narrower type to quite broad ones);
- Covering the differences in **geographical coverage** (from missions defined on a local or national basis to ones that are formulated at an international level);
- Covering different **thematic areas** (Climate change, energy and transport, Health, Circular economy, Re-industrialisation, and Security and resilience related initiatives);
- Involving **different types** of mission-oriented R&I policy approaches (e.g. projects, programmes, policies).

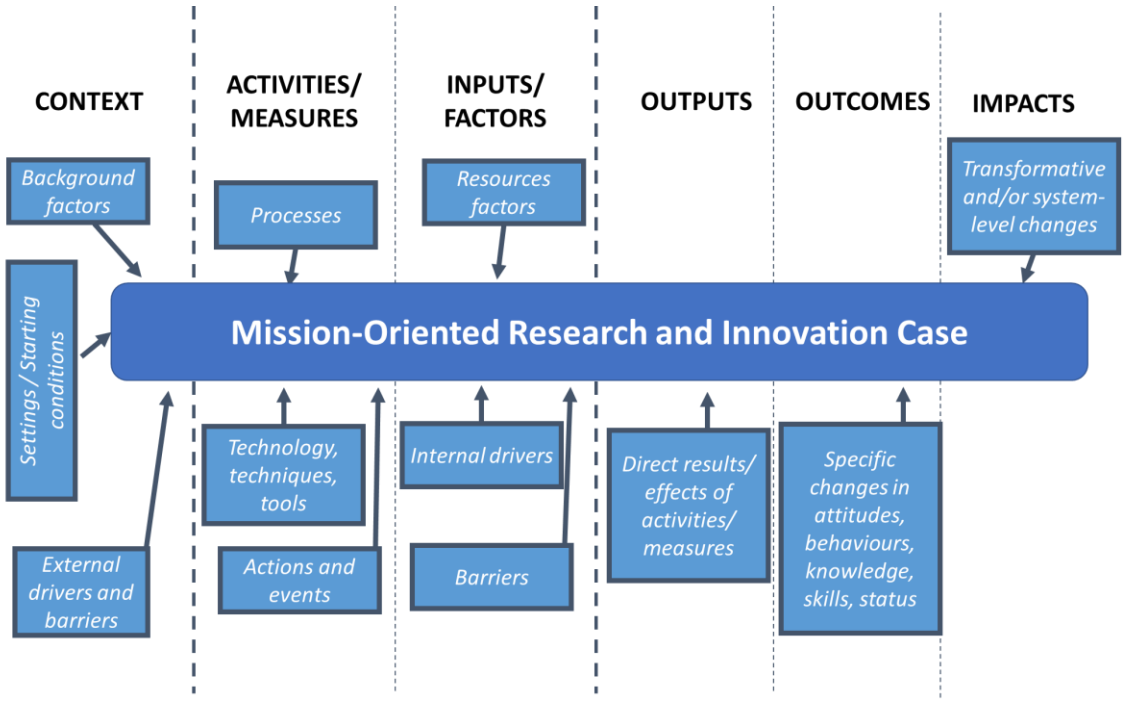
The following case studies have been selected: the Belgian Circular Economy initiative, KIRAS (Austria), the German High-Tech Strategy, the Japanese Hydrogen Society, the London City Climate initiative, the US Cancer Moonshot, and the European Active and Assisted Living (AAL) programme[1].

3.1.2. Case study approach

Logic charts were utilised as the 'backbones' of the evaluation for each case. The aim was to describe, analyse and relate the context, activities and measures, inputs and resources, and outputs, outcomes and impacts to the respective case (**Error! Reference source not found.**).

[1] It should be noted that seven case studies are building-on the findings of the mapping fiches, whereas three additional case studies were selected from the global long-list of initiatives resulting from the quick scan. The selection of ten initiatives for in-depth analysis was conducted together with the EC services.

Figure 5. Case study approach



Accordingly, the case study reporting followed the structure suggested by the logic chart, and each case study described and analysed:

- Summary of the case study (Chapter 1);
- Context and objectives of the initiative (Chapter 2 including a description and analysis of the contextual factors and objectives of the initiative);
- Resources and management (Chapter 3 including a description and analysis of the governance and coordination of the initiative, financing model, and key actors involved in the initiative);
- Policy instruments and wider policy-mix used for implementing the initiative (Chapter 4 including a description of the R&I policy instruments used for implementing of the initiative, and the connection with other policies);
- Realised or expected outputs, outcomes and impacts (Chapter 5); and
- Conclusions and lessons learned (Chapter 6).

3.1.3. Data collection

The information about these dimensions stemmed from documents describing the context and motivation for the mission-oriented R&I activity (policy analysis, strategies, white papers, etc.), the set-up, governance, modus operandi and resource endowments of the respective mission-oriented R&I (programme documents, administrative regulations and orders, etc.) and the perceived and measured effects (evaluation reports).

The case studies were mainly carried out utilising desk research, expanding the information collected in the quick scan and mapping phase. The data sources included information publicly available e.g. government/funding agency/initiative's webpage, existing academic and other types of policy studies, and other material describing and analysing the policies (e.g. news, magazine articles). In addition, with the primary data collection, interviews were used for some case studies to complement the desk research information.

3.2. Brief summary of the case studies

3.2.1. The European Active and Assisted Living Programme

Through the AAL Programme, some EU Member States and other economies co-finance initiatives for the development of ICT-based solutions. The objectives are to address the pressing ageing demographic challenge by ensuring active and healthy ageing, while supporting the development of European digital industries. In other words, the AAL Programme targets systemic transformation. The main challenges that it addresses is nevertheless the lack of a common vision for a European ageing demographic policy and the wide diversity of national health and eldercare systems. Despite appropriate instruments for the development and commercialisation of ICT-based solutions likely to contribute to the achievement of the set objectives, these innovations can hardly scale from one country to another. In consequence, the European added value of this initiative (still in process of being translated in a fully-fledged mission-oriented research and innovation initiative) is to stimulate transnational knowledge flows and international learning which will, in turn, contribute to national initiatives targeting health and ageing missions.

