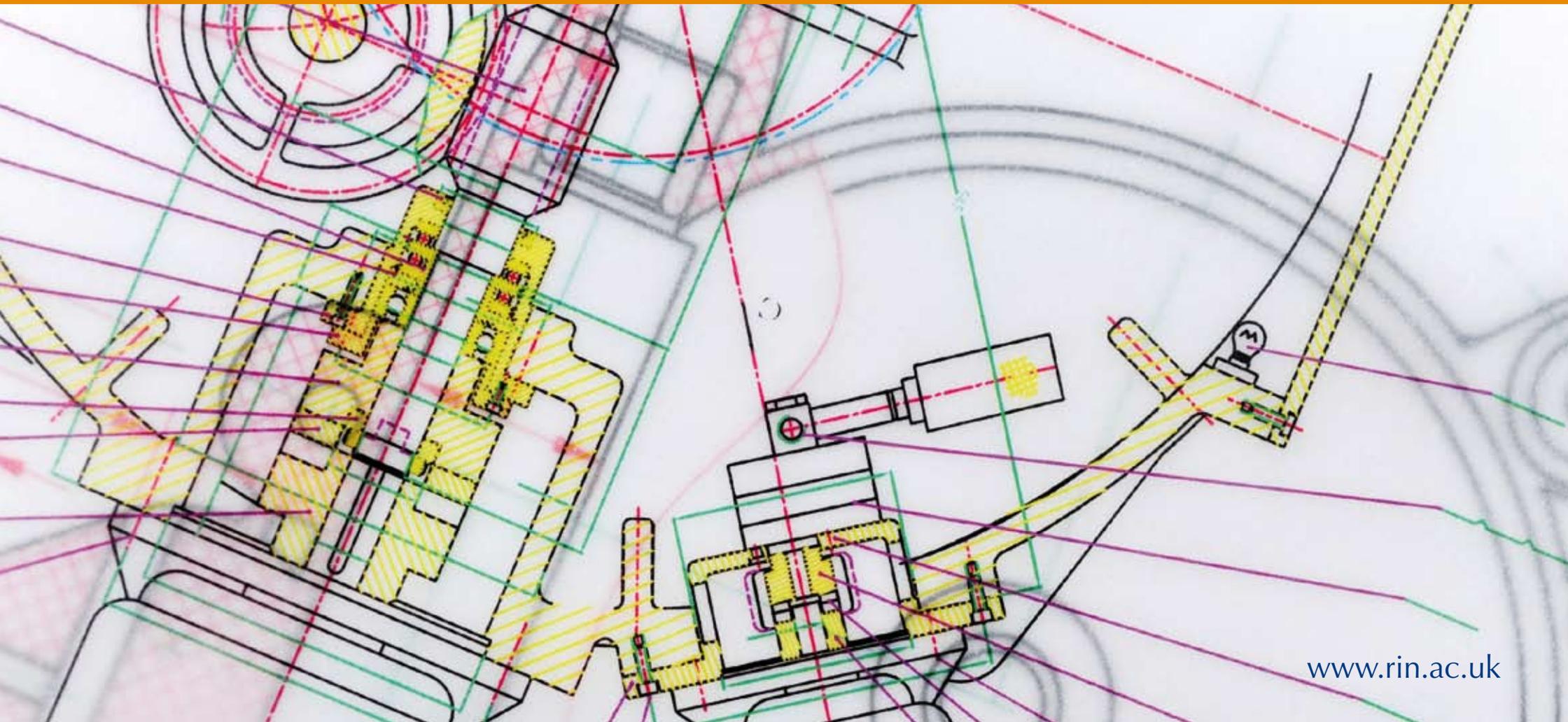


Information handling in collaborative research: an exploration of five case studies

A Research Information Network report

November 2011



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Contents

Executive summary	page 5
1. Introduction	page 9
2. Information handling throughout the research lifecycle	page 21
3. Key differentiators of information handling practice in collaborative research	page 34
4. Changing information handling behaviour: influencing factors	page 47
5. Conclusions and recommendations	page 50

Guide to abbreviations:

BBSRC	Biotechnology and Biological Science Research Council	PRISMA	Positive diveRsities of European priorities for reSearch and Measurement in end-of-life cAre
BL	British Library	RAE	Research Assessment Exercise
ESRC	Economic and Social Research Council	REF	Research Excellence Framework
ELN	Electronic Lab Notebook	RIN	Research Information Network
HEI	Higher Education Institution	RIM	Research Information Manager
IP	Intellectual Property	SGC	Structural Genomics Consortium
ICT	Information and Communications Technology	SME	Small and Medium Enterprise
JISC	Joint Information Systems Committee	STM	Science, Technology and Medicine
KT	Knowledge Transfer (office / officers)	TSB	Technology Strategy Board
LIS	Library and Information Services		

Executive summary

Between October 2010 and June 2011, TNS-BMRB conducted a study on behalf of the Research Information Network (RIN) and the British Library (BL), exploring the challenges to information handling in collaborative research and providing recommendations for potential interventions to help to enhance effectiveness.

Information handling is used here to encompass all pre-existing and new information sourced, organised, stored, shared and disseminated during a collaborative research project.

Background and method

Recent years have seen a growing number of research collaborations between HEIs (Higher Education Institutions) and external partners. Such partnerships are supported by increasing recognition in UK policy circles of their value as drivers of economic growth, the need for new streams of funding, and the benefits of tacit knowledge exchange to all involved.

This study focuses on information sharing and handling in collaborative research. There are several challenges to information handling when working in collaboration, including: navigating the differences in procedures, cultures and policies that exist within partner organisations; accommodating different legislation, such as the Freedom of Information Act (FOI) and the Data Protection Act (DPA); protecting intellectual property; and the practical complications of sharing information generated and stored on different sites.

Numerous solutions to these specific problems have been proposed, from the Lambert Toolkit of model agreements for rights to research outputs to Virtual Research Environments (VREs), designed to enable more effective and streamlined exchange of information. Several studies have considered more generic issues around information handling in research, looking at open access publishing, data repositories and web 2.0 tools, among other things. They have also explored possible interventions to improve

information management, such as the research information manager proposed by a British Library/UCL study. However, relatively little is known about how researchers working in collaborations have responded to the interventions designed specifically for their circumstances, or to the wider changes in the research arena. Furthermore, it is not clear whether interventions designed for purely academic research would also be valuable where non-academic partners are involved.

Therefore this study was commissioned by the RIN and British Library to provide empirical evidence of the challenges faced by researchers working in collaborations through the examination of five case-studies, all involving at least one HEI and external partners and selected to reflect a range of variables. The case studies comprised:

- a large multinational collaboration involving pharmaceutical companies and HEIs;
- a large European co-ordinated action between HEIs and public bodies involved with end-of-life care;
- a medium sized UK based project on material engineering involving HEIs and a mix of commercial partners including large multinational industrial organisations, SME manufacturers and university spin-outs;
- a small knowledge transfer partnership, developing a software and hardware package for use in residential care, involving one SME and one HEI;
- and a small exploratory collaboration involving a mix of commercial and third sector organisations, and an HEI.

These case studies were preceded by a literature review and followed by four workshops that tested and built on findings to reach a number of recommendations for improved practice.

Summary of key findings

1. Information handling practices were shaped by the particular conditions and pressures found within each collaboration.

In workshop discussions, funders and policymakers recognised the need for flexibility to meet individual circumstances and rejected the notion of a one-size-fits-all solution. The key differences which affected information handling in the case studies are highlighted below.

- **Contrasting needs and cultures** - defined by the mix of partners involved - led to compromises between 'open' and more restricted ways of working, such as selective information sharing, delayed publication, naming on patent applications, or tacit knowledge exchange. Where such compromises existed, the commercial needs for restriction were usually prioritised.
- The **intended outcomes** of a collaboration determined whether publishing was restricted (if the main focus was a commercial product) or expanded (if a desired outcome was dissemination) and the extent to which communication was carefully considered (particularly where learning more effective ways to collaborate was an overt goal).
- **Size** influenced the formality of information handling processes: in larger or more complex collaborations, the logistics of communication were more likely to have been considered and agreements more formalised than in small or low budget projects.
- **Geographic location:** The physical distance between partners spread across multiple sites presented day to day communication and information sharing issues. In the international cases, secondments were used as a way around this and to facilitate greater tacit knowledge exchange; alternatively work was apportioned so that each site was as self-sufficient as possible.
- **Previous experience** of collaboration helped to bridge cultural barriers and established a common language between researchers, promoting openness and greater use of informal channels. This was particularly true where partners had worked together before. Where there was no prior experience, face-to-face meetings, shared objectives and common ground through shared membership of professional networks all helped to build trust.

- **Funder involvement** could have a significant impact on project design and information management, particularly where partners lacked previous experience.
- Finding an appropriate balance of **formal and informal information channels** was important. Formal governance of information ensured that quality standards were maintained; information was delivered on time; and access restricted only to appropriate individuals (especially for larger or commercially sensitive projects). Informal information sharing – via email or telephone conversations – allowed for the quick exchange of knowledge and ideas and built trust and openness.

2. **Whilst there was scope to enhance information handling processes, this was not considered by researchers to be a significant issue and so there was limited motivation to change.** Researchers were reluctant to devote time and money to adopting new information management tools and services when they were satisfied with the status quo.
3. **Researchers sometimes lacked the necessary skills for good information management;** this presents a significant opportunity for library and information services, given the complexities of managing information produced and stored on multiple sites.
4. **Overall, there was limited awareness of the full range of services provided by library and information services within universities, and very little usage beyond accessing online journals.** Most researchers did not seek out support from libraries, and librarians were not trying to engage with researchers working in these collaborative projects.
5. **Whilst academic partners at larger institutions had good online access to journal articles, there was less consistent access in partner organisations,** with smaller commercial companies and universities facing some limitations. Academics, particularly within the larger universities, were usually responsible for disseminating published information, with little utilisation of larger commercial organisations' online journal subscriptions where these existed.

6. **When sharing published materials, researchers often ignored the specific conditions under which material was made available to them.** This was underpinned by a lack of understanding of sometimes complex licensing agreements and coupled with a culture of openness within collaborations and academia in general.
7. **Non-disclosure agreements (NDAs) were an important precursor to exchange of unpublished materials: this process was also facilitated by trust and a shared culture of openness.** Academic partners were conscientious in protecting their partners' IP; there was less clarity around what could be shared of the tacit knowledge they gained through collaborative research. Experience of working in collaboration built the necessary trust to accompany NDAs; commercial partners with less experience of collaboration remained cautious about sharing sensitive materials.
8. **There was little usage of online information management tools.** Despite the known benefits - for enhancing efficiency, communication and knowledge exchange as well as the long term value of information - there were significant barriers to uptake. These included perceptions around financial costs, concerns about the short term burden on researchers of adapting to new systems, and the significant influence of habit.
9. **Those with experience or knowledge of using digital information management tools were successful advocates;** championing their value for enhancing efficiency and safeguarding the long-term value of new information.
10. **There was little consideration of data management or storage in projects, limiting the potential for re-use of this information by partner organisations or others.** This was largely because researchers were focused on short-term project management and because long-term usefulness was not part of project goals or requirements. Where there was an intention to upload data to a central repository with access for those outside the project, this encouraged a more systematic approach to information handling from the outset.

11. **Researchers could deliver greater public value from collaborative research through wider dissemination and re-use of results.** But these actions can conflict with the needs of collaboration partners, particularly the commercial need to protect competitive advantage. In the pre-competitive space (exploratory research), dissemination was possible without undermining commercial value, thereby balancing public and commercial needs. In the pre-commercial space (applied research), protecting competitive advantage must be prioritised over dissemination in order for collaboration to be worthwhile for partners.

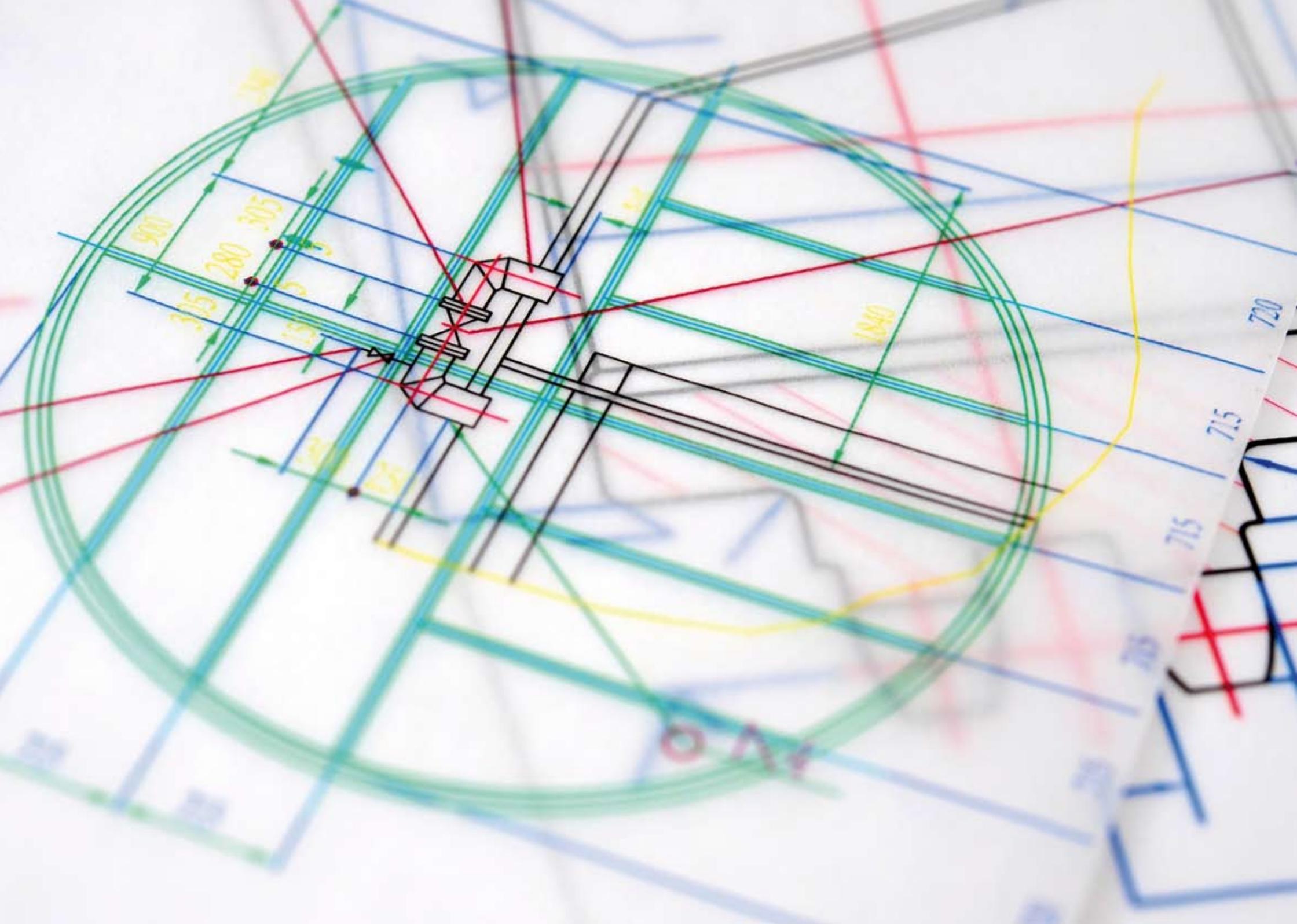
Conclusions and recommendations

Where handled well, information generated within collaborative research offers long-term value not only to the partners involved but also to others interested in exploiting the UK knowledge base.

Whilst a large number of studies, services, tools and funding mechanisms have been generated with the aim of overcoming the many challenges to information handling in collaborative research, few researchers were actually accessing them.

Researcher behaviour was influenced by a range of factors which can influence uptake of new behaviours: on a personal level in terms of beliefs, attitudes and habits; on a social level, the attitudes and actions of peers; and wider environmental factors such as funding structures and policies.

There are real opportunities for both LIS and funders together to harness changes in information management tools and practice, and influence policy, to ensure that the wider public value of information generated through collaborative research is realised.



1. Introduction

Background

The growth of collaborative and applied research

Research partnerships between universities and the public, voluntary and commercial sectors have become more prevalent in recent years and are set to increase in the future. Collaborative research allows organisations to share resources, to blend research ideas and methods and to avoid unproductive duplication of effort. By bringing together partners from different backgrounds, collaborative research can draw on tacit knowledge contained within different organisations, which is in turn shown to be critical to rapid innovation.¹ For universities, it leverages investment to supplement their core funding from government, allowing them to both demonstrate and increase the value of that investment. This is particularly important in the current financial climate, where research funding from public sources is increasingly constrained.

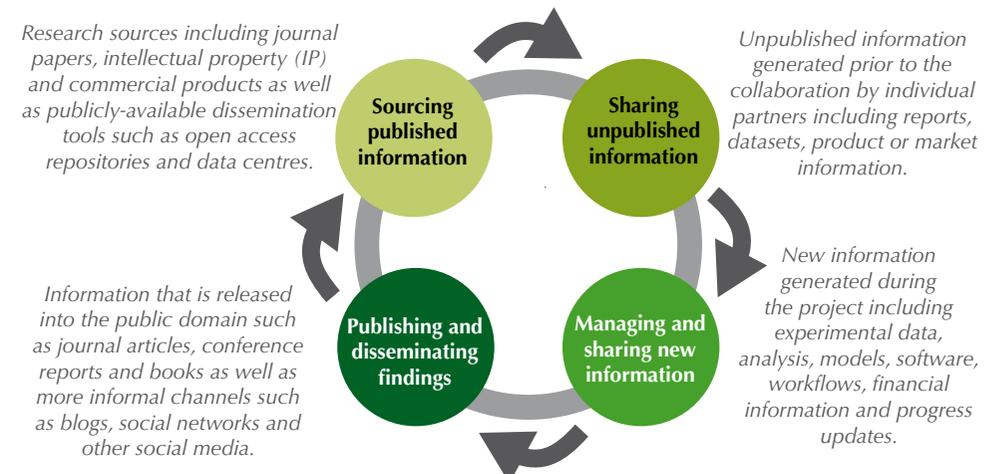
UK policy has supported this increase, recognising the value of collaborative research for driving innovation and economic growth as part of a growing interest in the 'impact' of research activity. The Lambert Report, published in 2003, indicated that research collaborations need to show real benefits to industry in order to attract investment, by bringing academic theory to bear on commercial problems.² It suggested that publicly-funded research must become more responsive to the needs of the economy and public services, and more focused on end-users.

Recent developments suggest that such impact can be found even in research which is not specifically designed with immediate social or economic benefit in mind. For example, pre-competitive research, which aims to build a knowledge base for future commercial exploitation, would traditionally be considered 'basic' exploratory research, without defined practical applications. This model is being successfully employed in the pharmaceutical industry, traditionally a fiercely competitive sector, where organisations are using collaborative approaches at an early stage in the research lifecycle, to help to streamline the discovery process.³

Information handling throughout the collaborative research cycle

Different types of information are sourced, created, exchanged and released throughout a collaborative research process. At the outset of a project, published and unpublished materials are brought together to create new information or processes. The original materials and new data feed into research findings, which are then shared with a wider community, subject to the original research agreement. The research findings thus become the initial information for further work, either within the collaboration or by external parties.

Figure 1: Information handling in the research lifecycle



Each of these stages brings specific challenges, outlined in greater detail overleaf.

