1. INTRODUCTION

1.1 THE RECODE PROJECT AND THE RECODE RECOMMENDATIONS

RECODE (http://recodeproject.eu) has leveraged existing networks, communities and projects to address challenges within the open access and data dissemination and preservation sector. The sector includes several different networks, initiatives, projects and communities that are fragmented by discipline, geography, and, stakeholder category, often working in isolation or with limited contact with one another. RECODE has provided a forum for European stakeholders to work together towards common solutions to shared challenges.

To this end, RECODE has used five disciplinary case studies in open access to research data (physics, health, bioengineering, environment and archaeology) to examine four grand challenges:

- stakeholders values and ecosystems,
- legal and ethical concerns,
- infrastructure and technology challenges, and
- institutional challenges.

On the basis of this work, RECODE identified two overarching issues in the mobilisation of open access to research data: a lack of a coherent open data ecosystem; and a lack of attention to the specificity of research practice, processes and data collections. These findings along with the horizontal analyses of the RECODE case studies in relation to the four grand challenges, have informed the following policy recommendations on open access to research data.

The policy recommendations that form the core of this deliverable are targeted at key stakeholders in the scholarly communication ecosystem, namely research funders, research institutions, data managers, and publishers. They will assist each of the stakeholders in furthering the goals of open access to research data by providing both over-arching and stakeholder-specific recommendations. These function as suggestions to address and attend to central issues that RECODE identified through the research work.

The current report thus comprises:

- a summary of the RECODE project approach and overarching recommendations
- targeted policy recommendations for funders, research institutions, data managers, and publishers
- practical guides for developing policies for funders, research institutions, data managers, and publishers
- resources to expedite the process of policy development and implementation among stakeholders

A short version of this report is available at the RECODE project website (http://recodeproject.eu), along with other reports produced in the framework of the project.

The stakeholder specific recommendations (in an earlier version), were discussed extensively at a workshop that took place in Amsterdam, on September 25th, 2014, in the frame of an RDA plenary meeting. Participants representing all four stakeholder groups to whom the

recommendations are directed to, took part in the workshop. The workshop largely validated the results of the project and the direction taken with the recommendations, and participants offered valuable input. For their participation and suggestions for the recommendations we thank all of the workshop participants.

1.2 OPEN ACCESS TO RESEARCH DATA

The discourse on open access to research data is aligned with the notion of rigorous science and the societal and economic benefits obtained. According to the European Commission "open access to scientific research data enhances data quality, reduces the need for duplication of research, speeds up scientific progress and helps to combat scientific fraud".[1] The Royal Society Report sees open inquiry as being at the heart of the scientific enterprise permitting "to identify errors, to support, reject or refine theories and to reuse data for further understanding and knowledge".[2] In such context open data is part of open science with the latter being defined as 'open data (available, intelligible, assessable and usable data) combined with open access to scientific publications and effective communication of their contents'.[3]

The development of open access has also been triggered by technological developments that give rise to new ways of making use of data and new opportunities for communication and collaboration among scientists.[4] The increasing use of computational technologies that allow massive datasets to be analyzed and shared has led to the transition in what has been termed the "fourth paradigm of science" based on data-intensive computing[5] or "data-led science".[6] More specifically, data-led science opens up new sources of knowledge through the development of digital means for producing, storing and manipulating data. This means that informatics are not only used as tools for supporting traditional ways of scientific research in a particular discipline, but more importantly have the potential to change fundamentally the development of a discipline.[7]

The interest in open data and the benefits derived from open access are nonetheless not new; on the contrary open access has been promoted over the past decades through a number of initiatives. Key milestones include the OECD Declaration (2004) on access to research data from public funding[8] on the basis of a number of objectives and principles,[9] followed by the

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[1]European Commission, Recommendation on access to and preservation of scientific information, C(2012) 4890 final, Brussels, 17 July 2012. http://ec.europa.eu/research/science-society/document_library/pdf_06/recommendation-access-and-preservation-scientific-information_en.pdf

[2]The Royal Society, *Science as an open Enterprise*, London, 2012. p.7. https://royalsociety.org/~/media/royal_society_content/policy/projects/sape/2012-06-20-saoe.pdf

[3]Ibid. p. 16

[4] For an overview of the key issues in the development of open access to research data, see Wessels, Bridgette, Rachel L. Finn, Peter Linde, Paolo Mazzetti, Stefano Nativi, Susan Reilly, Rod Smallwood, Mark J. Taylor, Victoria Tsoukala, Kush Wadhwa and Sally Wyatt, "Issues in the development of open access to research data", *Prometheus*, Vol. 32, No 1, 2014, pp. 49-66. http://www.tandfonline.com/doi/pdf/10.1080/08109028.2014.956505

[5]Hey, Tony, Stewart Tansley and Kristin Tolle, *The Fourth Paradigm*, Microsoft Research, Redmond, Washington, 2009. http://research.microsoft.com/en-us/collaboration/fourthparadigm/4th_paradigm_book_complete_lr.pdf

[6]The Royal Society, op. cit., 2012, p. 7.