3.2.2. The US Cancer Moonshot

Cancer Moonshot is the federal initiative launched by President Barack Obama in 2016 to accelerate cancer research, improve access to therapies for more patients and increase the ability to prevent and detect cancer early. Cancer Moonshot Initiative started under National Cancer Institute (part of National Institute of Health, an agency of the US Department of Health and Human Services). The aspirational target is putting the country on a path to achieve in five years research and treatment gains that otherwise might take at least a decade. The Cancer Moonshot Initiative, now funded through 21st Century Cures Act, continues to run the programme under former Vice President Jose Biden's Leadership as a non-profit organisation named Biden Cancer Initiative launched in June 2017. This initiative aims to develop and implement solutions to accelerate progress in cancer prevention, detection, diagnosis, research and care, and to reduce disparities in cancer outcomes. The initiative wants to inject urgency into the cancer research and care systems, and reimagine how the government, academia, non-profits and private sector can better organise their resources to collaborate to take on cancer, with the patients at the core of the initiative.

3.2.3. The Circular Flanders Initiative (Belgium)

The centrepiece of the Vlaanderen Circulair initiative, that exists since 2017, is the Flemish Materials Programme, which has been in operation since 2006. The scope of ambition of Vlaanderen Circulair has been extended to reach out to a significant number of stakeholders who were previously not or insufficiently involved compared to the Flemish Materials Programme. The scope has been broadened to include materials, energy, water and food. It consists also of Plan C, the Sustainable Materials Management (SuMMa) and the Agenda 2020. The non-profit organisation Plan C, established in 2012, has three core activities: vision development, the formation of a learning network, and the establishment and support of specific innovative projects. The Sustainable Materials Management (SuMMa) policy research centre, also established in 2012, supports evidence-based policy in this exceptionally multi-departmental domain. The work of Plan C and SuMMa have also been supplemented by an action plan, Agenda 2020. The circular economy in Flanders is embedded in a wider/broader societal vision for Flanders, Vision 2050, adopted in 2016, that aims a social, open, resilient and international Flanders that creates prosperity and

well-being in a smart, innovative and sustainable way, in which every individual count. The transition priority "circular economy" is in the joint responsibility of the Ministry of Environment and the Ministry for Economy and Innovation.

3.2.4. Clean Air London

The Greater London Act 1999 sets an obligation for the Mayor of London to develop an Air Quality Strategy. In 2010, the Mayor's Air Quality Strategy: Cleaning the Air was published seeking to meet the requirements of the 2010 Regulations on Air Quality Standards (the regulations transposing EU Directive 2008/50/EC) and conforming to the assessment criteria set out in them. The strategy includes diverse measures targeting construction, traffic, urban planning issues. Since then, the new mayor in 2016 has doubled the funds for fighting air pollution and has introduced "tough measures to reduce London's deadly air pollution". The new mayor has committed GBP 875 M (circa EUR 1 000 M) to "be invested in action to improve the quality of the London's air through to 2021/*22*". The overall aim of all the policies, measures, and strategies is to reduce pollution and ensure public health.

3.2.5. The German High-Tech Strategy

The High-Tech Strategy (HTS) was launched in 2006 by the German government as a comprehensive national strategy for all its ministries with the aim to sustain its position in global competition based on a structural up-shift of the German economy towards greater research and innovation intensity. The first phase of the HTS was mainly emphasising cross-sectional topics to foster structural change such as the improvement of industry-science relations for innovation, the conditions for high tech start-ups, the diffusion of new technologies, investments in skills and globalisation. An overarching target was to increase Germany's total intramural R&D expenditures to 3% of GDP, which was first met in 2015. This approach faced an overhaul with the launch of the "New High-Tech Strategy – Innovations for Germany" in 2010 and 2014, now relying on an expanded concept of innovation that includes not only technological innovation but also social innovation – and that includes society as a central player. Activities in the fields of science, research and innovation are now seen as enablers to contribute to solutions for global societal challenges by focusing on six "priority future tasks": Digital Economy and Society, Sustainable Economies and Energy, Innovative Work Environment, Healthy Living, Intelligent Mobility and Civil Security.

3.2.6. Hydrogen Society (Japan)

Japan's government and industry have jointly decided to implement a Hydrogen Society plan, starting in 2015, with completion by or beyond 2040. This decision was made in the aftermath of the 2011 Earthquake and Tsunami disaster, which forced Japan to look for alternative sources of sustainable energy. The Hydrogen Society plan consists of three phases: Phase 1 is an extension of the current fuel cell programme, which includes broader diffusion of fuel cells into the global market accompanied by dramatic cost reduction of both hydrogen and fuel cells. Phase 2 envisions the large-scale introduction of hydrogen power generation and the establishment of a wide-spread hydrogen supply infrastructure. Phase 3 would establish a zero-carbon emission hydrogen supply system throughout the manufacturing process.

3.2.7. KIRAS – Sicherheitsforschung (security research, Austria)

The security research programme KIRAS was established in 2005 by the Federal Ministry for Transport, Innovation and Technology (bmvit) and was the first national security research programme within the EU. Eligible projects can be categorised into three tiers. Tier 1 projects (probing action) comprise feasibility and usability studies. Tier 2 projects (cooperative research and innovation projects) feature application-oriented R&D while Tier 3 projects (development of components and demonstration activities) target concrete applications. In addition, Tier 4 projects (R&D support activities) comprise studies and R&D services. Projects are of a cooperative nature. The programme requires the participation of at least one agent from the public sector, the research sector, business sectors as well as a participant from the field of the humanities, social or cultural sciences.

3.3. Synthesis and analysis of the case studies

3.3.1. Overview of the case studies

The initiatives selected for the analysis cover a balanced selection of case studies, in terms of:

- Geographical coverage (five European, one US and one Asian initiatives);
- Thematic area (two Health, one Energy and transport, one Circular economy, one Re-industrialisation, one Security and resilience related initiatives);
- Type of initiatives (two policy approaches, two programmes and three initiatives); and
- Governance level of the initiative (four national, one international, one regional, and one city-level initiatives).

