From Projects into Operations: Lessons for Data Handover

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Abstract

Data from civil engineering projects can inform the operation of built infrastructure. This paper captures lessons for such data handover, from projects into operations, through interviews with leading clients and their supply chain. Clients are found to value receiving accurate and complete data. They recognise opportunities to use high quality information in decision-making about capital and operational expenditure; as well as in ensuring compliance with regulatory requirements. Providing this value to clients is a motivation for information management in projects. However, data handover is difficult as key people leave before project completion; and different data formats and structures are used in project delivery and operations. Lessons learnt from leading practice include defining data requirements at the outset, getting operations teams involved early, shaping the evolution of interoperable systems and standards, developing handover processes to check data rather than documentation, and fostering skills to use and update project data in operations.

Keywords: Management, Information technology, Codes of practice & standards
1 Introduction

Improving the performance of the built environment is important to achieving a sustainable 21st century society. Advances in digital systems offer opportunities to integrate information and use it to inform decision-making across the life-cycle of buildings and infrastructure (ICE IS Panel 2008; Jackson 2010). Yet these opportunities are wasted where documents rather than integrated data-sets are handed over from projects into operations. To capture lessons for data handover from leading practice, this research examines what data from civil engineering projects are valuable to leading clients in operating built infrastructure and how these are created, captured and refined.

Across research, practice and policy there has been a focus on changing construction industry practices from the use of documents with purely graphical components (lines, arcs and text), to models and objects, and then to integrated interoperable data (Bew and Underwood 2010; Richards 2010). New integrated software solutions provide opportunities to transform project delivery through the use of such integrated interoperable data. Design teams in civil engineering projects and seeking to implement them to develop systematic processes for digital delivery (Hartmann and Fischer 2007; Whyte, Lobo et al. 2010). Recent research articulates the value to clients of project teams using sharable information (Young Jr., Jones et al. 2009; Grilo and Jardim-Goncalves 2010) and Building Information Modelling (BIM) in both design and construction (Eastman, Teicholz et al. 2008; Smith and Tardif 2009).

Public and private sector clients have also become interested in data continuity across the life-cycle to improve the performance of their built infrastructure through the re-use of data from projects in operations. As a client, the UK government, for example, is interested in the use of open shareable asset information to drive: ‘significant improvements in cost, value and carbon performance’ (BIS/Industry Working Group BIS 2010, p.9). Rather than receiving documents, or models and objects, the desire is to receive integrated interoperable data.
(Jackson 2010). Here the data integration challenges extend beyond those in synchronous collaborative working, for example between engineers; or between engineers and fabricators (Harty 2005), to new challenges associated with data integration across temporally separated work tasks.

Historically, project management techniques have co-emerged with information management tools (Whyte and Levitt 2011). As new integrated information systems become implemented there are expectations of new opportunities for managing the delivery and operation of buildings and infrastructure. The contribution of this study is to articulate what data is valuable to leading clients, how they use data in the operation of the built environment and the lessons learnt by such clients and the supply chain for data handover from civil engineering projects. The following sections describe the research context and questions; the methods of data collection and analysis used in this study; the key findings relating to use of data in operations; and lessons learnt. The final section concludes by summarising key points; limitations of the study and directions for further research.

2 Research context and questions

2.1 Research context

There has been substantial research to develop new tools and processes for information management through the life-cycle of projects (e.g. Anumba, Bouchlaghem et al. 2000; Avanti 2006; ICE IS Panel 2008). The goal of integration of stages, disciplines and systems within the project, is common to Integrated Project Delivery (IPD) and related tools and approaches such as Building Information Modelling (BIM) and Concurrent Engineering (CE). However, this integration is often not achieved in practice, with some stages of the project more integrated than others (Hassan Ibrahim 2011).
In Europe and the USA, there are initiatives to promote open standards, with governments beginning to use their client role to formalize the process of data exchange between software tools at the end of projects. The US Army Corps and GSA, for example, use an open standard, the Construction Operations Building information exchange (COBie), to import data into Maximo, a maintenance management software. This data exchange standard is for the capture and delivery of digital data from design, construction, and commissioning into operations (AIA 2007; East 2009; Jordani 2010), through the structured transfer of data from project software to asset management systems. Researchers have also been developing guidance for clients and projects teams on how to structure BIM data for different applications, including uses for operations and maintenance (Anumba, Dubler et al. 2010).