[7]The Royal Society, op. cit., 2012, p. 31.

[8]Organization for Economic Cooperation and Development, OECD Declaration on Access to Research Data from public funding, 30 January 2004, C(2004)31/REV1. http://acts.oecd.org/Instruments/ShowInstrumentView.aspx?InstrumentID=157 .

[9]These are the following: openness, transparency, legal conformity, formal responsibility, professionalism, protection of intellectual property, interoperability, quality and security, efficiency and accountability.

publication of OECD's principles and guidelines a few years later.[10] At EU level the most important initiatives are the Commission Recommendation 'on access to and preservation of scientific information' and the provisions in Horizon 2020. The Recommendation encourages member states to define clear policies accompanied by concrete objectives and indicators to measure progress, financial planning and implementation plans, including the allocation of responsibilities. Horizon 2020 includes a pilot action on open access to research data. The pilot, that covers for the 2014/15 period seven thematic areas[11] and corresponds to about € 3 billion or 20% of the overall Horizon 2020 budget for 2014 and 2015 aims 'to improve and maximize access to and re-use of research data generated by projects'.[12] Open access to research data has also been promoted through an increasing number of reports and roadmaps some of which have been produced in the framework of projects. Examples include the reports produced from projects like Opportunities for Data Exchange (ODE), MedOANet, APARSEN, or the League of European Research Universities (LERU) Roadmap for Research Data.

Nonetheless, progress on open access is rather slow highlighting that the transition to open access is neither easy to achieve nor cost free: it requires investments in infrastructure and technology, and more importantly a change in research culture which takes time to take effect. In relation to the latter, this means that significant variation is expected between disciplines as the development of open access is already common practice in some of them, while important obstacles are still observed in others.[13]

The difficulty in promoting open access is observed even in relation to defining basic notions, i.e. open access and research data. According to the Berlin Declaration open access contributions include original scientific research results, raw data and metadata, source materials, digital representations of pictorial and graphical materials and scholarly multimedia materials.[14] In its Guidelines on Open Access to Scientific Publication and Research Data in Horizon 2020 the European Commission defines open access as "the practice of providing on-line access to scientific information that is free of charge to the end users and that is re-usable"[15]. In the context of research and innovation, "scientific information" can refer to i) peer-reviewed scientific research articles (published in scholarly journals) or ii) research data (data underlying publications, curated data and/or raw data)".[16] The Royal Society Report defines open data as those that meet the criteria of intelligent openness; i.e., data that are

[10]OECD Principles and Guidelines for Access to Research Data from Public Funding, OECD, Paris, 2007.http://www.oecd.org/sti/sci-tech/38500813.pdf .

[11]These seven thematic areas are the following: 1. Future and Emerging Technologies, 2. Research Infrastructures- part e-infrastructures, 3. Leadership in enabling and industrial technologies-Information and Communication Technologies, 4. Societal Challenges: Secure, Clean and Efficient Energy- part Smart cities and communities, 5. Climate Action, Environment, Resource Efficiency and Raw Materials, 6. Societal Challenge: Europe in a changing world-inclusive, innovative and reflective societies, 7. Science for and with Society.

[12]European Commission, Guidelines on Open Access to Scientific Publications and Research Data in Horizon 2020. Version 1.0, 11 December 2013. p. 8 http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-pilot-guide_en.pdf .

[13] Archambault, E., Amyot, D., Deschamps, P., Aurore, N., Rebout, L. & Roberge, G.: Science Metrix Report: Proportion of Open Access Peer-Reviewed Papers at the European and World Levels—2004-2011, August 2013. http://www.science-metrix.com/pdf/SM_EC_OA_Availability_2004-2011.pdf

[14]Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities.http://openaccess.mpg.de/67605/berlin_declaration_engl.pdf.

