Open access to scientific data and literature and the assessment of research by metrics[1]

Executive Summary and Recommendations

New digital technologies and ubiquitous communication offer unprecedented opportunities for science based on open processes. Open access to the scientific literature and to related data and software is a powerful mechanism for creating and validating knowledge, and for supporting the development of science as a public good, rather than as an activity conducted behind closed doors. It is consistent with the Principle of Universality of Science (Statute 5 of the International Council for Science), which requires "*freedom … of communication for scientists, as well as equitable access to data, information and other resources for research*". The Universal Declaration of Human Rights also includes as a fundamental principle the right to share in scientific advancement and its benefits.

Much of the discussion to date on open access has focussed on the economics of traditional science journal publishing, but we are rapidly moving into a new era in which there will be many dissemination mechanisms for the outputs of scientific research, and universal access to these outputs is achievable. The transition to this new era presents both challenges and opportunities.

Increasingly, those involved in the administration of research rely on metrics designed to assess the importance and impact of research as an aid to evaluation, with publication outputs in traditional scientific journals being the major focus. These metrics in turn affect the behaviour of researchers, such as their choice of journals, as they seek to maximize their performance as measured by the metrics used. They can contribute to the maintenance of high journal prices, promote intense competition rather than openness and sharing, and fail to recognise research contributions such as the production of datasets, software, code, blogs, wikis and forums.

[1] This report has been developed by a Sub-Group of the ICSU Executive Board, with input from individuals attending an expert workshop, ICSU Members and the ICSU Secretariat (see Appendix).

The International Council for Science advocates the following goals for open access. The scientific record should be:

- free of financial barriers for any researcher to contribute to;
- free of financial barriers for any user to access immediately on publication;
- made available without restriction on reuse for any purpose, subject to proper attribution;
- quality-assured and published in a timely manner; and
- archived and made available in perpetuity.

These goals apply both to peer-reviewed research publications, the data on which the results and conclusions of this research are based, and any software or code used in the course of the research.

Metrics used as an aid to the evaluation of research and researchers should help promote open access and open science, and the scientific community should be fully involved in their design.

The International Council for Science makes the following additional recommendations:

1. Business models for scientific publishing should be built for the benefit of the scientific enterprise, and take into account the needs of both scientifically developing and developed countries.

2. The mechanisms for achieving open access will vary by discipline, and for some fields of research there may be legitimate ethical or legal constraints on providing access to research data, and, in very limited cases, research findings themselves. However, openness should be the norm, which is deviated from only in clearly justified circumstances.

3. Vigilance is required so that new publishing and dissemination models do not compromise quality. There is an urgent need for the research and publishing communities to develop ways of signposting to authors and readers those journals and data repositories that have the necessary quality assurance and secure archiving processes in place.

4. Science publishers and chief editors of scientific publications should require authors to provide explicit references to the datasets underlying published papers, using unique persistent identifiers. They also should require clear assurances that these datasets are deposited and available in trusted and sustainable digital repositories. Citing datasets in reference lists using an accepted standard format should be considered the norm.

5. The International Council for Science endorses the OECD Principles and Guidelines for Access to Research Data from Public Funding as they refer to open access: "*Openness means access on equal terms for the international research community at the lowest*

possible cost, preferably at no more than the marginal cost of dissemination. Open access to research data from public funding should be easy, timely, user-friendly and preferably Internet-based."

6. Lack of clarity on what uses are permissible, or what requirements there are to request specific permission to use data, are barriers to openness and re-use. Therefore, all datasets should be accompanied by a clear licence which states what use is permissible, how the originator of the data should be acknowledged, and, only where necessary, who needs to be contacted for additional permission to use the data.

7. Along with the benefits that they obtain from full, open and free of charge data, scientists have a responsibility to make their own data and scientific results widely available as soon as possible. Embargo periods during which data are confined and not made available to others are not in the interest of good science.

8. Preparation of data management and dissemination plans and the early involvement of data managers should be prime requirements for all – or at least publicly funded – research projects and programmes. Evaluation of the performance and success of research projects and programmes by funders and other stakeholders should include data management and dissemination practices.

9. Science publishers and chief editors of scientific publications should require authors to provide explicit references to the software or code used in published papers.