1. M Knockaert and D Ucbasaran, Tacit knowledge transfer and technology commercialization: the case of science based entrepreneurial firms (summary), Frontiers of Entrepreneurship Research, 29/11, Article 5, 2009 <http://digitalknowledge.babson.edu/fer/vol29/iss11/5>

2. K Bhattacharya et al, A model driven approach to industrializing discovery processes in pharmaceutical research, IBM Systems Journal 44/1, 2005, 142-165 http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5386710

3. K Bhattacharya et al, A model driven approach to industrializing discovery processes in pharmaceutical research, IBM Systems Journal 44/1, 2005, 142-165 http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=5386710

Sourcing published information: A combination of changing technology and new business models for publishers has ensured that researchers have, in theory, access to a wider range of materials than ever before. Big Deals, whereby publishers make most of their catalogue available online to university staff and students, mean that researchers within subscribing institutions can use a wide range of content. However, this increased access, together with the worldwide growth in published articles, has led some researchers to complain of ‘information overload’; they cannot keep up with the volume of research made available in their field.

Online technologies go some way towards helping with filtration, with a number of sophisticated solutions for searching and finding articles offered by publishers. However, research indicates that academics tend to prefer more generic solutions, particularly Google and Google Scholar.⁴ Most academics take the results of these searches on trust, unaware that even Google Scholar is not a comprehensive index of all content that is theoretically available to them. This means that search results are often partial, and information can be missed. A study by CIBER investigated whether university researchers could get help from other specialist departments to source information more effectively. It found that “Researchers regard library staff as less proactive than research office staff in reaching out to researchers with customised information support.” Many researchers saw them as focused more on “...collection management, and on services to students, than on serving the needs of the research community in their institution.”⁵

Researchers outside academia have a leaner time when it comes to sourcing articles. Subscriptions to large numbers of journals are prohibitively expensive for all but the largest organisations. Pay-per-view access arrangements are generally perceived as complex and expensive, and are not widely used. One possible solution to this problem is open access research publication, which allows researchers to view

published articles free of charge. Although research has suggested that this could be an important route to more universal access to scholarly information, it is not yet sufficiently well-developed to offer a comprehensive solution for non-subscribers.

There is thus considerable disparity between researchers within and outside academia in terms of their access to published information. Licensing agreements are difficult for researchers to understand, particularly since these differ between publishers.⁶ In collaborations, we might expect this to result in unlicensed sharing of published content, particularly since we know that this is a familiar coping strategy for many researchers in both academia and business when faced with an information need that they cannot meet.⁷

Sharing unpublished information: Information may remain unpublished for a number of reasons. Chief among these is the lack of a positive incentive to publish, and there should be no barriers to internal sharing of information that is kept out of the public domain for this reason. However, in other cases there are more intractable reasons for choosing to keep information private.

For many academic researchers, unpublished data represent a source of possible future publications. Since these are the currency of academic advancement, crucial to both individual and institutional assessment exercises, researchers think very carefully before sharing data with external partners. In certain disciplines, data collection and analysis may be at the core of a researcher’s activity, with a single data set taking years to generate. Until the publication potential of such data has been exhausted, researchers tend to be very protective of it. This is recognised by research funders; one, who insists that data be deposited at the end of a project, allows researchers a further two years to work on the data before it becomes available to the wider academic community.

4. D Nicholas et al, Are social media impacting on research? CIBER, Charleston Observatory 2010, Nov 2010 www.ucl.ac.uk/infostudies/research/ciber/Charleston-2010.pdf

5. CIBER, Research support services in UK universities, 2010 www.ucl.ac.uk/infostudies/research/ciber/RSS-report.pdf

6. Overcoming barriers; Access to research information. RIN, December 2009 www.rin.ac.uk/overcoming-barriers

7. RIN, Gaps and barriers, forthcoming

There are also legal issues which may prevent internal data sharing. Researchers working on human subjects are bound by strict codes of conduct, covering the Data Protection Act and institutions' own ethical policies, most of which are restrictive. This often makes it difficult, if not impossible, to share information with anyone not named at the time of data collection.

For commercial organisations, legal issues are also an important consideration in sharing unpublished information. In general, they are particularly concerned with protecting trade secrets and confidential commercial interests, particularly given uncertainties about the impact that sharing information has on copyright and ownership of intellectual property.⁸ Furthermore, sharing information with a university could expose that information to Freedom of Information (FoI) legislation. While exemptions exist to safeguard commercial interests, such exemptions are subject to a public interest test, meaning that commercial information may still be exposed.

Managing and sharing new information: Previous studies have shown that researchers' methods for organising new information are highly idiosyncratic and, for the most part, rely upon a few low-tech tools such as memory sticks, email and face-to-face meetings. Uptake of digital technologies such as virtual research environments, open notebooks and wikis for sharing information is not widespread. In collaborations, this may mean that several different systems are operating in parallel, with few points of common understanding between research partners.

Research by the RIN⁹ and others reveals an information handling skills gap in the UK. Many academic researchers lack the necessary training in information management, and there are not enough information specialists to provide proactive, tailored support to research teams. The RIN's research highlights the value of information specialists in ensuring that data is well organised, meets standards that are consistent across the field

and can be reused in the future. But the status and role of information management within the overall skills training for academic researchers is unclear, which has led to inconsistencies in their knowledge and a lack of a common language between researchers, library services and information specialists.

Publishing and disseminating information: For most academic researchers, formal publication of results in an established journal is a crucial part of the research process. Publications are the currency of academic advancement, with success in both individual and institutional assessment exercises depending upon a strong record of publishing in high-impact journals. This establishes a claim to the novel findings of the research process and, at a more altruistic level, helps to ensure progress in the field by making information available for other researchers to build upon.

For non-academic partners, however, publication may be a lower priority – or, indeed, actively work against their desired outcomes for the collaboration. Commercial partners seeking patent applications need to be able to show that the work has not already been placed in the public domain, which rules out early publication by the academics. Public and commercial sector partners, on the other hand, may be so keen to disseminate the findings of their research in order to improve policy and practice that they effectively 'scoop' the academic researchers, reducing their chances of publishing in a high-impact journal.

8. CIBER, Research Support Services in UK Universities, 2010

9. Mind the skills gap: information handling training for researchers, RIN, 2008 www.rin.ac.uk/mind-skills-gap

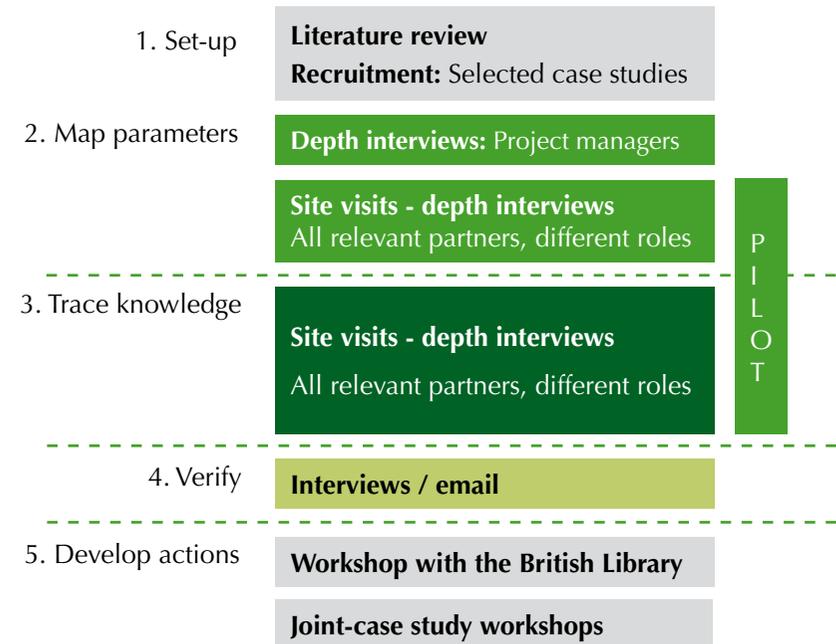
The need for further research

This brief exploration of the literature has outlined some of the legal, cultural and technical factors which may hamper effective information management in collaborative research projects. However, relatively little is known about how researchers experience these factors within collaborative research projects. This study was therefore commissioned to explore information handling within five cases. The resulting information will help funders, policymakers and institutions to establish the most appropriate environments, processes and guidelines to ensure knowledge and information flows more effectively in the partnerships they are encouraging.

Methodology

We undertook case studies of five research collaborations, each of which included at least one university and one external partner. Within each case, we began by forming a broad understanding of the collaboration structure via interviews with project managers and other main participants across the partner organisations. Through this process we identified key interviewees who would be able to provide insight into the collaboration's information management processes. A second round of interviewing focused on these people, alongside the original interviewees, to explore barriers to, and facilitators of, effective information handling and sharing. The five case studies were followed by a set of workshops with case study participants, funding bodies, and librarians, where we developed recommendations for future practice.

Figure 2: Overall research methodology



Selection of case studies

The five case studies reflect a range of criteria likely to influence information handling behaviour, including: the types of partners involved and their level of experience; the scale of the collaboration, based on the number of partners, stage and length of the collaboration; the scale of the project; the level of support received; and discipline. Table 1 provides an overview of the five cases.

Table 1: Participant cases

	Discipline	Aim	Partners
Intelligent Care	Technology	Developing a monitoring system for older people living in residential dwellings	1 commercial partner 1 university
UK Reactics	Engineering	Exploring the potential commercial applications of novel auxetic materials (materials which expand when stretched)	6 commercial partners 3 universities
PRISMA	Health / Social Care	European priorities for research and measurement in end-of-life care.	11 Partners, including 4 universities, with a range of public and third sector bodies.
Structural Genomics Consortium (Oxford)	Structural Biology	Pre-competitive mapping of protein structures to support new drug discovery	11 funders - mix of public and charitable funding and pharmaceutical companies. 3 universities
Locating Communications Heritage	Arts / Digital Technology	Developing a platform which enables mobile phone users to access history of communications and IT.	1 university 1 third sector (The Science Museum) 2 commercial

Although a range of disciplines are represented, the five cases are specific and we do not claim that the findings can be generalised to all collaborative research projects. Nonetheless, they provide a useful insight into some of the factors which can affect the efficiency of information handling in collaborative research.

Intelligent Care

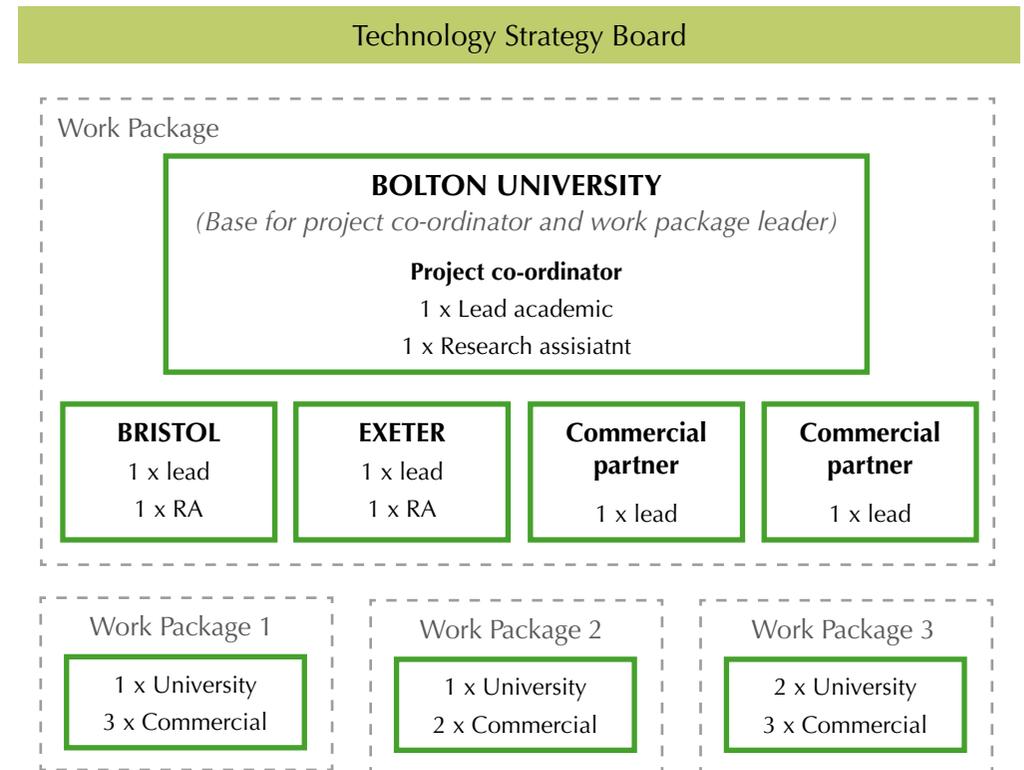
This small scale collaboration involved one commercial partner, operating care homes and providing care to older people, and one university. The aim of the project was to develop a software and hardware package to monitor older people in residential care. The project was a Knowledge Transfer Partnership (KTP) funded by the Technology Strategy Board (TSB). KTPs have the specific objective of supporting industry by promoting collaboration between SMEs and universities. A KTP advisor provided project management support and guidance. Two research associates were based within the commercial partner and were responsible for carrying out a market and literature review at the outset and developing the software and hardware. Support and advice was provided by the lead academics based at Portsmouth University. Contribution by the commercial partner was limited to guidance regarding the organisation's needs and commercial interests.



UK REACTICS

The collaboration involved three universities and six commercial organisations. The purpose of the research was to investigate the properties of auxetic materials (materials which have negative Poisson's ratios and therefore expand when stretched) and identify potential commercial applications. The work-package co-ordinator was based at the University of Bolton and the project management centred around this hub. There were four work-packages, each managed by a lead academic based at one of the universities. This case-study focused on work-package 4. The partners contributing to each work-package were selected according to their interest and expertise in the area which meant they were eligible to be named on IP applications. Junior academic researchers were responsible for generating experimental data and compiling research reports. Senior academics were responsible for directing research, quality control and advising juniors. Within the commercial partners, senior members of staff have contact who managed junior staff in generating data where required and fed this back to the consortium via the relevant work-package leader.

For confidentiality reasons, this organogram has been anonymised.

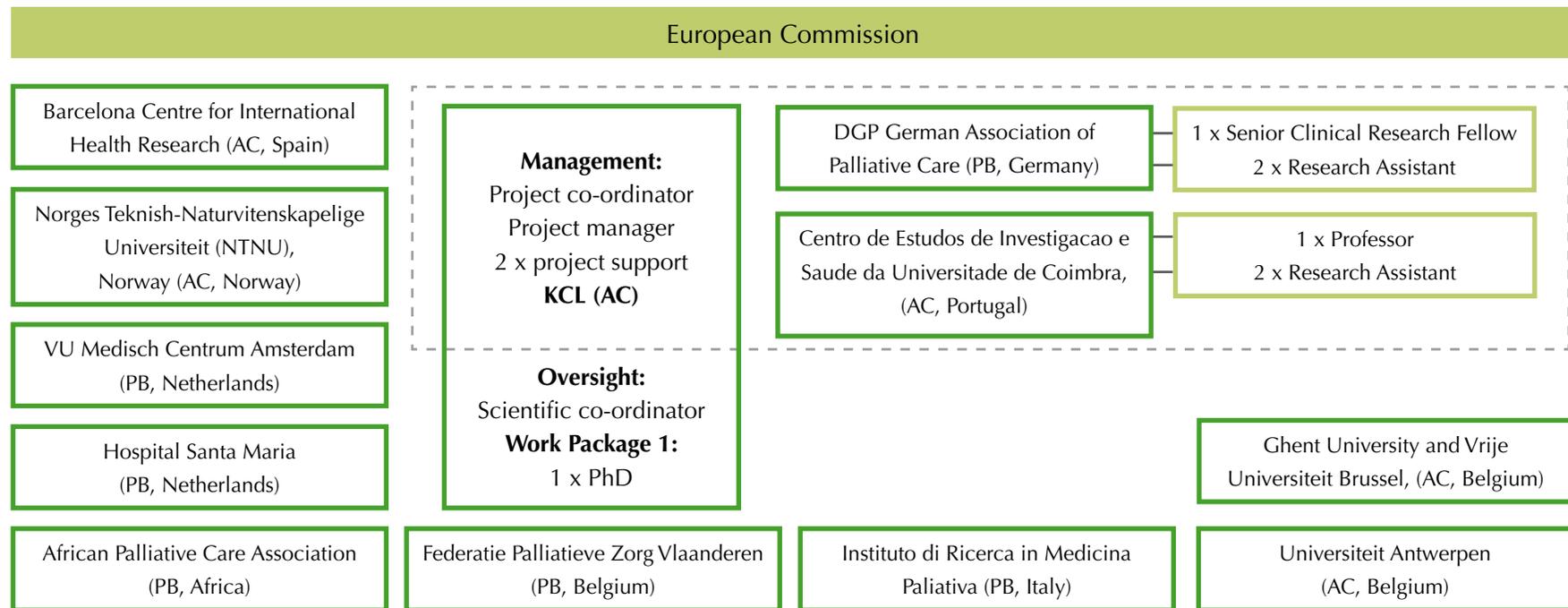


PRISMA

PRISMA is a major three year 'coordinating action' project funded by the European Commission (EC) involving nine European countries and eleven partner organisations. PRISMA is delivering an integrated programme coordinating research priorities and practice about end-of-life care across Europe and Africa by sharing practice, coordinating research and delivering research outputs, and identifying key priorities. King's College London (KCL) is the lead organisation, bringing together skills from across academia and clinical practice to deliver eight work packages.

Each work package has its own Work Package Leader (a researcher in a senior role in either an university or public body) and the project is overseen by a Scientific Committee and a Project Management Group, both led by very senior researchers at KCL. The work packages vary in size, with Work Package Leaders supported by one or more junior researchers, usually from the same organisation. The project management function, based at Kings, was supported by two Project Assistants, carrying out administrative tasks and communication, as well as KCL's EC Finance Contracts department.

