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MANAGING THE IMPLEMENTATION OF COMPONENT INNOVATION WITHIN CONSTRUCTION PROJECTS

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Over the past decade the construction sector has increasingly recognized the potential damage that low innovation levels has had on the long-term future and sustainability of the industry. Traditionally a low priority; a lack of value or importance has been assigned culturally to innovation and despite recent improvements its levels still lag behind other sectors. The problem centres not in the obvious idea generation and problem solving capabilities demonstrated within construction, but instead in the persistent inability of organizations and projects to effectively manage the implementation of innovations. The research aims to address an emerging need to engage with the problem from the perspective of the construction project. Projects are dynamic, complex, short-term, and unique in form. Within this context, innovation has traditionally been perceived as representing additional project risk and is often for a variety of reasons removed over the lifecycle of a project. This research focuses on the need to understand the management requirements surrounding the implementation of component innovations (i.e. the implementation of novel elements within a construction project). Legislative and market demands have seen a range of innovative products emerge as construction projects are required to adopt a sustainable path in their design and construction methods. To respond to this agenda, project managers need to understand the requirements associated with managing the implementation of such innovations as a process across the lifecycle a project. Presented are the findings of a mapping exercise of the innovation process displayed during three case study housing projects where the key phases, activities, and decisions points were identified. Interviews were conducted with those involved in the delivery of the innovation within the project; and explored the context, identified influencing factors and the experience of integrating the components with the project across its different stages. A model is presented, with the importance of aligning the innovation process with the objectives of the project highlighted.

Keywords: innovation, project management, sustainability, case studies.

INTRODUCTION

The existence of low levels of innovation has been a historically acknowledged phenomenon within the construction industry, but only over the past 10-15 years has it been viewed as a situation of any real concern (Langford *et al.* 2001). Its connection with wider problems such as productivity, quality and the increasing difficulties experienced within project management in an increasingly competitive and globalized construction market has led to these low levels being identified as a potential threat to

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the long- term sustainability of the industry. This was raised in U.K. government reports by Egan (1998) and Fairclough (2002) and formed a core issue within the wider 'rethinking construction' agenda. Despite a lack of quantifiable estimates of its impact (Blayse and Manley 2004), the perception is that improvements have been made over the past decade, but it is clear that the construction industry remains slow to embrace innovation and change when compared to other sectors (Barret and Sexton 2006). With a history of relative failure in entrepreneurial practices (McCroy *et al.* 2008); the dynamics of the construction industry present challenges for innovation given limiting factors such as its immobility, unanticipated levels of demand, the dominance of SME's, fragmented nature of its supply chains, traditional short-term focus, aversion to risk, highly contextual nature of each project, and an environment of complex social processes (Harty 2005). The traditional consideration of innovation within construction has focused at the strategic level or on particular types of innovations (Koskela and Vrijhoef 2001). This focus has failed to address the problem from the perspective to which the industry largely operates as a mode of production, i.e. the construction project. Indeed, Harty (2005) suggests that to improve innovation capability, a better understanding is required of the management implications of the contextual factors and complex social processes involved in the delivery of a construction project.

Construction projects are predominantly one-off and multi-party by nature and are dependent on high levels of problem-solving capabilities and creativity across the project team. Indeed, the likes of Winch (2003) and Ling (2003) suggest that the innovation problem centres not on a lack of idea generation and creativity capabilities, but instead on the industry's inability to effectively adopt and utilize innovations. Gann and Salter (2000) stressed that a failure to recognize the requirements for managing innovation as a process, has restricted the ability to effectively engage with innovation as a problem. A challenging context is presented given the fragmented nature of project based industries and the disparate nature of their teams. This environment restricts the potential for intra and inter-project knowledge transfer regarding the experience of the innovation process limiting the obvious potential for change and wider learning across the industry.