10. In research evaluation and assessment, metrics should be regarded as an aid, and not a substitute, for good decision-making. They should not normally be used in isolation to assess the performance of researchers, to determine appointments, or to distribute funds to individuals or research groups, for which expert review is indispensable.

11. The International Council for Science endorses the San Francisco Declaration on Research Assessment (DORA), which recognizes the need to improve the ways in which the outputs of scientific research are evaluated.

12. The terms of contracts governing the purchase of scientific periodicals and databases by libraries serving universities and research establishments should be publicly accessible.

I. Introduction

New digital technologies and ubiquitous communication offer unprecedented opportunities for science based on open processes. Open access to the scientific literature and to related data and software is a powerful mechanism for creating and validating knowledge, and for supporting the development of science as a public good, rather than as an activity conducted behind closed doors. It is consistent with the Principle of Universality of Science (Statute 5 of the International Council for Science), which requires "*freedom … of communication for scientists, as well as equitable access to data, information and other resources for research*". The Universal Declaration of Human Rights also includes as a fundamental principle the right to share in scientific advancement and its benefits.

Much of the discussion to date on open access has focussed on the economics of traditional science journal publishing, but we are rapidly moving into a new era in which there will be many dissemination mechanisms for the outputs of scientific research, and universal access to these outputs is achievable. The transition to this new era presents both challenges and opportunities.

Developments in open access and Internet technologies are leading to innovations in scientific journal publishing, and to new models of peer review and publication. Traditional scientific papers are being augmented by a myriad of hybrid forms of publishing. While the limits of what can be distributed feasibly are eroded, both the publication of datasets and their linkage to traditional papers are becoming increasingly prevalent.

Open access to literature and data is a necessary, but in itself not sufficient, condition for the health of the scientific process. Also essential are rational procedures for evaluating research and researchers, so that the best can be supported. Increasingly, those involved in the administration of research rely on metrics designed to assess the importance and impact of research as an aid in such evaluation, with publication outputs in traditional scientific journals being the major focus.

These metrics in turn affect the behaviour of researchers, such as their choice of journals, as they seek to maximize their performance as measured by the metrics used. This behaviour can affect the ecology of scientific publications, leading, for example, to the maintenance of excessive subscription prices. Metrics that reward contributions to research such as the production of datasets, software, code, blogs, wikis and forums can serve to support open access, and promote the principle of openness and sharing. Thus open access and evaluation by metrics interact significantly, which is why they are considered together in this report.

II. Goals of open access

The concept of 'open access' to scientific literature was developed through three public statements in the 2000s: the Budapest Open Access Initiative[2] in February 2002, the Bethesda Statement on Open Access Publishing[3] in June 2003, and the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities[4] in October 2003.

The Budapest Statement defined open access as follows:

> *"There are many degrees and kinds of wider and easier access to this literature. By 'open access' to this literature, we mean its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. The only constraint on reproduction and distribution, and the only role for copyright in this domain, should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited."*

The Bethesda and Berlin Statements add that for a work to be open access, users must be able to:

> *"copy, use, distribute, transmit and display the work publicly and to make and distribute derivative works, in any digital medium for any responsible purpose, subject to proper attribution of authorship."*

The process of scientific discovery involves researchers being able to communicate their research results and audiences being able to access these results. At the same time, not all researchers have ready access to research funding and cost must not be a barrier to placing their results in the most appropriate journal, data repository or other outlet for that research.

The International Council for Science therefore advocates the following goals for open access. The scientific record should be:

- free of financial barriers for any researcher to contribute to;
- free of financial barriers for any user to access immediately on publication;
- made available without restriction on reuse for any purpose, subject to proper attribution ;

[2] http://www.budapestopenaccessinitiative.org/
[3] http://dash.harvard.edu/bitstream/handle/1/4725199/suber_bethesda.htm?sequence=1
[4] http://openaccess.mpg.de/286432/Berlin-Declaration

- quality-assured and published in a timely manner; and
- archived and made available in perpetuity.

These goals apply both to peer-reviewed research publications and the data on which the results and conclusions of this research are based. Metrics used as an aid to the evaluation of research and researchers should help promote open access and open science.