Table 10. Overview of case studies

Title	Country	Thematic area	Type	Level	Timeline
Active and Assisted Living Programme (AAL)	EU	Health	Programme	International	2013-2020
Cancer Moonshot	US	Health	Initiative	National	2016-2023
Circular Flanders	Belgium	Circular economy	Initiative	Regional	2012- 2020
Clean Air London	UK	Climate change / Health	Initiative	City	1999 – ongoing
High Tech Strategy (HTS)	Germany	Re-industrialisation	Policy approach	National	2006 – ongoing
Hydrogen Society	Japan	Energy and transport	Policy approach	National	1991-2040
KIRAS – Sicherheitsforschung (security research)	Austria	Security	Programme	National	2005-2020

The case studies assessed the basic characteristics of mission-orientation of the initiatives, and overall the initiatives show:

- Important direction setting and contributions towards solving societal challenges and/or industry transformation;
- Varying degree of intentionality, the US Cancer Moonshot and Japanese Hydrogen Society being the only initiatives assessed to have a high degree of intentionality;
- Almost all the initiatives mobilise both public funding and private investments, at least to certain degree;
- All the initiatives are focused on knowledge application (applied research, TRLs 5-9), and some also declare targets related to new knowledge creation (basic research, TRLs 1-4);
- The Japanese Hydrogen Society is the only initiative that clearly involves demand-side policy measures, although also Cancer Moonshot, Clean Air London, Circular Flanders, and German HTS show a certain degree of demand articulation;
- All initiatives show an important degree of multidisciplinarity and involve many different science and technology fields;
- All the initiatives have reflexivity mechanisms in place and show flexible policy design and timely monitoring activities, at least to a certain extent; and,
- Similarly, all the initiatives show at least some connections to international agenda and networks, and engagement of citizens.

Table 11. Mission orientation of the analysed initiatives

	AAL	Cancer Moonshot	Circular Flanders	Clean Air London	HTS	Hydrogen Society	KIRAS
Directionality	●●	●●	●●	●	●●	●●	●●
Intentionality	●	●●	-	●	●	●●	●
Clearly set timeline	-	●●	-	●●	●	●●	●
Public and private investments	●●	●●	●	●	●●	●●	●
New knowledge creation	●	●●	●	-	●	●●	●●
Focused on knowledge application	●●	●●	●●	●●	●●	●●	●●
Demand articulation	-	●	●	●	●	●●	-
Multi-disciplinary	●●	●●	●●		●●	●●	●●
Joint coordination	●●	●●	●	●●	●●	●●	●
Reflexivity	●	●●	●	●	●	●●	●●
Openness	●●	●●	●	●●	●	●●	●
Involvement of citizens	●	●	●	●●	●	●	●●

●● = Yes; ● = To a certain degree; - = No

3.3.2. Context and objectives of the initiatives

The starting points for missions are often **concrete societal or economic problems**. In London, it was the air pollution that led to an adverse health impact for society, for the Austrian security research programme KIRAS it was new security risk in the early 2000s (terror, technology risk, natural hazard risks), that incentivised its establishment, and for Japanese Hydrogen Society the triggering factor was the earthquake and tsunami in 2011 causing the Fukushima nuclear reactor meltdown resulting in an energy crisis in Japan. For many of the initiatives the scope is however much broader than the original problem to be addressed. In the Japanese case, the policy aims to transform the entire energy production and consumption system. Whereas, KIRAS for example was successful in including societal issues due to the involvement of project partners from the social sciences and the humanities. This led to a broadening of the perspective of technological innovators. London

recently announce aiming not only for a city with low air pollutants but becoming a leading smart city, including a range of new cutting-edge technologies to tackle a host of social, economic and environmental challenge. For the circular economy in Flanders, Belgium, it was economic reasons based on increasingly stringent environmental standards that had as consequence that in recent years almost no new mining sites have been approved while the Belgian economy is in strong need for raw materials. However, the Flemish government in 2015 embedded the initiative in a broader Vision 2050 where more emphasis is put on collaboration across industries and with stakeholders and the scope is broadened to include materials, energy, water and food.

The US Cancer Moonshot, the EU Active and Assisted Living programme and the German New High-Tech Strategy can be considered as initiatives **building on existing initiatives** and **pooling existing resources together for more concrete missions**. The Cancer Moonshot is a direct continuation of the War on Cancer initiative and it targets to accelerate cancer research to deliver results with a deadline of five years, and achieving scientific results that otherwise might take at least a decade. In the AAL initiative, some EU Member States and other economies co-finance initiatives for the development of ICT-based solutions to ensure active and healthy ageing, while supporting the development of European digital industries. The German HTS on the other hand is an umbrella policy aimed at inducing innovativeness across strategic industrial sectors of Germany.

The objective-setting of the analysed mission-oriented initiatives ranges between ambitious research and innovation targets to goals targeted to change an entire economic or socio-technical system. The US Cancer Moonshot, Austrian KIRAS and German HTS can be considered as **accelerator type of initiatives**, targeted towards enhancing and advancing scientific and/or technological development in a given area, whereas the Japanese Hydrogen Society, Clean Air London, EU AAL and Circular Economy Flanders are examples of **transformer initiatives** aimed towards a systemic change in a society.

Table 12. Objectives of the analysed initiatives

Initiative	Objective(s)
Active and Assisted Living Programme	• Improve quality of life of older people via ICT-based solutions to active and healthy ageing and to strengthen Europe's digital sector
Cancer Moonshot	• Accelerate cancer research, improve access to therapies for more patients and increase the ability to prevent and detect cancer early.
Circular Flanders	• Transition to a circular economy.
Clean Air London	• To reduce air pollution and protect the health of the population.
High Tech Strategy	• Foster research and innovation, and reduce barriers hampering R&I at all governance levels in order to keep Germany at international competitive levels regarding economic performance, R&D and innovation.
Hydrogen Society	• Transform the Japanese energy supply, distribution and use towards wide-scale uptake of fuel cell technology and hydrogen as an energy carrier and ultimately as a renewable source of energy through carbon-free hydrogen production technology by 2040.
KIRAS – Sicherheitsforschung	• Contributing to the sustainability of a high level of security for all members of Austrian society by promoting national research projects which correspond to the strategic objectives of the programme.

3.3.3. Resource and management

The **scale of the initiatives varies significantly** in terms of budget size. The annual budget varies between EUR 10-20 million (Circular Flanders, Austrian KIRAS) to several hundreds of millions of euros (Japanese Hydrogen Society, Cancer Moonshot and Clean Air for London).

Table 13. Budget of the analysed initiatives

Initiative	Budget
Active and Assisted Living Programme (AAL, EU)	EUR 700 million
Cancer Moonshot	USD 1.8 billion
Circular Flanders (Belgium)	EUR 5.5 million (2012 to 2015), in addition, EUR 6 million in circular innovation/entrepreneurship subsidies and EUR 30 million in investment capital.
Clean Air London (UK)	circa EUR 1 billion
High-Tech Strategy (HTS, Germany)	The total budget is hard to asses because the High-Tech Strategy is mainly an umbrella for a variety of government initiatives and programmes.
Hydrogen Society (Japan)	EUR 310 million annual public budget for the fiscal year 2017. Until 2040 the expenditure is expected to amount to several billion euro.
KIRAS – Sicherheitsforschung (security research. Austria)	EUR 110 million (first phase from 2005-2013) equalling annual funds of around EUR 12 million. The programme was extended to 2020 and until 2016 EUR 65 million were granted to eligible research projects.