2.2 Research questions

It is in this context of growing international interest in value to clients, increasing capabilities to use integrated interoperable data within projects but weaknesses in the handover of such data from civil engineering projects into operations that the research questions for this study were developed. As described above, this research set out to address two main questions:

- What data from civil engineering projects are valuable to leading clients in operating built infrastructure?

- How are these data created, captured and refined?

These questions arise in the context of a policy and practice focus on the value of data across the life-cycle (DCCA 2010; Jackson 2010) and a growing set of commercially available tools for using integrated data in asset and facilities management.
3 Methods

All stages of this research were conducted in close collaboration with industry as a form of ‘engaged’ scholarship (Green and Schweber 2007; Van de Ven 2007). The research was scoped and commissioned following a workshop between the research team and the Institution of Civil Engineers (ICE) Information Systems (IS) Panel that was hosted at the University of Reading. The issue of progressive life-cycle data value management for infrastructure had been identified as an important area for research-based knowledge outputs through a series of annual ICE practitioner events on ‘Information Management through Life’ (2007-9).

Responding to the need for research in this area, this study set out to capture lessons for data handover through interviews with leading UK clients and the UK supply chain. Before the empirical work started, an industrial steering group was set up to identify appropriate interviewees and guide the study; and the research proposal was considered and approved by the University of Reading ethics committee. While different types of infrastructure, such as roads, railways, utilities and complex buildings, such as airports and hospitals, have particular characteristics and face specific challenges, the study addressed the common issues of data handover across them.

Following a review of both the industry reports and the academic literatures, the plan was to conduct 12 semi-structured interviews: six with infrastructure clients and six with engineers involved in the delivery of major projects. The protocol for these interviews was structured around the research questions, focusing on establishing the data that are valued at the end of the project process; and how data are created, captured and refined ahead of handover. As summarised in Table 1, to deepen understanding of processes and issues, more than one person was interviewed in some companies.
The research data was analysed iteratively, using established qualitative analysis methods and software. The emergent findings around data value and use in operation and lessons learnt for data handover were discussed with the industrial steering group; presented at an event on ‘Engineering Management in the Digital Economy’ at the ICE, and to engineers and managers in other research advisory boards and related UK government/industry working groups. Feedback from these contexts was used to refine interpretations of the findings.

4 Data value and use in operations

4.1 Value to clients of accurate and complete data

Where clients managed safety-critical or essential infrastructure, such as in utilities; highways; railways; stations; airports; and hospitals, there was a particular focus on obtaining and updating high-quality data about physical assets to comply with regulatory requirements to ensure safe and ongoing operation. The interviews suggest that these clients also lead thinking about asset performance. One transport client described how an accurate and complete data-set was valuable to them for better decision making about capital expenditure (Capex) and operational expenditure (Opex) to enhance the performance of assets as:

*If you haven’t got good quality data you can’t optimise your Capex and Opex, with the wrong data you’re going to be replacing the wrong assets and taking the wrong maintenance or not maintaining stuff that needs to be maintained, so it’s really critical.*
Another client, in utilities, discussed the importance of accurate data for the maintenance of assets over a life-cycle that may be between forty and eighty years.

*If we don’t collect it correctly at the start it then puts you potentially at a disadvantage through its entire life cycle to make sure we maintain it properly. [...] You don’t know when it was installed or it’s not on the register you can’t then optimise what you replace and when you replace it.*

For other client operators, the question of what data to collect and maintain is also one of providing value for money as compared with external providers. The relationship with the firms that deliver projects was seen to develop over time, through a partnering ethos:

*Using the same people again and again because we have found it’s incredibly valuable in terms of procedures and them understanding what we want and what we expect. But also, you do build up that relationship, which means that you get added value out of, you know, they want to maintain the work.*

Getting the project team to understand ‘what we want’ was discussed in many of the interviews in quite different terms to the wider debate on integrated information referenced in the research context and introduction.

### 4.2 Data sources and formats

The asset register is the main data source about buildings and infrastructure that is used in operations. Built infrastructure is represented as a list of assets in an asset management system; alongside work orders and purchasing information. The asset register includes associated manufacturing data, performance characteristics, locations, and maintenance histories. The data used in operations and facilities management includes:
• Manufacturers’ data, such as feature code libraries, nameplate attributes and specifications, which are used for digital inspection, fault detection, maintenance and replacement.