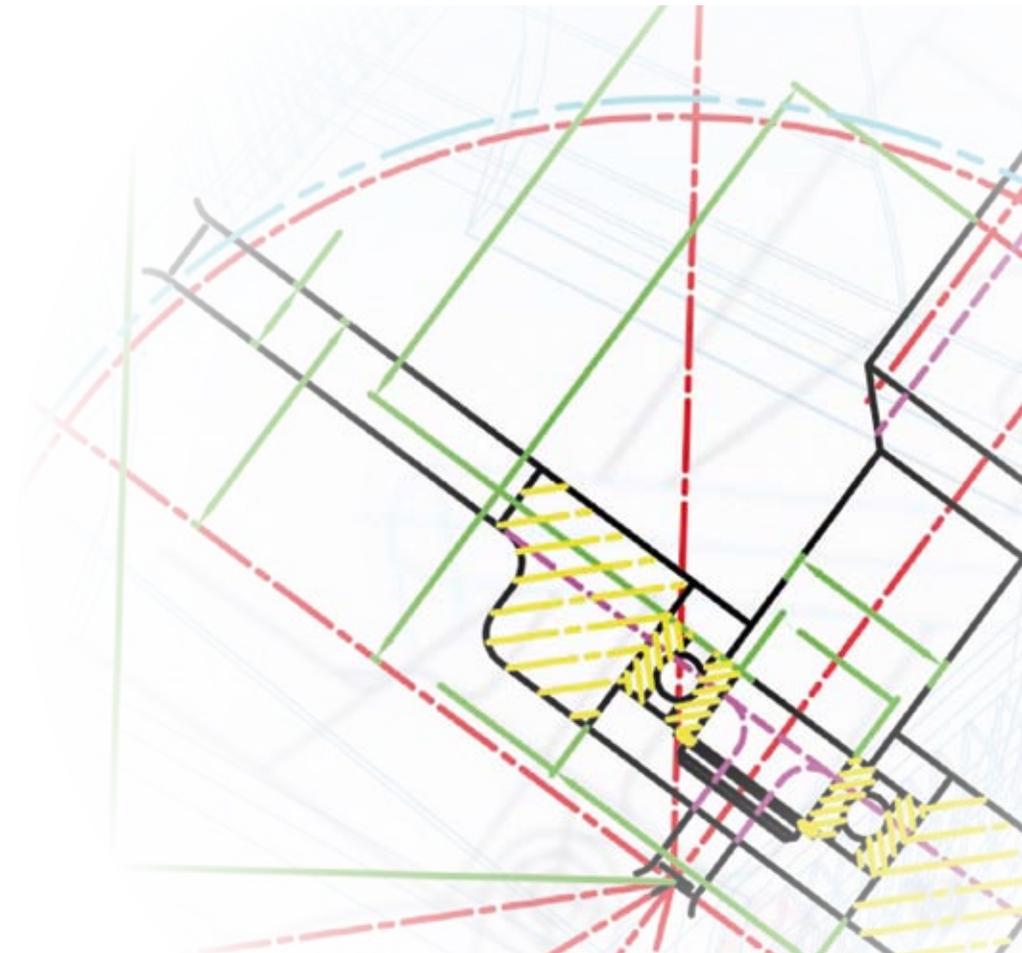
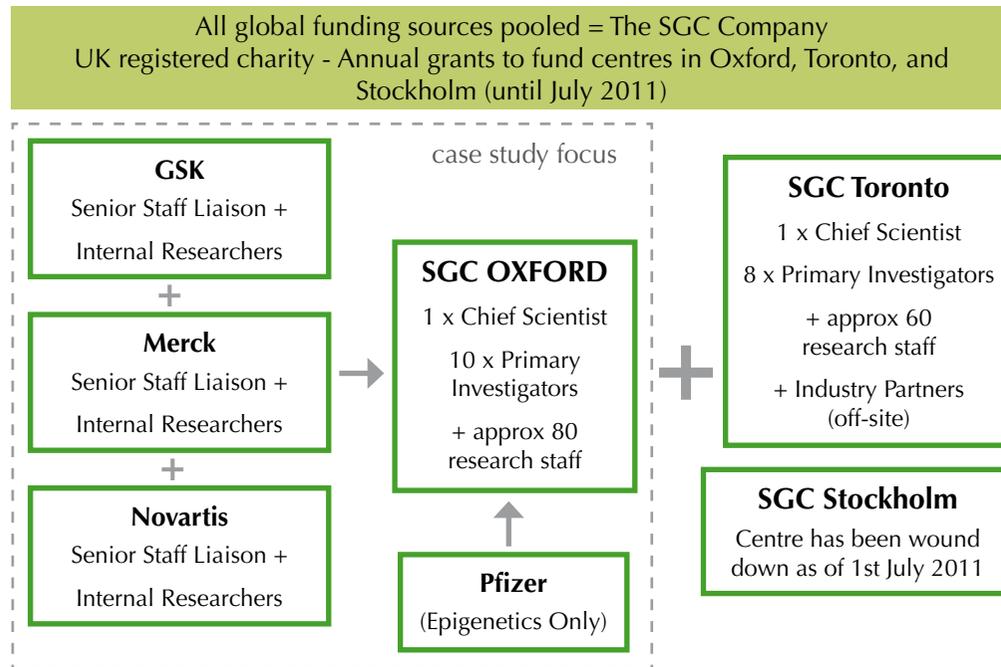
The area of focus for this project is indicated by a dotted line.



Structural Genomics Consortium

The SGC is a global consortium, comprising some two hundred scientists spread across three research centres at the University of Toronto, Oxford University and the Karolinska Institutet (Stockholm). Medically-important proteins from humans and human parasites are bundled into related families and distributed across the SGC centres, with each protein family assigned to a single lab, minimizing the need to co-ordinate efforts between labs. This case study focuses on the work of SGC Oxford as a proxy for the workings of the overall consortium; the Oxford centre specializes in identifying the structures of protein families involved in amongst others cancer and metabolic diseases.

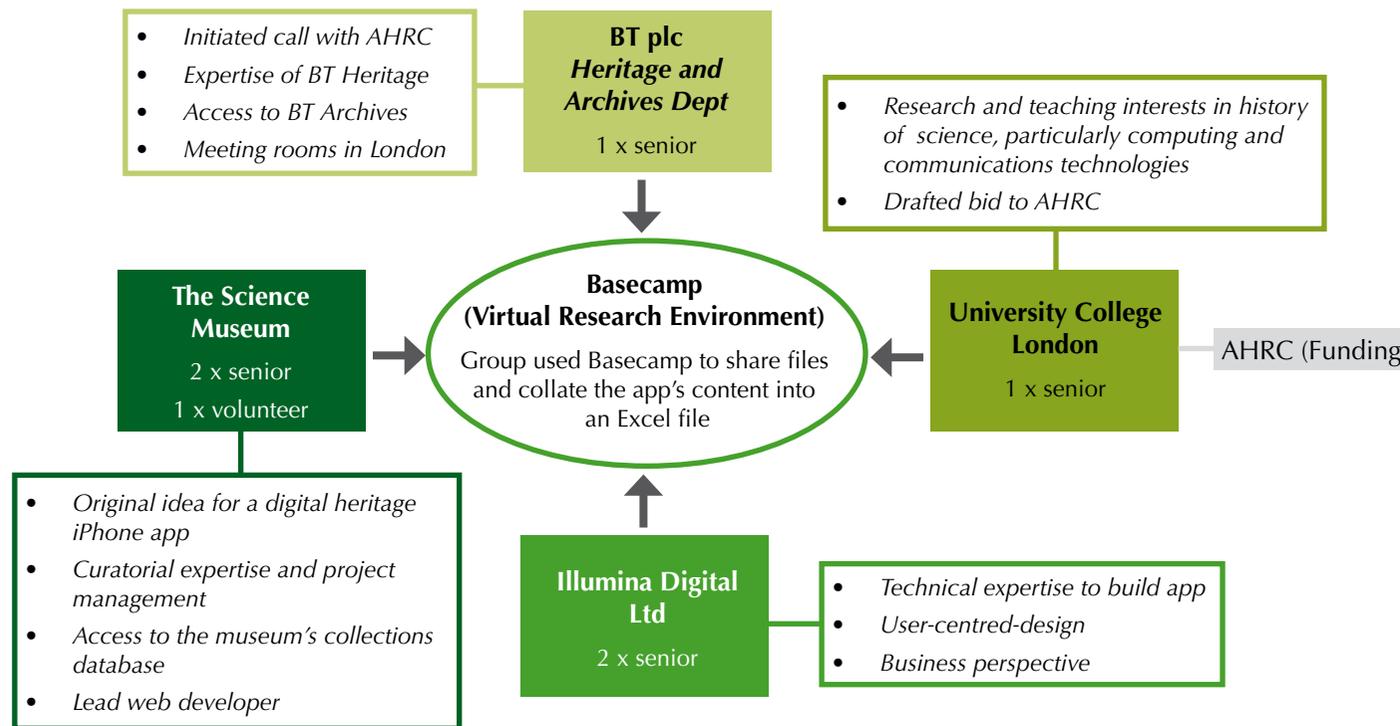
Each centre is free to form local partnerships academia and industrial partners and a strategic collaboration exists with certain industry partners; for example SGC Oxford collaborates with partner corporations on specific chemistry tasks. Senior members of staff act as the within the commercial organisations liaise with SGC Oxford and managed the work carried out by more junior researchers.



Locating Communications Heritage

This was a small collaboration involving just two senior staff from the Science Museum, two from Illumina Digital, and one each from UCL and BT Heritage. Some discrete tasks were delegated to internal staff at each organisation, but in general the aim was to rely on the skills of the project team and not to draw on wider organisational resources. The partners hoped that this would simplify decision making and communication

across the group, and avoid delays associated with formal collaboration agreements and the involvement of legal teams. Commercial partners brought with them a culture of 'fail fast', which seeks to avoid over-committing resources to pilot stage product development work of this kind. The project was thus self-standing and members did not access the wider resources of their respective institutions.



In each case study, a number of different partners were interviewed, to create - as far as possible - a 360 degree picture of information handling, from a range of perspectives. Within each participating partner organisation, interviews covered the following roles:

- Project manager
- Lead researchers / lead academics
- Research associates
- Finance and administration officers
- Knowledge Transfer officers

In terms of the final participant profile, there was a predominance in this study of academic researchers and commercial partners as distinct from those in the public or third sectors. The commercial skew was to some extent as a result of the predominance of science, technology and medicine collaborations. While the PRISMA case study involved public and third sector partners, the individual participants recruited from these organisations tended to be from academic backgrounds.

Table 2: Breakdown of achieved sample by participant type

	HEIs	External	Support
Intelligent Care	Project manager 1 x Leads 2 x Junior 2 x KT officers	CEO (commercial)	KT advisor
UK Reactics	Project manager 3 x Leads 2 x Associates 1 x Admin officer 1 x KT officer	2 x Leads (commercial)	
PRISMA	Project co-ordinator (lead) Project manager 1 x Junior researcher (external HEI) 2 x HEI Admin	1 x Lead researcher (public) 2 x Junior researchers (public)	
Structural Genomics Consortium (Oxford)	Project manager 3 x Leads 2 x Associates	4 x Leads (commercial) 2 x Associates (commercial)	
Locating Communications Heritage	1 x Senior	Project manager (third sector) 2 x Lead (commercial)	

Conduct of the research

Each case study was managed by a single interviewer, with interviews taking place in the participant's workplace or, where this was not possible, by phone. Discussions were semi-structured, using a topic guide to ensure consistency of approach while also allowing researchers flexibility to respond and probe on points as they emerged. The interviews were digitally recorded, and coded according to a common analysis framework. The researchers then returned to participants to validate the findings and ensure that sensitive issues were not included within the final report.

The UK Reactics case study was used as a pilot to test our two-stage approach to the research. This project was relatively large, allowing us to explore the issues with a range of participants including junior and senior researchers from universities and commercial organisations of different sizes. It was also complete, which meant that we could cover every stage of the information handling life cycle. No significant issues with the methodology were identified.

Upon completion of all interviews, and after an initial round of analysis, a series of workshops were convened with RIN and British Library staff, case study participants and representatives of funding bodies, Knowledge Transfer Partnerships, publishers and academic institutions. We used these sessions to reflect upon and validate the project findings, but also to begin developing our recommendations to support better information handling and sharing in collaborative research.

Guide to the report

This is a thematic report which outlines the key insights from the five case-studies and four workshops, examining the overarching barriers and facilitators to enhanced information handling in collaborative research. It is accompanied by five case-study reports which describe how information was handled in each of the collaborations and provides more detail on the specific issues, barriers and facilitators exhibited by each.

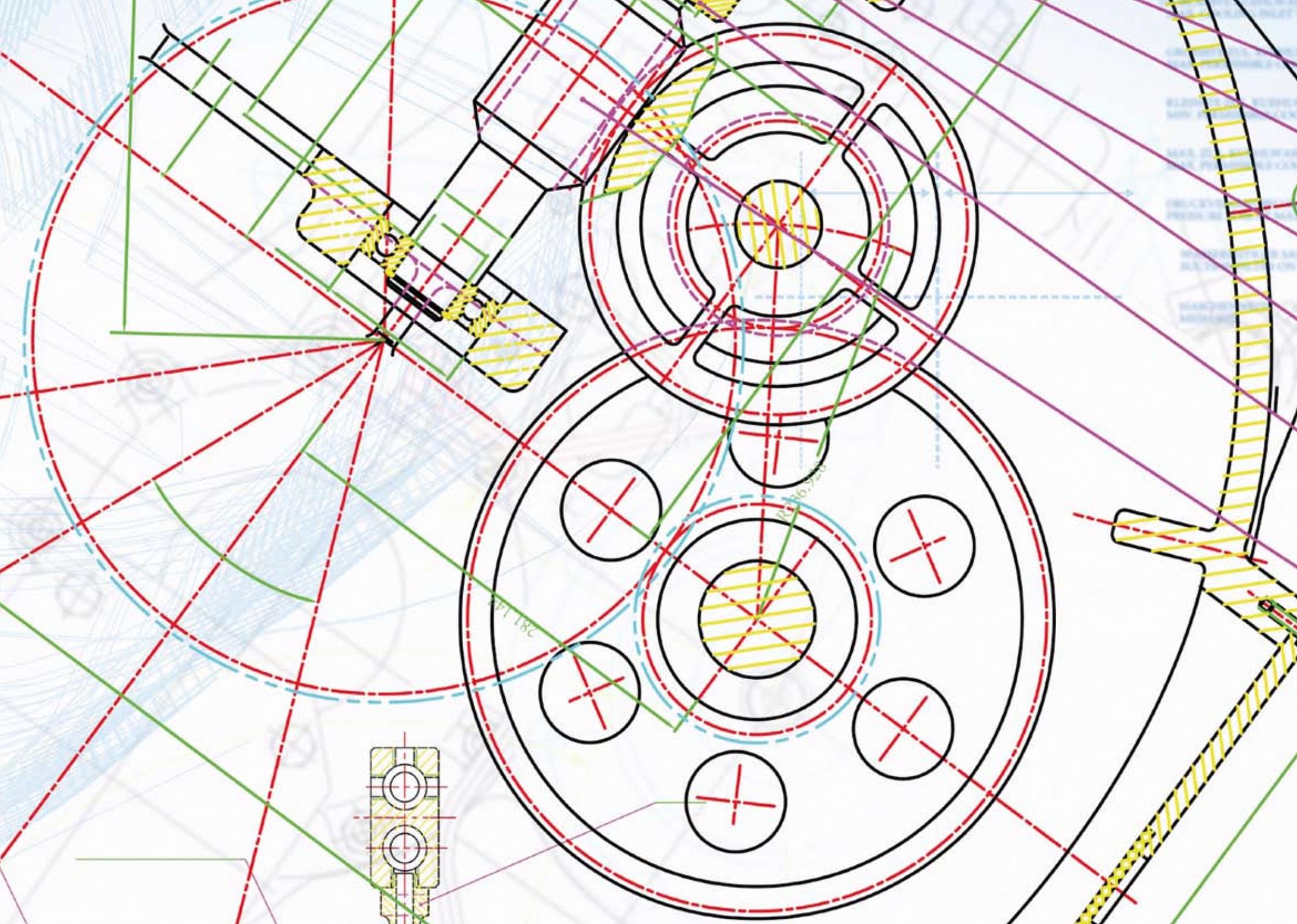
Throughout the report, verbatim quotes are used to illustrate key findings. These are referenced using the name of the collaboration and the type of participant. For example:

(SGC, Academic Researcher)

(Intelligent Care, Commercial Partner)

(Locating Communications Heritage, Third Sector Partner)

Chapter 2 explores researcher behaviour through the research lifecycle, using the case studies to show what does and does not work in supporting effective information management. Chapter 3 outlines the main dimensions which appear to differentiate information handling practices within the five collaborations. Chapter 4 provides a framework for influencing and changing information handling behaviour, based on these findings. Finally, Chapter 5 summarises the key messages from this research and provides recommendations to improve information sharing in collaborative research projects.

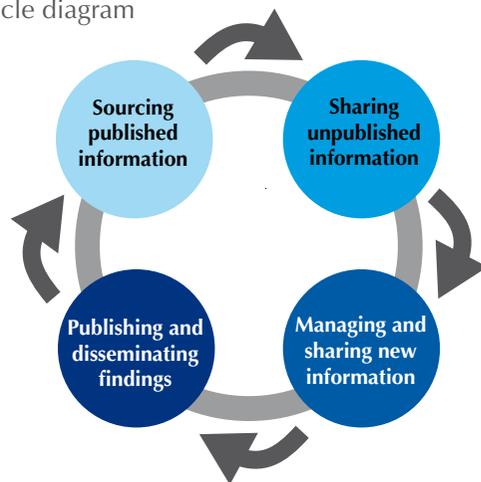


2. Information handling throughout the research lifecycle

In each case study, we looked at researchers' handling of information and knowledge at each stage of the research lifecycle. We tried to distinguish between formally-codified information and more tacit knowledge. Each stage of the cycle involves activities relating to specific types of information and knowledge:

- Sourcing published information – anything in the public domain, including journal articles, conference reports, books, datasets and grey literature.
- Sharing internal information and knowledge – anything held by partners prior to the collaboration, such as reports, datasets, product or market information, models, software, work processes and tacit knowledge.
- Managing new information – all information and knowledge generated during the project, including experimental data, analysis and models; procedural materials such as workflows, financial information and progress updates, tools such as software to analyse or present research outputs
- Publishing and dissemination – all research outputs including journal papers; IP and commercial products as well as dissemination tools such as open access repositories.

Figure 3: Research lifecycle diagram



Information handling was rarely a priority within collaborations. Any attention to this area generally focused on the final stage of publishing and disseminating. Mechanisms for sharing information and knowledge at earlier stages were rarely planned, and participants did not consider this to be a significant project risk. That said, project timelines outlined roles and responsibilities for generating data, and within the larger, more complex projects they also included a process for ensuring that information was fed back to the wider collaboration as needed. However, researchers did not feel that they needed further support or guidance in managing data, as their existing methods enabled them to meet their main project objectives.

Sourcing and sharing published information

There was no evidence that researchers experienced significant barriers when sourcing and sharing published information, for two main reasons. First, responsibility for this activity rested with the academic researchers who, broadly speaking, had good access to published materials via their institutional and personal networks. Second, researchers did not always consider the copyright restrictions in place on journal articles when sharing published information with partner organisations. Thus the collaboration as a whole rarely experienced barriers to access, even where those barriers legally ought to have existed for at least some partners.

Sourcing information

Previous research has shown that small and medium enterprises generally have limited access to journal databases, a finding which resonates with our cases. Some of the larger commercial partners (UK Reactics and the large pharmaceutical organisations in SGC) had access to extensive research resources, but there was little evidence of these resources being shared with partners to support the collaboration. Commercial partners would occasionally send relevant articles to other consortium members, but there was little planning for systematic usage throughout the project.

In some cases, the different levels of access enjoyed by large and small commercial organisations caused confusion, and the academics assumed that most partners had comparable (and high) levels of access, and could therefore legitimately be sent copyrighted materials – even when this was not the case.

Another level of complexity was added by the varying access levels of higher education institutions. Although university partners generally had better access than commercial organisations, smaller institutions sometimes had to rely upon larger partners to access necessary materials. For example, one junior researcher based in a smaller university did not have access to the papers she needed to complete her literature search, and so approached a colleague at a larger organisation. Other researchers at smaller institutions visited larger sites to take advantage of walk-in user rights.

Most initial information-gathering was done using online resources. For Intelligent Care, market information was an important priority. Researchers conducted a review of the market, legislation, potential manufacturers, client base and relevant trade associations, all gathered using publicly-available online sources such as organisational websites. For scholarly information, researchers used electronic journals and databases alongside search engines such as Google Scholar to identify relevant material. This was usually done by junior researchers, with differing levels of senior support across the five cases. Senior researchers also relied upon professional networks to learn about important content, and would approach colleagues for guidance on appropriate resources. Both online searches and personal networks were considered convenient and were habitual within academia.