The initiatives are typically coordinated by **public entities that set up and run the initiatives**. Although, the initiating and coordination are typically public matters, many of the **initiatives involve private actors** as well. KIRAS for example a vast majority of eligible projects included actors from the private and the public sector as well as at least one actor with a background in the field of humanities, social or cultural science. These public-private partnerships also lead to joint investments for a series of KIRAS projects. In the Flemish Circular Economy case, there is a strong involvement of business and business federations, not in terms of funding but in terms of network creation and learning. Similarly, the Cancer Moonshot can be considered as a joint initiative between public and private actors. Although the Hydrogen Society is coordinated by the Ministry Economy, Trade and Industry (METI), leading Japanese companies have very important role in the activities. Clean Air London is managed by the City of London in close cooperation with the communities and for some measures the communities also provide matching funding. There are also public private partnerships, such as the Clean Air Better Business, a programme that is rolling out emerging and available technologies where a market push is needed. The AAL case study shows a governance structure that is co-managed by national coordinators, and a central management unit that is headquartered in Brussels. The programme is co-financed by the European Commission, Partner States and industrial partners.

3.3.4. R&I policy instruments and wider policy mix used for implementing the initiative

The policy instruments applied to achieve the targets of the initiatives vary between **purely R&I oriented,** accelerator type of missions initiatives like Cancer Moonshot, Austrian KIRAS, or German HTS, to initiatives where **demand-side policy measures are in the core**, such as Clean Air London and Circular Flanders that can be considered as transformative missions aimed at achieving a systemic change in society in a set direction. Although both Clean Air London and Circular Flanders are mainly focused on demand-side measures, they also involve some activities supporting R&I. The London initiative has recently started to support a SME incubator seeking solutions for clean-tech, whereas Circular Flanders dedicates a part of its budget to coordinating applied policy research aimed at new tools and ways to communicate circular economy policies. Japanese Hydrogen Society initiative is an example of transformative mission that applies a very holistic policy mix focusing on both R&I and market demand, aiming to establish a

hydrogen-based the energy system in Japan The EU AAL is aimed at transformation of the health system but utilises mainly R&I policy measures to achieve the target.

Mainly R&I policy instruments

- Cancer Moonshot is entirely focused on cancer research involving measures supporting research activities, resource and infrastructure development, cancer prevention and control, and programme management and support.

- KIRAS is a national security research programme, hence with a sole focus on research and experimental development and innovation.

- The German HTS is coordinative umbrella policy in the areas of research an innovation, and it covers a broad spectrum of activities and actions to boost R&I in several thematic and cross-cutting areas.

  The AAL Programme aims at the achievement of its objectives mainly through two instruments: project-based financial support (via calls for proposals), and non-financial support to commercialisation (AAL2Business).

Mainly demand related policy measures

- The London City Air is basically aimed at supporting low emission measures, ranging from encouraging smart travelling, encouraging behaviour change and cycling, promotion of clean vehicles through green procurement standards, Electric Vehicle Delivery Plan and London Hydrogen Action Plan, targeted actions to reduce pollution in most affected areas, introducing hydrogen fuel cell buses, age limits for the taxis, low emission zones, encouraging people to work closer to home, etc. Most recently in 2016, a clean tech incubator has been introduced aimed at supporting small and medium-sized businesses to deliver low-carbon and clean-tech products that can help tackle the causes and effects of climate change.

- Circular Flanders supports personnel and undertaking applied policy research, developing unique tools and communicating the circular economy. In addition, there are programmes supporting circular innovation and entrepreneurship in the form of investment subsidies for businesses.

Holistic policy-mix involving both supply and demand-oriented policy measures

- The Japanese hydrogen society initiative relies on a broad-based innovation policy combining R&D push and market pull policy instruments to bring about a system-level transformation.

3.3.5. Realised or expected outputs, outcomes and impacts

The outputs, outcomes and impacts of the initiatives vary significantly by the scope, scale and progress level of the initiatives. Most of the initiatives analysed are not evaluated against short-term outputs but only against a range of direct and indirect outcomes and overall achievements towards the high-level targets. For example, Clean Air London initiative is monitoring the progress against the overall emission targets, whereas the German HTS initiative's success can be looked against the overall R&I performance indicators of the country. Similarly, the Cancer Moonshot is looking at the general progress of cancer research and enhancement made in cancer treatments. In many of the cases, the particular impact of the initiative is not separated from the overall progress made (i.e. London Air or Cancer Moonshot are not measuring the impact of the initiative activities in isolation). Other initiatives, such as AAL, KIRAS or HTS, the progress is assessed through more generic R&I input and output indicators. Many of the analysed initiatives are on-going, and their full economic and societal implications will appear only in the long-run and

in many cases beyond the time scope of the initiatives. The table below presents the realised and foreseen outputs, outcomes and impacts of the initiatives.