[15] European Commission, Guidelines on Open Access to Scientific Publications and Research Data in Horizon 2020, version 1.0, 11 December 2013 http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-pilot-guide_en.pdf

[16]Ibid.

accessible, useable, assessable and intelligible.[17] The OECD defines openness as "access on equal terms for the international community at the lowest possible cost, preferably at no more than the marginal cost of dissemination".[18]

Defining research data is equally difficult, since "any material used as foundation for research can be classified as research data".[19] The OECD uses a wide definition that includes any kind of resource useful to researchers,[20] while the European Commission defines as research data, that which "may be numerical/quantitative, descriptive/qualitative or visual, raw or analyzed, experimental or observational".[21] Definitions also vary with some contributions defining research data as potentially all data –including public sector information- and some limiting it to the product of research.[22] A further distinction is that between open research data and open data, with the latter mainly used in the context of open government initiatives.[23]

The above analysis indicates that notwithstanding the variability and differences in defining open access and research data, an increasing push is observed in developing and promoting further open access at both national and supranational level.

1.3 THE RECODE APPROACH

Despite the general consensus amongst policy makers on the benefits of open access for science, industry and civil society, there are still important barriers that need to be overcome. The RECODE project identified in particular two overarching issues in the mobilization of open access to research data: a lack of coherent open data ecosystem and a lack of attention to the specificity of research practices, processes and forms of data collections. Against this background, the report provides policy recommendations on open access to research data targeted at key stakeholders in promoting open access: research funders; data managers; research institutions; and publishers. In other words, the recommendations are targeted to those stakeholders within the open access ecosystem who have been identified in the framework of the project as instrumental in bringing about change.[24]These recommendations will assist the above stakeholders in furthering the goals of open access to research data in each of their organizations and networks. Recommendations include both overarching and stakeholder-specific ones as suggestions to address and attend to these two issues by building on or learning from existing experience. In doing so, RECODE recognises that in some situations it is

[17]The Royal Society, op. cit., 2012.
[18]OECD, op. cit., 2007, p. 15.
[19]Sveinsdottir, Thordis, Bridgette Wessels, Rod Smallwood, Peter Linde, Vasso Kalaitzi and Victoria Tsoukala, *Stakeholder Values and Ecosystems*, D1.1 RECODE Project, 30 September 2013. http://RECODEproject.eu/wp-content/uploads/2013/10/RECODE_D1-Stakeholder-values-and-ecosystems_Sept2013.pdf.
[20]Organisation for Economic Cooperation and Development, op. cit., 2007.
[21] European Commission, A Reinforced European Research Area Partnership for Excellence and Growth, COM(2012) 392 final, Brussels, 17.07.2012, file://filesrv/userdocs2/mangelaki/My%20Documents/Downloads/AReinforcedEuropeanResearchAreaPartnershipforExcellenceandGrowth.pdf .
[22]Bigali, Lorenzo, Thordis Sveinsdottir, Bridgette Wessels and Rod Smallwood, Peter Linde, Jeroen Sondervan, *Infrastructure and technology challenges*, D2.1 RECODE Project, 31 March 2014. http://RECODEproject.eu/wp-content/uploads/2014/04/D2.1-Infrastructure-and-technology-challenges.pdf.
[23]Heinz Pampel and Sunje Dallmeier-Tiessen, Open Research Data: From Vision to Practice, Bartling Sonke and Sascha Friesike (eds.) Opening Science, The Evolving Guide on How the Internet is Changing Research, Collaboration and Scholarly Publishing, 2014.
[24]The mobilization of key stakeholders is a central issue in bringing about change. It has been addressed in RECODE WP6, cf. Linde, Peter, Bridgette Wessels, Rod Smallwood, Merel Noorman, Sally Wyatt, Jeroen Sondervan, Feasibility of using existing open access networks to support the harmonization of open access: A report examining the feasibility of using existing open access networks to support the harmonization of open access policies across Europe, D6.1 RECODE Project, forthcoming.

appropriate to build consensus and transfer good practice across disciplines and stakeholder groups, while in others it is appropriate to enable and support specific groups to maintain their particularity in relation to disseminating, preserving and re-using research data. In addition, for each stakeholder group good practice examples are provided that can serve as "models" for providing open access to research data. Finally, the recommendations and good practice examples will reduce "costs" associated with providing open access, as stakeholders do not need to develop their own expertise, but can use this information as a foundation to develop their own policies, support actions and initiatives. In such a context researchers, as the producers of data and consequently the origin point of the data lifecycle, emerge as an essential component of open access processes whose needs, concerns and interests must be considered in order to work towards a strong open data ecosystem.