The construction industry is currently experiencing rapid change as it responds to the economic downturn; and the legislative and market demand for the increased sustainability of the products and processes it offers. Firms struggling to retain a presence within a shrinking market are increasingly viewing sustainable construction as a potential avenue to achieve market advantage. An ability to align and demonstrate expertise around this agenda is therefore essential for firms at both a strategic and operational level. This cannot be achieved without the ability to innovate and effectively implement change in the products and processes offered in response to the desired changes. However, project managers are faced with a culture where innovations are often removed during the project process due to an association with uncertainty and additional risk resulting in time honoured practices (potentially unsustainable) being reinstated (Forbes 2001).

The paper examines the innovation process; the need for construction focused innovation models; and presents the findings of a mapping exercise of the innovation process and its management across the lifecycle of three case study housing projects. These examine the implementation of innovative products associated with sustainable construction, illustrating the key phases, activities, and broad decisions points requiring consideration across the innovation process.

MANAGING INNOVATION AS A PROCESS

Zaltman *et al.* (1973) defined innovation ‘as an idea, practice or material artefact perceived to be new by the relevant adoption unit’. This highlights two key components that management requires in order to deliver innovation: 1) it is novel in the eye of the beholder, and 2) it is adopted in practice. This understanding provides the basis for the likes of Rogers (1983) to observe that innovation as a concept exists as a process that requires to be managed from its inception through until its termination of use. Innovation requires a distinct approach to management that reflects its needs as a process (Tidd *et al.* 2003). Innovation theory and modelling has predominantly emerged from the context of product and process development within multi-national organizations. The likes of Gann and Salter (2000) and Slaughter (1998) were critical of the industries prevalence to consider models reflective of this context, as this fails to truly consider the complexities and dynamics of the construction industry. Whilst such models provide an understanding of the underlying principles of innovation management, a need exists to support this with contextually based models that reflect the nature and challenges of managing the process faced by construction professionals in practice. This focus has been identified by the likes of Bossink (2004) to present a rich empirical basis for considering innovation and improving its management within construction management research.

COMPONENT INNOVATIONS

For the purposes of this research, component innovation is defined as an innovation that refers to the creation and/ or implementation of a new element within the construction project (adapted from concepts by Tidd *et al.* (2003) and Rogers (1983)). It is necessary to specify that those component innovations emerging as products from the construction-manufacturing sector represent a significant proportion of innovation activity within construction (Langford *et al.* 2001). Although these represent product innovations in the traditional sense to the organizations producing them, to the construction project they are merely a component which makes up the wider project. A meaningful area for empirical focus is presented given the current focus this type of innovation is receiving within sectors such as housing as they attempt to embrace the changes required to deliver sustainability.

METHOD

A longitudinal case study approach was selected as a suitable lens within which to follow the innovation from its inception through to its completion or termination of use. Such an approach allows the innovation process to be mapped as a complete process and considered in the context of an active construction project. A narrative based approach delivered through interviews focused on understanding the nature of the innovation process, its integration with the wider project, the project management approach taken and the overall experience encountered by those involved. In total 12 individuals were interviewed across the three case studies (4 each), with the respondents identified as those directly involved in the decision making and its delivery within the project process. The structure of the interviews aimed to allow the respondent to tell the story in their own words, ensuring that external influences are limited. Each lasted between 1-2 hours, were recorded and transcribed, with respondents revisited at different points in the project process to ensure that the evolution of the process and the experience of practice were captured.

Each case study represented a project environment where the innovation being implemented was novel to those involved and as a result was consistent with the earlier definition. However, care was required to ensure that the sample selected reflects the variations in the nature of the innovation and the project environment experienced in practice. Consequently, a set of attributes reflecting the varied and dynamic nature of both innovation and project environment were identified in order to guide the selection of the case studies. The attributes were developed following interviews with a series of practitioners operating within the construction project environment. These emerging attributes were then reviewed against established innovation theory to ensure that key aspects were not missed. The emerging innovation attributes reflected the type of innovation (system, process or component), scale (incremental or radical), and source (internally or externally generated). Attributes were also identified relating to the project and these were the project environment (multi-party or in-house), its political environment (public or private sector) (Thomson 2006). Figure 1 illustrates the coverage of the three case studies across these attributes reflecting an attempt to identify variation in the attributes with the exception of the type (i.e. component) and source (i.e. externally generated), given the focus of the paper.

