MONITORING OPEN ACCESS FOR KNOWLEDGE SHARING IN SYSTEMS ENGINEERING RESEARCH, AN EVIDENCE BASED APPROACH

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ABSTRACT

The Open Access Movement has been striving to grant universal unrestricted access to the knowledge and data outputs of publicly funded research. However, evidence suggests that in the systems engineering domain such policy is largely ignored. This paper presents the rationale, methodology and preliminary results of an evidence based enquiry that investigates the dichotomy between policy and practice in Open Access of systems engineering research in the UK.

Keywords: Systems Engineering Research

INTRODUCTION

The web provides without doubt the most efficient mechanism to exchange explicit knowledge, as long as this is codified and represented using appropriate formalisms and supporting artefacts. A wealth of research, platforms and technologies has been produced in recent decades much of it thanks to considerable investments in publicly funded research to support explicit knowledge sharing on the web. Despite the availability of good practices and no shortage of publicly available knowledge sharing tools and platforms, much knowledge produced by publicly funded research is still not shared, or only notionally shared, and there is no indication that the uptake of Open Access policies is actually monitored by anyone at any level. The research aims to:

– identify what policies and practices regulate the explicit sharing of knowledge generated by publicly funded research in the UK.
– evaluate to what extent, and via which mechanisms and behaviours, the adoption of OA policies and knowledge sharing artefacts and processes are adopted in the UK systems engineering research today.
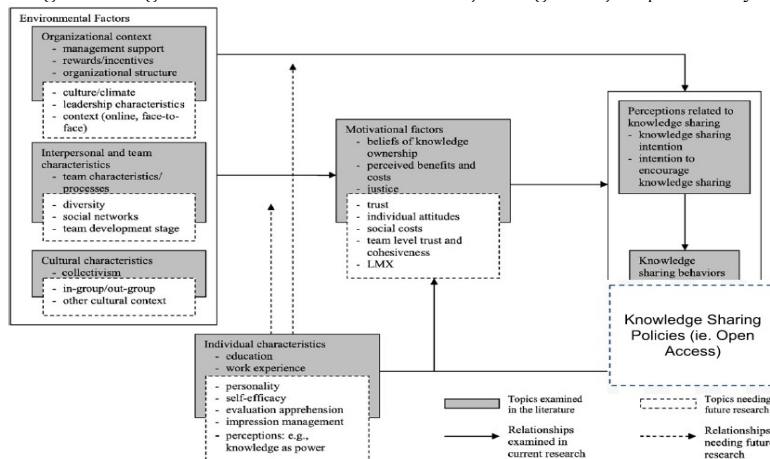
OPEN ACCESS, KNOWLEDGE SHARING AND POLICY

One of the main drivers behind Open Access initiatives, especially in the research and scholarly publications domain, is to encourage and promote knowledge sharing (Calise et al). However, a recent comprehensive state of the art review in 'Knowledge Sharing' (Wang, Noe) fails to identify the gap between knowledge sharing policies, such as Open Access policies, and the actual practice. This research identifies such a gap as critical, and targets it with an 'evidence driven' research strategy and proposes a series of interventions.

CONTRIBUTION AND ORGANISATION OF THIS PAPER

The degree of adoption and implementation of knowledge sharing policies such as open access to facilitate and promote knowledge exchanges is largely driven by the 'practice', especially the case in grassroots movements of pioneering academics and institutions from which much of the current efforts originate (Suber). The original diagram summarizing the gaps and direction for knowledge sharing generated by Wang in 2010, does not contain any pointers to either Open Access nor to knowledge sharing policies in general. The diagram below has been modified to show the gap in knowledge sharing and policy research, and the discussion in the corresponding section further below in this paper 'Open Access and Knowledge Sharing' provides the justification and references for introducing such a modification.

Knowledge Sharing Future Research Directions, Wang et al, Updated by Di Maio

This paper aims to identify and address the gap between theory and practice in Open

Access in Scholarly research. It is organised as follows:

Knowledge sharing challenges: introductory discussion, and scope of the work.
Evidence and what works: overall research approach and Evidence Based Research, and an outline of the research plan.
Knowledge sharing behaviours and NECTISE: segmentation of the research field.
Open access and knowledge sharing: filling the gap between two research strands.
The surveying instruments: introducing Open Access Monitor and the Knowledge Audit Framework.
Preliminary findings: the initial results of this research to date.