As such, the development of open access to research data needs to be:

- ✓ Characterised by a partnership approach involving the key stakeholders, researchers, and institutions
- ✓ Supported by an integrated institutional and technological data infrastructure
- ✓ Guided by ethical and regulatory frameworks
- ✓ Informed by research practices and processes in different fields

Developing open access to research data in a way that is informed by awareness of differences in research practices within and between disciplines and characterised by a partnership approach among key stakeholders helps to ensure engagement from the wide range of research communities and to better embed it within research practice and process.

The policy recommendations presented here are informed by these overall findings as well as a series of horizontal analyses of the RECODE case studies in relation to four grand challenges:

- ✓ Stakeholder values and ecosystems
- ✓ Technological and infrastructural challenges
- ✓ Legal and ethical challenges, and
- ✓ Institutional and policy challenges.

In formulating the recommendations, RECODE incorporated the results that the project produced on the above four areas of work and examined from the perspective of the stakeholders to whom the recommendations are addressed. Furthermore, it conducted a review of scholarly literature, policy documents, and reports, significant work of other EC-funded projects (e.g. ODE, APARSEN, PARSE.Insight) and relevant documents to provide an overview of the current policies, practices and challenges for these stakeholders both in the EU and abroad to making open research data open, identify issues of importance and concern and present institutional solutions to these issues.

The present section provides a short presentation of the work carried out by the project, which in turn informs the recommendations, arranged by sequence of work.

Stakeholder Values and Ecosystems[25]

The first grand challenge that RECODE analyzed was the stakeholder values and ecosystems. Identifying the stakeholders in research and data ecosystems is of particular importance as it

[25]This section draws on Sveinsdottir et al., op. cit., 2013, p. 21.

supports the development of a coherent approach to open data while it also ensures that the policy recommendations are informed by practice. Their number is quite large and their nature diverse, including (among others) national governments, the industry, the public, mass media, publishers, scholarly and professional societies. This complex ecosystem has been studied through the development of a functional taxonomy, in essence re-structuring the stakeholder list around a number of broad functions. The functions (or entities) identified are: 1) funding and initiating, 2) creating, 3) disseminating, 4) curating, and 5) using, all of which are interconnected through flows. The open access ecosystem is thus formed of the above community of stakeholders with multiple functions, yet sharing the same overarching values and motivations with regard to open access.

According to the proposed taxonomy, each stakeholder can have multiple functions (primary and secondary), yet it is the primary function that defines a stakeholder's position within the open access ecosystem. A primary function performer is a performer with an essential importance to the function, while secondary stakeholders are performers not essential to the function. Whereas each stakeholder can only have one primary function, the existence of multiple secondary functions (along with the primary one) results in an over-lapping of functions. This over-lapping contributes to the further blurring of responsibilities, and renders the development of open access policies a challenging task as it involves numerous stakeholders with multiple and inter-related responsibilities.

The added-value of the RECODE proposed taxonomy is that it allows us to understand the complexity of the ecosystem and to gain an overview of the values and motivations of open access to data across the different stakeholders (including researchers). In addition, it permits us to understand that the issues addressed throughout the project are not always experienced or interpreted in a uniform way from the different stakeholder groups as a result of their different functions in the ecosystem. Thereby, the ambition to make more research data openly available is not straightforward, requiring considerable effort and involving different phases like ingestion, storing or providing access.

On the basis of the RECODE functional taxonomy we have identified four stakeholder groups as key actors in promoting and bringing about change in open access policy implementation for research data: 1) funders, 2) data managers, 3) research institutions, and 4) publishers. While the project acknowledges the existence of a large number of stakeholders in the open access ecosystem, we focus on the above-mentioned four categories given their central role in the ecosystem and their capacity for bringing about change, and thus the RECODE recommendations are targeted to these stakeholder categories.

In relation to the values and motivations, there is an overarching consensus among the community of stakeholders on the value of making data open.[26] The benefits of open access to research data relate to the increase in productivity and quality of scientific work, the economic and social benefits obtained, while there is a clear sense of open access to research data as a general public good. The benefits are therefore seen in the value-context of science as a great value to society, with society benefiting through an on-going dialogue in which knowledge emerges through science as a cumulative process, and the motivations deriving from the above values. Nonetheless, despite this overarching consensus, stakeholders within each functional

[26] More extensive on the benefits of data sharing, the report just released by the RDA: The Data Harvest. How Sharing Research Data Can Yield Knowledge, Jobs and Growth. A special report by RDA Europe, 2014, https://europe.rd-alliance.org/sites/default/files/report/TheDataHarvestReport_%20Final.pdf

area are also aware of the practical issues entailed in developing open access (namely the key challenges studied in the framework of the RECODE project). Values and motivations are also understood differently by researchers, and from within specific disciplinary and interdisciplinary perspectives as different disciplines vary in their degree of openness, on how they share within their community and their overall attitude towards open access.