III. Scientific publishing and business models

Open access is increasingly becoming a reality: the necessary technology exists, and barriers blocking access are mostly addressable. While running a good journal or repository costs money, there is little doubt that there are resources already used to support scientific publication sufficient to sustain a system such that the limited funding available to any individual ceases to be a barrier to publishing or accessing research material. What is less clear is how to move from the current situation to such a system.

The two main tracks for open access – 'Gold' and 'Green' – both have their keen supporters and detractors. The Gold track involves publishing in a fully open access journal or website. Subjected to the same peer-review procedures as a traditional journal, the open access journal is usually available online. Through it, the published paper is available immediately and is free at point of use. The Green track involves researchers self-archiving their papers in an institutional or subject-based repository; these papers may or may not have already been published in a non-open access journal. Such repositories increase the availability of some otherwise published articles that may have been subject to restrictions on reprinting or text mining, and may thus enable work to be propagated across the Internet and exploited for novel applications. Repositories also allow authors to keep track of who is downloading their data.

There are numerous business models for Gold open access journals, most involving the payment of a processing fee on the part of someone. Open access may be provided by traditional publishers alongside their subscription-based journals, or by publishers wholly dedicated to the principle of open access. The open access journal business models themselves may be hybrid (with some open access articles along with subscription based ones), or fully open access. The dissemination of research results is fundamental to the process of research, and thus the marginal costs of this can appropriately be considered as a valid call on research budgets. Major research funding organizations are beginning to expect open access to the research they support, with many of them already adopting Green open access self-archiving mandates.

The goals of open access advocated above can be satisfied by subscription, gold, hybrid, or other business models, whether implemented by non-profit, learned society or commercial publishers, but only if robust procedures are in place to ensure that those who do not have the means to pay for publication or access, or who are not affiliated to recognized institutions, are

not disadvantaged. Business models should operate first and foremost for the benefit of the scientific enterprise, and take into account the needs of both scientifically developing and developed countries.

The question of access can be complicated by the practice by publishers of 'bundling' journals, as widely varying subscription deals are struck with libraries serving university and research establishments. Open access to the terms of these contracts would help move the current system to one better suited to the interests of science.

IV. Quality assurance

Scholarly journals are only of value if users can be certain of the quality assurance process, which depends on the integrity of authors, editors, reviewers and publishers. Vigilance is required so that new publishing models do not compromise quality.

Peer review of the research paper, though not always perfect, has been perceived as the best mechanism available to ensure quality. However, there are innovative developments taking place in peer-review mechanisms, and care has to be taken not to stifle this innovation whilst at the same time providing the necessary quality assurance to authors and readers. The spread of social media is likely to change academic publishing fundamentally, influencing both the publication process and the distribution of research. Social media also provide opportunities to address some of the concerns raised within the scientific community about the traditional quality control system.

In this rapidly changing landscape, there is an urgent need for the research and publishing communities to develop ways of signposting to authors and readers that journals have the necessary quality assurance (and secure archiving) processes in place. Recent work by the Open Access Scholarly Publishers Association and others on the Principles of Transparency and Best Practice in Scholarly Publishing[5] provides some valuable guidance.

V. Open access for scientific data, software and code

Science is best served by full and open data being made available at no or minimal cost and without restriction on re-use. Such access allows for extensive exploration, experimentation and model evaluation by all scientists who wish to do so.

There is a strong worldwide momentum for open access to data. The 34 members of the Organisation for Economic Co-operation and Development (OECD) have agreed at ministerial

[5] http://oaspa.org/principles-of-transparency-and-best-practice-in-scholarly-publishing/

level on a statement on *OECD Guidelines and Principles for Access to Research Data from Public Funding*[6]. On open access, the OECD principles state:

> *"Openness means access on equal terms for the international research community at the lowest possible cost, preferably at no more than the marginal cost of dissemination. Open access to research data from public funding should be easy, timely, user-friendly and preferably Internet-based."*

The International Council for Science endorses these OECD guidelines and principles and encourages their adoption in all countries. In so doing, it recognises that the creation of datasets carries a cost, but when the public sector is responsible for these creation costs then it is in the interest of good science to encourage the widest possible use and re-use of the data. Data that originate in the public sector should normally be available free of charge or at most at the cost of fulfilling a user request, such charges to be limited to the costs of preparing and distributing datasets and not to include the cost of the original data capture.

