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The Challenge of Managing Modern Complex Projects

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ABSTRACT

This paper presents a review of the most significant contributions on the topic of project complexity. It sets this review within the context of the development of project management as a topic receiving increased attention from both academe and practitioners. Following this review, a proposed framework of project complexity is presented alongside a more granular componentry of project complexity derived from work published by the UK's National Audit Office. The proposed framework is then tested via application to a live case study that is proffered as being a case of project complexity. The purpose of the paper is to present a coherent argument for what can be understood to make a project complex with the paper being the first phase in a research project that seeks to understand what expert project practitioners see as making projects complex and how these experts approach the management of such projects

KEYWORDS: Management of Projects, Project Complexity, Complexity Framework

Introduction

This paper summarizes the commencing phase of a larger project to look at what makes modern projects complex and learn what expert managers of projects do when faced with such complex projects. The scope of this paper is to seek to distill and then add to the current discussions on our understanding of what makes modern projects 'complex'. This commencing phase will culminate in setting out a framework that both defines what a modern complex project is and allows for the future incorporation of appropriate management actions. The second phase, which is out of scope for this paper, will involve the interviewing of expert project practitioners to both confirm the framework and its elements that make a project complex, and identify what these experts suggest are the most appropriate ways of managing such projects.

The paper is premised on the observation that as the management of projects has become better understood and practised, so mankind's project ambition and ability have increased and expanded. Put simply, our species is now, post the impact of both industrial and computational/digital revolution, undertaking ever more and ever more ambitious, difficult and challenging projects.

In this expanding universe of projects many will inevitably comply with the 'standard' requirements for what we can consider as traditional project management. However, as we increase the scale and difficulty of the problems, opportunities or challenge we face, so we have to move beyond the simple and traditional approaches to project management. This is not a new argument and it has been picked up in the earlier work of Shenhar & Dvir (Project Management Institute. 2008; Shenhar, Aaron J. & Dvir 1996) as well as their later work (Shenhar, Aaron J & Dvir 2007).

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Defining terms

The word 'complex' is used in this context with careful consideration and adherence to strict definitions. The Oxford English Dictionary defines the word complex as both noun:

> *"A whole comprehending in its compass a number of parts, esp. (in later use) of interconnected parts or involved particulars; a complex or complicated whole."*

As well as an adjective:

> *"Consisting of or comprehending various parts united or connected together; formed by combination of different elements; composite, compound. Said of things, ideas, etc. (Opposed to simple, both here and in sense.)"*
>
> (Oxford English Dictionary 2016)

The word complex is often used interchangeably with the similar word 'complicated'. Again, referring to the Oxford English Dictionary, we find it variously defined as:

> *"Folded together"; "Tangled"; "Consisting of an intimate combination of parts or elements not easy to unravel or separate; involved, intricate, confused"; complex, compound: the opposite of simple".*
>
> (ibid)

In considering the above definitions it becomes evident that there is much commonality. However, there are arguments about important differences. For example Cuban's argument, (Cuban 2014) based on the work of Glouberman and Zimmerman (Glouberman & Zimmerman 2002), is that complicated tasks (or projects) are fundamentally underpinned by logic and rationality and are amenable to engineering and mathematically led approaches and require highly skilled people often using computers. Examples of this are the Apollo Moon landing and similar space missions. Cuban's argument is that a complex task (or project), however, is distinct as not having such clear linearity in logic, rationality and inherent predictability. A key feature of the examples given by Cuban are that they are fundamentally people driven - healthcare, justice and education are cited, but this is primarily due to the interest the author and article has in focusing on the world of systems – as healthcare, education and justice are clear examples thereof. Although out of scope for this paper, it is important to note that there is a separate and extensive literature on complex systems (Sayama 2015) and complex adaptive systems (Miller & Page 2007; Schuster 2001).

The separation of characteristics that demarcate the complex from the complicated lead to the appreciation of layering or dimensional attributes. This has been recently picked up in the work of Lessard et al (Lessard, Sakhrani & Miller 2014) with their three-tiered 'house of complexity' approach including institutional, project organizational and performance parameters. Indeed, conceptualizing about complexity - what comprises it and how to conceive it, as set within the context of projects - is a fertile area of academic writing (Williams, T 1997; Williams, TM 1999). Yet, as the very recent review from the UK's National Audit Office notes, successfully delivering many of the UK's most major projects still remains a deeply questionable challenge and one that has real risks for the potential triple bottom line failure of being delivered late, being more expensive than expected and not delivering the expected range and standard of benefits (National Audit Office 2016).