From a researcher's perspective five concerns have been identified as potential barriers to developing open access to data: competition for prestige and funding, the amount of work involved in making data meaningful in open access, the limited value that publishing data receives as a valuable scientific activity, the concerns in relation to making sensitive data open, and the need to provide access to the context in which data is analysed and collected. This means that developments in open access have to be sensitive to the specific processes of scientific practice to ensure that the research rigor is maintained while facilitating open access.

Infrastructure and Technology Challenges[27]

The second grand challenge focused on infrastructure and technology. 'Infrastructure' includes technological assets (hardware and software), human resources, procedures for management, training and support to its continuous operation and evolution. The RECODE report on infrastructure and technology concluded that technological challenges are not viewed as a high concern in implementing open access to research data when compared to financial, cultural and legal ones.

The main infrastructure and technology challenges identified by the project were grouped in five broad categories: heterogeneity and interoperability; accessibility and discoverability; preservation and curation; quality and assessability; security. Heterogeneity and interoperability cover issues that arise because of different ways of formatting, storing, operating and standardizing data, thus rendering seamless open access to research data a complex technological undertaking. The importance of interoperability lies in the fact that it allows data exchange between researchers, institutions, organizations, countries etc., while further benefits are derived by producing deeper and better-integrated understanding. Closely related to interoperability issues is the sustainability of research infrastructures; as many data centers rely on short-term funding, there is a danger of datasets getting lost in the event of not being able to secure follow-on funding.

Issues of accessibility and discoverability highlight the need for metadata standards and standard data formatting. Measures addressing the problems related to data discovery and access include digital object identifiers (DOI) and persistent identifiers to data publishers, datasets, the data record itself, data versioning and data citation, data usage index (DUI) and effective data citation mechanisms.

Preservation and curation have already been identified as technical and infrastructural barriers inhibiting the sharing of research data. To address this challenge investment in long-term preservation must be undertaken along with efforts to keep hardware and software up to date. Delegation of responsibility for data storage and accessibility to neutral institutions (national institutional repositories or digital libraries) has also been confirmed by the on-line survey conducted within the framework of the study of technology and infrastructure challenges. Yet, technical solutions for data management and preservation are often fragmented and designed for a narrow purpose, rather than adopting a more centralized approach.

[27]This section draws on Bigagli et al., op. cit., 2014.

Finally, quality, assessability and security issues require (among others) the establishment of processes for ensuring quality standards, development of appropriate education and training material, certification schemas and accreditation processes.

The identification of the above barriers points to the central role repositories, libraries and publishers have in developing appropriate solutions.

Legal and Ethical Challenges[28]

The third grand challenge analyzed legal and ethical issues. The project examined in particular both legal issues such as intellectual property rights, including copyright, trade secrets and database rights, privacy and data protection and open access mandates and ethical ones including the unintended secondary use, misappropriation and commercialization of research data, unequal distribution of scientific results and disproportionate impacts on scientific freedom. In particular the project looked into how these different issues impact on a range of stakeholders such as policy-makers, researchers, repository managers, and institutional representatives.

As shown from the RECODE analysis, intellectual property rights, especially in relation to data that has been purchased from commercial organisations or cultural data, can act as a significant barrier to providing open access to research data, as sometimes the data creators may not hold the intellectual property rights to the material they collect and to which they seek to provide access. Similarly, research participants, rather than researchers, institutions, repositories and other stakeholders, have primary control over the use of personal information for research purposes, which can limit the extent to which this data can be made available in open access. Furthermore, these legal regimes often create a complex landscape, with real consequences for researchers, organisations and institutions. Open access mandates from governments and funders may place researchers and institutions in a situation where they are pressured to provide open access to data, despite the fact that intellectual property rights or data protection rights specifically and explicitly limit their ability to do so.

