

Making the Case for Research Data Management

Angus Whyte (DCC) and Jonathan Tedds (University of Leicester)

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Introduction – Doing More with Less

Higher Education research managers need to coordinate an ever-broader range of research outputs and outcomes. In this briefing we show how institutions have taken a lead in establishing research data policies and services that will support them. We show how these are giving measurable improvements in research capability, and in the institutions' ability to respond to policy-makers and regulators. Institutions require coherent frameworks to establish the organisation, resources and technology capable of generating these benefits. This in itself presents challenges in achieving coherent change across the many disparate components within an institution. The pressure to do so with fewer resources means that JISC-led initiatives like the *Managing Research Data* programme and the *Shared Services and the Cloud Programme* come at an opportune time.

The prospects for sharing resources to gain efficiencies and more effective collaboration are extending beyond established areas such as IT Services, Library and Research Support. Just as academics are producing digital research assets in greater volume and variety, data management services are joining computation as resources that can be pooled more effectively. Benefits may also be found by considering other parts of the research cycle that can be served through repository services already established to manage research articles.

Tools, services and standards are emerging to help researchers manage their research assets, and to make more widely available the evidence including raw and processed data that underpins their research articles. Effective management is providing institutions with new ways to find synergies across research groups, producing new knowledge by engaging a broader range of stakeholders, and enabling wider reuse of data in teaching and learning, commercial exploitation and policy development.

Measuring the Benefits

37% Projected saving in staff time from moving Oxford University Classics Dept database to centralised virtual service (38)

69% Increase in citations for clinical trial publications associated with making their microarray datasets publicly available (14)

500% Growth in datasets downloaded from Economic and Social Data Service 2003-2008 (36)

One-day delay cut to 5 minutes Estimated time saving for crystallography researchers to access results from Diamond synchrotron, by deploying digital processing pipeline & metadata capture system (38)

(See sources of further information)

Researchers' needs are likely to span the related areas of research data management, curation, and preservation. Research data management concerns the organisation of data, from its entry to the research cycle through to the dissemination and archiving of valuable results. It aims to ensure reliable verification of results, and permits new and innovative research built on existing information. Preservation is about ensuring that what is handed over to a repository or publisher remains fit for secondary use in the longer term (e.g. 10 years post-project). Curation connects first use to secondary use. It is about ensuring that project results are fit to archive, and that valued research assets remain fit for reuse. This briefing focuses on research data management, its drivers and benefits found. We locate these in the JISC Managing Research Data programme, and take a snapshot of the experiences of one institution, the University of Leicester.

The Drivers

There has been a decisive shift towards greater oversight of the research process motivated by the driving principle of data as a public good. This shift is seen in the concerns of policy-makers, and in changes in legislation and its implementation. The needs are being addressed through coordinated action by funders including the UK Research Councils, charities and JISC, with significant responsibilities falling to HEIs and individual researchers.

Research Integrity

Research integrity is a key issue for policy-makers. The House of Commons Select Committee on Science and Technology concluded in 2011 "... employers must take responsibility for the integrity of their employees' research". They also call for regulatory oversight to ensure funders and institutions fulfil their responsibilities (1). Data management is a means to assure research integrity, and the UK Research Integrity Office (UKRIO) states in its Code of Practice:

"Organisations should have in place procedures, resources (including physical space) and administrative support to assist researchers in the accurate and efficient collection of data and its storage in a secure and accessible form. Researchers should consider how data will be gathered, analysed and managed, and how and in what form relevant data will eventually be made available to others, at an early stage of the design of the project." (2)

Legislative Change and Regulatory Compliance

A related point is that effective data management can mitigate risks to institutional reputation. These may surface as researchers balance requirements for

disclosure and confidentiality. Measures to comply with Data Protection and Freedom of Information legislation need constant monitoring, given rulings by the Information Commissioners Office on the withholding of research data requested through FOI, for example. Partly in response to the Independent Climate Change Emails Review in 2010 JISC developed new guidance for researchers in responding to FOI requests for research data (3). Dr Malcolm Read, executive secretary of JISC, said at the time: "...We need to move away from a culture of secrecy and towards a world where researchers can benefit from sharing expertise throughout the research lifecycle." (4)

Funders' Data Policies

To foster good practice, Research Councils UK has coordinated a statement of *Common Principles on Data Policy* (see box below) asserting that "...making research data available to users is a core part of the Research Councils' remit".