Some academics spoke of the lack of time available to absorb and sift through the information they collected. Many participants highlighted the need for strategies to help filter and refine the information to make it manageable and relevant; for Intelligent Care the KTP Associate took on the role of producing summaries of material and circulating these to the group, rather than distributing the source papers alone (see case study example 1).

“Some KTPs are using artificial intelligence tools to filter information to find the relevant stuff, to find the needles in the haystack and bring the relevant information to the attention of the partners; assessing information is a critical success factor”. (KTP Advisor, Intelligent Care)

Case study example 1: Academic researcher - role in filtering information

The Intelligent Care project required extensive information sourcing, drawing on academic papers, patents and market data to understand the viability of the technology and the potential market value. The commercial partner did not want to be overloaded with information. Therefore, the academic associates were responsible for filtering and summarising pertinent information and communicating that to the commercial partner during weekly review meetings.

Overall, there was little acknowledged use of library and information services by academics to source published information, and very little contact between library specialists and researchers. Overall, researchers felt that any benefits from using the library would be outweighed by inconvenience.

- Contacting or visiting the library was considered inconvenient when compared to searching online or accessing online journal databases which was instantaneous and available via researchers' own desktops. Although online access was managed by their institutional library services, few researchers were aware of this, leading to their belief that they rarely used library and information services.
- Library and information services provided by academic institutions were considered too generalist and designed for students rather than researchers.
- There was a belief that university libraries were of limited use as sources of commercial information and information could be better sourced online or through direct contact with the company in question.

- There was limited awareness of specialist libraries and even where individual researchers were aware of a specialist service, they did not always pass this knowledge on to others within the collaboration.
- Academic partners' expertise in the field was seen as sufficient; it was felt by all partners that the academics selected already had a good knowledge of the theoretical background to the research and were able to draw on professional networks to fill any gaps.
- Sourcing and filtering relevant information was considered to be a necessary exercise for researchers, particularly as this process led to a deeper understanding of context of the project and the wider knowledge base.

Case study example 2: Using specialist LIS

In future the project manager for Locating Communications Heritage was keen to draw on the Science Museum's library (held within the Imperial College library), JISC and special collections at the British Library. The Oral History Department of the British Library was also identified as possibly playing a role in future developments of the smartphone app, such as the inclusion of audio or video clips.

Case study example 3: Using specialist LIS

A specialist library was used by one researcher working on a literature review within PRISMA. The Halley Stewart Library at St Christopher's Hospice comprises an extensive collection of books, journal articles and various types of unpublished printed material, on hospice and specialist palliative care and allied subjects. He had learnt about the service during his PhD and accessed it again as part of this project to source the required papers.

There were examples of individuals who engaged with library resources very effectively during their collaborations (see case study examples 2 and 3), suggesting that low use of library services is partly linked to poor awareness of what is available. There were examples of important resources going unused by all but a few researchers, such as a specialist library on palliative and end-of-life care maintained by St Christopher's Hospice in London.

Sharing published information

When sharing published research information, researchers did not generally recognise or adhere to copyright restrictions, despite strict restrictions on sharing for commercial use with associated financial penalties. There were several underlying reasons for this:

- Differences in access levels between large and small commercial partners meant that researchers found it hard to judge who could legitimately be sent the information.
- Most publishers have specific licence agreements, meaning that what might be legitimate sharing for one publisher constitutes an infringement for another. Most researchers could not make the distinction.
- Confidentiality agreements contributed to the belief that researchers were able to share any information within the collaboration.
- Researchers' own understanding of the copyright laws was in some cases limited.

In all cases, researchers tailored their sourcing and sharing of published information to meet the specific needs of their partnership. Several collaborations required literature reviews, particularly where projects were building on existing learning to create commercially-viable products. But it was rare for all partners to need direct access to the primary research, and in many cases the digested review was adequate.

The overall breakdown of work among collaboration partners determined much of the information-sharing behaviour. Academic partners in Locating Communications Heritage, for example, reviewed existing materials to produce descriptions for the smartphone application, but the commercial partners developing the software had no need to see that information. Similarly, the three SGC centres in Oxford, Toronto and Stockholm were purposely given entirely different protein groups to work on, so there was no need to share project-specific information, although there is a certain degree of exchange with regards to core technologies. PRISMA, on the other hand, had more linkages between the different work packages. In these cases, the results of literature searches were shared, and overall information needs were discussed at monthly project meetings with the heads of each working group.

Sometimes, partners needed *less* information rather than more. Commercial partners, in some cases, did not have the time or inclination to read large amounts of background information, so academic partners were expected to digest and pass on only the most relevant content. This attitude was particularly prevalent among the smaller commercial organisations, while some larger organisations with more resources to commit to the project would view it as an opportunity to maintain their knowledge of the wider field (see case study example 4).

Case study example 4: Different information needs

The UK Reactics consortium included both large industry partners and SMEs, including manufacturers and university spin-off companies specialising in IP. The smaller organisations were less able to devote time to reviewing the associated literature. However, the commercial organisations viewed the project as an 'academic exercise' and an opportunity to understand the direction research was taking in their field, although this did result in IP activity for the larger organisations. Consequently, they were interested in gaining insight into the wider theoretical background, and gave additional time to the project in order to allow their researchers time to digest materials.

Key findings

- The scope of published information sourced in collaborations depended largely on the importance to the project and the knowledge of academic researchers, who were the principal gatekeepers.
- Some academics sent copyright information to commercial partners without a full understanding of potential financial penalties.
- Few academics were utilising university library services or working with information specialists in large commercial organisations.
- Opportunities exist for library and information services to support imbalances in access to published information, provide specialist support, to help synthesise information, and provide advice on copyright.
- Lack of awareness, ingrained habits and a lack of a proactive, tailored approach from library and information services themselves present distinct barriers to uptake.

Sharing internal unpublished information

With the exception of SGC - which did not involve generating or protecting existing IP - and Locating Communications Heritage - which was a pilot project - all collaborations had non-disclosure agreements (NDAs) which safe-guarded researchers' background IP when sharing unpublished information. But NDAs – in isolation – were not always enough to support the free flow of unpublished information. Trust between individuals was also critical, and emerged either from longstanding personal relationships based on previous experience of working together or from a shared culture (such as between those with academic backgrounds).

"You need to reinforce with the academic what can and can't be discussed and you need to develop those relationships over time and build that trust up and as you build that trust up you come into a position where you can divulge more and more to them"
(UK Reactics, Commercial partner)

Cultural norms within different commercial organisations also had a significant impact on attitudes to sharing unpublished information. The most significant barriers emerged when commercial partners were asked to share their unpublished data. The default position of some commercial organisations was to treat all information as confidential unless there was a specific request for unpublished information, in which case special consideration was given to releasing those materials. In one collaboration, commercial partners withheld internal data which they knew to be relevant; although this did not damage the project, sharing the data may have avoided duplication of work.

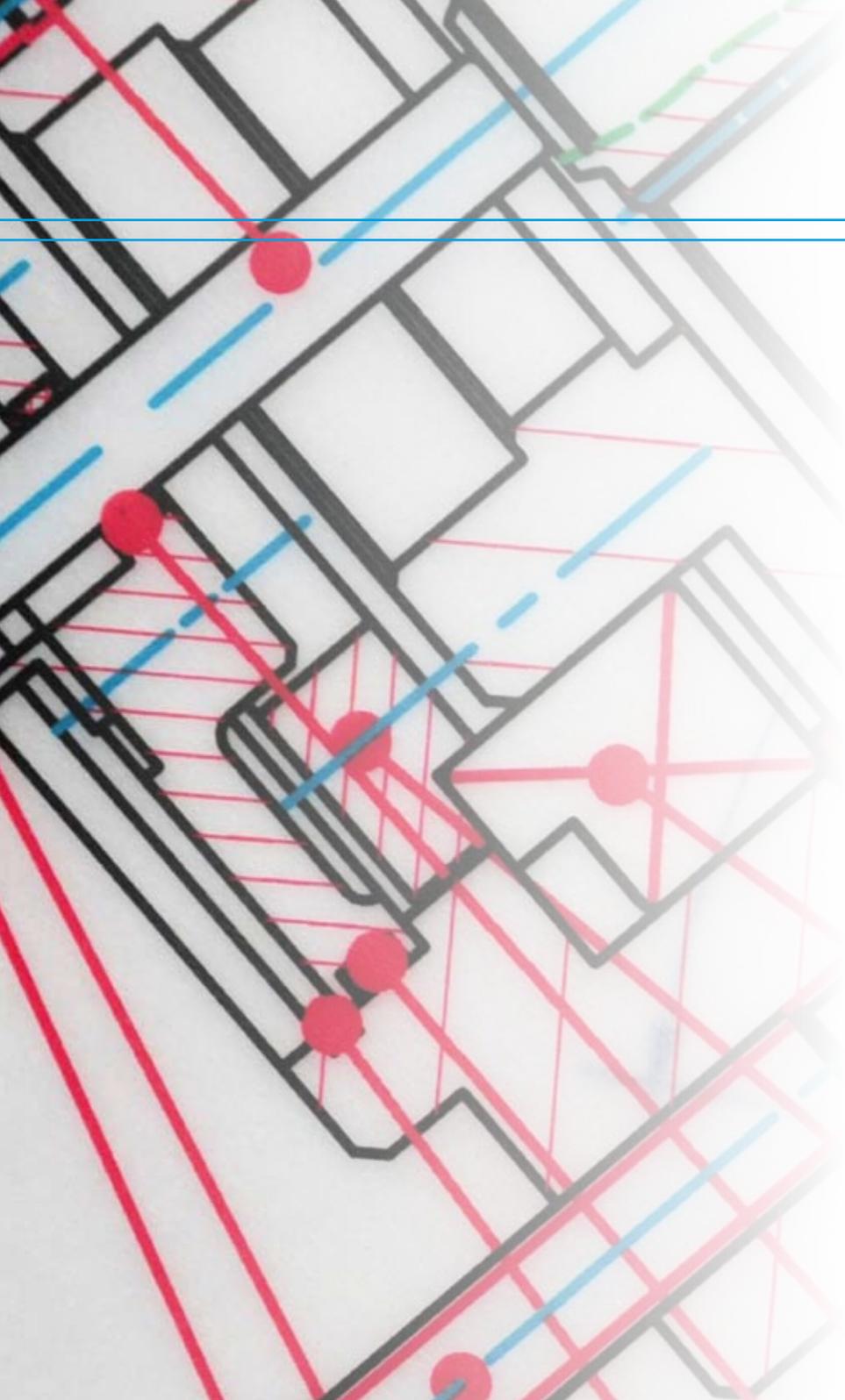
Across the five cases, academic and public sector collaborators seemed to have much more open practices, and there was no evidence of these partners withholding information pertinent to the research. This was more complicated when academics were working concurrently on several different collaborations. The information they could share was set out in NDAs relating to each project, and academics were clear about restrictions on IP, research materials, data and other information outputs. But there

was less clarity about the tacit knowledge they gained through those collaborations, which they regarded as part of their intellectual capital. This included subject-specific knowledge concerning the outcomes of different processes and the implications of research findings on wider academic discourse, as well as methodological expertise and knowledge of effective working practices in collaboration. On reflection, academic researchers felt that the distinction between confidential information and their know-how was not always clear and as a result they were more cautious where the focus of two projects was similar. However, academic researchers felt able to judge what information they could share in an informal setting without jeopardising the commercial advantage of other partners.

Free sharing of unpublished information was important to help researchers tap into areas of knowledge or expertise they might not otherwise have been able to access, and in some cases this was important to project outcomes. So where commercial or ethical sensitivities affected formal information flow, collaborations found compromises which allowed tacit knowledge exchange to take place, to ensure that the necessary information could be used. Some examples are as follows:

- Discussing commercially sensitive issues over the phone rather than communicating by email which would leave a record.
- Using strict information governance to prevent the sharing of commercially sensitive information within the consortium (see case study example 5).
- Ensuring that data was 'de-sensitised' by removing any ethically or commercially sensitive information (see case study example 6).

"We make sure that whatever data we share, within the partners, is not sensitive; whatever data we share is sort of de-sensitive"
(UK Reactics, Commercial partner)



Case study example 5: Strict information governance

In the SGC case, all information sharing happened with the academic SGC hub only. Commercial partners were not required to share internal information with each other. Sensitive information, such as the list of proteins nominated for investigation by partners, was anonymised to protect the strategic interests of individual companies.

Case study example 6: stripping out sensitive information

Third sector researchers in the Locating Communications Heritage project removed any details of benefactors and valuations from the database information they shared. Commercial researchers in UK Reactics created anonymised data sets that mirrored their own results without releasing commercially sensitive information.

Key findings

- Barriers to sharing unpublished information were more likely to arise when commercial researchers were required to share their internal data.
- Non-disclosure agreements were considered essential to the free exchange of information, but trust was equally important in securing sharing of sensitive information.
- Cultural norms can affect information sharing practice, with commercial partners more likely to adopt a cautious approach and academic partners more likely to be open.
- Changes to the funding environment may also be making academics and public / voluntary sector bodies more reluctant to share.
- Research outcomes were not necessarily affected by reticence to share data, as researchers could still share their expertise in ways that avoided exposing sensitive information.

Managing, sharing and storing new information

The core business of each collaboration was to generate new data and insights, but managing, sharing and storing new information was given less consideration in project planning than any other stage of the information management process. Planning, where it did occur, focused on final deliverables, and management of new information was seen as nothing more than a means to that end. Interviewees did not believe that this had a detrimental effect on research outcomes, but workshop participants suggested that poor management of new information could prevent re-use or wider dissemination in the future.

On a practical level, there are several challenges to data handling which are specific to collaborations:

- Information is often created and stored on different sites;
- Different organisations use different systems/software;
- There is a need to co-ordinate the contribution of several different organisations which may have different time pressures;
- The data produced may be commercially sensitive and therefore not appropriate for all partners to see;
- The Data Protection Act places restrictions on how personal data can be stored and shared.

When generating and sharing personal information, researchers were aware that they had to comply with the Data Protection Act and institutional agreements, although in practice researchers were not always clear on the details.

Within several collaborations partners stored data locally and shared analysis of parts of the data on an ad hoc basis. This often involved sharing of tacit knowledge, with a commercial partner bringing its market knowledge to bear on a dataset in order to identify the most important areas for future work, for example.

In all five case studies, tacit knowledge sharing was at its most intense in this stage of the work. For most partners, this ad hoc sharing was quite adequate for the project's aim.

Data management received relatively little attention during the project planning process for two main reasons. First, it was not seen as a potential 'problem area' for future disputes, in the same way as IP ownership or non-disclosure were, and therefore not flagged for particular attention. Second, little value was attached to raw data and the associated analytical tools. Researchers wanted to avoid information overload, and so only wanted to see the data they needed to carry out a specific task.

Third, many of the smaller organisations did not have the capacity or knowledge to implement advanced information management processes:

"I've only come across [Virtual Research Environments] in huge companies so far, who have got massive intranets and resources and use that way of working internally...a small company might have got as far as we've got the internet, we'll open a file!"
(Knowledge Transfer Advisor, Intelligent Care)

Where a greater emphasis on data management existed, this was usually because it was central to the project's purpose. SGC, for example, had carefully to manage the data it sent to commercial partners for analysis to ensure that none of them gained a competitive advantage. The consortium also had to ensure that none of the partners could benefit from research findings before they were released publicly. The main aim of Locating Communications Heritage was to develop a model for future collaborations, and researchers were therefore forced to think about the process of data management rather than simply adopting habitual behaviours.

There was little evidence to suggest that failing to plan and manage new information caused significant problems for any of the other three case studies. But workshop participants mentioned projects which had experienced inefficiencies and required additional funding because datasets were difficult to navigate and share with other partners. For example, on one STM project analysis software was not specified at the outset and data outputs were consequently incompatible. It is possible that similar problems may exist for our case studies, but that researchers are not yet in a position to notice them, particularly if the research has not yet been completed.

Some participants acknowledged that there were possible benefits to better data management. These included saving time, increasing transparency and better opportunities for learning and knowledge exchange. But these benefits were usually outweighed by concerns about additional administrative burdens.

"[Sharing information via email and CD] did work, but I don't think it was a very efficient way [...] after some time I may lose the CD or it might get corrupted or I might not even know that it exists [...] so I think we need to have a centralized database. Having said that [...] we shouldn't put any additional constraints or paperwork for us"

(UK Reactics, commercial partner)

Across the five case studies, there was little evidence of researchers adopting central data repositories, virtual research environments or online tools for storing or sharing data. The main barriers were perceptions such as:

- concerns about security and whether repositories could be hacked into or data stolen;
- uncertainty about whether they were disclosing information when uploading it to a repository;
- uncertainty about the effect on IP ownership and whether the organisation which hosted the repository would effectively own all the information;

- the impact on efficiency if the repository was difficult or time-consuming to use; and
- the costs of setting it up and managing it.

Many of these perceptions could be addressed by a better understanding of the issues involved, particularly those about security and IP. Above all, researchers were heavily influenced by habit. Rather than exploring new tools or methods, they tended to use familiar systems which they knew to be appropriate, and 'tried and trusted' methods of handling and storing data. Like most other areas covered by this study, management of new information was strongly determined by cultural norms.

That said, an individual researcher with experience of using data repositories could sometimes persuade the rest of the collaboration to adopt them. Once colleagues had been convinced, the influencer then had to educate them to get the most out of the repositories. Researchers working in fields such as digital technology, where the use of online platforms was more commonplace, were particularly successful influencers. They had a better understanding of the benefits of a well-managed dataset and had learned to overcome any barriers. But people with these skills do not exist in most research collaborations.

Key findings

- Researchers lack clear motivations to plan data management and to store or publish data for long-term reuse.
- Data repositories have the potential to improve information collection, sharing and re-use.
- Barriers to greater use of data repositories are substantial and include researcher inexperience and habitual preference for familiar tools.
- Researchers with experience of using such tools and their benefits can act as influencers to drive wider uptake.

Disseminating and publishing research results

In all five case studies, there was some degree of planning for disseminating and publishing outputs. This area received the most attention of the four research lifecycle stages, and perhaps reflects researchers' preoccupation with outputs and outcomes.

Three of the five case studies used standard agreements provided by their funders as a basic template for their agreement, but customised it to reflect the specific needs of their projects. Areas for negotiation included how IP ownership would be determined; where, when and how information could be published or disseminated; and how disputes would be resolved. Although some participants were aware of the Lambert toolkit – particularly project managers, who were more familiar and knowledgeable about collaboration agreements – the toolkit was not used by any of the case studies.

SGC and Locating Communications Heritage did not use existing agreements to shape their negotiations. The SGC project managers spent a year at the outset of the project negotiating an entirely new contract. As they were developing a unique model, standard agreements were not considered appropriate. In addition, the negotiation phase was important to build relationships and trust with industry partners. The Locating Communications Heritage team decided that negotiating a collaboration agreement would place an unnecessary administrative burden on the project. None of the partners expected to gain a commercial advantage from participation and there were strong personal relationships between individuals as they had worked closely on projects before. That being the case, the trust between partners was considered sufficient for the project to proceed without a formal agreement.