This paper therefore seeks to build off the considerable body of work that now exists for both understanding and assisting in managing those types of project that would, under normal practice definitions, be considered as 'complex' (Hass 2009; Pryke & Smyth 2006; Remington & Pollack 2007). The objective of the paper is to set out the ambition, objectives, limitations

and boundaries of the research and establish a working definition of what comprises a modern complex project. This will then form part of a bigger undertaking to seek the views of a wide range of expert project and program practitioners on what they see as making modern projects particularly complex and what management remedies they advocate.

Contextualizing

Whilst the area of project management has become both widespread and popular amongst both practitioners and, more recently, academics and scholars, the area of project management is still establishing itself as professional specialism within both the academic and practitioner worlds (Morris, PW et al. 2006); (Hodgson 2002). In the practitioner environment, the move to 'Professionalize' project management has been championed by the Association for Project Management in the UK through its application for it to be awarded the Royal Charter to recognize the discipline of project management as a true and fully registered profession thus placing it on a par with other accredited professions such as to be found traditionally in accounting, law, and engineering; and more recently, in marketing and banking. The fact that project management has received increasing recognition in both academe and practitioners for its specialist knowledge base, skills and aptitudes is therefore a major milestone in its development and maturity.

As the 'profession' of project management continues to build its intellectual base of dedicated scholars and practitioners, so it builds up its lexicon. To some the phrase 'project management' is a ubiquitous term that is sufficient to describe the topic or area, but to many it is insufficient. Put simply, since all projects are not the same, 'project management' is not generic in its application. Two examples are offered to prove this point. First, from project management there is a variant: 'program(me) management. Programs are not the same as projects and there is much literature on the differences (Evaristo & van Fenema 1999; Morris, P & Pinto 2010; Pellegrinelli 1997, 2011). At broadly the same time as the specialist literature on program management was being written and published another literature was emerging on 'megaprojects' (Flyvbjerg, Bruzelius & Rothengatter 2002; Merrow, E & Merrow 1988; Priemus, Flyvbjerg & van Wee 2008). It is fair to say that in terms of principles, both programs and megaprojects are based in and on the world of projects and their management, but both are distinct, different and have their own specialists and publications. Within the world of projects there are specialist sub-genres in areas such as project risk (Kendrick 2009), project leadership (Briner 1996), project governance (Williams, TM, Samset & Williams 2012), and project benefit realization (Office of Government Commerce 2002). There are also now highly established literatures in both agile project management (Goodpasture 2016; Highsmith 2010) and lean project management (Ballard & Howell 2003; Riis 1993)

It is in this context of increasing specialization and differentiation that this paper seeks to set out its place. The paper starts from the observation that the term 'complex project' has gained some degree of traction in the worlds of practice, research, training and education[3] as projects have become more prevalent. The two simple questions that this paper seeks to answer are, in the context of an increasingly complex world, what is understood by this term 'complex project' and what are the issues, particular to this class of project, that managers of such projects need to both know about and practice?

[3] See for example the International Centre for Complex Project Management: https://iccpm.com/, The Complex Project Management Course: http://www.pmcollege.com/courses/detail/complex-project-management, and the paper "And then came Complex Project Management": http://espace.library.uq.edu.au/view/UQ:13419

The paper is structured as follows: proceeding this opening and orientating introduction there will be a brief review of the development of project management with a specific interest in when the term 'complex project' first gained traction. This will be contrasted with the popularity and traction gained by the similar terms of program management and megaprojects. The paper will conclude with reflective comments and recommendations aimed at three groups of principal stakeholders: policy-makers, practitioners and academics.

Literature Review

The specific discipline of project management has existed for less than 100 years, although the toolset that still underpins project management, namely the precursor to the Gantt chart and Critical Path Networks, is now over 120 years old, with the Gantt Chart itself now over 100 years (Morris, PWG 2013). From these early deterministic approaches, the development of the Program Evaluation and Review Technique (PERT) reflected the post second world war period of rapid technological progress coupled with national defense urgency. It was in this cold war era that true project management emerged, with managers charged with delivering demanding projects that required the expanding of knowledge boundaries and the development of new tools, techniques, organizational structures and skill-sets (Morris, PWG 2013).