KNOWLEDGE SHARING CHALLENGES

Knowledge is one of the most valuable resources for individuals and organisations. Despite decades of research and practice in knowledge management, knowledge sharing and reuse remains elusive, fragmented and compartmentalized (Mandl, et al). Several disciplines have been converging in recent years to facilitate and increase knowledge exchanges and pervasive web based technologies have removed many of the physical barriers to knowledge sharing. However many challenges still inhibit optimal knowledge flows. This research targets the challenges associated with accessing knowledge that has been generated using public funding via public research councils in the UK: the UK is one of the countries perceived to be leading the 'freedom of information good practice' and which has been spearheading the 'open access' since inception. In particular, since this research originated in the NECTISE framework the current focus of the enquiry is on systems engineering domain, however the research instruments and methodology can be generalized and targeted to other research domains. In summary, the central problem this research tackles is that despite the existence of widespread open access policies which appear *prima facie* to be adopted uniformly by UK Research Councils, knowledge generated by Systems Engineering research using public funds is still not available to the public and sometimes not even to co-researchers.

EVIDENCE OF WHAT WORKS (AND WHAT DOESN'T)

Knowledge reuse challenges can be examined under different disciplinary perspectives, but when tackled 'as a whole' systemic traits such as 'entanglement' emerge; as discussed in related work (Di Maio) which require complex socio-technical systems approaches.

The driving question that overall motivates the enquiry is:

How can the gap between OA policy and practice be identified and filled?

The study contains several levels of 'meta analysis' that synthesise evidence from different research methods, each contributing a piece of 'evidence' to help answer the question above.
Evidence Based Research emerges from a field known as 'Evidence based practice':

*Evidence-based practice (EBP) method in the behavioural and social sciences developed
out of the evidence-based movement in medicine, which aims to inculcate in clinicians
"the conscientious, explicit, and judicious use of current best evidence in making
decisions about the care of individual patients" (Sackett **et al.**, 1996).*

The rationale of EBR is rooted in clinical practice in the health and medical domains, however a methodology has grown out of it, that has been adopted byother social science disciplines. Paynter (Paynter) notes that :

*While it may seem par for the course that professionals would use research to
inform their practice, history is replete with examples of the opposite – practice based
on the authority of their proponents rather than actual evidence of their efficacy. (Hatcher **et al.**, 2005).*

A typical EBP research process consists for example of the following steps:

(1) Formulate the question.

(2) Search for answers.

(3) Appraise the evidence.

(4) Apply the results.

(5) Assess the outcome

(Gray, 2004).

This research, detailed in the sections that follow, complies with the central tenets of what constitutes a 'systemic review' method (EPPI) :
- Explicit and transparent methods are used following a standard set of stages.
- It is accountable, replicable and updateable.
- User involvement is built into the research design.

Research Design

The study being undertaken consists of two main research components:

Critical Appraisal

1) A critical appraisal (evaluation) of Open Access and other Knowledge Sharing policies that guide or regulate academic practice in the UK (Davies), aimed at answering the following questions:

Exploratory evaluation: what policies are there? (literature review, surveys and interviews with civil servants and experts)
Impact evaluation: do people know about these policies? (survey)

The steps undertaken in these research components are:
- Identify public research funding bodies
- Survey their policy and implementation strategies
- Identify possible misalignment and weaknesses (hypothesis?)
- Form a baseline of good practice according to the relevant policy
- Test the degree of adoption of the relevant policies across target samples of the academic population see 2)

2) **Survey the Field** – A survey of a targeted sample of the population and projects of UK academic projects to see to what extent they match the policy, and identify the need for interventions. A survey instrument is designed to carry out data collection for this sample called OAM, Open Access Monitor (www.openaccessmonitor.org) . The steps followed in this research component are:
- Select Cases to be audited (following the inclusion criteria)
- Gather base datasets following OAM
- Analyse the findings according to multiple methods (qualitative, quantitative)

Inclusion criteria for the selection of cases in the current study are all the projects related to the target domain (in this study systems engineering research), the research partner organisations are 'networked' (i.e. the members of the organisations rely on electronic means of communications to work/communicate) and are UK-based projects publicly funded through one or more UK research councils.

Motivation and Chain of Evidence

The initial trigger for this case was provided by the NECTISE Case discussed in the

following section. A random survey of academics (including principal investigators, researchers and postgraduate students) in related departments showed little or no awareness of Open Access principles. A series of ongoing interviews and email exchanges with experts investigates various aspects of the problem space.