• Performance characteristics (environmental, health and safety, warranty, security, regulatory approvals, residual risks or hazards, emergency contacts), used for compliance, performance monitoring and remediation if anything goes wrong, e.g., if a product is still in warranty it can be replaced and the client needs to be aware of who to contact in good time.

• Locations of assets are tracked in spatial data. For example utility providers collate data in geographic information systems (GIS) and use it for location of assets, replacement and customer service. Operators in the field use global positioning systems (GPS) to update data. As-built drawings, engineering and architectural models reflect the true objects onsite and how they have been placed, perhaps differently from as-designed initially.

• Maintenance histories are developed as work orders are created, fulfilled and logged in the system. Operation and maintenance (O&M) data are often provided by civil engineering project in manuals that are used for reference, with relevant data input into the asset management system.

This asset register is generated and updated by clients. Geometric models and drawings are not used extensively, and are more often used as reference documentation, than as an updated data-set.

4.3 Challenges of using project data in operations

To gain value from data, clients faced the challenge of first, ensuring data accuracy and completeness at the end of the project; and second, keeping data up-to-date for use in operations. As one client noted these are:
Two different things, making sure you’ve captured it all, keeping it up to date.

Checklists were used to ensure completeness of information at handover, but identifying the right data was difficult for clients as their facilities and asset management teams usually got involved at the end of project delivery. As one engineer involved in the delivery of complex buildings, noted:

*We’re not really in that situation where we’re on a project with a designer and the constructor and the facilities manager all working off the same data. It just doesn’t happen in the line of business that we’re in.*

Sometimes the checklist could indicate that information was complete, but no one had the time to check through all the details thoroughly so when a fault occurred in the asset then the operations team could not locate the relevant information or found that it was missing.

Hence, clients and operators expended a lot of time and effort searching through volumes of information which could have been provided in more readily useable or supported formats. An example given was a problem with the front door of a building that arose in its second year after delivery. The operations team had manuals which led them on a search through other sections and documents, but they could not find the right information. It turned out to be easier for them to contact the manufacturer of the door directly rather than trying to search through the manuals for the information required.

It is vitally important that data can be updated in operations. One example given was the importance of updating information after small projects such as asbestos removal. Yet getting information in formats in which it can be updated is challenging as there are different skills involved in project delivery and operations management. Interviewees described how facilities and/or asset management teams lacked the ability to manipulate and use some types of information generated in civil engineering projects. For example, many projects use models at the design and construction phase, but not in operations. As one operator
explained, they are not resourced to cope with 3D information. While in 2D, information is stylised, for example with pipes laid side by side; in 3D, it would be possible to look at pipes exactly as they are in reality (on top of each other), which could help avoid problems when carrying out maintenance work. However, for this manager, the focus was on attributes rather than geometries, and 3D models had not yet shown themselves to be as valuable as 2D information, which was less costly to obtain and maintain and fulfilled their immediate tasks adequately.

There were also situations in which data-sets were available but not re-used. For example, one client explained how data are sometimes available but not used for contractual, insurance and liability related reasons:

*Often the information isn’t reused even though it’s available. We probably spend a couple of million pounds on surveys a year for facilities that we actually have information about, even if that information is provided. We haven’t lost it, we can access it, we can find it, we can provide it but our suppliers will still commission surveys.*

Hence, while there is a strong interest in a data-centric approach, there are organizational, as well as technical challenges to data reuse.

5 **Lessons learnt on data handover**

Clients are seeking scalable approaches to data continuity as they commission projects and takeover built assets. Capturing data from projects is important not only for major projects but also the many smaller projects, including refit and refurbishment projects, which are often more numerous and need to be linked into the same maintenance system.
Lessons that can be learnt from leading clients’ practice include: 1) defining the data requirements at the outset of the project, 2) getting operations managers involved in handover early, 3) playing an active role in industry initiatives to shape development of interoperable systems and standards, and 4) developing handover processes for checking data rather than documentation and using and updating data from the project in operations.

5.1 Defining the data requirements

The leading clients interviewed were interested in defining the data required at the outset, by making sure:

*That our briefs are very good, that we’re very clear on what the deliverables are at different stages of the project and that we’re very good at clearing obstacles out of the way for our suppliers.*

To achieve continuity of data across the handover from the project into the commissioning and testing of the building and then operations, many of these clients had internal governance procedures, to ensure that data was complete at handover and that operation managers were trained to use it.