Before the advent of the digital age and the World Wide Web, datasets used or produced for research activities were in most cases peer-reviewed during the publication process and captured in the printed form of the published scientific papers. The traditional scholarly publishing paradigm is now increasingly challenged by the nature and diversity of formats and communication media, and the increasing size and complexity of digital datasets used as input or produced as output of scientific research. The concept of publishing data separately emerged a decade ago to ensure that these essential parts of the scientific record were made available in an intelligible form to the scientific community. It varies depending on the research field and includes *ad hoc* practices – such as providing datasets as supplemental material to traditional papers hosted on a publisher's website – as well as the publication of self-standing data articles in specialized data journals.

Science publishers and chief editors of scientific publications should require authors to provide explicit references to the datasets underlying published papers, using unique persistent identifiers such as the Digital Object Indicator (DOI). They also should require clear assurances that these datasets are quality-assessed and made available – through internationally recognized standards to facilitate reuse and repurposing – in trusted and sustainable digital repositories, such as those of members of the International Council for Science World Data System (ICSU-WDS) or with a Data Seal of Approval. Members of the International Council for Science should actively promote these practices within the scientific community.

Citing datasets used in research articles' reference lists using an accepted standard format should be considered the norm, as is currently the case with the citation of scientific papers. Conforming to this norm and recognizing data as a first-class research output provides a powerful incentive for sharing data within the scientific community. The principles of data citation have now matured and should be supported and adopted by the scientific community. A good exemplar for the promotion of this norm is the joint effort by more than 25

[6] OECD Principles and Guidelines for Access to Research Data from Public Funding, http://www.oecd.org/dataoecd/9/61/38500813.pdf

international organizations working in this area – including CODATA, DataCite, ICSTI and WDS – to develop and promote the adoption of a Joint Declaration of Data Citation Principles.[7]

In some scientific areas, data collected for research and the public good (such as for the local provision of weather services and warnings) can, when made freely available to the commercial sector, be used for their commercial benefit. With proper attribution and backing of the originating organization, this can have enhanced overall benefits. Without such recognition the originating organization may lose the support of government or other funders for the collection and processing of the data, resulting in the loss of services for the public good and of research outputs.

In situations where ethics are a concern (for example in animal experimentation), assurance that studies generating the data have been conducted in adherence to basic ethical guidelines should be provided.

Science funders need to provide sufficient resources as part of their research grants to ensure the adequate management of research data during and beyond the lifespan of publicly funded research projects and programmes.

Science publishers and chief editors of scientific publications should require authors to provide explicit references to the software or code used in published papers. As in the experimental sciences, the reproducibility of computation -- numerical, symbolic, etc. -- is also a cornerstone of the scientific method, and should be standard operating procedure for the computational aspects of research.

VI. Copyright and licensing

While many aspects of national copyright laws have been standardized through the two major international copyright agreements[8], copyright laws of most countries retain some unique features. Some jurisdictions have required formalities to establishing copyright, but most recognize copyright in any completed work without formal registration. One exception is provided by the notion of fair use or fair dealing, a limitation and exception in certain common-law jurisdictions to the exclusive right granted by copyright law to the author of a creative work. Many science publishers still require authors to assign copyright to their journals so that they control the dissemination and re-use of an author's work. The evolution of digital media and computer network technologies and resultant information mining innovations have

[7] Data Citation Synthesis Group (2014) Joint Declaration of Data Citation Principles http://www.force11.org/node/4769

[8] The Berne Convention for the Protection of Literary and Artistic Works of 1886 (usually referred to simply as the Berne Convention), and the Universal Copyright Convention (UCC) of 1952.

introduced new complexities in enforcing copyright, raising fundamental issues about the basic philosophy of copyright law.

In the case of data, users have traditionally needed to contact data holders to request a copy of their datasets and to ask permission to use the data for a specified purpose. With more and more datasets being made openly accessible for download from the internet, the requirement to request copies of data is diminishing. However, even though data are readily available for download, it is not always clear whether the principle of free, unhindered re-use of the data is being applied or that restrictions are in place. Lack of clarity on what uses are permissible, or requirements on users to request specific permission to use data, are barriers to openness and re-use. In order to ensure clarity as to how data can be used, all datasets should be accompanied by a clear licence which states what use is permissible, how the originator of the data should be acknowledged, and, only where necessary, who needs to be contacted for additional permission to use the data. There are a number of organizations that are working to provide standard licences that are well suited for use with open datasets and the scientific literature.