Although the specific agreements differed, there were three common features:

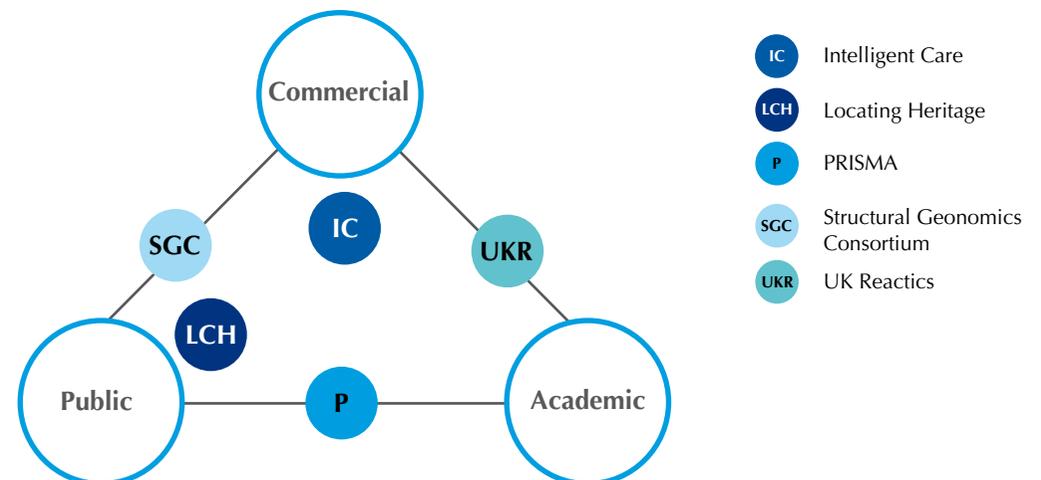
- In all cases there had been some form of negotiation about the nature of the outputs at the start of the project;
- All partners had agreed to the terms of the agreement; and
- Most cases included a procedure for dispute resolution.

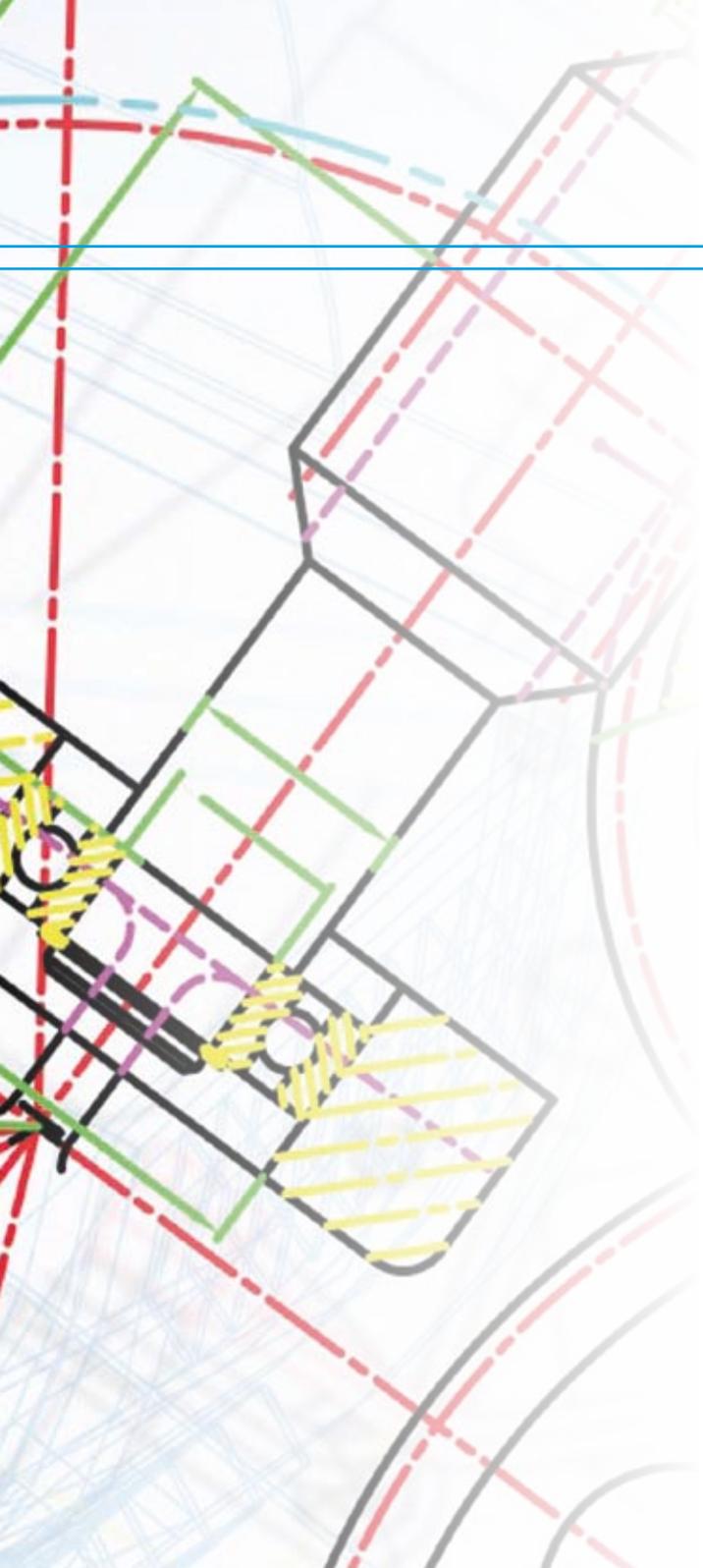
The contrasting – and in some cases opposing – needs of different partners within a collaboration could lead to problems around dissemination. In broad terms, the needs of partners depended upon their sector:

- Commercial partners wished to protect their competitive advantage, often by restricting, delaying or preventing academic publication entirely.
- Academics wanted to publish original research to enhance their reputation, which would help them secure future funding.
- Public funders wanted to demonstrate public value by disseminating their results – either for reuse by other researchers or as information for society at large – and by encouraging further collaborative working.

The different case studies can be plotted according to the primary drivers of their publishing and disseminating strategy, as illustrated in figure 4. Explanation of how the different component needs - publishing, commercialising and public value - are balanced is then provided in the case study examples.

Figure 4: The primary dissemination drivers for each of the case studies





Case study examples illustrating the different collaboration models which affected dissemination strategy.

Case study example 7: Protected working and open dissemination, in pre-competitive space

Structural Genomics Consortium (SGC) – The objective of the project was to build a pre-competitive knowledge base and reduce duplication of research through rapid open access dissemination. Therefore, from the inception of the project, dissemination of research data was an explicit goal. The aim was to map medically-relevant protein structures; from which academics and particularly the pharmaceutical industry could improve targeting of drug candidates and so far more than 1000 structures have been delivered, which is above the set milestones.. By bringing this information to the global pharmaceutical and clinical community without restriction the project minimised wasted resources in early stage drug development by avoiding multiple organisations working on the same protein structures in secret.

The SGC has helped to develop new software to deliver the research into the wider proteomic and clinical community, resulting in a novel platform (iSee) for displaying the interactive 3D structure of a protein, with integrated contextual information and references to other published work. The SGC has also worked in collaboration with major publishers to implement and use the iSee platform to provide a paradigm shift in the way that structural biology data and knowledge is distributed in peer reviewed journals. One example is a collection of SGC papers published by the pioneering, non-for-profit, open access scientific publishers: the Public Library of Science (PLOS)(see www.ploscollections.org/article/browse/issue.action?issue=info%3A%2F10.1371%2Fissue.pcol.v02.i04)

Why it worked: To ensure all industry partners were treated equally and to build trust, steps were taken to maintain 'black boxing' of work in progress, meaning that partners were not able to access working data held within the SGC centres and blind testing of anonymised compounds submitted by partners, all to ensure no advantage was given to any of the industry partners ahead of results being published. The finalised protein structures are uploaded to the SGC website and into a global public repository (see www.ebi.ac.uk/pdbe) as soon as they are generated. After public release of protein structures, how these findings are taken forward by partners for drug development remains confidential and is commercially sensitive to each individual pharmaceutical partner. Indeed the wider industry enjoys the same level of access to these results as the companies actively paying to be part of the consortium.

Case study example 8: Pre-commercial, non-publishing

Intelligent care – The collaboration aimed to develop both software and hardware to monitor the elderly in residential care. There was no scope to protect their intellectual property by filing for patents, because they were not generating any novel technology. Therefore, it was critical that the research outcomes remained confidential. There was no scope to publish research findings, although allowances were made for the publication of papers on the methodology.

Why it worked: The Knowledge Transfer Partnership assigned an advisor who ensured that researchers were given learning and development opportunities. In this way KTP collaborations support SME businesses whilst also giving researchers experience and training at an early stage in their career. The research assistants who were carrying out most of the work were at an early stage of their careers and so they valued the opportunity to gain experience within a commercial setting. However, this was on the basis of a fixed-term contract, and the researchers recognised that in the long term they would need to publish in order to progress.

Case study example 9: Pre-competitive, non-publishing

Locating Communications Heritage - this small scale pilot project explored the potential to create a smartphone app which would link information and multimedia with the exact location of an artefact or site of importance to the history of communications technologies. The partners decided that a formal agreement on dissemination was unnecessary because there was no immediate intention to commercialise the product; rather the project was concerned with testing the concept of an app and building working relationships necessary to take the idea forward. Although negotiating a contractual agreement was not considered cost-effective considering the added expense of involving the different legal teams, it still required the individuals working on the project to negotiate roles and responsibilities. Trust between the individual researchers made this possible.

Why it worked: Pre-competitive research with little commercial advantage to be gained from working in the collaboration. In addition there was trust between partners due to their previous experience of working together.

Case study example 10: Pre-competitive, delayed publication

UK Reactics – The project had an explicit commercial objective, to investigate the properties of a selection of auxetic materials and identify any potential commercial applications. It was therefore important to protect any competitive advantage gained through discoveries made during the research, and it was agreed at the outset that publication could be delayed in order to allow commercial partners to file for IP on any technology that was believed to have a viable commercial application. A 28-day vetoing window allowed all partners to review papers before they were released, to determine whether publication should be delayed. In practice, only one publication was significantly delayed.

Why it worked: Partners had considerable experience working of working in collaboration, and academic partners understood commercial sensitivities around publication while commercial partners understood academics' need to publish. Within the materials engineering field, being named on an IP application was considered to be as prestigious as publication.

In each case, the background of the partners and their specific circumstances determined the scope for negotiating a mutually-acceptable solution. Intelligent Care, for example, focused on developing a product which did not require any novel technology, and was therefore ineligible for IP protection via a patent application. If the information were put into the public domain, there was nothing to stop competitor organisations from manufacturing the device themselves and reaching the market first. For this reason, academic partners were not allowed to publish without the agreement of the commercial partner, and were not allowed to publish anything that revealed how the device was manufactured. In this case, it limited the academics' need to publish, but the junior researchers considered the experience and expertise they gained an adequate – if time-limited – replacement in terms of their professional development.

Case study example 11: Co-ordinating, disseminating and publishing

PRISMA – The primary goals of the project, as stipulated by the European Commission, were to encourage best practice both through dissemination of results to the wider research community and practitioners and by creating a network through the process of the research. The HEIs and public bodies were also able to publish findings through academic journals. Therefore, it was necessary to utilise a range of channels, including high profile journals, websites and press releases as well as drawing on networks (such as Help the Hospices) to reach practitioners.

Why it worked: The requirement to disseminate and to co-ordinate was the foundation of the project and built into deliverables. This requirement was largely consistent with the academic need to publish. Authorship was agreed upfront and negotiated throughout but to a large extent was dictated by the formal governance structure which assigned partners to working groups and underpinned by academic culture of trust

UK Reactics, although subject to similar pressures, was able to offer academics a slightly more flexible approach, where commercial partners were given a 28 day window to veto a proposed publication in order to protect their IP, as was standard practice within materials engineering collaborations. Journal articles were submitted to the IP owners for approval and also to the consortium as part of the project deliverables. In most instances IP applications had already been filed before the publication was submitted to the consortium, and so researchers were given permission to publish. In one case, the commercial partners were given six months to investigate the technology further before deciding whether the paper could be published.

PRISMA reached a similar compromise, although here it was the academics seeking to prevent their public sector partners from sharing the findings too early. The primary research objective was to disseminate best practice guidance to practitioners around Europe, so early sharing of results was desirable. Nonetheless, general dissemination

was delayed until journal articles had been accepted, as the partners recognised that there may be less interest in publishing the research findings if they were already in the public domain.

Broadly speaking, and depending of course upon the mix of partners and stakeholders involved, drivers of research dissemination existed in a clear hierarchy. Protecting commercial advantage – where this occurred – took precedence over all other outcomes. The academic need to publish and build reputation came second, and the need to gain public value from disseminating or encouraging further collaborations was rarely prioritised.

In some cases the hierarchy was less important, as the interests of several stakeholders could be served by the same approach. In the SGC, for example, data were carefully isolated within the academic part of the consortium and then published openly; this meant that no commercial partner gained an unfair opportunity whilst also securing the public value required by the project funders. In UK Reactics, the academics worked in a discipline where naming on a patent application was considered as prestigious as publishing in a journal, so the needs of both commercial and university partners were met. Workshop participants suggested that the effects of this hierarchy could be minimised further by the new Research Excellence Framework, which will link research funding to outcomes and ‘impact’ as well as output, traditionally measured via journal article publication. But it is not yet clear how this will be implemented, and how long it will take to change established attitudes towards academic publications as a measure of academic success.

Where dissemination was a main project aim, (SGC, PRISMA, and Locating Communications Heritage), the collaboration paid considerable attention to tailoring its message to various audiences. The Wellcome Trust requires that all papers originating from research which they have funded is made publically available and is open access. Therefore, the SGC’s dissemination included making a collection of key journal articles open access via PLoS, and novel e-publishing of results in an enhanced interactive format (iSee, case study example 12). Both PRISMA and Locating Communications

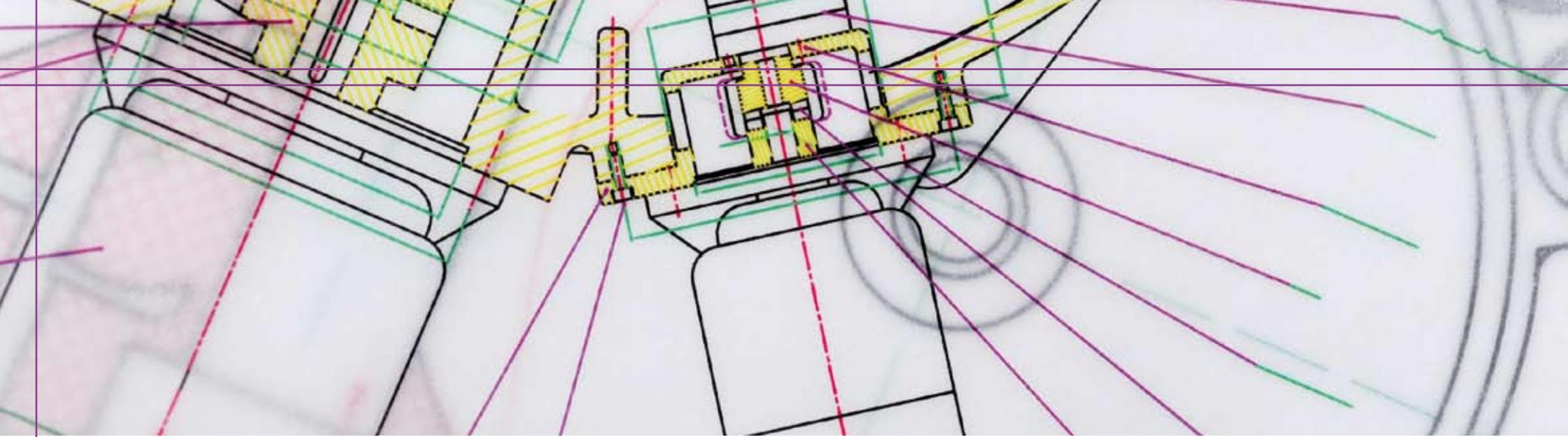
Heritage identified the benefits of involving the public in their dissemination strategies. The Locating Communications Heritage project set up a blog to involve the public and the heritage community throughout the process. The intention was to pursue this online dialogue within the app in a second phase. Whilst full engagement presented more challenges for PRISMA because of the frailty and vulnerability of their particular audience, they were careful to communicate findings; the project manager and project lead carefully planned dissemination methods and established templates to ensure that summaries were written in lay terms which were then published on the PRISMA website. They also built relationships with relevant practitioner networks via public body partners who proved invaluable in disseminating to these audiences.

Case study 12: Open access dissemination

SGC publishes protein structures as rapidly as possible and without restriction, both via its website and into a public database (PDB). The enhanced iSee datapack format developed by the SGC allows users to view and manipulate the 3D structure, with embedded notation and key features highlighted. The format is intended to engage the proteomics community, clinicians and students.

Key findings

- It was common practice for all partners to agree a dissemination strategy.
- Strategies were bespoke to the project and reflected the research outcomes and the needs of individual partners.
- Currently the compromises involved may be limiting the public value that could be gained from wider dissemination of collaborative research.
- Changes to the funding environment and open access methods suggest a way forward that incorporates greater public value.



3. Key differentiators of information handling practice in collaborative research

At each stage of the research lifecycle, multiple factors affected information handling, with each factor either intensifying or reducing the effect of other factors. Within our five cases there was little homogeneity in terms of the issues identified or the solutions which partners developed in relation to these factors, suggesting a need for nuanced planning and flexibility. Funders and policymakers made clear in the workshops that they were keen to avoid imposing a one-size-fits-all solution for information handling and sharing, since that could cause unforeseen knock-on effects.