*We do we have a project management process, [...] we have various procedures, checklists, policies around every stage of a project to ensure that those things are done so it was governed around collecting information.*

However the interviews suggest that the handover stage can be a particular challenge as it is: “*not seen as the sexy end of the project*” for designers and engineers that work on civil engineering projects, and:
If it’s not a part of the contract or it has never been mentioned in the design stage, it is a very, very difficult task and an expensive task to include that in the end of the project.

Hence, leading clients recommend establishing the type of asset information required, the right way to collect that data, the best format and the right people to collect it at the outset of the project.

5.2 Starting handover procedures early

Leading clients promote the involvement of managers that will operate the built infrastructure right from the design stages of the project, with handover procedures and training beginning before key delivery professionals leave. Early involvement enables facilities and asset managers to discuss operations with designers before they disengage:

Whenever the building is handed over to me, definitely I would like the information then, but I would like to hold training sessions before everyone leaves the site, basically, because at handover: “this is it, whatever the building is that’s yours and we’re all going”, that’s what the perspective is from the contractor’s side. But if the facility manager is involved earlier in that, so that if, the first time he doesn’t get it right, so he can at least ask the – maybe the M&E – guys who are present on site to explain to him again.

The relationship between client project managers and the life-cycle operation team was something about which a number of clients commented:

Getting our life cycle team to take ownership of the information once they’ve got it. That’s what I’d like to see, so actually they’d acknowledge that it’s there and they’ll use it without keep coming back to the last project manager that worked on that site, which is the big temptation. […] You’re the project manager, can you
just tell me what sort of doors we used?’ ‘Look up the as-built information, it’s there for you, you don’t need to involve me.

Pre-handover meetings which involve those responsible for maintenance were one way to address this; but there were challenges in getting these staff involved at this stage; and this also required a positive form of interaction from the operation managers. One interviewee described where this was not the case:

They came almost with the attitude of trying to destroy what the contractor had done, saying: ‘Well we wouldn’t have done it like that and we don’t like that and we don’t like those units. We wouldn’t have put them there.’

Despite the challenges of implementation, at which the above quote hint, early involvement of operations managers was seen as being able to help address problems related to reusing and refining the data later in operations, setting data requirements early on and checking that relevant and accurate data are being handed over.

5.3 Shaping interoperable standards and systems

Interoperable systems and standards are crucial for data continuity across the life-cycle as the main data structures, formats and uses in the delivery of projects differ from those used in asset or facilities management. Leading clients and the supply chain are active in industry initiatives to develop such standards. An engineer using CAD layering conventions in utilities noted how 50-60 layers of information were needed in an area where:

The standard as it stands at the moment, give you no more than about three or four [layers] I think, so we just can’t use them, and that’s where we need to be involved in these, sort of, processes to make sure that we’ve got the flexibility built in to expand areas where we need to. If you try and cover everything in the main standard you’ll end up with a million different layers, which is no good either.
They needed layers for the existing layout, for any diversions and for examining future supplies. The limitations of standards often force their customisation, and there is interest among practitioners in ensuring their ongoing involvement in developing standards for data exchange and information sharing. Another client noted that:

*I want to accelerate the wider industry filling the gaps because at the moment [our company] has its own common language that I mentioned earlier. As we exploit more and more aspects of Building Information Modelling and as more and more architects and engineers use Uniclass, it may make more sense to migrate in that direction, but as a client using any sort of coding system like that, it’s quite unusual.*

Clients use multiple applications and face challenges in moving data between applications that are common in construction and the applications they use in operations such as asset management systems. One utilities provider gives the example of the interface between the GIS and CAD systems:

*From our perspective the interface between GIS and CAD is something that really needs to be solved. Certainly up until probably 18 months ago, they were seen as two different systems that couldn’t talk to each other. Now they’re seen as two systems that can, with a lot of tweaking, talk to each other but we know there are things that would make that a lot easier.*

At the same time, reliance on proprietary formats and systems can limit the client’s and main contractor’s ability to choose the best delivery teams, for example, as:

*If you look at the Revit [a proprietary CAD package] database outputs they would be product specific or platform specific and that wouldn’t really meet our needs. We would feel constrained in which designers we used, I think, if we were to go that specific, but equally I’m cautious about formats that require two lots of translation.*
Errors in the data are often introduced in translation and open exchange standards often involves translation from proprietary project software into the open format and then a second translation into proprietary asset and facility management tools.