The DCC tracks and summarises funder policies, including Research Councils and some major charities (5). The EPSRC, for example now requires research organisations to preserve data securely for at least 10 years, and "... ensure that effective data curation is provided throughout the full data lifecycle, with 'data curation' and 'data lifecycle' being as defined by the Digital Curation Centre" (6).

The increasing UK activity in this area parallels significant international effort, especially across Europe, the US, and Australasia (7). In the US, the National Science Foundation has mandated Data Management Plans as a condition for funding, and the European Commission is to require these plans for projects funded in its 8th Framework programme from 2014.

Summary of Research Councils UK - Common Principles on Data Policy

Public good: Publicly funded research data are produced in the public interest should be made openly available with few restrictions

Planning for preservation: Institutional and project specific data management policies and plans needed to ensure valued data remains usable

Discovery: Metadata should be available and discoverable; Published results should indicate how to access supporting data

Confidentiality: Research organisation policies and practices to ensure legal, ethical and commercial constraints assessed; research process not damaged by inappropriate release

First use: Provision for a period of exclusive use, to enable research teams to publish results

Recognition: Data users should acknowledge data sources and terms & conditions of access

Public funding: Investment is appropriate and must be efficient and cost-effective.

(Full text at: <http://www.rcuk.ac.uk/research/Pages/DataPolicy.aspx>)

Research is Global and more 'Data Intensive'

Funders expect UK research to be international in scope. The Royal Society has reported that over a third of all articles published in international journals are internationally collaborative, up from a quarter 15 years ago (8). Researchers need data management tools and services to work this way. Research data is itself often seen as a form of infrastructure, as it is the basis for 'data intensive' research; a trend spreading from fields such as genomics and astronomy across many domains. As the European Commission *Riding the Wave* report points out, this trend calls for 'collaborative research data frameworks' (9). These should help develop the emerging pan-European collaborative research data infrastructure, and avoid isolating the islands of good practice.

Institutional Policy Responses

In response to these drivers, some UK Universities have started to develop policies on research data management (10). Oxford University published its Commitment to Research Data Management in 2010 (11). The University of Edinburgh's adoption of the UKRIO Code of Practice for Research was an important stepping-stone to its Research Data Management Policy, announced in 2011 (12). The policies do the following:

- Identify areas of responsibility for the institution and for researchers
- Commit the university to develop appropriate guidelines, training and support, including mechanisms and services for storage and backup
- Support deployment of data repositories and/or mechanisms for registering metadata about research data
- Recognise that management and curation of research data requires cooperation and coordination with research funders, and with existing national and international providers of data services and subject-based repositories

It is worth noting that these policies build on earlier work supported by the JISC *Digital Repositories and Preservation programme* in the projects *EIDCSR* and *DataShare* respectively. Other institutions are likely to similarly develop policies to fit their specific needs and contexts. There remain open questions about exactly who is responsible and when at each point within the complex research ecosystem (13).

Further incentives for change are the Research Excellence Framework, and the Research Councils' coordinated monitoring of research outputs and outcomes. Datasets have yet to make a mark in research assessment terms compared with the traditional article. This is likely to change with evidence that making data related to an article publicly available correlates with higher citation rates, at least in fields that have built the necessary repositories, standards and collaborative culture (14). These include astronomy, where the number of research papers based on second use of data from the Hubble Space Telescope has now overtaken those based on the initially proposed use (15).

The development of standards and mechanisms for citing data, e.g. Datacite (16), and for identifying contributors e.g. ORCID (17), will also help datasets gain more recognition as outputs in their own right. Standards-compliant research information systems will provide mechanisms to track dataset usage and enable this to be rewarded (18). The requirements to do that will be grounded in evidence of the benefits. As the remainder of the briefing shows, the benefits of having data in a reusable form are the opportunities it creates – for services to lay the foundation for new

research, create material for teaching and learning, improve engagement with the community and business, and inform policy or product development.

Building the Services: a Snapshot of Activity

The HEFCE and JISC conducted a feasibility study for a UK Research Data Service (19), which identified the need for a shared approach across institutions to help them build research data management skills, capability and organisation. This is being supported through the *Shared Services and the Cloud* and *Managing Research Data* programmes, including a coordinated approach to delivering training, tools and good practice through the Digital Curation Centre. *The Managing Research Data* (MRD) Programmes have already pump-primed initiatives to build services in a number of universities.