The chain of evidence for this research is illustrated in the table below:

NECTISE Case >>>>>> Initial evidence
Survey >>>>>>>>>>>> Evidence of awareness among the engineering community
Interviews>>>>>>>>> Evidence from funding councils
Audits>>>>>>>>>>>>>Systemic survey of the field (ongoing)

NECTISE

The underlying, endemic problem tackled by this research is well illustrated by one of the exploratory cases that initially triggered, and largely still motivates, most of this research: EPSRC funded NECTISE (www.nectise.com), a 4 million GBP research project awarded to a consortium of prestigious Universities for 'networked capabilities in systems engineering'. As a doctoral training account holder (DTA) tasked with advancing the state of the art in 'knowledge reuse and learning in networked capabilities research for systems engineering' and receiving doctoral research funding from the NECTISE project consortium, it was essential for this researcher to acquire and examine existing project knowledge before the state of the art could be advanced further. However, the only knowledge resources publicly available via the NECTISE website were a static list of published papers (not hyperlinked, nor available via the site, just published as a static list on an html page). Due to a complex set of contractual arrangements, despite the fact that the project was publicly funded by EPSRC, the coordinating research partner was BAE Systems, a private company which operates a policy of strict knowledge control. BAE never shared nor published any system diagrams, nor vocabularies or data dictionaries in relation to NECTISE. An endless sequence of emails to obtain access to the knowledge artefacts related to the project between the doctoral researcher and entire research hierarchies of academics and officers in charge generated no results but prompted a vital question that motivates and justifies much of the current line of enquiry: if this research is publicly funded via EPSRC (Engineering and Physical Sciences Research Council), and EPSRC says like all other UK Research Councils that it embraces 'open access' policies (reference), why can't everyone, especially a researcher funded by the same project, find any of the project knowledge they need to carry our their research task?

INVESTIGATING KNOWLEDGE SHARING BEHAVIOURS

An empirical meta analysis of the research field, via literature review and international field work, helped to identify significant differences that could contribute to shape the different knowledge sharing behaviour. For example a combination of factors, including Country, Job Role, Industry, Organisational Culture, can all impact to some extent knowledge sharing attitudes and behaviours. While the theoretical part of the study is able to be both generalised and domain independent (the research design and instruments can be modified to target different segments of the research field, or different research domains) this analysis resulted in high level matrix that narrows the scope of the study, which is currently limited to systems engineering research in the UK (see the grey cells in the table below).

Geography	Industry	Sector	Role	Culture	Policy
World					
EU					
UK	Systems Engineering	Academia	Researchers, Research Adminstrators		Funding body, Institution

Segmentation of the research field

OPEN ACCESS FOR KNOWLEDGE SHARING

Open Access is the broad name that identifies a progressive movement and a series of initiatives that have gradually lowered the barriers to access publicly funded research outputs. There is a long and rich history that documents how this movement evolved thanks to the efforts of individuals, groups and collectives that has finally been embraced at least to some extent by institutions (Suber). One of the first key OA interventions, the Budapest Open Access Initiative defines of open access:

By "open access" we mean its free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. The only constraint on reproduction and distribution, and the only role for copyright in this domain, should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited. (Budapest Open Access Initiative, 2002)

The Budapest Declaration was followed by other initiatives of similar scope and impact; the Bethesda Statement on Open Access Publishing in June 2003 and by the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities which the following year was included in the World Summit on the Information Society

Declaration of Principles and Plan of Action (reference).