Project	Type of innovation	Scale of innovation	Source of innovation	Project management	Political environment	Specifics of innovation
Grass Roof	Component	Radical	External	Multi-party	Public funding	Grass roof
Passivent	Component	Incremental	External	Multi-party	Public funding	Ventilation system
Roof insulation material	Component	Incremental	External	In-house	Private funding	Insulation material

Figure 1: Case study selection grid with innovation and project attributes

Analysis of the case studies was conducted individually using process mapping techniques and organizational network analysis to identify the key phases, activities and decision points of the innovation process in relation to the stages of the project lifecycle. In addition, analysis was conducted around the contextual factors which influence the delivery of each phase of the process such as the environmental, cultural, and internal project factors. Each of the interviews were individually coded and analysed under the principles of grounded theory to ensure that the emergent nature of the research was retained. Once a process map (early stage model) emerged for each case study it was presented to members of the project teams for consideration and refinements were made. The three maps are cross mapped against each other, with the individual interviews again considered to identify potential gaps and to consider the context of differences observed.

BACKGROUND TO CASE STUDIES

Grass roof case study- considered the process of selecting and then integrating a grass roof into a block of new build flats commissioned by a housing association for the provision of social housing. The client was aware of the potential offered by grass roofs and through discussions with the architect and manufacturer of the material decided to consider it for the project. The funders were convinced of the merits of delivering such a high profile project and agreed to assist with additional funding in order to pilot its use for future projects. The innovation was included in the concept design, becoming an integral part of the design and was eventually installed by a specialist contractor who worked closely with the construction team. The apparent ease of its installation compared to traditional roofing materials resulting in the construction team feeling relaxed about the process, and evidence suggests a reduction in the long term maintenance costs which reduced fears from the client body. The key

concern related to how effectively the grass roof would integrate with the remainder of the project. Through careful management of the process, the client body (project managers for development) was able to work with the design team to ensure that these implications were managed and problems resolved.

Ventilation system case study- considered the process of selecting and then attempting to implement a new passive ventilation system within a similar block of new built flats for social housing with a housing association as the client. The passive ventilation system aimed to replace electrical fans with a system that operated on a series of flaps and vents and therefore met the sustainability criteria laid out in the design brief. The client body had used the concept within a previous project; however, the intention was to use an updated version with the aim of expanding its use within other projects. The innovation represented one of a number of sustainability criteria which the client desired to implement within the project and the architect attempted to integrate as many as possible into the detailed design. However, the innovation was withdrawn from the project late in the design phase, largely because of problems relating to its integration with other components introduced on the roof, such as solar panels and a grass roof. For the design team the innovation placed too many unknowns on the use of a mix of higher profile innovations due to the need to have the vent outlets protruding through the roof itself. The team's uncertainty resulted in the passive ventilation system being rejected, in an attempt to protect those deemed of greater importance to the overall success of the project.

Insulation material case study- considered a private housing developer who decided to proactively try out an innovative roof insulation product with a view to achieving market advantage prior to stiffening building regulations. The development was for high value domestic housing and the developer felt this allowed for a sufficient margin to absorb any uncertainty or risk from adopting previously untried and still expensive materials. The architect was the driver or champion behind its use, and was responsible for managing its development within the project. Close consultation was achieved with the site team throughout the process, and this resulted in the innovation being embraced at a practical level during its implementation on site. The material was a lot thinner than traditional materials, lighter, and easier to implement and this was effectively communicated to the site team from an early stage. Although initially expensive, this cost will drop over time as the product gains greater market share and potential savings in energy costs for future building users are observed over the years.