Whilst this era gave rise to the tools and skills that form the foundation of project management, the history of the latter part of the twentieth century and the beginning of the twenty-first have changed both the nature of projects and the context and environment in which they are set. The work of Morris for the more general historical review (ibid) and Winch for the construction sector (Winch 2010) describes how the nature of projects and the contexts they are set within have changed. Whilst many will still relate to the Iron Triangle (Atkinson 1999) of delivering a project to schedule, agreed budget and to conform to specifications, projects now face many more challenges than they did in the 1950s. There are many reasons for this escalation in the nature of the challenge (Morris, PWG & Hough 1987).

First is the fact that we have become more familiar with what projects are and how to deliver them. We have now a full industrial project ecosystem of project-based organizations, specialist tools and techniques, methodologies, education, training and qualifications (Ekstedt 1999). This world can be illustrated best by the raft of organizations that are either exclusively dedicated to project management (PMI, APM) or dwell in this world (US: NASA, Department of Defense; UK: Infrastructure and Project Authority). With this emerging project-focused ecosystem it is not surprising that the projects taken on have been grander and more ambitious (Flyvbjerg, Bruzelius & Rothengatter 2002).

Second, we have a far wider variety of sectors and regions that are utilizing this project management ecosystem. From the traditional project sectors of construction and civil engineering, we have seen the rise of projects set in industrial and process engineering, the energy sector, defense, and aerospace, information technology and telecommunications, pharmaceuticals, leisure and culture and, most recently, organizational change and adaptation (Merrow, E & Merrow 1988; Merrow, EW 2011).

Third, the invention, innovation and widespread deployment of a raft of varying technologies have had a profound impact on what projects can do and how project management can be exercised (Tatikonda & Rosenthal 2000). From the rise of the computer, through the ubiquity of information technology and telecommunications, to the invention and utilization of a wide-ranging palette of materials from the nanoscale upwards, has meant that we can consider projects that range from mapping the human genome to landing probes on comets in distant parts

of our solar system. We can now build structures that are over one kilometer high, that can take humans to the deepest depths of the ocean, and allow people to live in orbit of the Earth for many months.

Fourth and finally in this illustrative list, we have more transparency and awareness of what is happening in the world of projects (Crawford & Helm 2009). Partly as a result of technology and partly related to the spread of democratic capitalism, we have a general ability to be aware of and investigate much that is happening, including what is happening on projects. This is most acute on civilian projects funded by taxpayers in established and mature economies and societies. Here, there are both scrutineers from agencies representing the taxpayer and a free press. Both would expect (in the former case – demand) access to public sector projects to see what is happening and pass judgement on what they find. One only has to look at the longitudinal history of the modern Olympic Games to see a project-centric history of the success or otherwise of the venues that host these summer and winter sporting events (Chalkley & Essex 1999).

The discussions on project complexity can be traced back to the seminal work of Morris and Hough (ibid) and then the cornerstone works of Baccarini (Baccarini 1996) and Williams (Williams, T 1997; Williams, TM 1999). In this literature, complexity is deconstructed into the following elements or characteristics.

The first key concept identified is structural complexity which itself is a composite term that encompasses the number and interdependency of linkages of the various parts that comprise the project. It would include the organizations, contracts, technological platforms, processes and systems that all come together to deliver the project. Baccarini, and then Williams, notes a useful distinction between the structural complexity of the project delivery apparatus and the structural complexity of the product (or service, or hybrid). This then has strong resonance with the world of complex products and systems (COPS) (Davies & Hobday 2005), which adds to the rich mix of complexity with both the multiplicity of objectives sought from the project and the number and type of stakeholders who will have interest and or involvement in the project. A final dimension of project complexity is the uncertainty which accompanies projects that are either vast in size, very long in terms of the duration between project germination and cessation, and or the level of boundary or paradigm-breaking that project is expected to achieve. Hence the Apollo Moon landing in the US in the 1960s and the current Hinkley C nuclear power station being considered in the UK can both be accurately and certainly described as both complex and complicated projects (BBC 2016; Chaikin 1998).