The programme's first phase (2009-2011) included initiatives with a broad institutional remit, and others focusing on specific disciplines and cross-disciplinary requirements. These projects have delivered innovative outputs to complement the capabilities being established through JISC Advance, JANET and the National Grid Service. Many of the project outputs have been designed to be reusable or adaptable. The JISC website (20) and an 'InfoKit' (21) expand on the following examples.

Data management planning approaches

The DCC's tool DMP Online (22) helps project teams create data management plans before and during research projects. The DMP-ESRC Project produced a set of Data Management Recommendations for Research Centres and Programmes (23) also useful for planning in research groups and departments in other disciplines. The ERIM Project examined issues at the University of Bath's Innovative Design and Manufacturing Research Centre (IDMRC) and produced a Draft Data Management Plan (24). The HALOGEN Project at the University of Leicester showed how central IT Services could support research projects, identify potential cost efficiencies and promote collaboration across departments and disciplines (see next section).

Best practice support and guidance

The Incremental Project has produced template web pages for providing support and guidance for managing research data, as implemented at the University of Cambridge (25) and the University of Glasgow (26).

Research data management platforms

The ADMIRAL Project (27) at Oxford University developed a pilot data management infrastructure for life science researchers. Their two-tier approach first supports researchers' local data management, and secondly offers an easy and secure route for archiving annotated datasets to an institutional repository. The FISHnet Project (28) developed a platform for research data curation and sharing in freshwater biology. The platform features a 'Traffic Light System for Data' and the FISHNet server-side technology stack, and will be hosted by the Freshwater Biological Association. The I2S2 Project (29) implemented its Information Model using the ICAT Lite 'personal workbench for managing data flows'. This allows the user to manage data, to capture provenance information and to "commit data" for long-term storage.

The Sudamih project at Oxford University (30) developed infrastructure to support humanities researchers in the form of a 'database-as-a-service' platform. Working initially with researchers in the life-sciences at the University of Manchester, the MaDAM Project (31) provided a platform to meet their requirements. These projects both sought to generalise the tools to other research groups and disciplines.

Requirements analyses and case studies

The Institutional Data Management Blueprint project examined research data management challenges across a number of departments at the University of Southampton to produce its Findings Report (32).

Requirements were also extensively documented in other projects including Sudamih, Incremental, and MaDAM, in some cases also providing gap analyses, followed by case studies to collect experiences from the piloting of the tools that were developed.

Training materials

The JISC MRD programme in 2009-11 funded a variety of projects to develop training materials (20). These address a range of disciplinary needs including archaeology, health studies, humanities research, performance and visual arts, psychology, microscopy, social anthropology, social science, and geoscience.

Identifying Benefits and Organisational Challenges

Identifying the benefits achievable and the case for sustainability was an over-arching theme of the Managing Research Data programme. Benefits were analysed through a series of case studies by consultants Charles Beagrie Ltd. The results add to the evidence base for a managed approach to research data, e.g. from case studies identifying benefits of making research more open (33).

Demand for services is growing, as shown by a joint study by the JISC and Research Information Network (RIN) which has identified rapid growth in usage of directly funded national data centres. Research efficiency was the most widely supported benefit of these, with researchers mentioning ways in which the centres had saved them time, money and effort (34). Case studies have also highlighted the scale of the challenges presented by the complexity and

Metrics for Institutions

- New research grant income
- Research dataset publications generated
- Improvement in citation impact from articles with publicly available data
- Improvements in benchmark results
- Cost efficiencies for services or depts
- Re-use of infrastructure in new projects

Metrics for Researchers/ Research Teams

- Grant income/success rates
- Visibility of research through data citation
- Improvement in routine back-up of data
- Reduction in lead time for data requests
- Time saved on data mgmt/ grant proposals
- Effectiveness of research tool/software

Metrics for Research Support Services

- Take-up in user community for services
- Data deposits with a repository
- Downloads of datasets held
- Activity based costing methods
- User feedback
- Datasets created/maintained

Metrics for Scholarly Communication

- Citations to datasets, research articles
- Citations to data management methods
- Datasets with enhanced metadata
- Reuse of data in teaching & learning
- Increase in user communities
- Service level agreements for nationally important datasets

diversity of researchers' practices (35). Engagement of researchers and research outputs with the wider community and business is an increasing focus for HEIs and Government. There is a need for long and medium-term planning to address the complexities involved.