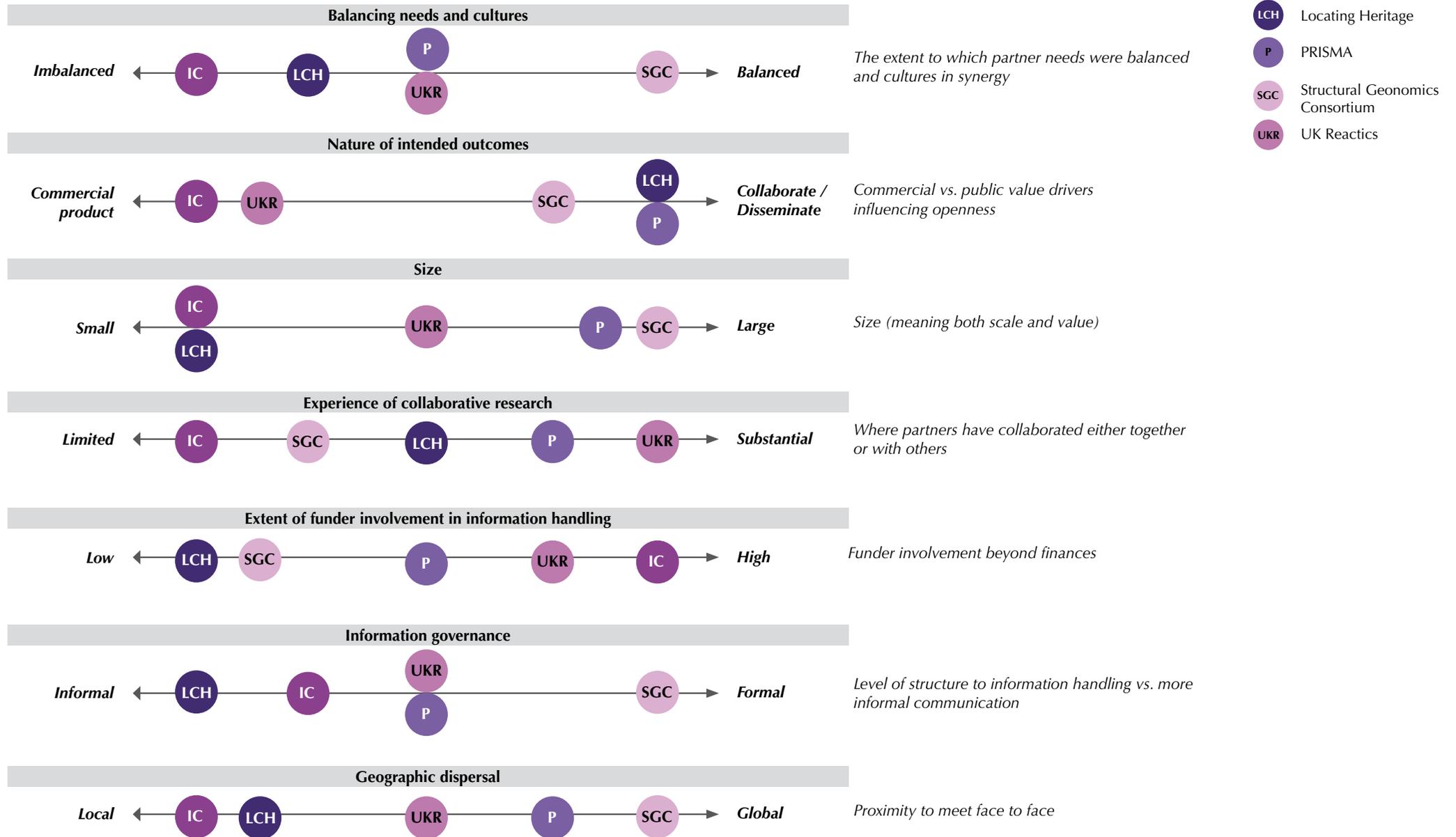
The key differentiators are, in summary:

- Balance of needs and cultures – were the needs of different partners met, and were the cultures within the partners complementary or contradictory?
- Nature of intended outcomes – is the project focused more on a commercial product or wide dissemination?
- Size – how big is the project in terms of money and other resources (time, number of researchers and experimental equipment)?

- Previous experience of working in collaboration – both in general and with the same partners.
- Extent and nature of funder involvement – including any support or advice provided as well as any mandatory elements which affected working practices.
- Formal governance versus informal communication – were information sharing procedures formally agreed and monitored or did researchers share information on a more informal basis?
- Geographic dispersal – the physical distance between partners.

Figure 5 plots the case studies according to each of the differentiating factors. Each differentiating factor is then described, with an explanation of the positioning of case studies, and the resulting differences in information handling.

Figure 5: Comparison of collaborations according to differentiating factors



- IC Intelligent Care
- LCH Locating Heritage
- P PRISMA
- SGC Structural Geonomics Consortium
- UKR UK Reactics

Needs and cultures

The mix of partners is an obvious but important differentiating factor for information handling practices within research collaborations. Each partner came to the collaboration with particular expectations and requirements, and with established ways of handling information. To an extent, these can be managed by a careful project design and setup, but where needs and cultures are very different, barriers to effective information handling can arise. The scale shown below (figure 6) indicates the similarity between working cultures and the extent to which needs of both parties were met with the collaboration outputs.

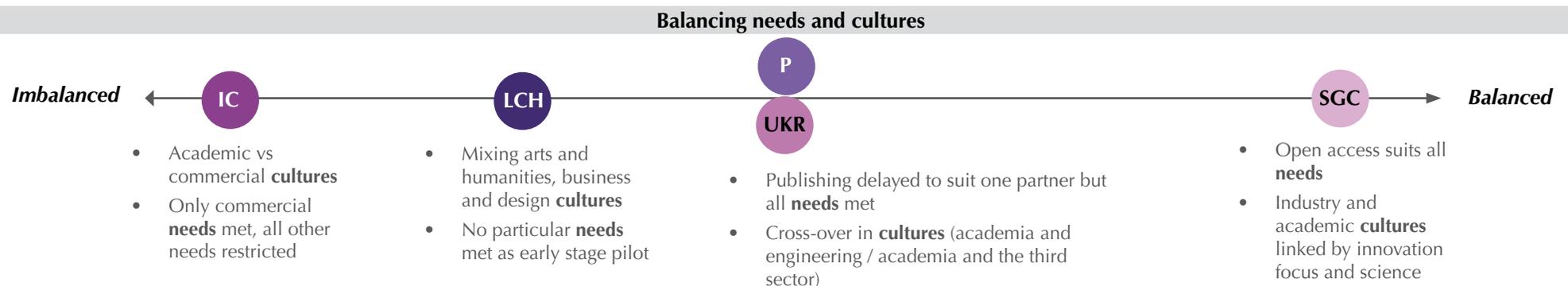
The SGC represents a well-balanced case, as partners were all committed to the open publication of protein structures. In addition, there was some overlap between the working cultures within the SGC's labs and those of industry partners. By contrast, the Intelligent Care collaboration focused on developing a product, and this outcome was firmly prioritised in information handling agreements, thereby placing limitations on academic publication to ensure that commercially sensitive information was not divulged.

PRISMA and UK Reactics prioritised the desired outcome of one partner (for example filing for IP or publishing in high impact journals) and delays or restrictions were placed on other partners, although procedures were in place to ensure that all partners were able to achieve their desired objectives in the longer term. As a pilot project, Locating Communications Heritage focused more on exploring the potential of a future collaboration, and therefore there were few conflicts in terms of outcomes. However, there were a number of different working cultures to incorporate.

Within some of the larger collaborations, it was not just a question of balancing the expectations and cultures of academic and non-academic organisations, but also incorporating the differences between large and small companies. Identifying and managing these differences represented considerable work for all of the partners involved.

“This [collaboration] we've had to do the most work in terms of getting the contract right. Partly, I think because people have just generally got sharper in terms of what they needed in an agreement and there were nine partners on this which does take time to get everyone's approval [...] in this we had, not just universities but large multinational and small SME partners who again will have very different experiences and requirements [...] and very different resources to call on [...] so it was quite complex” (UK Reactics, Academic)

Figure 6: Balancing needs and cultures



The various organisations involved in a collaboration also had to establish standards for sharing information within the project. Each partner brought expectations based on its own internal systems, behavioural norms and past experience; from these separate positions the organisations needed to reach agreement on the appropriate way for the collaboration as a whole to organise itself. In particular, industry was seen to be much more time-sensitive than academia.

Another important cultural difference between the academic and commercial partners (in particular) was around openness. Both academic and commercial organisations were happy to share information with colleagues in their own organisation. However, most academics also routinely shared information with counterparts in other universities, even though these academics were, in some respects, their competitors. This trust-based relationship was considered fairly commonplace within academia, and shaped working practices with all kinds of external partners. Academics were thus often less guarded than their commercial partners when sharing information, both within the academic community and externally.

Commercial partners demonstrated much more caution in sharing information, treating all research partners as external bodies and showing reluctance to provide them with sensitive data. This caution could, in some cases, affect the collaborative project's progress. Commercial partners were less likely to share information speculatively, usually only releasing data or advice to partners following a specific request. This meant that it could be difficult for partners to ascertain what information the company held which could be relevant to the collaboration.

The case studies revealed various compromises that were used to alleviate commercial partners' concerns. These included building in veto periods so that commercial partners could file for IP before academics published their findings; 'blinding' data sets in order to disguise key findings that would give a partner a competitive edge; removing sensitive material so that data could be shared with all partners; and generating dummy datasets. These compromises were carefully planned, and processes were put in place to ensure they did not affect the research outcomes.

Academic and non-academic partners also differed in their approaches to communication. Commercial organisations seemed more open to the use of new technologies such as online collaborative platforms; many interviewees felt that these were increasingly common tools within business. Academic researchers were perceived by some commercial partners to be more wedded to familiar methods and technologies, to have a different communications culture from the business world, and to respond less quickly to email discussions, often preferring phone calls or (ideally) face-to-face meetings. Most partners had a limited awareness of available technologies and none of the case studies had fully adopted a Virtual Research Environment (VRE), due to concerns about data security and the IP and disclosure implications of uploading information to cloud-based platforms.

That is not to say that these cultural divides in information handling culture are impassable or universal. In the SGC, the common nature of the work meant that information handling practices and technologies were similar in the central SGC lab and the industry lab. Furthermore, the pre-competitive work of the SGC requires ongoing collaboration on experimental science; internally among the SGC's staff scientists, with ad hoc research partners visiting from other HEIs to pursue mutual interests, and externally with partners working offsite across the pharmaceutical industry investors. This means that experimental data is managed in line with scientific and industry convention, with all partners using a combination of interoperable database software, accompanied by lab notes stored in an Electronic Lab Notebook (ELN) package.

In the engineering collaborations there was some evidence that academics valued the experience of working within commercial cultures, very different from their own experiences. For early-career researchers, collaborative research builds skills for the future, enabling them to translate theoretical knowledge into practical solutions.

"It gives exposure to real world problems. It can sometimes be an eye opening experience in terms of what actually industry requires, what are the problems they face and the solutions they can be happy with."
(Intelligent Care, Academic supervisor)

Given these cultural differences, the success of a collaborative project also hinged to some extent on the capacity of researchers, with their own concerns and priorities, to negotiate and adapt to the needs and behaviours of other individuals working on the project. Personalities and existing relationships were an important precursor to effective information exchange. But they remained a secondary consideration when selecting partners for a research collaboration: it was always more important to achieve the right mix of skills and access to the appropriate resources.

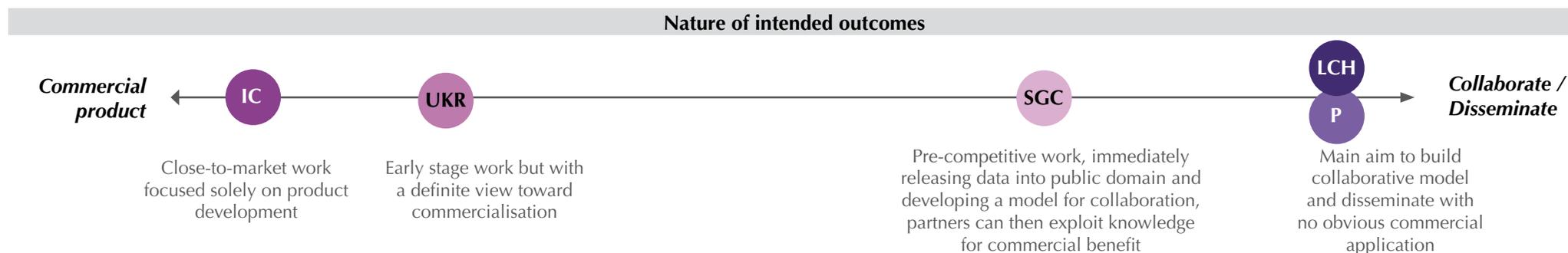
Nature of intended outcomes

Information handling and sharing practices were also shaped by the overall objectives of the collaboration. The key distinction is between projects seeking to disseminate research findings as widely as possible, or to establish the basis for future collaborations, versus commercially-minded projects that were aiming to develop and retain control over a new product or service.

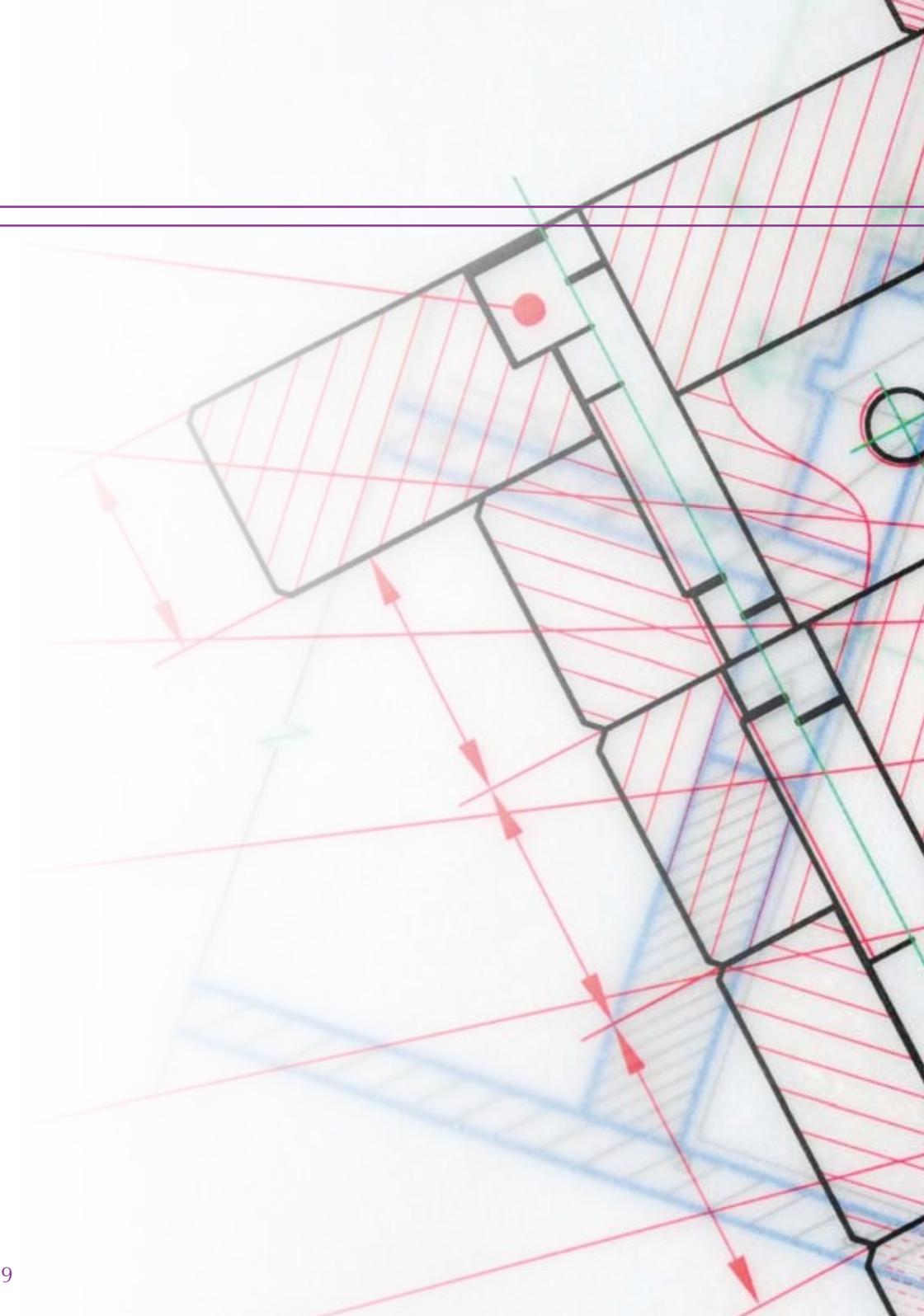
Intelligent Care and UK Reactics both had a clear commercial focus. Reasonable restrictions were placed on dissemination, to meet the needs of the academic researchers once the appropriate commercial protections were in place. By contrast, PRISMA's funding arrangements specified that dissemination of research results was a primary objective. Alongside academic partners' desire to produce papers targeted at prestigious high impact journals, there was a continuing drive within the collaboration to produce publishable outputs of use to the clinical community and to build communication networks of mutually interested researchers. As a pilot, Locating Communications Heritage was primarily concerned with testing the concept (developing a mobile phone app) and determining whether the collaboration model was effective. The SGC model was unique, as dissemination and collaboration were both key objectives, but in support of a longer term commercial (and competitive) goal.

Those projects focused on commercial product development had quite restrictive policies around information sharing. All decisions were affected by the commercial partners' anxieties about intellectual property. When agreeing what to share, industry partners emphasised preservation of existing IP and securing rights for any new products and services developed. They were also keen to ensure that any business strategy deemed sensitive was protected. This limited the opportunities for academic publication.

Figure 7: Nature of intended outcomes



In projects focused on dissemination, a different set of issues came to the fore. In these instances it was openness, rather than protectiveness, which jeopardised academics' abilities to publish; the non-academic partners' eagerness to share their findings meant that researchers might not be able to claim 'novelty' or assert their ownership of new insights via a published article before the information reached the public domain. PRISMA dealt with this by building publication in prestigious academic journals into its project objectives, and ensured that this complemented the wider programme of press releases, conferences, symposia and the project website in the project communications plan. In the SGC, the academics accepted that they were not able to publish academic papers before the research results were released into the public domain, but were compensated by the high prestige of participating in the project. Indeed, the SGC's entire strategy was defined by a desire to share as much information as quickly as possible, thereby creating efficiencies by enabling collaboration in an industry which is traditionally fiercely competitive. Within this highly-open environment, however, certain elements were not shared (such as the target lists of each participating company), in order to protect the longer-term commercial interests of commercial partners.



Previous experience of working in collaboration

Previous collaborative experience affected information exchange and handling in two ways. First, it helped establish the trust needed to underpin more open information sharing, and second, it provided an understanding of how to negotiate differences in processes and language. This was particularly true when partners had worked together before, but also to a certain extent when partners had worked in collaborations with similar organisations.

Trust between partners in a collaboration was often built on their previous experience, and this trust formed the foundation of all parties' confidence about sharing information. Personal relationships encouraged a proactive and open approach to information sharing, particularly where there were commercial or ethical sensitivities.

“Getting to know each other personally makes a huge difference, otherwise you're just a faceless collaborative and it doesn't really mean a lot – it's much easier when you're trying to badger people for things if you have that level of contact” (PRISMA, Academic)

Experience of working collaboratively also helped to overcome problems arising from conflicting needs and cultures. Researchers in well-established partnerships developed an understanding of how individual collaborators preferred to work, and of cultural norms in the partner organisations. This helped them to communicate more effectively, sharing information in a timely manner.

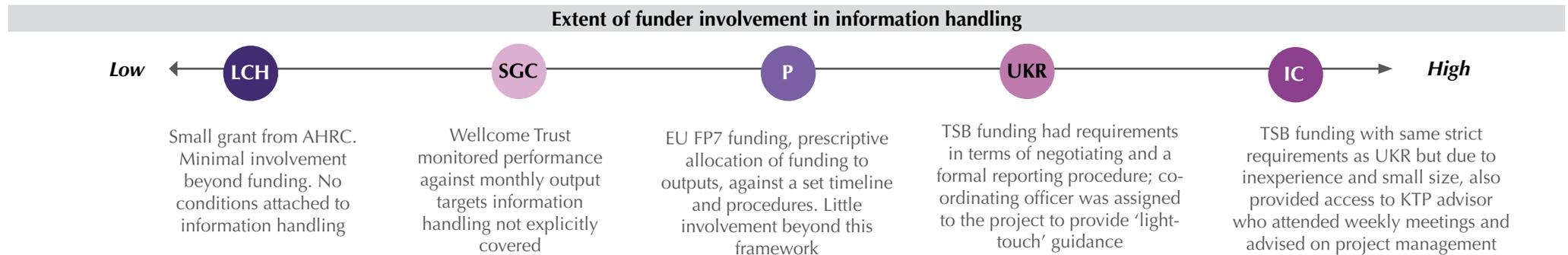
Where researchers were not in long-established relationships with their partner organisations, other methods were sometimes used to build trust. PRISMA held an initial meeting to establish shared objectives and an understanding of the concerns and priorities of all partners, and the SGC recruited its commercial partners by using trusted professional contacts as entry-points into negotiations. The focus on building relationships in these early stages supported information flows later in the projects, ensuring that researchers could approach each other for help and access to information that they could not get directly.