MAPPING THE INNOVATION PROCESS

The mapping of the innovation process from the generation of the idea through to its completion or termination within the project, revealed a linear process closely aligned with the stages of the overall project lifecycle. This is not surprising for component innovations given they are by nature an element of the project and tend to reflect the phases of planning, design, construction and use. Whilst a linear process should be expected due to the project nature of the environment, the emergence of three decision gates punctuating this process was a significant observation. The decision gates were observed to mark a transition in the nature and function of the activities of the process, with progression marked through the satisfaction of a given criteria reflective of the phase of the process and authority granted by those involved (with the nature of the individual varying depending on the phase of the process). This forms four phases of the innovation process identified as the initial, formulation and development, implementation, and handover and the alignment of these phases across the project

lifecycle of the three case studies is demonstrated in Figure 2. For the purposes of illustration the RIBA Plan of Works 2007 will be used to illustrate the stages of the project lifecycle.

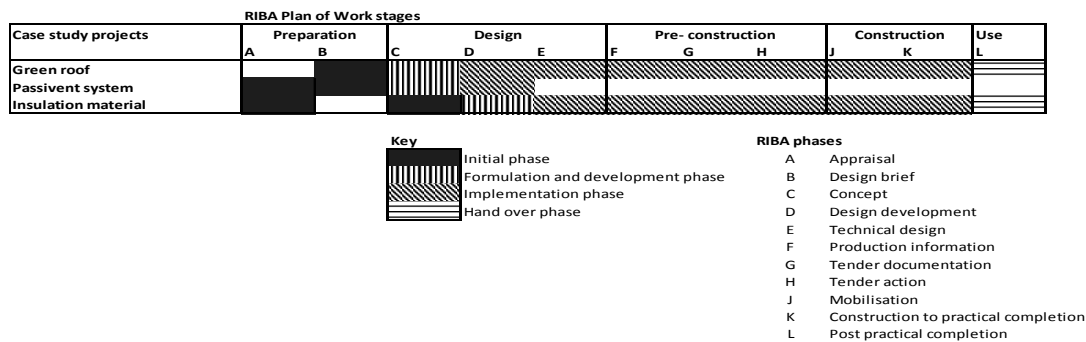


Figure 2: Mapping of innovation process with project lifecycle

Figure 3 details the findings from the cross mapping of the three case studies illustrating the activities (phase process), factors of influence (i.e. environmental, internal project factors and cultural factors) and the activities undertaken by management to facilitate the activities of the process (management control system). Illustrated are the three decision gates which are understood as 1) decision to develop the concept; 2) decision to implement; and 3) decision to complete implementation; and the resulting four phases. From the interviews it was clear that the innovation process experienced two levels of management control, one related directly to the internal function of the phase (i.e. management control system) and the second related to the overall management of the innovation process and its integration needs with the project. The selection of an appropriate team also emerged as a significant element and this is captured in figure 3 detailing the considerations associated with pre-selection, requirements for selection and post selection. The detailed activities or factors identified represent the end point of the coding, creation of nodes and categorization process associated with the analysis of the interviews and the integration of the three case studies into one model. The four phases and the overall innovation management layer are explored in the next section.

Initial phase- represents the activities associated with gaining the authority required to progress the innovation from its conceptual form as a philosophy and to begin to formulate and develop it for practical application. In preparing the project for the first decision gate, two sub-sets of activities emerged, 1) assessments relating to the suitability, viability and the initial implications of the concept in practice, and 2) those activities relating to the presentation of the idea to the team and ensuring that a plan is established for an initial methodology for the process. The grass roof and passive ventilation case studies both illustrated an example where the client emerged with the idea for the innovation in response to its emerging visibility within similar projects and a need to gain experience. Analysis revealed that their role thereafter was to sell the idea to the rest of the team (i.e. design team) and ask them to consider its suitability for the project. The background environmental factors were positive for considering these innovations given the emerging sustainability agenda and this was highlighted by the additional funding secured in the case of the grass roof to reduce the financial risk associated with its delivery. In the context of the insulation material case study the architect was the idea champion, and required to sell the concept and business case to the client (i.e. the development manager). Observed was a gap in the activities from its initial emergence at a project meeting during project appraisal, and

it re-emerged during the concept design stage when the development manager recognized the ability of the project to absorb the relative risk due to the high value of the houses. It was clear that once the case was made to the team, the wider contextual factors were favourable given the alignment with the sustainability agenda.