The literature on complex projects has continued to be produced over the last 20 or so years. Significant contributions have been made on this subject by both scholars and more practitioner-orientated authors. Within this literature the work of Remington and Pollack (Remington & Pollack 2007) stands out. The book is predominantly about the tools that can be used to manage parts of or entire complex projects, but it does so within a coherent framework that, building off the work of Baccarini and others, sees project complexity ordered in dimensions. Remington and Pollack suggest four such dimensions of a complex project:

1. Structural Complexity
2. Technical Complexity
3. Directional Complexity
4. Temporal Complexity

(Source: Remington and Pollack, 2007, pp.6-8)

Structural complexity is driven by the scale of the management challenge presented by the project. Technical complexity is driven by the boundary-stretching nature of the product or object of the project. Directional complexity is driven by the diverse range and views of critical stakeholders. Lastly, temporal complexity is driven by the emergent potential long-lasting projects have to be altered as they reflect and are influenced by external environments.

In the US, the Project Management Institute has produced or inspired various contributions on the topic of project complexity, with both various White Papers and a practical guide (Project Management Institute. 2014). In this PMI practitioner space, the work of Hass (Hass 2009) proposes a Project Complexity Model that has eleven elements:

1. Time/Cost
2. Team Size
3. Team Composition and Performance
4. Urgency and Flexibility of Cost, Time and Scope
5. Clarity of Problem, Opportunity and Solution
6. Requirements Volatility and Risk
7. Strategic Importance, Political Implications, Multiple Stakeholders
8. Level of Organizational Change
9. Level of Commercial Change
10. Risks, Dependencies and External Constraints
11. Level of IT Complexity

(Source: Hass, 2009, pp. 44-45)

For each of the above, three categorizations of project context are offered: independent, moderately complex and highly complex.

In the UK an interesting and potentially valuable contribution to this literature has been made by the National Audit Office (National Audit Office 2013). This report advocates the use of a tool called DECA (the Delivery Environment Complexity Analytic). Its creation was stimulated by the NAO's repeated observation of problems with major public sector-driven projects. They note:

> "We found striking patterns in the reasons for projects failing, which all related to the importance of understanding the delivery environment and complexity of the project when making a decision whether to proceed." (NAO, 2013, p.4).

In a similar way to the work of Hass, the DECA identifies 12 areas that together combine to, in essence, define project complexity. These are:

1. Strategic importance
2. Stakeholders/Influencers
3. Requirements and benefit articulation
4. Stability of overall context
5. Financial impact and value for money
6. Execution complexity (including technology)
7. Interfaces/Relationships
8. Range of disciplines and skills
9. Dependencies
10. Extent of change

11. Organizational capability: performance to date
12. Interconnectedness
    (Source: NAO, 2013, pp.6-7)

For each of the above the NAO propose assessment and scoring of the level of complexity using a range 1 (low) to 3 (high).

The emerging picture of what comprises a complex project is that it is multi-faceted. This then presents a challenge for those managing such projects as they will be faced with a unique project challenge that will need an equally unique set of management actions and remedies in order to deliver the project successfully.

It is in this context that the consideration of a simplifying framework would appear to be a useful construct.

Methodology for the Framework Development

The research enquiry is a combination of confirmatory and exploratory. Its confirmatory elements are the generation of the componentry that will be used to construct a framework for defining and assessing modern complex projects. The exploratory aspects of the research are the formulation of the framework. The framework will be derived from two sources; the first will be the existing literature as reviewed. The second will be to draw from the authors' practical project experience. Here, the research is believed to benefit from the authors' range of experiences both within and outside academe. Both the authors have significant experience of complex projects. One of the authors has substantial experience of researching, designing, building and testing complex space instruments that are flown on missions by both NASA and ESA. The other author has significant experience of major construction and the design, build, finance and operation of prisons and immigration detention centers. These rich sets of experiences, totaling to more than 30 years of practical project management experience, were pooled and then used to consider what the 'essence of project complexity is'. This was deliberately done blind of the literature on the topic so that a comparative analysis could be conducted. From this comparison a framework is able to be produced. This proposed framework will be critically evaluated first by peer academics and, after necessary modification, will be used as the basis of the second phase of the research, which will be the interviewing of a range of expert project practitioners using the framework as the primary research instrument.