The MRD cost-benefit studies have gauged the effects of focused interventions to develop systems and processes for researchers, identifying possible metrics (see table). However, the field is characterised by short-term projects, and as the report points out, data repositories require a critical mass of data and users. This will depend on the maturity of the domains involved and their data management: "Many benefits will only emerge over a longer timescale. Longer-term effects tend to arise from a complex combination of developments and circumstances, which can be difficult or impossible to disentangle and attribute to use of a single data repository, dataset, or research data management project" (36).

Creating the Environment: Experiences in one Institution

The University of Leicester (UoL) believes effective management of research data is a critical success factor. Key to this is requirements gathering to support research data management planning, which in turn needs coordination of research and IT expertise which may be in other departments or central service, and may be external.

UoL has already taken strategic actions to support its researchers' data management needs and promote long-term preservation and dissemination of the data they produce. In 2011 it approved an ambitious IT Strategy giving its central IT Service a clear mandate to provide comprehensive information management services. This aims to underpin all aspects of the University's mission, including its research, in the most cost-effective manner possible (37). The document responds to funding bodies' announcements regarding principles that must be adopted for managing research data. In particular, it sets the direction for radical change in the funding model for IT research infrastructure, to enable sustainable access to data in the long-term.

Within the central IT Service, UoL created a 'Research Computing Services' (RCS) team (in 2008) whose aim is to support researchers' needs. This is now staffed with seven IT professionals, all with research backgrounds. The team launched a new High Performance Computing (HPC) facility in 2010 and has gone on to pilot various server and database hosting services on a 'local cloud' of virtualised infrastructure. For example, the ALICE HPC system

reduced genomic sequence processing time by a factor of 60, so work that took 35 hours now takes 35 minutes.

The University was a Pathfinder for the UK Research Data Service (UKRDS). This provided an excellent opportunity to engage a wide range of researchers in requirements gathering, and to generate enthusiasm for solving data management challenges at Leicester. Through this initiative the role of 'Research Liaison Manager' was established and pioneered nationally. Staff in the role have built effective relationships with a wide range of research teams and central services and helped identify, define and prototype the services that researchers need at institutional level. The role demonstrated the importance of a significant research background to understand the needs of researchers, as well as familiarity with research IT.

The JISC MRD funded interdisciplinary project HALOGEN (History, Archaeology, Linguistics, Onomastics and GENetics) proved to be a good template for effective partnership with the research community (www.le.ac.uk/halogen). The project identified the data management needs of researchers involved and the organisational requirements. In doing so it established the institution's best practice for storage and management of diverse cross-disciplinary research data. HALOGEN covered all phases of the project life cycle through to the implementation of a practical, cost effective solution for data access, sharing, curation and preservation. This exploited the University's assets in IT Services and other centres of excellence in terms of hardware, software, storage and technical expertise.

Direct benefits of the HALOGEN work can be summarised as:

- Enabling new research opportunities and stimulating new collaborations
- Improved scholarly communication and access to data
- Verification, re-purposing and reuse of data and methodologies
- Increasing research productivity and protecting returns on earlier investments
- Increasing the skills base of individuals

The researchers involved have consequently won £1.3m over 5 years for a Leverhulme Trust interdisciplinary research theme called Diasporas to exploit the HALOGEN database for new research across genetics, arts and humanities.

HALOGEN was a key driver for developing a Database Hosting Service, which provides a common infrastructure for hosting research applications. This uses the open source 'LAMP' stack (Linux, Apache, MySQL and PHP) running on VMware Virtual Machines. This is being deployed for the shared cloud-based service BRISStkit (www.le.ac.uk/BRISStkit). This service will host and combine biomedical research datasets across the University

and NHS research teams working with tissue samples and anonymised patient data. The infrastructure is designed so it can be replicated either locally or in externally hosted cloud services brokered by JANET, testing their potential to contain costs. The University expects to show that cloud services can be securely exploited without exposing the organisation to significant risk. The local NHS Trust has successfully renewed its NHS Biomedical Research Unit status with the explicit intention of exploiting such infrastructure.