Open Access to Scholarly Knowledge, has been a huge and growing movement, which is of an even larger and more important contemporary phenomenon, access to Public Sector Information. In the USA, the origins of PSI have been traced back historically to a couple of hundred years ago [Ganapaty], however in our days the main piece of legislation to make public information accessible by statute is the FOIA Act, which was established around half a century ago in 1966 [FOI]. In Europe a PSI Directive [EU PSI Directive 2003] was implemented much later, in 2003; although it took several years for member states to take it up and enforce it, and is currently at the centre of all sorts of governance discussions across the many EU countries. The gist of these pieces of legislation is to grant public access across the board to information held and produced by public authorities, to ensure administrative transparency and accountability and equal access to information to all stakeholders. The core underlying motivation for transparency and accountability of public administration through the public release of data and information is to establish trust and confidence in the corresponding governing institutions, and to allow citizens to make informed decisions and to participate in the governance and decision making processes. Public Sector Information has always been one of the main sources of primary data for many research activities and data centric services, but thanks to the current explosion of cloud based technology applications and infrastructure new market opportunities are opening up. Europe is currently fibrillating at the prospect of the potential economic explosion of what is referred to as 'PSI- commercial' reuse; however with globalization, what happens in the EU directly or indirectly influences the rest of the world. However neither the EU Info-Society nor the director of SPARC, one of the main international initiatives driving OA practice to date, could answer (in private correspondence) the question from existing data and knowledge 'how much open data from Public Sector Information is generated by publicly funded research?'
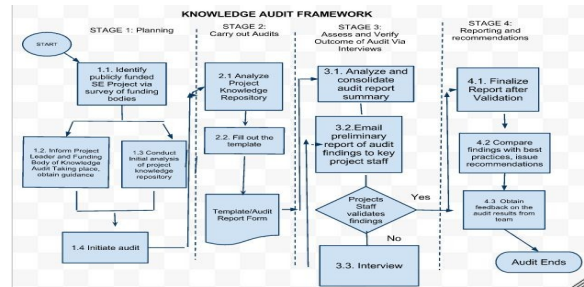
AUDITING THE FIELD

An evidence based research instrument is devised, called Open Access Monitor (OAM). (www.openaccessmonitor.org). OAM consists of simple guiding principles, a process and data collection instruments (forms) and corresponding public data repositories to store the audited data. It is developed at 'near zero cost', that is, using freely available development tools (Google apps) OAM evolved from Knowledge Audit Framework (KAF) a granular research inventory toolkit to audit publicly shared knowledge resources, KAF-SE is a domain specific instrument tailored to inventory the level of sharedness of knowledge resources in systems engineering, with a high

level of technical specification. The KAF auditing process is illustrated in the image below.

Knowledge Audit Framework Process

After piloting KAF-SE in the field, it emerged that the auditing instrument was over specified, i.e. it targeted very granular systems engineering knowledge (looked for systems specifications and diagrams for example), while the majority of projects in the systems engineering research do not even have a website, and of those which have a website, very few have links to accessible copies of deliverables and papers. Therefore OAM evolved out of KAF, in that it adopts its core process and inventorying mechanism, however, it uses an 'abbreviated protocol' (a simpler and less granular inventory process). OAM uses different inventorying templates to gather evidence about existing Open Access Policies (Policy Monitor) and about how publicly funded projects embrace the policies (Project Monitor). OAM also encourages and supports public intervention by providing an open, publicly accessible record of civic interventions (i.e. it logs email requests sent to funding bodies when Open Access resources in relation to a given project are not found).

How OAM works

OAM helps to answer the following questions:

1. What are the Open Access policies of each funding body? How is the implementation of these policies monitored?

2. Which Open Access knowledge resources are shared in the public domain for each publicly funded project?

3. If a specific Open Access resource is not located, OAM encourages individual independent 'auditors' to write to the corresponding funding body, and to log such enquiry, related correspondence and responses in a public record.

PRELIMINARY RESULTS

Below a summary of preliminary findings of the investigation to date, corresponding to each research components: policy evaluation (theory) evidence from the field (practice)

Policy Evaluation, Preliminary Results

In 2010 a policy evaluation effort was initiated as part of this research with the goal of assessing what extent funding councils and the government implemented and monitored Open Access policies. Different methods for policy evaluation were adopted in combination (Purdon et al). The research dimensions and corresponding driving questions are:

Exploratory evaluation: what policies are there?
(literature review, surveys and interviews with civil servants and experts)
Impact evaluation: do people know about these policies? How are these policies adopted in the field? (surveys, audits)

Outcomes of this evaluation suggest the following considerations:

1. The policy landscape is fragmented across different levels. For example, different policies addressed loosely different layers of the information management chain, for example: Data, Information, Knowledge.

2. There are different policies with different scopes and purposes, all targeting roughly the same 'knowledge sharing' space, but which are not harmonized,
- Public Sector Information, EU Directive
- Open Access. EU Directive, Budapest Declaration, etc
- Information Sharing, PSI directive UK

3. Some of the current legal provisions for the protection of Intellectual Property, and programmes such as 'Knowledge transfer' that restrict knowledge flows between academia and industry, could be in conflict with Open Access policies. Such conflicts should be resolved with clear guidelines as to what level of data, information and knowledge should be made Open Access by mandate, and which levels can be

protected by patents and copyright to allow research outputs to benefit from commercialisation opportunities and economic gain.

