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ScienceDirect
International Journal of Project Management xx (2015) xxx – xxx
International Journal of Project Management
www.elsevier.com/locate/ijproman

Managing change in the delivery of complex projects: Configuration management, asset information and 'big data'

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Received 30 September 2014; received in revised form 5 February 2015; accepted 12 February 2015

Abstract

As we enter an era of 'big data', asset information is becoming a deliverable of complex projects. Prior research suggests digital technologies enable rapid, flexible forms of project organizing. This research analyses practices of managing change in Airbus, CERN and Crossrail, through desk-based review, interviews, visits and a cross-case workshop. These organizations deliver complex projects, rely on digital technologies to manage large data-sets; and use configuration management, a systems engineering approach with mid-20th century origins, to establish and maintain integrity. In them, configuration management has become more, rather than less, important. Asset information is structured, with change managed through digital systems, using relatively hierarchical, asynchronous and sequential processes. The paper contributes by uncovering limits to flexibility in complex projects where integrity is important. Challenges of managing change are discussed, considering the evolving nature of configuration management; potential use of analytics on complex projects; and implications for research and practice.

Keywords: Complex projects; Configuration management; Change; Asset information

1. Introduction

Digital technologies radically transform project delivery. Twenty years ago, Morris described the evolution of project management as closely related to developments in systems engineering, modern management theory, and the evolution of the computer (Morris, 1997: p.2). Today, mobile hardware, cloud computing and integrated software are becoming used for storage and retrieval, automated search, and prototyping and simulation functions. As such technologies are adopted in project-based industries, their use is breaking the mould of established approaches to project management, enabling more rapid and agile forms of organizing (Levitt, 2011; Whyte and Levitt, 2011). Up-front project planning, using multiple layers of work breakdown structures, became established by the 1960s in the management of large complex projects (Morris, 1997: p.44). New digitally-enabled approaches are emerging in industries, such as consumer electronics, software development, biotechnology and medical devices, that operate in dynamic and less predictable situations in which plans need to be updated and modified during project delivery (Whyte and Levitt, 2011). In these, data analytics and visualization using large digital data-sets – along with rapid, informal interaction and exchanges of information – provide the basis for more responsive, flexible and real-time decision-making (Levitt, 2011).

The information used to make decisions in the management of complex projects is generated and stored digitally. Complex projects are a set of projects that share particular defining characteristics: they are high-tech, capital intensive engineering projects that are of a significant scale, relatively long duration, and require firms to work collaboratively across firm boundaries in project delivery (Davies and Hobday, 2006; Hobday, 1998; Miller et al., 1995). Such projects deliver complex product systems, such as aircraft, experimental facilities and

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http://dx.doi.org/10.1016/j.ijproman.2015.02.006

Please cite this article as: J. Whyte, et al., 2015. Managing change in the delivery of complex projects: Configuration management, asset information and 'big data'. Int. J. Proj. Manag. http://dx.doi.org/10.1016/j.ijproman.2015.02.006

railways. Their delivery requires systems integration capabilities, as complex product systems are designed and integrated through a network of component and sub-system suppliers (Davies and Mackenzie, 2014; Davies et al., 2009; Hobday et al., 2005). Within these projects information about complex product systems is developed across multiple firms, involving diverse professions and trades, as these organizations interact through the digital systems.

A starting point for our work is the observation that, as we enter an era of 'big data', asset information is becoming a project deliverable. *Data* are unprocessed, often described as "unorganized facts" (e.g. Faucher et al., 2008: p. 55), while *information* is interpreted and presented to inform in a given context. Owners seek to use asset information to achieve sustainable and safe performance of complex systems through the life-cycle. An asset may be an assembly, sub-assembly, or component, but is the smallest unit maintained by an owner. The term 'asset information' is used to describe information about an asset, which may include the provenance, part types and serial numbers, design life, maintenance schedule, and design rationale for sub-systems or components. As data gets reused across the life-cycle, sets of data and information become combined and can be mined, interpreted and used in new ways. The UK government, for example, is, as a client for built infrastructure, requiring project teams to deliver asset information through building information modelling (BIS/Industry Working Group, 2011); and seeks to aggregate and combine data-sets, connecting them with Smart City and Smart Grid initiatives as part of a strategy for Digital Built Britain (UK Government, 2013).

Established approaches for managing change on projects use configuration management, a systems engineering approach with origins in the mid-20th century. In its original form, configuration management is characteristics of what Levitt (2011) describes as 'project management 1.0.' It involves hierarchical, sequential and asynchronous processes; managing change against a baseline. Its use focuses attention on assets as *configuration items*: sub-systems or components that have value to the organization, in which changes will often have systemic consequences on the function or layout of other items within the product structure and hierarchy. The baseline is an agreed description of one or a number of assets at a point in time, where the current configuration of a complex product system is described by the latest baselines plus approved changes.

New practices of managing change in complex projects might be expected as we enter an era of 'big data', in which internal and external data-sets become linked and asset information becomes a project deliverable. Morris argued that:"*rigorous change control is fundamental to good project management*" (Morris, 2013: p.126). Poor change control is one of the issues that limits managers' ability to execute viable project plans (Pinto, 2013). Others see projects, themselves, as information processing systems (e.g. Winch (2010) drawing on Galbraith (1973, 1977)). As project management information systems (Braglia and Frosolini, 2014) are increasingly used, altering the pace and complexity (Shenhar and Dvir, 2007) of projects, there are challenges to the: "*heavy formality of several of the techniques to manage large-scale, one-time, non-routine projects*" (Morris, 2013: p. 133). Here, Morris, like Levitt, points to software projects, in particular, as rebelling, using agile forms of management, through small projects with close developer-customer relationships.

The aim of this research is to articulate how changes in assets and the associated asset information are managed in the delivery of complex projects as we enter the era of 'big data.' This is done by analysing leading practices in three organizations: Airbus, CERN and Crossrail. Each of these organizations delivers complex projects; relies on digital technologies to manage a large volume of information; and uses configuration management to establish and maintain the integrity of the complex product system and associated information (see Table 1). Airbus is an aircraft manufacturer, operating in the aerospace industry and engaged in production of commercial and military aircrafts, with long-term projects to design and develop new aircraft designs and bring them into operation. Its headquarters are in France but the supply-chain is global, with the assembly of each plane involving thousands of companies and millions of parts. CERN is the European organization for nuclear research and the largest particle physics research establishment in the world, with 21 member states, 6 observer states and more than 80 collaborating countries. Its mission is to provide scientists from all around the world with tools to study the building blocks of matter and the origins of the universe. Crossrail is the largest construction project in Europe, with 14.8bn funding, delivering a new 100 km rail route with 10 new stations and a tunnel through central London connecting 40 stations. It has a complex supply-chain involved in delivery with more than 1,300 contracts.

Table 1
Background of organizations studied, and their industries.

	Airbus	CERN	Crossrail
Industry	Aerospace design and manufacturing	Nuclear research infrastructure	Civil engineering and railway infrastructure
Background	Leading aircraft manufacturer of commercial and military aircrafts, with a substantial international supply-chain.	Largest particle physics research establishment in the world with tunnels and particle accelerators	Design and construction of new railway across London with tunnels and 37 stations
Relationship to projects	Long term internal projects to design and manufacture new additions to the fleet, such as the A380, integrating sub-systems and components and delivering to customers.	Experienced project owner, managing supply-chain delivering accelerators such as the Large Hadron Collider (LHC)	Delivery client for a mega-project, the duration of which is 2008–2018, interfacing with future operators of the railway.
Location	France	Switzerland	UK

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