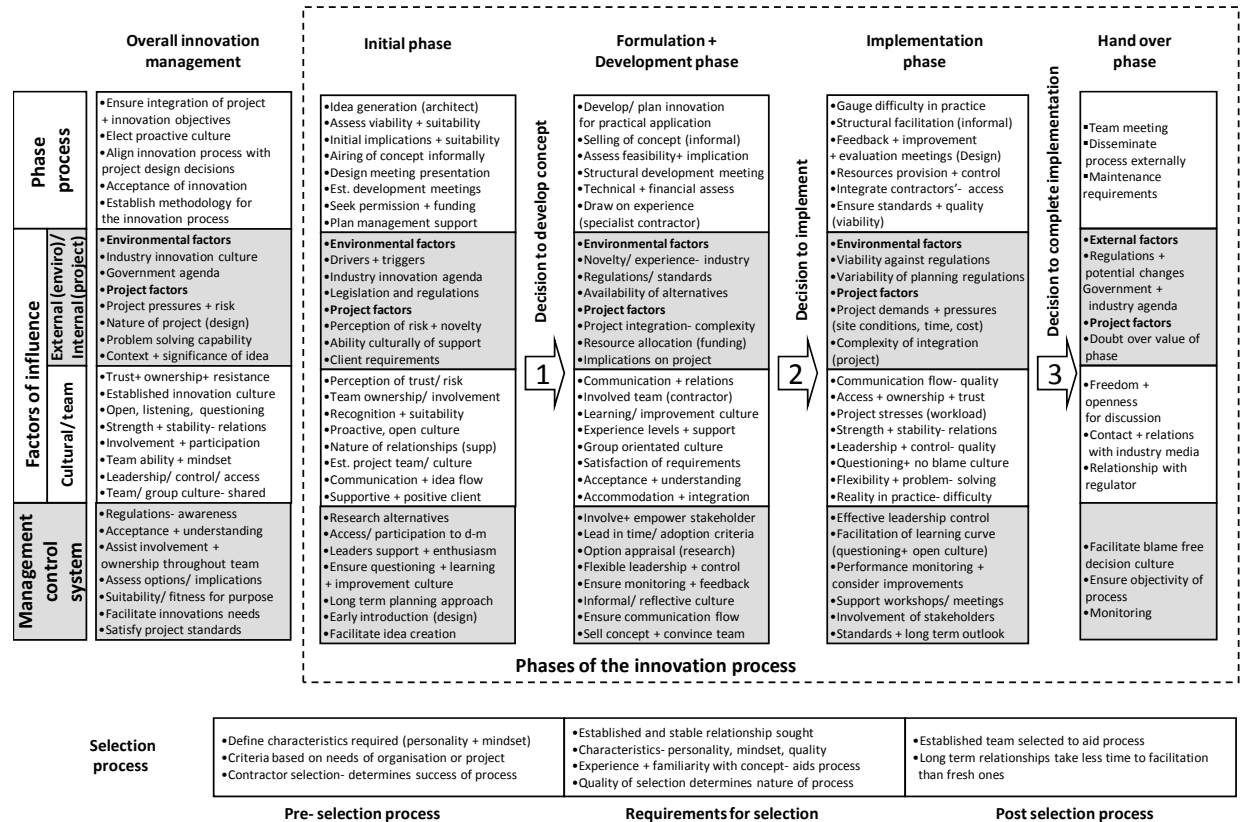


Figure 3: Emerging component innovation process model for projects

Formulation and development phase- represents the process of transferring the concept from a philosophy into one that is developed and ready for implementation. The need to convince the decision makers that the innovation has been developed sufficiently to enable it to be implemented, defines the nature of the activities of this phase. Although they appear in a varied manner within each case study, it is possible to divide them into two sets for the purpose of this discussion: 1) activities of assessment (feasibility, technical, financial, risk and impact assessments) and 2) activities of planning (planning and development for implementation or practical application; those associated with ensuring that the technological and infrastructural conditions are formulated for the project specifics; and the assessment and planning of its integration requirements). The importance of these activities to the success of the innovation process was highlighted in all three of the case studies. In the context of the grass roof and the roof insulation material case studies, the thoroughness with which the respective idea champions assessed the overall suitability of the project and planned its implementation presented the rest of the project team (designers, contractors, and maintenance) with a clear case for its inclusion and a detailed understanding of its implications for their role within the project. Within the passive ventilation case study these activities were just as thorough, but through up doubts over the suitability of the innovation for the project. This led to a loss of support for its inclusion within the project team resulting it other innovations being favoured due to their closer alignment with the overall project goals. In this context, the innovation

was allowed to pass the decision gate, and included in the concept design but was at risk of being dropped during the implementation phase (i.e. during detailed design).

Implementation phase- involves the process of managing the implementation of the developed concept and represents the transformation into its practical function. Evaluation of the activities of the phase revealed that they can be split into three sets: 1) activities relating to the structural planning and facilitation of the implementation process (an established methodology and programme, sufficient provision of resources and control, and structural facilitation measures), 2) activities connected to the monitoring and feedback of the performance of the implementation process (gauging the difficulty in practice, feedback, improvement and evaluation meetings, and monitoring standards and quality during implementation), and 3) activities associated with supporting the inclusion of all of the stakeholders within the process (integration of contractors and subcontractors, and catering for wider stakeholders). The revisiting of activities was also determined to be a feature of this phase, until progression was authorized through the satisfaction of the decision gate.