VII. Legitimate constraints on open access

Whilst openness is good for science the mechanisms for achieving open access will vary by discipline, and for some disciplines there may be legitimate constraints on open access to research data, and in limited cases, research findings themselves. However, openness should be the norm which is deviated from only with good reason.

The main areas in which there may be justifiable restrictions on openness are those of personal information, safety, national security, sensitive commercial and cultural information and other information likely, if released, to cause harm to research subjects. For example, in the biomedical and social sciences the release of research data without appropriate safeguards on anonymity could enable research subjects to be identified. It is a common principle of ethical practice in the humanities and social sciences research that research subjects provide data on the basis that this will not be made publicly available, and the latter need to have given appropriate consent for release of personal information. In the environmental sciences, release of research data on the locations of rare species may endanger those species through the unwelcome attention of collectors. Similarly, to encourage the realisation of economic benefits from publicly funded research, most extant research funder data policies acknowledge that it is legitimate not to make commercially sensitive data available while patent applications are pending.

Individual disciplines have protocols for identifying when it is appropriate to be open and when the public interest is best served by constraining access. These are often supported by, and

developed in the context of, national legislative frameworks relating to freedom of information and protection of personal data.[9]

There may also be technical limits on supporting openness, where the volumes of data or other technical constraints may be such that it is not feasible to make the data 'open to all'. In such cases, means should ideally be found to enable processed and derived data to be made open, until such time when ideally the full dataset can be opened up.

Along with the benefits that they obtain from full, open and free of charge data, scientists have a responsibility to make their own data and scientific results widely available as soon as possible. A professional approach to data management in science, as advocated and practised for example in the ICSU-WDS, encourages rapid access to scientific data by all scientists. The terrain for scientific progress is at its most fertile when data are open and widely available, and embargo periods during which data are confined and not made available to others are not in the interest of good science.

The landscape of embargo periods is chaotic, with large variations by discipline and by country. In some instances embargo periods lead to data never being made available to the scientific community at large: this is highly undesirable.

VIII. Open access in less developed countries

Open access can have clear benefits for less developed countries, which need an unrestricted flow of scientific knowledge to support local research, the growth of their scientific communities and to be able to contribute to global research. At the same time, the specific needs of local authors, journals and policymakers should be recognized in any discussions of open access. In some settings, authors aiming to publish in international journals are unlikely to have the funds to meet article processing charges. Fee waivers and support for publishing and data preparation and deposition within research grants are examples of mechanisms that can respond to this reality.

Many journals in the less developed countries have already embraced open access with no article processing charges. The university departments and scholarly associations that support many of these periodicals should be encouraged to continue to cover their modest costs so that there are no barriers for authors. Green open access offers obvious advantages to developing countries. Strong local journals are a crucial part of the scientific 'ecosystem', and their

[9] A report from the UK's Royal Society provides a valuable summary of the boundaries of openness. *Science as an open enterprise*. The Royal Society Policy Centre Report 02/12 issued June 2012. http://royalsociety.org/policy/projects/science-public-enterprise/report/

increasing efforts to professionalize, improve quality and become more attractive to local and international authors need active support. Likewise, there is need to promote efforts to develop and maintain trusted, sustainable data repositories.

IX. Archiving

Enabling long-term preservation of, and access to, research publications and data is a challenge facing the scientific research community and those working in digital preservation. Long-term preservation of the research record should be ensured as much as is practical given current skills and abilities in digital preservation. This is a shared role for libraries, digital archives and publishers.

Two of the major initiatives for the archiving of publications are worthy of note. arXiv[10] began as a repository of electronic preprints of scientific papers in the fields of mathematics, physics, astronomy, computer science, quantitative biology and statistics: all of these preprints can be accessed openly. It now contains an increasing number of postprints and final published versions ('versions of record'). PubMed Central[11] is a major archive of biomedical and life sciences journals to which free of charge access is a core principle.