Field research, preliminary outcomes

An exploratory survey carried out in 2009 asked 30 academics (researchers and postgraduate students) at the Engineering Faculty of a UK University, selected randomly (were physically approached on campus) and anonymously (their names were not recorded) from a local population sample, whether they knew what is Open Access, and what is the Budapest Declaration; all answers were negative (nobody knew what Open Access is, nor what the Budapest Declaration is). This motivated a wider, more structured and targeted survey. Four initial pilot audits were carried out on projects funded from public research councils in the UK with the primary goal of assessing the usefulness of the research instrument, the Knowledge Audit Framework (KAF). The outcomes of these pilots indicate that the quality, detail and sharing formalisms adopted by each project varies greatly and that it does not always depend on the existence of an explicit knowledge sharing policy. However other factors, such as organisational and funding body culture, may contribute to the level of granularity and knowledge sharing formalisms adopted. The quality and type of knowledge shared in publicly funded systems engineering research tends to be high level information, limited reusable system knowledge is routinely published and shared. Although all projects tend to have a web page, used mainly as a pro forma and no consistent formalization is adopted. The pilots contributed to refine the research instrument, and KAF evolved into a more lightweight, more agile and simplified research protocol (abbreviated protocol) currently adopted in OAM. A larger scale evaluation from the field is currently being carried out and results will be reported as soon as available. So far, the evidence gathered suggests that:
- Researchers in systems engineering are not aware of OA policies.
- Research institutions do not have mandates in place to support OA policy.
- Funding bodies do not monitor, or do not specify 'how' they monitor the implementation of OA policies.
- Policies that support knowledge sharing such as OA are fragmented, contradictory and no plan exists for their implementation.

INTERIM RECOMMENDATIONS

Research Councils UK (RCUK) and the Higher Education Funding Council for England (HEFCE) on May 25th 2011 announced plans to work together to ensure greater open access to published research (Announcement, 25 May 2011) . One of the contributions

of this research consists of a policy integration and alignment recommendation, illustrated in the diagram below:

Intervention: Integration and alignment of the various policies regulating the space.
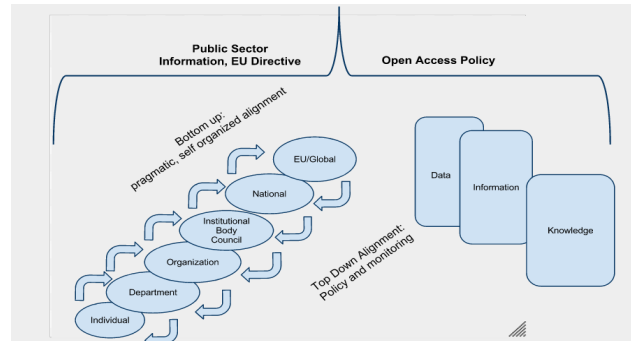
A policy integration and alignment framework should:
a) enable dual track, i.e. encourage compliance from the bottom up (self archiving) but also encourage funding bodies and regulators to implement the policy via regulatory measures (mandates) and monitor their implementation.
b) bridge the current fragmentation between data, information and knowledge policies which currently address different levels of granularity of the knowledge sharing policy space.
c) devise and implement an overall integrated Open Access policy monitoring strategy which should be in line with the EU PSI Directive 2003.

Cost Benefit Recommendation, and OpenAccessmonitor.org

The Government has not yet disclosed budget allocation for the initiative announced by RCUK in May 2011. It is expected that budgetary considerations will play a role in how effectively the monitoring of Open Access policies implementations will be. If carried out manually, and without the appropriate use of ICT, the cost of monitoring policy implementation could exceed its benefits. However, if a simple automated policy monitoring process is implemented by mandate, say via a web service such as openaccessmonitor.org, the burden of monitoring could be distributed across the research community or even crowd-sourced which would reduce the material costs of a much needed monitoring to almost zero.

CONCLUSION
This paper presents the rationale, methodology and preliminary findings of a study

aimed at better understanding the state of the art of Open Access in Systems Engineering in the UK. It also introduces OAM, a near zero cost public environment to support the monitoring of open access policies and presents preliminary conclusions and recommendations as a contribution toward the more generalize challenge of bridging the gap between Open Access Policy and Practice.

ACKNOWLEDGMENTS

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