Open access to research data raises several ethical concerns as well. Many echo or exacerbate existing concerns about sharing research data in general. For example various disciplines have formalized principles on ethical research in their codes of ethics urging their researchers to treat data confidentially and to ensure that the benefits and benefits of research are equally distributed. Failing to meet these ethical standards may not only cause harm to research participants, but can also prove detrimental to the scientific enterprise or society. Open access to research data raises concerns about the ability of researchers to adhere to these standards and the disruptive effects it may have on existing infrastructures and practices. Unintended secondary use can damage identities, reputations and relationships between individuals, and may even endanger research subjects or sites as well as the public trust in science or social institutions. The valid concerns described above are not necessarily reasons to avoid providing open access altogether. In some cases, the benefits of providing unrestricted access to data can offset the potential risks.

[28]This section draws on Rachel Finn and Kush Wadhwa, Mark Taylor and Thordis Sveinsdottir, Merel Noorman and Jeroen Sondervan Legal and ethical issues in open access and data dissemination and preservation, RECODE project, Deliverable D3.1, 2014 http://RECODEproject.eu/wp-content/uploads/2014/05/D3.1-legal-and-ethical-issues-FINAL.pdf .

A further issue examined relates to privacy, as open access and privacy seem difficult to reconcile. Anonymisation of data does not suffice to mitigate the risk for all data sets. As a result of technological advances and the availability of increasingly more digital data sets, anonymisation can be more easily undone, while in some cases it is not even possible because the data content enables identification and resists effective obfuscation. Finally, open access to research data can level the playing field, but there is no guarantee that all stakeholders will benefit equally. It may reinforce or even lead to an unequal distribution of those results. Those who lack the required scientific, technical or cultural capital and resources to make use of data are at a disadvantage, even when the data are formally open to all.

Overall, the analysis concluded that while new solutions should be sought to provide legal and ethical pathways to open access, the current push must accept the existence of some limits and caveats that may be related to intellectual property or data protection and ethical research practice.

Institutional Challenges[29]

The final grand challenge addressed focused on institutional issues. Financial support, evaluating and maintaining the quality, value and trustworthiness of research data, training of researchers and other relevant stakeholders as well as awareness-raising on the opportunities and limitations of open access to research data have all been identified as key challenges faced by institutions such as archives, libraries, universities, data centres, and research funders.

In relation to financing, while the potential cost-savings have been central to the discourse surrounding open access, the latter is not cost-free, thus placing an important burden on institutions as a result of their ability to secure the necessary funds for open access to research data. Funds are needed for the various phases in the data life cycle project including preparation, ingestion, sharing and archiving. Such costs are not only related to projects generating large data sets but can be quite heavy even for smaller individual projects. Technological developments may place an additional burden as the introduction of new practices may necessitate the need to secure further funds. At the same time, it is not always clear as to who shall bear the related costs, while institutions are being under increasing pressure to define the costs related to data management. Measures to address financing issues include the creation of economies of scale through multi-institutional collaborations, cost modeling and exchange of information on costs and the development of funding models that take into account the long-term curation of research data.

Ensuring the quality of data is a further issue of importance as researchers need to have some level of confidence in the accuracy and soundness of open research data. High quality of research data is an integral component for the ability to reuse data. In many disciplines, formal and informal mechanisms are in place to check the quality of research data produced, but open access to research data often requires additional mechanisms, for instance, to ensure that data are re-usable and interpretable. Several stakeholders are involved in these processes, including, beyond the researchers, data repositories and data centers, research consortia, and publishers. While institutions have developed various strategies such as peer- review procedures, citation records, standard metadata, transparent review and publishing practices issues still remain. Solutions for addressing this challenge include the further development of research cultures in

[29]This section draws on Noorman Merel, Vasso Kalaitzi, Marina Angelaki, Victoria Tsoukala, Peter Linde, Thordis Sveinsdottir, Lada Price and Bridgette Wessels, Institutional Barriers and Good Practice Solutions, RECODE Project, Deliverable D4.1, 2014. http://recodeproject.eu/wp-content/uploads/2014/09/RECODE-D4.1-Institutional-barriers-FINAL.pdf .

which data is an integral part of the evaluation system, the development by journals of standards, methods and criteria for reviewing data effectively, along with the development of new publishing products (namely data journals and data articles) that contribute in enhancing the quality standards of research data or finally the use of altmetrics.

Institutions are also expected to play a key role in providing training to both researchers and other relevant stakeholders, such as data managers. In developing appropriate training and educational courses institutions are faced with the diverse needs and knowledge levels between and within disciplines, established research cultures and the pace of technological developments. Closely related to the above is the need to raise awareness on the opportunities and limitations surrounding open access. Institutions can have an active role in this respect too, through the adoption of different strategies which nonetheless necessitate collaboration with other stakeholders.