Institutional planning has been agreed within the University's governance structure through the establishment of a new Research Computing Management Group. The IT Research Liaison Manager and PVC Research and Enterprise have been key actors. This has brought high-level support for developing a keen institutional understanding of cultural issues and constraints on exploiting cloud-based services; including those to be delivered, and others as they become available nationally or internationally.

The University's governing Council has highlighted the need to ensure the integrity of its research data, particularly where that data is sensitive. It was thus crucial to map sensitive and confidential data holdings across the institution, to develop policy and prioritise where intervention and support is needed most urgently. As a result, flags have been embedded in the central grant costing system to trigger support requests for researchers if (i) they might use, reuse or generate sensitive data and (ii) they require help in planning and costing of research IT in a funding proposal.

Leicester has also extensively piloted DCC-developed tools. In developing its policies and procedures, the University has collaborated with other institutions and the DCC to help implement the emerging national frameworks. This has helped identify the timeline for institutional development in Table 2 below.

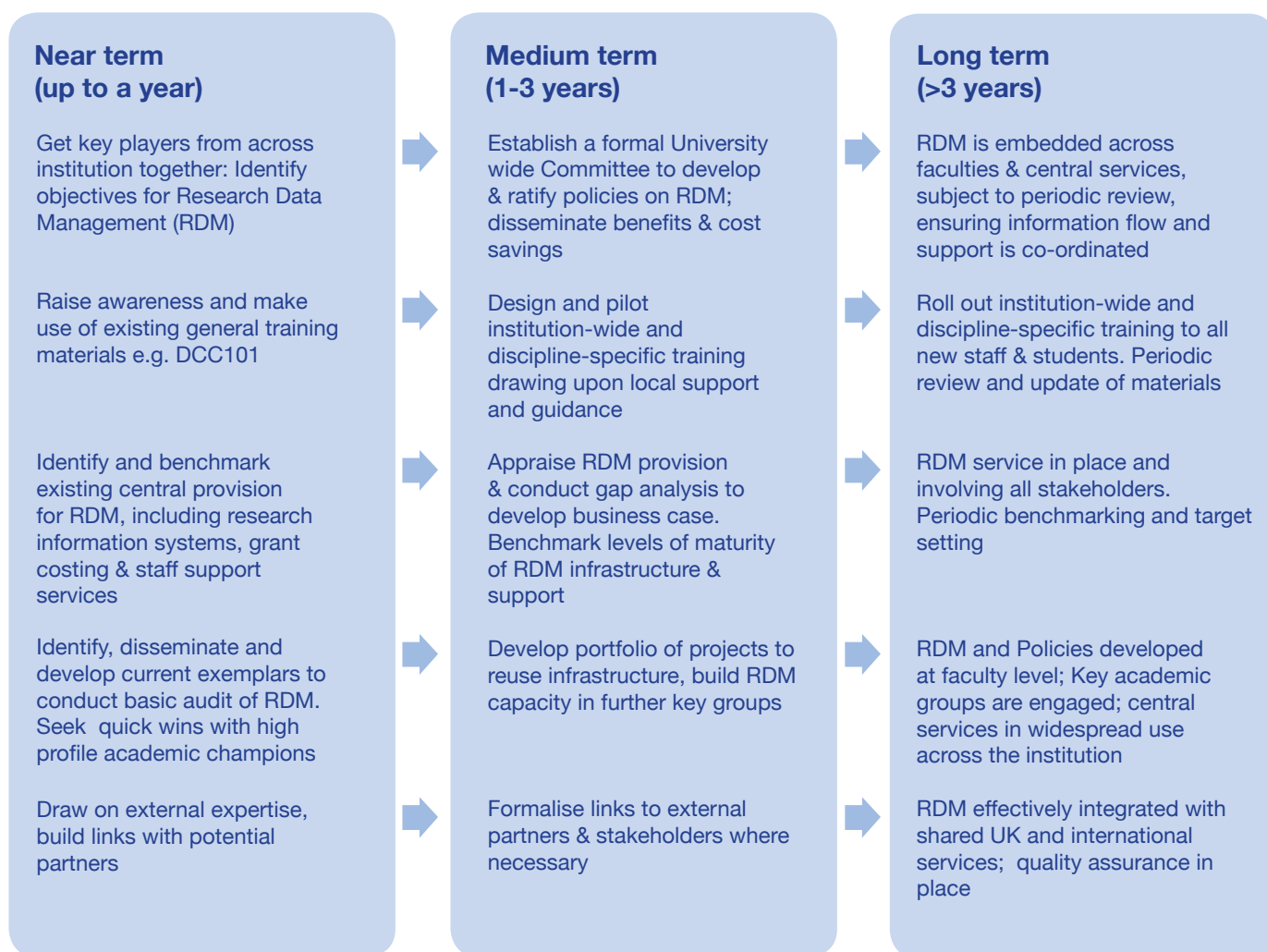


Table 2: A suggested timeline for institutional development

Looking to the Future

We can expect to see growth both in services and the range of providers, as pan-European and global 'research data infrastructures' develop. UK Higher Education is building skills and capability in research data management as a key component of the UK's e-infrastructure for research and innovation. Institutions can consider how to incorporate a timeline like that shown in Table 2 into their strategy. Data management and curation activities will increasingly be supported 'in the cloud', where services will be provided on a 'Software-as-a-Service' (SaaS) basis.

Complementing the *Managing Research Data Programme*, the JISC and HEFCE *Shared Services and the Cloud Programme* is providing shared infrastructure for research data management (38). This includes core virtual server infrastructure (a 'cloud') to offer cost effective data management and storage services to HE institutions, to be managed through JANET and Eduserv. SaaS applications to meet common requirements for research data services are being developed, some based on prototypes from the MRD programme. These include the Leicester University *BRISKit* service mentioned above, and the ViDaaS 'database-as-a-service' developed at Oxford. In addition, SRF developed at Southampton will provide electronic lab data management and collaborations tools. Dataflow developed at Oxford provides an integrated set of tools to manage data within projects and then to store it for the longer term, simplifying the set up of Sword compliant data repositories and the submission of data to them. The Shared Services and the Cloud programme is also developing services for administration in conjunction with JISC Advance. These include SaaS applications for research management, electronic resource management, and secure distribution of documents.