The archiving of research data for long-term preservation is often seen as the final step in the data lifecycle. However, archiving – when appropriately planned and executed – provides opportunities for data re-use and ultimately maximizes the original investment. The lifespan of datasets goes beyond that of research projects. Unfortunately, data archiving is frequently overlooked in the preparation of research projects and programmes, and this can result in the loss of hard-obtained datasets.

Preparation of data management and dissemination plans and early involvement of data managers should be prime requirements for all – or at least publicly funded – research projects and programmes. Such plans should include provision for the use of internationally agreed-upon standards and long-term preservation and dissemination in trusted digital repositories to increase availability and potential re-use of datasets. Science funders should play a key role in monitoring the implementation of these plans. Evaluation of the performance and success of research projects and programmes by funders and other stakeholders should include data management and dissemination practices.

X. Open access, metrics and research evaluation

The research record, and in particular journal publications, provides the basis for most research evaluation exercises. Assessment of the research performance of a country, institution or

[10] http://arxiv.org/help/general
[11] http://www.ncbi.nlm.nih.gov/pubmed

individual is largely based on measures of traditional publication output. A variety of metrics have been designed to 'objectively' assess journal publications and these are used – often in isolation and sometimes as an adjunct to peer review – in research evaluation exercises across the world. These metrics have an enormous influence on how science is practised. Commonly used metrics (citation indexes, impact factors, h-index) can emphasise quantity rather than quality and tend to promote intense competition at the expense of openness and sharing. If the full potential of open access to science is to be realised, new metrics will be required that incentivise open-access approaches and value research outputs that go beyond traditional journal publications.

The use of metrics for the evaluation of research, and in particular the over-reliance on the Journal Impact Factor (JIF) for evaluating journals and assessing scientists' publication records for career advancement, has been the object of serious concern in recent years. The flaws in the JIF, when used in evaluating research, are well documented and are set out in the San Francisco Declaration on Research Assessment (DORA)[12]: it is a misleading measure for research performance since citations within journals vary considerably; it does not take sufficient account of the diversity in practice between different fields; it encourages manipulation and is too easily gamed; and it is insufficiently transparent. The predominance of the JIF has negative effects, entrenching the status of certain high-profile closed access journals, sustaining high subscription fees and militating against a shift towards open access.

Journal-ranking metrics can put titles in less developed countries at a disadvantage. The current criteria for inclusion mean many such journals have little chance of appearing in the Thomson-ISI Journal Citation Report and are thus not captured by common metrics. Research evaluators in the less developed countries urgently need to find meaningful ways of assessing the impact of locally generated research and encouraging open access approaches that can promote the growth and application of science in their own regions.

Metrics that do not take into account the semantic content of a citation are relatively blunt instruments, and the difference in practice between disciplines and the wide variation in timescales also need to be taken into account. Deployed as one of a range of indicators, article-level metrics would be one way of encouraging a more balanced assessment based on scientific content and contribution. Such a shift would also help reduce the incentive to publish in high-priced but 'prestigious' journals.

The design of metrics needs to recognize that the research communication landscape is changing. Metrics and other indicators should be extended to accommodate the publication

[12] The San Francisco Declaration on Research Assessment was initiated in December 2012 by the American Society for Cell Biology (ASCB) together with a group of editors and publishers of scholarly journals. A worldwide initiative, the Declaration recognizes the need to improve the ways in which the outputs of scientific research are evaluated, and gives important pointers towards this. It is proposed that the International Council for Science endorse this Declaration. http://www.ascb.org/dora/

and impact of increasingly diverse, but significant, forms of scholarly contribution and intellectual property, as well as the 'traditional' research article.

The use of metrics for research evaluation should itself be approached scientifically. Metrics are statistics, and the smaller the sample to which they are applied the less reliable they become; their apparent 'objectivity' can be illusory. Funders, institutions, scientific journals and researchers should deploy metrics conscientiously with due sceptical regard for the statistical and evidential limitations of the data available. In research evaluation and assessment, metrics should be regarded as an aid, and not a substitute, for good decision-making. They should not normally be used in isolation to assess the performance of researchers, to determine appointments, or to distribute funds to individuals or research groups, for which expert review is indispensable.

Open access needs to be both encouraged and rewarded in research evaluation processes, with the scientific community being fully involved in the design of any appropriate new metrics and peer review mechanisms.

Appendix. Contributors to this report

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