Table 14. Outputs, outcomes and impacts of the analysed initiatives

Initiative	Corresponding outcomes, outputs and impacts
Active and Assisted Living Programme (AAL, EU)	**Outputs:** • Almost 200 projects funded over 2008-2016 involved more than 1500 partners (with a public funding commitment or around EUR 300 million) **Outcomes:** • Improvement of collaboration between firms and end-users. • Improvement of collaboration between firms and research organisations. • Accelerated commercialisation of profit-making ICT-based solutions (and components thereof). **Impacts (expected):** • The AAL Programme is deemed at least 'somewhat effective' in achieving its socio-economic objectives.
Cancer Moonshot	**Outputs:** • The US is the most prolific producer of cancer research publications. US researchers have dominated research production for the past decade, producing more publications per annum than Japan, the UK, France, Germany, and Italy combined. • The Partnership for Accelerating Cancer Therapies (PACT) announced in October 2017 a collaboration between the NIH and eleven pharmaceutical companies to work together to accelerate the development of new cancer immunotherapy strategies. The agreement includes USD 215 million investments over the next five years. **Outcomes:** • Advances in technology, including imaging techniques, new drugs and treatments, therapeutic interventions and insights and discoveries into the fundamental nature and causes of cancer, have led to cures and to improved quality of life for people diagnosed with cancer. • There is a great flexibility for the biomedical scientists to move across public institutions and private sector, which has fostered an R&D environment that produces a high rate of commercialisation. **Impacts:** • Too early to assess the impacts as the initiative has commenced in 2016.
Circular Flanders (Belgium)	**Outputs and outcomes:** • The outputs and outcomes of the initiative are difficult to quantify as no overall targets have been set so far, and no comprehensive indicators to monitor the initiative exist. **Impacts (expected):** • It has been estimated that investing in a circular economy could cut materials expenses by 2% to 3.5% of GDP, and could create 27 000 new jobs, ranging from high-tech positions to low-training positions.
Clean Air London (UK)	**Outputs:** - **Outcomes:** *Realised* (2008 to 2013): • NOx levels have decreased by 25% • PM10 levels have decreased by 20% • PM2.5 levels have decreased by 27% In all cases, the decrease is less than the target. *Expected*: To meet the EU's air quality targets by 2025. **Impacts (expected):** • London will have the best air quality of any major world city by 2050, going beyond the legal requirements to protect human health and minimise inequalities.
High-Tech Strategy (HTS, Germany)	**Outputs:** • Implementation of a common structural understanding of RTDI policies on federal government level. • The HTS led to a targeted increase of public R&I spending in certain areas. • Scientific and commercialisation output increased. **Outcomes:** • The HTS helped to improve framework conditions and performance of the German research and innovation as a whole • Credible mid-term planning security helped to increase Germany's total intramural R&D expenditure to 3% in 2015, which was a declared goal. • The number of R&D personnel increased by one third between 2006 and 2015 with a pronounced increase especially in the business enterprise sector. • Germany reached the group of innovation leader countries in the European Innovation Scoreboard and remains there stable. • Germany ranks on third position behind China and the USA regarding its trade share in knowledge intensive goods.

	Impacts: • So far, no overarching impact evaluation of the HTS strategy in its thematic priorities have been undertaken.
Hydrogen Society (Japan)	**Outputs:** • Publications and patents in the field of fuel cells and hydrogen. **Outcomes:** • The uptake of fuel cells (residential fuel cells, fuel cell vehicles and other hydrogen-powered devices) has progressed, and the hydrogen refuelling station network is expanding. • Cost decrease of fuel cell and hydrogen energy technology has progressed steadily. For each doubling of residential fuel cell production volume, the price has dropped by 15%. **Impacts:** • As for economic, environmental and social impacts, it is too early to assess the overall effectiveness of the hydrogen society initiative. The potential is obviously enormous, but risks of difficulties with reaching sufficient scale are also considerable.
KIRAS – Sicherheitsforschung (security research. Austria)	**Outputs:** • The initiative contributed to the development of a series of security strategies but also to the invention and implementation of more tangible outputs like the ultra-light photovoltaic energy station for disaster response teams, drone surveillance systems for flood and firefighting hazards or mobile devices including an integrated database for rescue teams like ambulance and firefighters. **Outcomes:** • Positive effects on public security was perceived by end-users (78% of the users saw positive effects according to a survey in 2014). • Additionally, 92% of the funded companies and 84% of the research institutions have, at least partially, developed new fields of research. **Impacts:** • As of 2017, EUR 71 million of funding (211 projects) led to EUR 141 million of value added. Over 2 600 jobs were created or utilised, 50% of which can be classified as high-skilled employment. Additionally, EUR 68 million were created in terms of tax and contributions to social security. • Impacts from the increased level of security and preparation as well as the increased efficiency of communication and surveillance stemming from the realisation of the programmes objectives are yet to be evaluated.

3.4. Conclusions and lessons learned

Long-term direction setting and the commitment of public governments are important success factors of the initiatives analysed. Targets of the initiatives are often formulated with long time horizons and beyond a legislative period. Initiatives such as Clean Air London, Japanese Hydrogen Society or Circular Flanders are examples of ambitious, long-term, strategic target setting aimed at achieving a change in the society. Cancer Moonshot, AAL, KIRAS and HTS on the other hand, are initiatives targeted to accelerate the technological development towards a set direction.

Many of the initiatives show **strong public leadership** and centralised "ownership" of the mission. The Clean Air London initiative is owned by the city Mayor, the cancer initiatives in the US are strongly associated with ex-Presidents of the US, and the Hydrogen Society in Japan is strongly endorsed by the Prime Minister of the country. These cases are examples where prestigious individuals have given their face to initiatives. This is considered to provide high-level visibility to initiatives and results in irreplaceable credibility gains in the eyes of citizens and an even wider international audience.

Public policy leadership and significant **injections of public funding** are among the common success factors of the analysed initiatives. The governmental role can however vary significantly between the initiatives, and evolve over the course an initiative, e.g. from initial capability building and infrastructure support towards supporting market creation and demand building, or vice versa. This evolution of the role of public policies can be seen in the US cancer initiative, which has evolved from an initial large-scale publicly-funded capability building endeavour (War on Cancer) towards a results-oriented initiative, where private investments and funds play a key role (Cancer Moonshot). Similarly, the Japanese Hydrogen Society initiative has evolved to involve measures targeted to upscaling and

demand incentives. The Clean Air London initiative has recently added a SME incubator initiative involving R&I elements.

Horizontal and vertical coordination of policies are important characteristics of the initiatives analysed. Regulation and demand-side policies are often necessary complements to R&I policy, and the policy mix needs to be coordinated in a cross-cutting and timely manner. Good examples of coordination across policy silos can be seen for example in the case study of the Japanese Hydrogen Society, where supply- and demand-side policies are jointly defined, and cross-sectoral coordination mechanisms between the key government departments are in place. The Circular Flanders and German HTS initiatives have also successfully broken down silos between different policy fields. Similarly, the multi-level governance between different jurisdictions is an asset that can set free unused synergies. Examples such as the AAL initiative (EU-national level), Hydrogen Society Japan (national-local/regional levels) and Clean Air London (city council-local councils) can provide valuable insights how multi-level governance can be best implemented.

An important precondition for a successful initiative is a **broad basis of existing capabilities and knowledge**. For instance, in the case of Japanese Hydrogen Society initiative, the wide collaboration between government, industry, and academia within an established structure of science, technology, and innovation coordination mechanisms, is considered as an asset for achieving the targets of the initiative. When moving towards large-scale deployment of fuel cell technology, Japan has been able to tap into the results of earlier decades of fundamental research. Likewise, the US Cancer Moonshot is building on a knowledge base generated during decades of fundamental basic research (under the previous initiative, War on Cancer) and the initiative relies on a sophisticated scientific and technological research system, with a high level of coordination between the actors. The established, existing structures are considered to allow the leverage of most of the synergies and complementarities, and to accelerate the delivery of the results and benefits.