Figure 8: Experience of collaborative research



Extent and nature of funder involvement

Figure 9: Extent and nature of funder involvement



Funder involvement varied significantly across the five cases. Both SGC and Locating Communications Heritage received minimal input from the research funders (the Wellcome Trust and the Arts and Humanities Research Council), despite being at opposite ends of the spectrum in terms of size and resourcing. For PRISMA and UK Reactics, there were mandates covering reporting and progress updates, and some support and advice was available, although input into the research design and project management was minimal. For Intelligent Care, the KTP Advisor, assigned by the funder, played a greater role. This was largely because the two research associates responsible for project management and for sourcing, generating and storing of information, had relatively little experience of collaborative research. Therefore, KTP advisor provided guidance and advice on project management within the TSB guidelines. Advisors generally adopted a light-touch approach, providing advice and guidance where it was required and mediating any disputes.

"The role of that third party is to listen and watch and see when things start to look as if they could go off the rails. And coach them back into operation [...] and we know that if you take the monitoring officers out of the projects, all hell breaks loose" (Workshop attendee, KT Advisor)

With regard to information management, funders were primarily concerned with ensuring researchers agreed on IP ownership and non-disclosure agreements for information informing the research, and information produced as a result of the research. Researchers working on both the Intelligent Care and UK Reactics projects felt that funder involvement in these areas helped to ensure that robust agreements and project management systems were in place.

Contracts and agreements with funders often acted as a first point of reference when issues arose. The PRISMA contract, for example, was referred to throughout the project to ensure information was disseminated in an appropriate way:

"[Referring back to the contract was useful] in terms of understanding how we can disseminate information, in terms of understanding the European Commission's role in relation to what information we are producing, so their disclaimer statements and things like that, in terms of understanding what groups have in terms of ownership of the data that's being produced, in terms of media, in terms of funding and budgets, in terms of reports for them, so it has been quite handy." (PRISMA, Project Manager)

Collaboration size and geographic dispersal

Figure 10 illustrates the size of the five case study collaborations, determined by the number of partners and by the resources involved (particularly researcher hours and the budget, where this information was available). SGC is the largest collaboration by some distance. Intelligent Care was small in terms of research hours, but the project was longer-term and more intensive than Locating Communications Heritage, which involved a large number of individuals and organisations working at relatively low intensity.

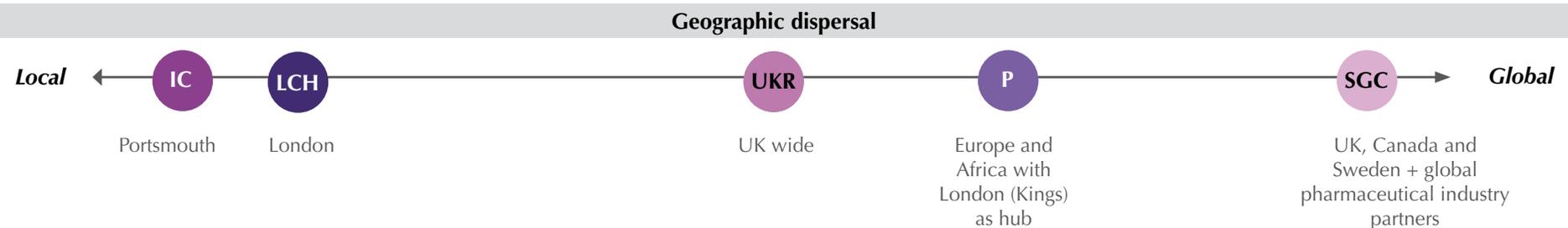
Figure 11 shows the geographical dispersal of the case studies. None of the cases were co-located, and only two were based in a single city.

Unsurprisingly, large and dispersed collaborations relied upon relatively formalised structures for sharing information and knowledge. PRISMA, for example, built knowledge sharing into their funding bid, securing money for an introductory meeting for all international partners, and finance to support researchers spending several months in partner institutions overseas. The global SGC consortium 'designed out' the need to share research information by ensuring that each of the three labs worked on discrete protein families, making each centre virtually autonomous and free to organise and manage itself locally, although the centres shared technical advances and best practice. In most of these cases, the project manager assumed a particularly important role in ensuring that processes worked smoothly and that everybody had the information they needed to do their part of the work.

Figure 10: Collaboration size

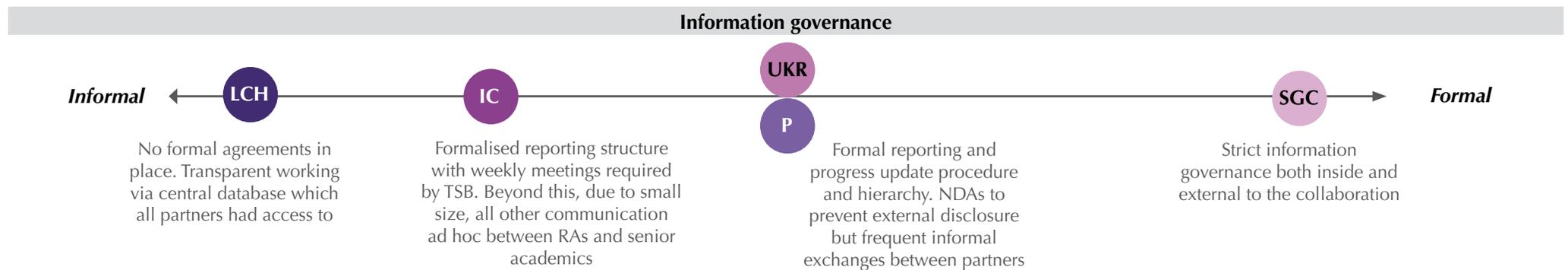


Figure 11: Geographical dispersal



Formality of information governance procedures

Figure 12: Formal and informal information governance



The previous five dimensions acted together to determine the formality of the information governance procedures, and how closely those procedures were followed. SGC and Locating Communications Heritage fall at the extremes of the spectrum. In part, this is because SGC is a large international collaboration, which requires strict information governance to function, while Locating Communications Heritage is a small, localised collaboration which can afford to be more informal. But in both cases factors other than size and dispersal affected their choice of information management regimes. SGC had to impose strict information governance procedures in order to protect the viability of the collaboration: it was essential that none of the commercial partners gained an unfair advantage – or were prejudiced – by careless information management.

Locating Communications Heritage, by contrast, decided that formal arrangements would increase the burden on researchers, who had limited time to spend on the project, and increase legal costs to the limited project budget. Intelligent Care, although involving fewer researchers than Locating Communications Heritage, had a more formal information governance framework, due to the TSB's concerns about the partners' lack of experience.

Formal governance structures helped collaborators to meet crucial deadlines, and to ensure that information was delivered to the right people at the right time. But in all five cases, informal channels were used alongside the formal structures in order to share information. These communications helped researchers answer questions quickly, and also contributed to building stronger relationships of trust.

Much of the day-to-day information exchange in UK Reactics happened informally, and was not recorded or monitored. As a consequence, there was limited scope to review or reuse the information shared between partners during the collaboration. However, researchers were resistant to formalising the process if this reduced the efficiency of day-to-day communications:

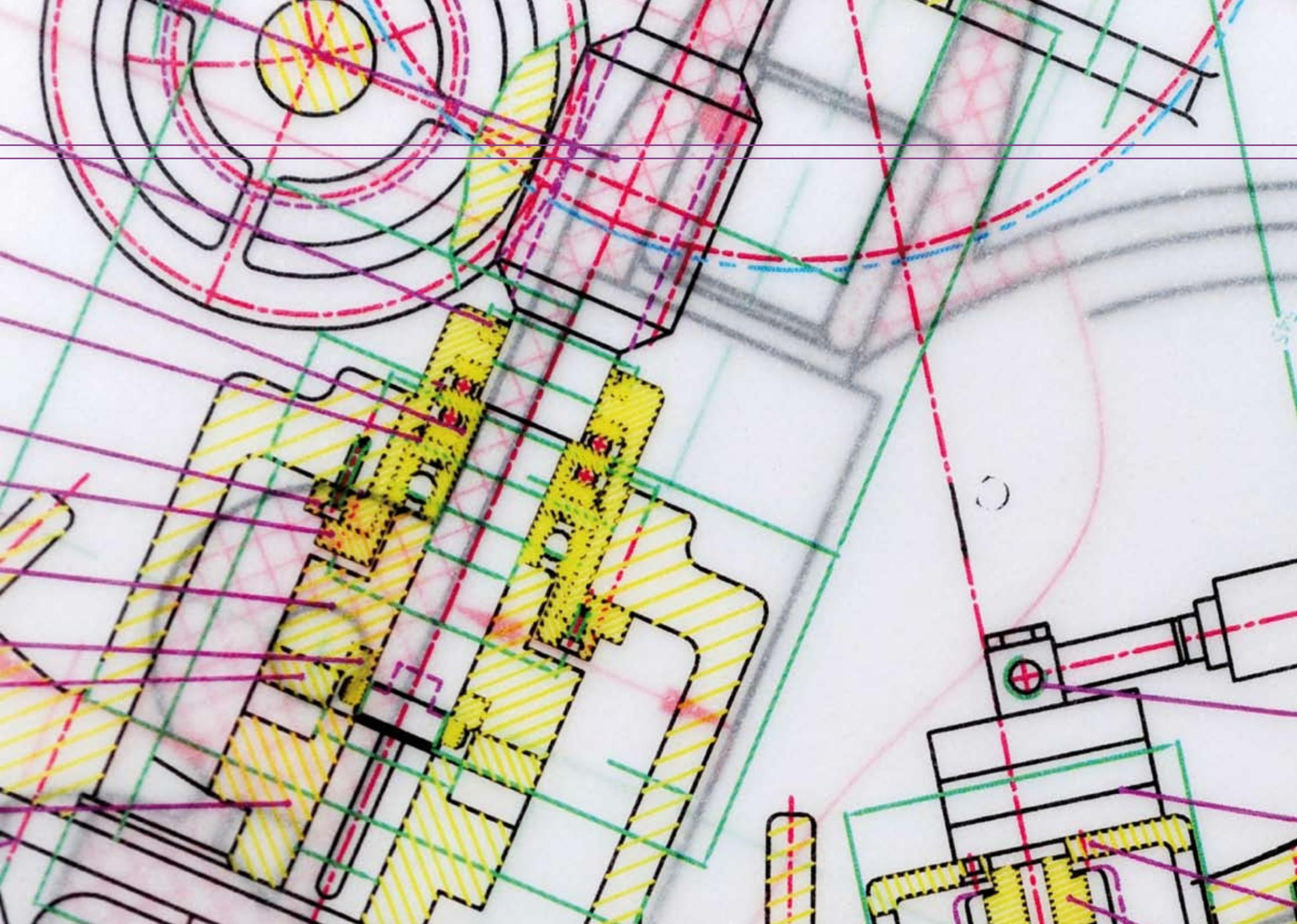
“[Information sharing processes] shouldn’t put unnecessary restrictions on us, unnecessary paperwork [...] so I would rather have it informal but at some point of time storing the data centrally so that it is accessible to all the partners, I would rather have it that way than have a very rigid set of rules” (UK Reactics, commercial partner)

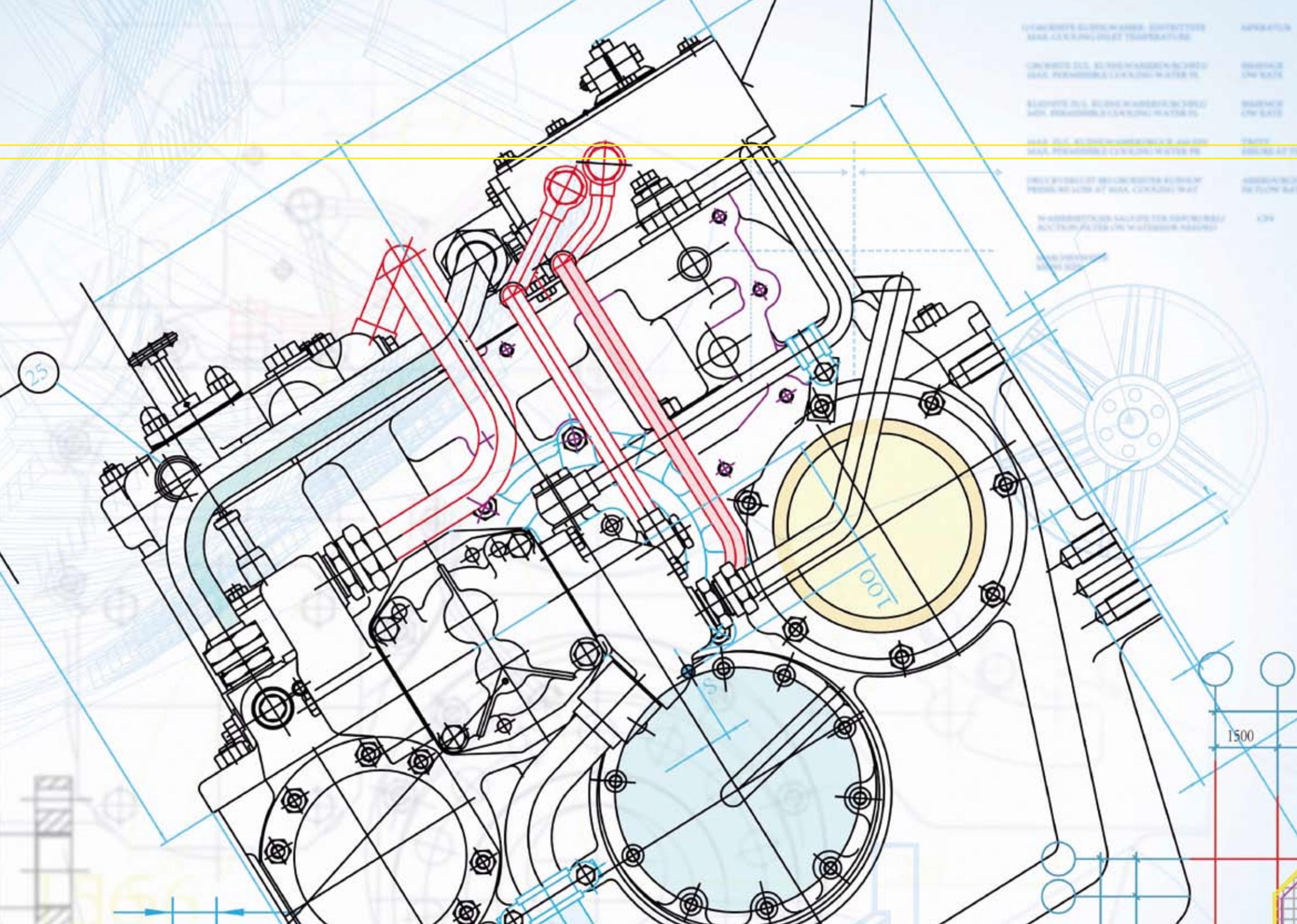
Across the five case studies, there was little policing of formal information governance. It was assumed that all researchers understood the restrictions in place, but in practice only project managers and senior staff showed a good understanding. Junior researchers believed that they did not need to understand the contract, feeling that strategic decisions were made over their head.

The project manager was crucial in supporting information sharing, establishing and monitoring formal governance but also encouraging informal communication. In PRISMA, for example, the project manager set up systems for monitoring outputs and carried out careful planning to co-ordinate the different working groups. Having a project manager who ensured that these activities were maintained was considered critical to changing behaviour within the collaboration.

"The way she managed the project and because she's very focused on setting up systems and following through, that dramatically changed the way that people worked." (PRISMA, Academic)

With regard to informal communications, the project manager mediated information challenges and was in regular contact by telephone and email with all partners. Informal communications created a shared identity between partners which encouraged them to communicate and share information with others.





4. Changing information handling behaviour: influencing factors

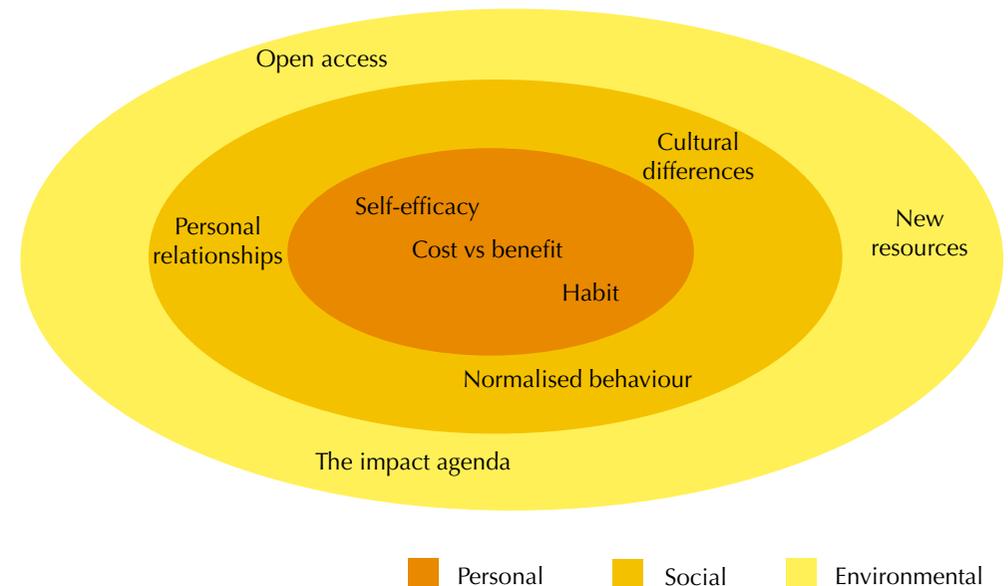
This research has shown that information handling practices in collaborative research vary significantly. There are a number of factors which act upon individual researchers and upon collaborations as a whole to determine information behaviour. If we want to improve information handling in collaborative research, we cannot simply increase the support and services that are already available. Rather, we need to focus on changing the factors that influence the uptake of such services.

Chapter 1 of this report highlighted several developments in the support, funding and services provided by research funders and libraries, designed to ensure better information sharing. However, evidence from five case studies documented in chapters 2 and 3 revealed both barriers and facilitators that determined whether researchers exploited these services. Ultimately, the uptake of services is dependent on a range of factors operating at three levels:

- the **personal** level: how researchers' beliefs, attitudes and habits impact on their attitudes to new information handling practices;
- the **social** level: how behaviour change is influenced by the attitudes and actions of their peers; and
- the **environmental** level: how the structures and policies relating to the wider research community dictate whether researchers consider adopting or are able to adopt new behaviours or tools.

Figure 13 below outlines the personal, social and environmental factors which we found to influence behaviour change; these are then explained in the next few pages.

Figure 13: Factors influencing researcher behaviour



Personal factors

- **Self-efficacy** – Uncertainty about whether different information handling procedures would be appropriate or viable for their work; and concerns that researchers themselves did not have the necessary skills and expertise to implement change.

Researchers need reassurance that new tools or behaviours are straightforward for them to implement and are flexible enough to meet their specific needs.

- **Cost versus Benefit** – Whether the benefits of making the necessary changes would outweigh the costs (financial, time) when compared to their own preferred approaches to work.