Results and Discussion

The existing literature appears to suggest two approaches, with proposed labels of the 'ordered models' and the 'lists'. Lessard et al, 2014; Williams, 1997, 1999; Remington and Pollack, 2007; Baccarini, 1996 would be categorized as ordered, whereas Hass, 2009 and NAO, 2013 would fit the list categorization better.

The authors set about the intellectual task of creating an ordered framework without seeking to be unduly biased by the existing literature and drawing on their own project experience. Approximately 12 hours of discussion over eight meetings were held with notes exchanged in between iterated and refined, until the following five factors of project complexity resulted:

A. The Project Backdrop (i.e. the situation that results in the proposed project)

B. The Project Ambition (i.e. the case put forward for embarking on the project)
C. The Project Organization (i.e. the entity (including the procurement route) that delivers the project)
D. TheProject Deliverable/Outcome (i.e. the boldness/uniqueness/sophistication of what the project produces
E. The Outcome Context (i.e. the situation that uses the deliverables etc.)
Source: authors

As a test, the NAO's DECA was further reviewed as the 12 items listed in the DECA are headings that themselves contain further elements. Table 1 presents 25 factors that are proposed as a list of items generating project complexity derived from the DECA. These 25 items appear to fit well into the framework (A-E) above. For example, the project backdrop, ambition, and deliverable would all explain item 3 (media interest). However, item 6 (the degree of challenging requirements) would be a more technical way of describing part of both the project ambition (B), the project's deliverable (D) and indeed the project organization (C).

1	Senior organizational interest	15	Degree of project technology novelty
2	Organizational impact	16	Ability to test and learn
3	Media interest	17	Number and type of interfaces
4	Stakeholder significance (number, interest, power)	18	Number and type of interdependencies
5	Degree of challenging objectives	19	Quality of leadership and decision-making
6	Degree of challenging requirements	20	Size of the project team
7	Out-turn success metrics	21	Diversity of specialization within the project
8	Stability of external environment	22	Location of project team and richness of connectivity
9	Experience and expertise of governance	23	Disruptive influence of the project on critical players: sponsors and users
10	Relative resource requirements (money, people, IT,)	24	Sponsor/client capability and capacity
11	Where the money is coming from and how it is supplied	25	Interconnectedness of the project to the parent/client/sponsor organization
12	Impact on key suppliers		
13	Degree of process novelty		
14	Degree of system novelty		

Table 1 Project Complexity Categorization based on DECA. (Source: based on NAO, 2013)

Whilst the work of the other authors will also be considered, it is this table 1 that will be the subject of empirical study proposed in this research project.

An initial desktop validation of the framework (comprising the five factors A-E and table 1) is needed and, drawing on the approach taken by (Green, Kao & Larsen 2009), the framework will be tested against a real project presented as an example of a modern complex project.

Case Application: University College London's Campus Expansion at Stratford

UCL has embarked on a major program of work entitled 'Transforming UCL'. This is a major program of work totaling in excess of £1.2 billion and taking 10 years. Within this major

program is the development of an entirely new campus within the Queen Elizabeth Olympic Park in Stratford, east London. This is the site of the London 2012 Olympic and Paralympic Games.

The new campus, referred to as UCL East, will cost circa £400m and be built in phases. When complete it will provide circa 125,000m^2 of gross internal floor area and will house circa 2,500 students and 400 academic and research staff (UCL 2016).

If we take the framework and apply it noting the contents of table 1, the following can be derived:

A. The Project Backdrop (i.e. the situation that results in the proposed project)

UCL has expanded and developed and is now a major world-class university. Given UCL's current location is central London, further expansion on the existing site is simply not affordable as the price of property in the vicinity is extremely and indeed prohibitively high. At the same time that UCL requires more space to expand, so there is a UK government interest in providing the promise of enduring legacy from the London 2012 Olympic Games. Moreover, as London's citizens invested heavily in the 2012 Games, the Greater London Authority, as the government of London, had a keen interest in the regeneration of this part of London. Therefore, at principal level we have four complex sets of stakeholders:

I. UCL (itself a complex composition of differing interests)
II. The UK government
III. The London government
IV. The local community

Finally, in the context, we have to note that UCL had previously actively considered expanding into this part of London via moving on to the site of an existing and functioning social housing estate. This scheme led to significant criticism and concern and was abandoned. From the above it is proposed that this is a complex project backdrop.