An adequate **infrastructure and culture for knowledge, information and data sharing** are also among the common success factors of the initiatives. Collaboration across scientific disciplines or technologies creates opportunities to leverage untapped synergies. KIRAS for example acknowledged this by the mandatory inclusion of partners from the social sciences and the humanities. In effect, this leads to projects and technologies with a higher potential to be applied as, for example, legal restrictions were already included in the process of developing the technology and hence did not restrict the usage of the technology afterwards. Likewise, Cancer Moonshot involves many different technologies (e.g. ICT, biotechnology) together aimed at accelerating cancer research. Another example of a cross-technology initiative is the AAL, which aims to support the development and deployment of ICT-based solutions in the health sector. The German HTS is targeted to reinforce research and innovation in multiple key industrial sectors of Germany.

Regulation, policy and legal frameworks are recognised as decisive factors for the success of the initiatives at least in the cases of the Circular Flanders initiative, Cancer Moonshot and German HTS. The regulatory framework is a very powerful tool that can have an important role in mission-oriented initiatives, both by fostering demand and by erasing the barriers for scientific and technological results to gain access to the market.

Demand articulation and engagement of users and citizens are aspects frequently associated with mission-oriented policy approaches. However, it seems that citizen engagement is a challenge for many of the initiatives (e.g. Cancer Moonshot, Austrian KIRAS, AAL). Some initiatives also mention challenges to raise private investments (e.g. Clean Air London), especially for missions aimed at solving societal problems. The private investments are often seeking shorter-term profits, whereas missions have a longer time horizon. Initiatives such as Cancer Moonshot, Hydrogen Society Japan, Austrian KIRAS and Circular Flanders provide examples (different types and scales) of engagement of end users and companies with the missions.

A successful mission-oriented R&I policy is complemented by a **rigorous monitoring system**. Periodical assessment of the progress allows to count on a powerful criterion to

continue and reinforce the initiative, and if needed to take the necessary actions to re-steer the initiative. The initiative monitoring should be based on target setting but simultaneously allow periodical assessment of the progress made against lower level milestones and goals, ensuring that the mission is on the right track and meeting the targets set. A transparent monitoring system is also considered as an effective element for stakeholder and citizen engagement.

Although all the initiatives analysed in the case studies are ongoing missions, for which the final **results and implications are still to be realised**, it can be said that mission-orientation can serve as a tool for setting strategic orientation and priority of policies over a long period of time. Examples such as Japanese Hydrogen Society, or Clean Air London have already demonstrated significant progress towards the targets set. Similarly, Cancer Moonshot, KIRAS, AAL and HTS have showed how concentration of R&I funds to areas of societal and/or industrial importance can result to more coordinated and focused advances in scientific and technological development. Independently of the overall mission of the initiative, the target setting needs to be at adequate level (not too narrow, not too broad), and at best, a rightly set mission-oriented target can be a powerful tool to unleash a co-creative process greater than the sum of its parts. This requires however, a clear and shared vision, and top-down leadership to orchestrate and monitor the progress of activities.

4. CONCLUSIONS

The present Study has collected evidence on mission-oriented research and innovation (R&I) policies and initiatives in order to understand and characterise them better. For that purpose, a global mapping exercise identified around 200 such initiatives currently ongoing in the European Union, its 28 Member States and its main trade partners. Among them,44 were further analysed in respect to their background, design process, feasibility exercises, governance, resources, policy mix, and relationship with other initiatives. This exercise additionally helped refine the definition of mission-oriented research and innovation. An in-depth analysis of seven mission-oriented R&I initiatives offers additional insights on how they may vary along different dimensions. One of the main findings of the Study is that mission-oriented R&I initiatives are multi-faceted. However, more generalisable favourable characteristics, pre-conditions and governance structures are identified to facilitate their design, implementation and the achievement of their objectives.

4.1. Diversity of mission-oriented R&I initiatives

In contrast to the (grand) challenges which are broadly defined as areas for priority policy intervention, mission-oriented R&I initiatives aim at tackling specific and well-identified problems (which are the most often part of broader challenges). For instance, while climate change is a challenge, a mission can be the reduction of CO_2 emission from transport in a specific location, by a certain percentage, and by a certain date. Our empirical evidence reveals that mission-oriented R&I initiatives typically are ambitious, exploratory and ground-breaking in nature, often cross-disciplinary, targeting a concrete problem, with a large impact and a well-defined timeframe. More specifically, they have the following characteristics:

- A ***clearly defined (social, societal or technological) target,*** preferably qualified and/or quantified so that the progress, achievements and outcomes are ***measurable,*** and it is easy to determine whether the mission is achieved or not;
- The achievement of the mission is defined for a ***specific timeframe*** and progress should be monitored along ***predefined milestones***;
- The initiatives are of ***relatively large scale***, as they mobilise a significant public and/or private investments and other resources and their expected social and/or economic impacts should be large. The size of mission-oriented R&I is nevertheless, first and foremost, dependent on the thematic area and the mission specified;
- Mission-oriented R&I initiatives are ***often needed to drive a 'systemic' or 'transformative change'*** and are – due to their ambition – quite often of an explorative and ground-breaking nature;
- Mission-oriented R&I initiatives are often ***cross-disciplinary and cross-sector***, as they should involve many different technologies and involve many different actors; and,
- The achievement of mission requires the use of a ***mix of policy instruments*** going beyond the mere R&I policy instruments.

Furthermore, the global mapping exercise of mission-oriented R&I initiatives and the in-depth analysis of a number of them highlight two additional features shared by most, if not all, these initiatives:

- They are implemented by empowered governance (structure) that can be easily identified and that can be held **accountable** for achieving the results;
- They emerge from a **sense of urgency** that is shared amongst a broad category of **stakeholders**, in relation to something that is considered problematic.

Most of these characteristics are combined with 'systemic' policies (e.g. multi-actor/stakeholder involvement, multi-sector perspectives). ***The main differentiating feature is nevertheless the directionality and intentionality of mission-oriented R&I policy.*** This is what sets related initiatives aside from other policies including also challenge-oriented policies.