Organisational responsibilities for research data

Organisational responsibilities for research data

Ownership and management

Policies and procedures

Policy review

Sharing / Access to Research Data

Preservation and continuity of research data

Internal audit of research activities

Monitoring and feedback of publication

Metadata management

Legal compliance

IPR and rights management

Disaster planning

From Anne R. Kenney and Nancy Y. McGovern, "The Three-legged Stool: Institutional Response to Digital Preservation (ppt)", *II Convocatoria del Coloquio de marzo, Cuba, March, 2005*.

The JISC-supported Digital Curation Centre cuts across both programmes. It is working with institutions to grow and sustain their 'human infrastructure' in this area. This is primarily by holding awareness-raising roadshow events¹, and providing tailored support to managers in individual universities. The latter work includes coordinating training provision, and benchmarking current provision to help managers establish requirements and develop the required capabilities. The DCC tool *CARDIO* (Collaborative Assessment of Research Data Infrastructure and Objectives) is a benchmarking tool for data management and curation strategy development, for use at the departmental or research group level (39). It draws on a model for assessing institutions' level of preparedness on three aspects; technology, resources and organisation; the latter providing a useful checklist of areas of responsibility (see box).

The DCC will also continue to develop tools and provide these on a SaaS basis, including the DMP Online tool for data management planning. These tools will be further developed to sustain planning, implementation and self-assessment at project level, research group, and institutional levels.

Conclusions

Institutional policy development is required as a basis for coordinated action on data management. The objective is no different from that of research itself; to benefit science, scholarship and provide wider social and economic impacts. Technology is making it feasible to provide a more transparent research record, a record that both science and society demand in the interest of reproducibility and openness. A strong case for managing and curating research data can be made, as a means to assure research integrity and to provide improvements in research efficiency and in the effectiveness of institutional support.

Case studies have illustrated the types of benefit to be gained. More work is needed to follow up the work begun on developing and applying metrics to assess the impacts. Researchers and organisations need methods to identify and monitor how data management contributes to specific research trajectories. But it is already clear that Institutions need effective processes and procedures if their researchers are to deal with technical and regulatory changes in scholarly communication. The first priority for researchers is typically more clarity on roles and responsibilities and the support available.

¹Data Management Roadshows

<http://www.dcc.ac.uk/events/data-management-roadshows>

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