B. The Project Ambition (i.e. the case put forward for embarking on the project)

The case for UCL East is not straightforward as both the UK government and London government are willing to offer significant financial help to UCL, but this help comes with conditions. The primary one is that the initial phase (50,000m^2) must accommodate new activities and must not be a transfer of existing staff and activities. The reasoning is that new activity will add to the net level of employment and economic activity and thus confirm the promised regeneration. For UCL this presents a significant challenge and opportunity, for it needs to comply with these 'new activity' conditions if it is to receive the help it requires, but it also needs the new campus to ease the pressure on its primary campus. Delivering these conflicting objectives whilst also ensuring that the activities conducted in the new campus are themselves financially viable justifies the claim that the project is ambitious.

C. The Project Organization (i.e. the entity (including the procurement route) that delivers the project)

The project organization is still in the process of being fully assembled, so this is a dynamic area. What has become clear is that with so many interested parties, and with the various pressures and expectations, the project organization will need extremely strong leadership and clear governance structures and system. The fact that UCL has gone to financial markets to borrow considerable sums brings into play the scrutiny of the lenders, who will further add to the level of sophistication of the project organization. Thus, it is proposed that a simple project organization would not be sufficient to ensure the success of this bold project.

D. The project Deliverable/Outcome (i.e. the boldness/uniqueness/sophistication of what the project produces).

The project deliverable is a set of buildings that will be built by and for UCL. It has never embarked on such a bold campus extension before, yet its Gower Street main building is truly iconic. It will part of the legacy of the London 2012 Olympic Games and will be expected to last well into the future, as UCL begins to look at celebrating its bicentennial anniversary in 2026. As the first phase buildings are arguably the most challenging as they have to accommodate new activity, designing a building that will be respected and admired for its contribution to the public realm, enduring in its appeal, and be capable of housing activities that are at the forefront of science and knowledge would all suggest that the project deliverable will not be as straightforward as 'just another university building'.

E. The Outcome Context (i.e. the situation that uses the deliverables etc.)

Finally, the buildings that will finally comprise this new campus will not come on-stream until the 2020s and they will be expected to function for decades into the future. Thus, the designs will be used by those in the future that we do not know and cannot confidently predict how they will be using the buildings. If one uses the standard PESTLE[4] analysis in the context of UK higher education establishments one can see both actual and the potential for major change. Whilst universities have endured and are not seen as having a fundamentally threatened future, the nature and conduct of universities have been altering, especially in the UK, with funding now tracking students more than historically coming direct from government, technology having a dramatic effect on both research and teaching, and geopolitics and social change radically altering the profile of both staff and students. For these reasons it is felt extremely reasonable to argue that the project will finally emerge into a highly complex operational context.

Having initially tested the proposed framework on a live project it is felt that it is sufficiently reasonable to warrant further testing. Should the testing initially, via academic discourse, be successful then the next phase of the project will commence. The next phase will seek to the framework and contents of table 1 to better understand what comprises modern complex projects and what managing such projects then demands from those tasked with their project management. Three key practitioner organizations will be approached to seek permission to canvas their members for views. A combination of survey and interview will be used, and it is expected that a range of illustrative case studies will be revealed. The three UK-based organizations that will be approached are:

1. The Major Projects Association
2. The Infrastructure and Projects Authority
3. The Association for Project Management

Conclusions

This paper has sought to further refine our understanding of what makes projects complex. It represents the first phase of a two-phase research endeavor that has the ultimate objective of both understanding what makes projects complex and what expert practitioners,

[4] Political, Economic, Social, Technological, Legal, Environmental

principally in the UK, suggest are the best ways of managing such complex projects. The paper has demonstrated considerable interest in this topic from a range of authors spanning from academe, through official national organizations through to the practitioner. In so doing, it has revealed the approaches taken, some being more conceptual and others comprising lists of topics or elements. From this, this research has proposed a structured five-element framework which is seen as working with a deconstructed detailed list of project complexity components derived from work of the UK's National Audit Office. This proposed framework has then been initially tested on a live complex project.

This research project and paper have sought deliberately to walk the fine line to satisfy both the engaged scholar and the thoughtful practitioner. It intends to satisfy these two communities through presenting a single focus on a rigorously derived yet common sensical approach to what is a complex project and its setting, and what it takes to manage one.

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