Mission-oriented R&I initiatives are not a monolithic group but consist of diverse initiatives varying along the aforementioned characteristics. The 44 initiatives that were further investigated as part of the mapping exercise, for instance, have a budget between EUR 2 million and EUR 4.7 billion. Similarly, while some initiatives follow a roadmap with clearly defined milestones, other seemingly focus exclusively on the achievement of their ultimate goals and not of intermediate targets.

The Study makes a distinction between two types of mission-oriented R&I initiatives: on the one side, those narrowly defined and aimed at single, well-defined and, the most often, scientific and/or technological objectives (the so-called 'accelerators'); and, on the other side, initiatives more broadly defined addressing wicked and often societal problems and implying the transformation of systems (the so-called 'transformers'). However, both types of mission-oriented R&I initiatives should be considered as ideal-types. ***Mission-oriented R&I could be placed along a spectrum ranging from accelerators to transformers, most of them, if not all, consisting of a mix of accelerator and transformer components***. For instance, the Active and Assisted Living (AAL) programme is overall a transformer initiative as it aims at the transformation of the eldercare systems. However, for achieving this objective, it needs to support projects of a smaller scope with a view to develop ICT solutions, an objective which is rather in line with those of accelerators.

Because the targeted problems are complex, especially when they relate to societal and 'wicked' problems, their solutions might require the implementation of multiple projects and rely on several policy interventions, some of which may not conform to the definition of mission-oriented R&I initiative. In other words, ***some umbrella programmes***, like the German High-Tech Strategy, can be considered mission-oriented as it targets well-specified problems, but consists of mission-oriented components and non-mission-oriented components.

Furthermore, the global mapping exercise shows that mission-oriented initiatives vary in terms of scope, geographical scale, timespan, level of policy decision for their design, governance structure and policy mix. Most of these features depend on the nature of the problems that the initiatives aim to solve.

Hence, policymakers intending to move R&I policy towards mission orientation will need to cope with the facts that there is ***a plurality of mission-oriented R&I initiatives rather than a singular definition*** *and that* ***there are scales of mission-oriented R&I initiatives***.

4.2. Pre-conditions for mission-oriented R&I

Mission-oriented R&I policies and initiatives – like any other policy – do not emerge in a vacuum. They are ***influenced by existing institutions (comprising of the legal framework and cultural background) and policies already in place***. The comparative analysis of the mapped mission-oriented R&I initiatives reveal, for instance, that the extent to which their design is open to non-government actors depends on cultural and political factors. While China usually follows closed top-down process, the more transparent and open approach in Europe seeks consensus among the engaged stakeholders. An advanced culture and adequate infrastructure for knowledge, information and data sharing is another success factor for mission-oriented R&I initiatives as it eases cross-sector and -disciplinary collaboration and creates synergies.

An important precondition for the success of mission-oriented R&I initiatives is a ***broad basis of existing capabilities and knowledge and long historical trajectories and***

prior creation of R&I capacities, on which they can build on to achieve their objectives. For instance, the US Cancer Moonshot is explicitly relying on the knowledge base generated during decades of fundamental basic research under the past War on Cancer.

The importance of existing capabilities and knowledge for the achievement of targeted missions leads to two observations. First, because of differences in national R&I systems and capabilities, it is highly likely that ***a move towards mission orientation decided and designed at the European level will have different impacts across the EU Members States***. Secondly, if the European Commission decides to give its R&I policy a mission orientation, it should consider ***not focusing exclusively on applied research and innovation and overlooking basic research***. The future FP9 could instead put more emphasis on basic and early stage research with a strong bottom-up orientation, as this would probably have the strongest leverage effect in terms of contributing to Europe's knowledge base. If the current three-pillar structure is maintained, it is advisable that mission-oriented R&I initiatives should not be confined to the third pillar (societal challenges) but should also be articulated in the other pillars (scientific excellence and the European Innovation Council). While not supplanting the prime rationales of the latter pillars, contributions for example from the European Research Council (ERC) and the key enabling technologies (KETs) to mission-oriented R&I initiatives should be sought wherever needed for achieving the mission targets.

The overall context of mission-oriented R&I initiatives contributes to their ***legitimacy***. Most of them have their origins in concrete societal or economic problems, such as pollution, unsecure energy or water supplies, floods, security hazards or epidemics. ***Stakeholders and citizens usually share a clear sense or necessity or urgency*** to address and solve them. This does not apply exclusively to societal missions, but also to more technological and economic missions. Many of the investigated mission-oriented R&I initiatives show ambitions for defining the national research and technology agenda, and, in some cases, also placing industry as a frontrunner at international level. Such ambitions require the buy-in by stakeholders, including citizens who could otherwise be reluctant to contribute to their achievement.

These preconditions influence the legitimacy and impacts of mission-oriented R&I initiatives foremost at the national level. For instance, R&I initiatives for improving the security of buildings against seismic hazards would be more perceived as urgent and consequently legitimate in countries like Italy or Greece than in the European Nordic countries which are much less exposed to this risk. Similarly, a mission for a plastic-free ocean may be have less political and societal support in the European countries without seaside. As long as the European Member States do not share the same sense of urgency or do not equally commit themselves to solving specific missions, EU mission-oriented R&I initiatives, like the Active and Assisted Living (AAL) programme, may face a problem of collective ownership hampering its implementation and achievement. If the European Union decides to move its R&I policy towards mission orientation in the future Framework Programme, it should consider ***avoiding seeking, for each related initiative, unanimous agreement***, but to develop them in 'variable geometry' and '***coalitions of the willing'***. In other words, mission-oriented R&I initiatives supported via FP9 will gather the Member States that express interest in participation only.

4.3. Implementation of mission-oriented R&I initiatives

Most mission-oriented R&I initiatives identified and analysed in the context of this Study have been ***initiated by public organisations*** (national and local government, public agencies) and ***designed in a top-down manner*** (without excluding nevertheless early industry involvement). Four publicly-dominated governance models have been identified: cross-governmental coordination; coordination by a single public organisation (e.g. a ministry or an agency); coordination by a purposefully created body; and coordination via a public-private partnership. These new (public) management models and cross-silo coordination at the level of government, in addition to experimenting new ways of policy-making involving many stakeholders in different phases of the policy-making process, can

be considered as important characteristics of mission-oriented initiatives. Missions require the set-up of specific governance structures with full-time professionals and to keep close contact with all stakeholders. A balanced system of separation of powers between steering, strategic and financial decision-making and the day-to-day management must be established from the outset.