The benefits of adopting new behaviours need to be made clear to researchers. Case study examples and word of mouth are effective tools for demonstrating value and providing a realistic sense of the likely costs as well as ways to minimise these.

- **Habit** – The tendency for researchers to continue to carry out research as they have always done. Many of the reasons given for resisting change (e.g. that it is too difficult, time consuming or it brings little value) may be rationalisation for continuing with their habitual behaviours.

It is difficult to address the impact of habit without compelling the desired behaviour change through regulation. However, addressing other influencing factors and normalising desired behaviours will encourage researchers to try new information handling practices, which they may over time adopt as their routine behaviour.

Social factors

- **Cultural differences** – Different working practices, opposing views about openness and differing expectations about how information would be shared make any diversion from the status quo more complex when working in collaboration.

External support may be necessary to identify new services or practices which are suitable for all parties and to mediate any negotiation necessary to implement change.

- **Personal relationships** – Information flows more smoothly through professional networks, in particular with colleagues who have built up a personal relationship.

The effectiveness of personal relationships in maximising information exchange should be recognised and actively promoted. Within collaborations, this may mean supporting better informal communications, and within the wider research communities it may involve using networks as channels to disseminate good practice.

- **Normalised behaviour** – Social norms (i.e. behaviours perceived to be common practice by colleagues and peers) have an important effect on researchers' behaviours.

The uptake of new technology and information sharing practice will be enhanced where these behaviours are shown to be commonplace amongst other researchers, perhaps led by library and information services (LIS) with innovation enthusiasts.

Environmental Factors

- **Funder involvement** – Some public and third sector funders (and some private sources) are already requiring recipients to demonstrate wider public benefits through open access publishing.¹⁰ Research funders are also mandating that research data should be deposited and made available after completion of a project and that organisations adhere to a data management policy. This forces behaviour change, as researchers must consider how they store and handle data to ensure it is ready to publish.

Over time, these conditions will encourage better handling of data. However, it should be noted that compelling behaviour in this way can also have perverse effects, encouraging partners to withhold information or to cease collaborating in order to protect sensitive information. Measures should be sufficiently light-touch and well-considered to avoid acting as disincentives.

- **The impact agenda** – The impact agenda has the potential to synergise commercial and academic needs, and overcome some of the barriers to more open sharing of information. The new REF will take account of a wider range of factors in evaluating research effort, including the impact of research. This may reduce the pressure on academic researchers to publish in peer-reviewed journals as the sole driver of reputation and future funding.

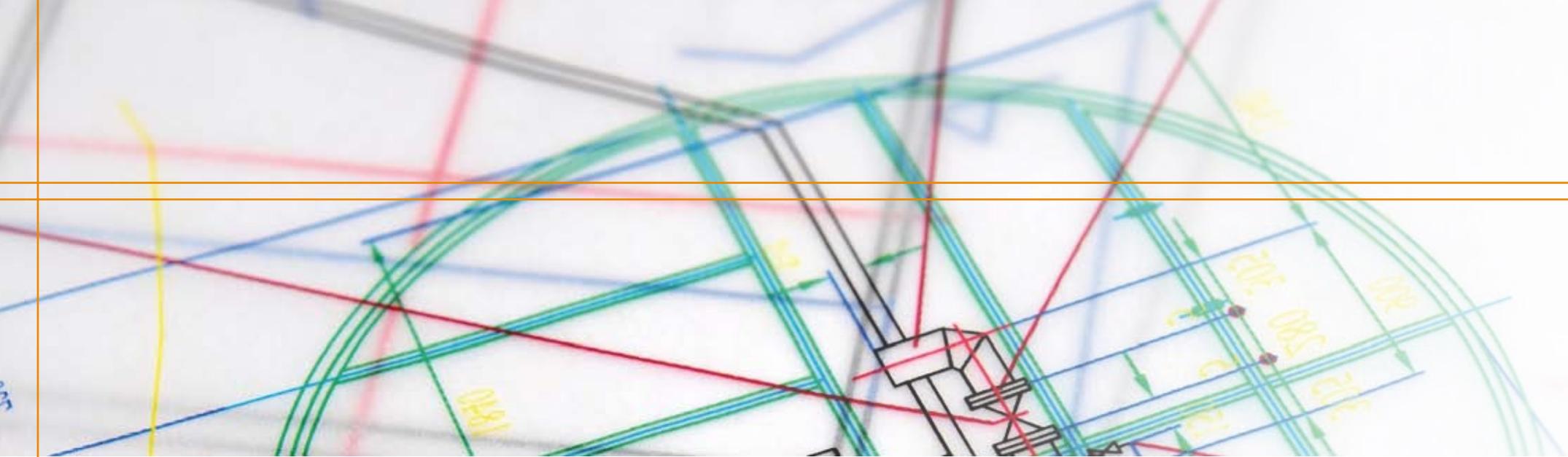
There is an expectation that academic researchers will be more able to carry out pre-commercial confidential collaborative research whilst also aiding career progression and recognition within academia. However, the full impact on researcher behaviour will only be known once the new system has become embedded, which will take some time.

- **Targeted tools and resources** – Making tools and resources easy to adopt and targeted to researcher needs will overcome some of the barriers to uptake at the personal level. As library services re-think their core functions, their offer is changing to reflect a different range of needs. In part these changes involve providing support and guidance regarding information and data management. New communication tools and services for managing information are also emerging and being backed by agencies like JISC and research funders.

These new resources should minimise the burden of change on researchers but they will need to be marketed carefully, since researchers are unlikely to seek these out themselves.

The recommendations set out in Section 5 are designed in the light of these influencing factors.

10. Such as the Wellcome Trust's open access publishing policy and ESRC's requirement that projects publish all data online.



5. Conclusions and recommendations

This final section summarises our findings from this research, and provides recommendations for specific actions necessary to implement the desired changes. The recommendations reflect insights from the five case studies, the literature review, a workshop with British Library information specialists, and three further workshops with a range of research funders, information specialists, publishers and researchers involved in collaborative research.

Conclusions

- Information management is more complex when working in collaboration. This is illustrated both in terms of practical issues, such as collating information held at different sites with different procedures and standards, and cultural differences, which lead to conflicting attitudes and behaviours within and outside the collaboration. Many of the barriers to effective information handling identified in this study are recognisable from previous work, but the complexity of the collaborative environment will mean that solutions need to be tailored carefully.

- Each collaboration is different; a unique combination of influencing factors shapes the way that partners interact. Negotiating the cultural differences between partners affects dissemination and partners' willingness to share unpublished materials. Collaborations adopt an approach to information handling which suits their particular circumstances and priorities. This tends to be an iterative process, led by the project manager, which develops over time as partners gain more experience working together.
- Relationships between people are key to information flow within collaborations. Sourcing information from colleagues is commonplace and they are often the first point of call for academic researchers. Furthermore, researchers are likely to learn about the benefits of new procedures, tools or services through personal relationships with other researchers. Project managers are largely responsible for ensuring that information handling is effective and meets the needs of different partners. However, they do not always have the necessary skills to critically review the project needs, nor the time to investigate technological advances and new tools to enhance information sharing. Third party support, usually from co-ordinating

officers working for project funders, is valuable in mediating between partners, particularly in negotiating and finding compromises to suit the needs of both parties, thereby bridging cultural differences. In addition, co-ordinating officers provide expertise in project management which researchers themselves may not have, even though they fulfil this role within a project.

- Responsibility for sourcing published information usually rests with the academic partners, and they often share journal articles across the partnership. Researchers are not always aware that partners in their project may have different levels of access to published content, and even where they are aware that other researchers may not have access to the content they have identified as useful, this does not prevent them from sharing it.
- Knowledge and information generated within research collaborations is not always shared beyond the research partners. Sometimes this is because the content would not be useful or interesting to anybody outside the partnership. But in some cases it is due to commercial sensitivities and non-disclosure agreements. Where information is disseminated, peer-reviewed journals remain the preferred channel. Ensuring public value through other, more open, forms of dissemination – the web, for example – is often not considered as a project objective.
- Although tools or processes for handling information would enhance the future usability of data, they are not essential to meeting research objectives and are therefore not prioritised by researchers. Researchers were also concerned that using such tools would add costs, in terms of time and resources. Changing behaviour is therefore considered valuable only where researchers recognise an added benefit in managing the information shared and generated during the collaboration.
- There are some information sharing enthusiasts among the stakeholder groups (university and commercial researchers, library and information services and funders) who drive innovation and challenge the status quo. Researchers who were forced to change the way they handled information themselves, because they were required by their funder to do so, became advocates for change if they had experienced greater efficiencies.

Recommendations

This study suggests that improved information management, whilst not a pressing need for collaborations, can bring a number of benefits to the conduct and outcomes of collaborative research across stakeholder groups:

- For research funders, improved information handling contributes to meeting project objectives efficiently and for the best possible public value.
- For commercial or public sector partners, there may be time and cost savings.
- For academic researchers, the tacit knowledge which they gain by working in collaboration with non-academic partners and the quality of their publications will be enhanced if there are fewer restrictions on information flow.
- For library and information specialists, there may be scope to evolve and expand their roles as information specialists and to add value to research which supports the economy and contributes to the knowledge base in the UK.
- And for all of the above stakeholders, the potential for data to be reused is increased.

Our study suggests that behavioural change is unlikely to happen unless prompted by a third party. Research funders and policy makers have the greatest leverage in changing the way research is carried out, and can also help change social norms around information management by supporting information handling enthusiasts in promoting good practice. Funders and policy makers therefore have a critical role in promoting change, although researchers themselves and library and information specialists also have important responsibilities.

Changing the way that information is handled requires changes to the research environment. Such changes must be balanced against the risk of perverse impacts which might compromise the existing trust and informality which are clearly important in collaborations. Our findings have led us to the following recommendations.

1. Maximising uptake of existing resources through better signposting

Finding	Recommended actions
<p>While funding and support services are available specifically to support information handling in collaborative research, awareness of such services is low and inconsistent amongst researchers.</p> <p>Many researchers were concerned about the financial costs and administrative burden of implementing changes to their information handling processes, and this prevented them from taking practical steps that would help them improve their information handling.</p>	<p>Policy makers</p> <p>Carry out a review to consolidate information about different services and resources including:</p> <ul style="list-style-type: none">• Funding opportunities that are available to improve information handling and to support information specialists;• Information specialists, including their specialism and costs;• Information management tools and their key benefits. <p>Funders and advice points (e.g. knowledge transfer advisors, university business development offices)</p> <p>Signpost this information at the proposal stage or other advice points and help researchers to demonstrate the value of additional support for their specific project in order to apply for additional funding.</p>

Aim / outcome:

- a) Improve interconnectedness by linking services to funding opportunities.
- b) Ensure researchers are aware of funding opportunities and services to minimise the time and financial costs of changing behaviour.

2. Embedding local solutions in collaborations

Findings	Recommended actions
<p>Library and information services are beginning to change their offer to meet emerging researcher needs. Library services could usefully contribute tailored advice and expertise on managing information for collaborative research projects.</p> <p>Researchers do not have the time, and do not see the need, to improve their skills in information handling and needed third party support to identify appropriate tools. There was a perception that library and information services were not relevant, and researchers did not approach librarians at the bidding stage for advice on the likely cost of services.</p> <p>The needs of each collaboration were different, shaped by specific dynamics between each partner, which means that local solutions are more likely to be effective at securing change.</p>	<p>Library policy bodies</p> <ul style="list-style-type: none"> • Review the cost of services and find a pricing model that works for different types of user. • Review institutional capacity to determine whether these services are best offered locally or whether national research libraries are best placed to provide such services. • Develop case studies which identify the benefits of library and information service involvement in collaborative research projects. • Support professional development for information professionals so that they can begin to meet the specific needs of collaborative researchers. <p>Information professionals</p> <ul style="list-style-type: none"> • Use existing collaborative research support structures – particularly university knowledge transfer offices – to engage with projects at an early stage and help plan effective research management. • Develop knowledge and awareness of issues and concerns around information management in collaborative research – such as IP protection and who owns data within the cloud – so that these can be addressed. • Engage with all partners in collaborations to understand the specific needs of each group and of the collaboration as a whole, possibly using the project manager as a first point of contact. • Utilise the library space to engage with researchers by providing meeting spaces and workshops and training courses on information management in collaborations. <p>Project managers</p> <p>Approach information professionals at the pre-proposal stage to request a costing for information management services and build the costs into their budget.</p>

Aim / outcome:

- Support data sharing by ensuring data is well organised and can be re-used in the future.
- Reduce the burden of information management on researchers.
- Engage researchers by demonstrating how an information policy can improve efficiency, reduce costs and enhance the impact of research to and help them to secure funding.
- Raise awareness of the services that information professionals provide and ensure librarians across HEIs and research libraries are consistently promoting their skills and expertise.

3. Promoting information policies to encourage greater consideration of information handling

Finding	Recommended actions
<p>Issues with information sharing arise where information handling was not planned during the set-up stage.</p> <p>Agreeing how information will be managed was not front-of-mind at the outset of a project; researchers were preoccupied with negotiating how the research outcomes would be managed and made assumptions about how other organisations would handle information; researchers may also be reluctant to raise issues or concerns at an early stage in the project.</p> <p>Each collaboration has different needs and issues in relation to information handling and therefore requires a unique policy which takes these into account.</p>	<p>Funders and advice points</p> <ul style="list-style-type: none"> • Provide toolkits and guidance for project managers and advisors on developing an information policy including using new tools and services and where to get advice; • Support existing or develop initial requirements for an information policy, outlined in funding applications; • Ensure that information policies consider all types of information, not just outputs or information which is sensitive (although this type of information will require special attention); • Monitor the implementation of information policies throughout the lifetime of funded project and make this requirement consistent across all research funders. <p>Project managers</p> <p>Conduct a knowledge audit at the outset of a project to determine what information and resources are held internally within each partner, and seek out support in developing an information policy which suits the project and the partners involved. At the end of the project, work with the project team to establish the added benefits of adhering to the information policy, with a particular focus on time and cost savings and the potential to reuse content.</p>

Aim / outcome:

Ensure that information handling is considered at the outset and throughout a project and researchers consider sourcing, sharing and managing all types of information throughout a project rather than focussing on publishing and dissemination.

Negotiating an information policy manages expectations and determines;

- a) what data partners believe / expect the other will share; and
- b) what might cause an embargo or other restriction on sharing information.

4. Changing social norms towards more effective information handling by building networks

Finding	Recommended actions
<p>There are difficulties in ensuring wider uptake of recognised good practice, beyond individual researchers who had a particular interest.</p> <p>Professional networks and personal relationships were critical in learning about resources, services and new ways of working. Researchers often favoured informal communication channels as a way quickly and efficiently to draw on the expertise of others.</p> <p>Interventions that build social norms and replicate informal communication channels are valuable in promoting desired behaviours and overcoming habit as a critical barrier to change.</p>	<p>Funders</p> <p>Underpin the information policy requirements outlined in recommendation 3 with workshops, networking events and seminars focused on information management, to help researchers connect with each other and with information professionals.</p> <p>Information professionals</p> <ul style="list-style-type: none"> • Build on the engagement with individual projects (Recommendation 2) to identify key advocates for better information practice, and support and encourage them in their attempts to engage with the wider team; • Recognise researchers' preference for informal communications networks and rapid responses by allocating a single point of contact for each research project and ensuring that person is fully up-to-speed with any information issues within the project. <p>Library policy bodies</p> <p>Provide training and support events for those librarians working with enthusiastic advocates for change, to educate them about new developments in information management and give them an opportunity to extend their networks by communicating with each other.</p>

Aim / outcome:

- Leverage researchers' predisposition to use personal relationships to source information by providing an informal point of contact and establishing relationships between researchers and library and information specialists.
- Support researchers in becoming influential 'champions for change' in their own professional settings.
- Promote information management networks through endorsement and financial support by funders, by signposting researchers to these networks and by requiring successful applicants to engage with relevant networks.
- Develop social norms by encouraging enthusiasts to share best practice and discuss the value of change.
- Maintain momentum by assigning library and information advisors for whom networking would be an explicit part of their role.

5. Informing researchers about how and why they should manage their data in the long-term

Finding	Recommended actions
<p>Researchers who were required or intended to deposit information in repositories as a project outcome had a more systematic approach to data handling and became advocates of the benefits of managing data.</p> <p>Although there was support for data deposit by funders and policy makers, this was not on the agenda for most researchers. Within these case-studies, there was little evidence of researchers actively seeking to contribute to the data commons, or to use other people's data for their projects. This increases the risk that data is being recreated unnecessarily, and means that research outputs are not generating as much value as they could.</p> <p>Researchers worry that sharing data may compromise their ability to publish their findings or – particularly in industry – to protect their intellectual property. They are particularly nervous about the implications of engaging with third-party suppliers, including web applications, as they fear that this may constitute legal disclosure and thus affect their patent applications.</p>	<p><i>Policy bodies and funders</i></p> <p>Promote the benefits of data repositories particularly within industry, where there is likely to be the greatest resistance;</p> <ul style="list-style-type: none"> • Consider making it a requirement in some funding calls that the information generated will ultimately be made available for re-use, once IP is secured, academic researchers have released any intended publications and any ethical or quality issues are addressed. • Be aware of the potential for perverse incentives to, for example, withhold sensitive information (to protect from online publishing of data) or to avoid taking part in collaborations where open publishing of data is a project aim. • Encourage researchers to seek out and use existing data sets for funded projects, through specific funding calls and information about data from previously-funded projects. <p><i>Repositories</i></p> <p>Make researchers aware of the various options for long-term management of data, including those that do not include immediate open publication.</p>

Aim / outcome:

- Optimise the collection, storage and reuse of research information funded by public sources by establishing a long-term strategy for central and institutional repositories.
- Incentivise researchers to make their data compatible with the repositories' protocols by standardising information policies and encouraging researchers to utilise the repositories themselves.

Ultimately, while information handling may not be a priority at all points for researchers, there are opportunities to enhance the value of collaborative research, particularly for funders, through more effective and more open practice.

Information practices are to some extent evolving to accommodate the challenges of collaborative working, in particular the different motivations of the various partners. But in cases where data from collaborations is not stored or published, and is therefore not available for reuse, the information life cycle is weakened; this data cannot be used by researchers on subsequent projects to test or develop findings, as the information lifecycle suggests it should.

There is also an opportunity for library and information services to play an increased and evolving role in aiding researchers in collaborations to optimise information handling, particularly in the adoption of new tools, access to resources and in managing and storing data.

The recommendations suggested above seek to harness the energy and innovation currently occurring in information sharing technology and at the policy level by translating them into researchers' own behaviour and practice. Only by doing so will these opportunities take hold and improve research collaborations in the future.

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It is available to download at www.rin.ac.uk/collab-res-case

Design by Catherine Gray

About the Research Information Network

Who we are

The Research Information Network has been established by the higher education funding councils, the research councils, and the national libraries in the UK. We investigate how efficient and effective the information services provided for the UK research community are, how they are changing, and how they might be improved for the future. We help to ensure that researchers in the UK benefit from world-leading information services, so that they can sustain their position as among the most successful and productive researchers in the world.

What we work on

We provide policy, guidance and support, focusing on the current environment in information research and looking at future trends. Our work focuses on five key themes: search and discovery, access and use of information services, scholarly communications, digital content and e-research, collaborative collection management and storage.

How we communicate

As an independent voice, we can create debates that lead to real change. We use our reports and other publications, events and workshops, blogs, networks and the media to communicate our ideas. All our publications are available on our website at www.rin.ac.uk