### 5.4 Developing handover processes to check data and use and update it in operations

Clients develop their own internal standards, drawing on the wider standards but customizing these to serve their workflows, as a utility provider explained:

> The previous GIS system that we had was developed virtually in-house. The new one is an ESRI which is obviously a big player in the GIS world but it has been ... the data model behind it is [ours], it suits [our] needs. So the data that comes back, driven by the feature code library and by our standards and specifications is very much bespoke to the [company] working model.

One client of complex buildings described how the different performance requirements in different parts of their operation led them to manage a wide range of components without models that were in formats they could easily use, thus:

> The suppliers of that sort of equipment don’t seem to be set up to provide object models at the right level of detail. We don’t need an object model that tells you how to make the whole lift; we need something less than that that tells us the performance of it, the key maintenance aspects in the dimensions, the speeds, those sorts of things.

Clients have project management teams that oversee projects, checking deliverables against milestones not only the project on site up to the completion and handover but also the provision of information as they close out, however as two clients described:
You’ve got to rely on the project delivery team having provided the right information and having done the checking along the line, you can audit but to sit down and say ‘Right check everything that’s come in’ we haven’t got that luxury anymore.

They’re not specifically checking every document if it’s right, to check that it’s the same, correct information because in many instances they don’t know, especially if it’s a specialist engineering type project.

For the first of these clients, the big issue is missing where they have warranties, and hence paying to replace components that were still under warranty.

6 Improving data handover

6.1 Motivation for data handover

The main motivation for data handover is the value and use of data in operations. This study suggests that, while the various types of infrastructure have different characteristics, across them there is an understanding of the value of accurate and complete data. As discussed in section 4.1 clients value data to improve the performance of built infrastructure by:

- Improving operational expenditure and capital expenditure decisions; and
- Ensuring compliance with regulatory requirements to ensure safe and ongoing operation.

The handover of data from civil engineering projects into operations is often poorly implemented, with key engineers leaving the project before data handover and clients sometimes trawling through data to create their own spread-sheets. As discussed in section 4.3, in operating built infrastructure, such clients face the challenges of:
• Ensuring data accuracy and completeness is delivered at the end of the project – though leading clients have processes in place to check data at handover it is common to find that data is not available when required;

• Using data that are handed over in operations – where data are often not reused in operations, either because of difficulties in findings the relevant information, or for organizational reasons, such as contracts and liability; and

• Keeping data up-to-date in operation of the built infrastructure – where data from projects is handed over it maybe in unfamiliar formats and the appropriate tools, methods and skills are not always available to clients to update data during operations.

6.2 Lessons for data handover

Based on the above findings in section 5, the lessons learnt from leading practice, which form recommendations for civil engineering clients, include:

• Defining data requirements at the start of the project to obtain the ‘right’ data, which are accurate, complete, relevant, and in the most appropriate format;

• Starting handover processes early to get operations managers engaged before key engineers leave the project and allow them to share learning;

• Playing an active role in industry initiatives to shape development of interoperable systems and standards so that these support the type of built infrastructure; and data exchange required; and

• Developing handover processes for checking data rather than documentation and using and updating data from the project in operations.

For clients, making change based on the first two of these recommendations requires action at the project level, and on the second two requires action at a corporate level. For engineers
involved in the delivery of projects these lessons learnt have implications for delivering value to clients; and for helping clients achieve their goals by developing processes to use data through the life-cycle.

6.3 Limitations and directions for further research

A limitation of this study is its focus on the practices of a few leading practitioners and the analysis of generic lessons across different kinds of infrastructure. The study highlights the importance of emerging areas of research, in which scholars have developed guidance for new clients on how to set up BIM (Anumba et al., 2010); and the work of policy makers in providing standard processes for data handover that replace documentation. For utilities, road and railway network operators it is important to get the industry to adopt a set on standard classifications that bridge across their GIS, CAD and asset management systems. Such new directions also involve addressing the ownership and liability issues that mean that sometimes data are not used although available; and evaluating effective mechanisms for the early involvement of operators. This research highlights the crucial importance of data handover in managing the performance of the built environment. Further research is required to understand how to implement and get full benefit from it within the different types of infrastructure.

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