For future mission-oriented R&I initiatives at the EU level, ***new forms of governance should therefore be considered***. These could include: dedicated institutions responsible for mission-oriented R&I (e.g. a 'European energy agency' or a European 'smart grid consortium'.). Such organisations might emerge from competition among (consortia of) existing national agencies to run mission-oriented R&I initiatives on the EU scale (following the role model of the German 'Projektträger'), to public private partnerships.

The role of public organisations in the implementation of mission-oriented R&I initiatives is not restricted to the overall coordination of all concerned stakeholders. They are additionally responsible for ***setting long-term direction towards and commitment to clearly identified missions***. Targets of the initiatives are often formulated with a long-time horizon and beyond a legislative period. Mission-orientated R&I policy can thereby serve as a tool for setting strategic orientation of policies and societal values and priorities over a long period of time, and encourage all relevant stakeholders to engage and take actions (in a coordinated manner) in this direction. ***The direction setting is not however a question of 'picking winners' but rather a process of prioritising the societal or technological targets and creating favourable conditions for the best solutions to merge, co-evolve and compete***. Governments and other public organisations in charge of mission-oriented R&I initiatives and policies must 'own' the mission-oriented R&I initiatives and ensure that a clearly defined vision is shared among relevant stakeholders, and orchestrate related activities often in a top-down leadership role. This implies sometimes coping with contradictory objectives. The governmental role can however vary significantly between the initiatives, and evolve over the course an initiative e.g. from initial capability building and infrastructure support towards supporting market creation and demand building.

Despite the dominant role of public organisations in the design and implementation of mission-oriented R&I initiatives, the role of other stakeholders, including the business sector and citizens is essential for the success of a mission.

For instance, many of the initiatives identified and analysed in the context of the present Study show ***novel ways of financing the initiatives putting emphasis on contributions from the private sector***. In addition to public financing via large-scale public budgets, public funds or state-owned investments banks, private investments have been indeed encouraged by the setting-up of public-private governing organisations or by the implementation of dedicated policy incentives such investment subsidies and fiscal measures. Private investments are crucially important to ensure the continuity of the initiatives, and to mitigate the dependency of the initiatives relying too much on governmental support and the possible disruptions subsequent to changes in cabinets and administration.

While involvement of industry is deemed of key importance and is encouraged and eased via a series of measures, ***citizen engagement is a challenge for many of the mission-oriented R&I initiatives observed***. Furthermore, end-users and/or consumers are often targeted rather than the broader group of citizens. Mission-oriented R&I initiatives should find an appropriate balance between direction-setting top-down approach and bottom-up implementation which ensure, at the same time, public acceptance and then legitimacy of policy interventions. Therefore, in most observed mission-oriented R&I initiatives, citizens engagement have been limited to actions aimed at ***increasing public acceptance and buy-in***. In very few instances, citizens have been involved in decision making and engaged in process of co-design or co-creation of solutions to missions.

Mission-oriented R&I initiatives involve the need for ***coherent policy actions across a number of policy areas and levels***, i.e. a 'policy mix'. For most of them, the targets

should be set in the relevant (non-R&I) policy domains (e.g. transport or energy.) and R&I policy need to be accordingly articulated. However, few observed mission-oriented R&I initiatives have R&I as a starting point and main focus. In such circumstances (e.g. Human Brain Project), the objectives may be to improve R&I capabilities for better addressing specific problems.

In contrast to purely R&I oriented policy measures, mission-oriented R&I initiatives targeting societal problems implying the transformation of systems should ***mobilise holistic policy mixes including demand-side policy instruments (e.g. public procurement, investments subsidies, fiscal measures) and putting emphasis on a better match between demand and supply***. However, the implementation and management of those policy mixes are not an easy task. None of the transformer-type mission-oriented R&I initiatives that were observed as part of the present Study have been successful in their aims of mastering the supply and demand sides in a balanced and timely manner. In several instances, demand-side policy instruments contributed to the achievement of targeted missions, but benefitted primarily foreign companies instead of domestic ones. Furthermore, policy mix should be designed such that they encourage the development and accelerate the uptake of appropriate solutions without, however, focusing support on specific technologies.

Policymakers and other relevant stakeholders should persistently support and commit to mission-oriented R&I initiatives while ***being reflexive and flexible enough to reassess and re-steer them*** based on their progress and dynamics of technological and market developments that they induced. In order to be able to do so, a successful mission-oriented R&I policy needs to be complemented with a rigorous monitoring and an elaborated evaluation system. Periodical assessment of the progress allows is a powerful criterion to continue and reinforce the initiative, and if needed to take the necessary actions to re-steer the initiative. The initiative monitoring should be based on the target setting but simultaneously allow periodical assessment of the progress made against lower level milestones and goals, ensuring that the mission is on the right track and meeting the targets set. Transparent monitoring system is considered also an effective element for stakeholder and citizen engagement.

Furthermore, mission-oriented R&I initiatives should be ***evaluated against criteria adapted to their objectives and the problems that they target***. In other words, the evaluation of mission-oriented R&I objectives should not consider merely their performance in regard to R&I indicators, such as the number of patents. Whereas it may be often easy to determine whether purely scientific and/or technological mission-oriented initiatives (accelerators) have achieved their objectives, the transformation of systems is much more difficult to assess.

In conclusion, in the analysed mission-oriented R&I initiatives, a ***confluence of a clear societal need or urgency, long-term but reflexive direction setting and commitment of public policy-making, adequate public funding combined with private investments, scientific and technological capabilities, and 'buy-in' of stakeholders, with all sharing a common vision***, appear to be appropriate ingredients and factors of success. The main characteristics of mission-oriented R&I initiatives, in addition to their directionality and intentionality, defines their multi-faceted nature which implies adaptability in the way they are designed and implemented. Their governance, policy-mix, evaluation and monitoring mechanisms, the involved stakeholders must be determined foremost by the objectives that they aim to achieve and the problems that they need to solve.

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In view of the preparation of the future research and innovation Framework Programme of the European Union (FP9), the study collects and analyses evidence of current and past mission-oriented research and innovation initiatives in European Member States and other major economies. A desk research improves the understanding of mission-oriented R&I initiatives. An inventory and the analysis of ongoing initiatives addressing major global issues, such as climate change, ageing or food security, explore their implementation and management, including their governance structure, the policy mix as well as the monitoring systems and evaluation mechanisms. The Study highlights that there is a plurality of mission R&I initiatives. Directionality and intentionality nevertheless differentiate them from other initiatives. The success of these initiatives highly depends on pre-conditions, such as institutions and policies already in place as well as existing capacities and knowledge.

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