Within the case studies, the move into the next phase results in a firm decision to include the innovation within firstly the detailed design stages and secondly to its inclusion during the construction stages of the project. The grass roof and insulation material case studies saw firm support for the innovation across both the design and construction site based teams due to the buy in which they felt for the innovation. Planning the logistics involved in delivering and fitting the innovations from a site perspective was observed to be very important within both these projects given the contrast with traditional practices. The roof insulation material was much slimmer than traditional insulation and had implications for those fitting it into the roof spaces, and the grass roof needed a lot of storage space on site and to be lifted up to the roof as a roll and then slowly laid. However, careful planning and constant feedback between the various teams ensured that any problems could be overcome. The project teams also benefited from being able to see the overall benefits of the innovations to the project as a whole due to their inclusion in the decision making process. However, in the passive ventilation case study a lack of feedback between the design team and the client resulted in a problem in the integration of the different innovations in the design of the buildings roof. Given the lower level of priority assigned to the innovation, the decision was taken to drop it from the project. This decision was not a failure on the part of the innovation process, but instead represents a success for its management in spotting potential problems and protecting the long term interests of the project by withdrawing the innovation.

Handover phase- represents the final phase of the process where performance is evaluated and the requirements for the future of the innovation are considered (i.e. its maintenance and operation, and lessons for its future consideration). Analysis revealed two types of review process within the case studies, one informal which was unstructured and unplanned stemming from discussion amongst the team members about their experience and another formal exercise centred on a post-evaluation meeting structured prior to the disbandment of the team. Evidence suggested that the phase plays a significant role in maximizing the transfer of knowledge and in facilitating learning amongst those involved prior to the completion of the process. In the context of the grass roof case study, the team gained significantly from a formal meeting to focus purely on the evolution of the innovation, through an assessment of both the integration of the project/innovation objectives, and the facilitation of its management. As a housing association, the client body placed value on wanting to

learn for the future and aimed to gain the view point of all the involved project members. This is an important process in ensuring that both intra and inter project knowledge about the innovation (i.e. its performance) and the experience gained in its management is transferred beyond those directly involved in its delivery. The passive ventilation case study failed to provide a post-evaluation meeting to discuss the innovation's removal during the design phase, and this runs the risk of team members failing to transfer the lessons for future projects.

Overall innovation management layer- is identified as overseeing the four phases of the innovation process by monitoring and providing both influence and feedback between the phases and between the innovation process and the wider project across its lifecycle. This represents the directing, guiding, monitoring and feedback roles of the overall innovation management and illustrates the two way nature of its interaction with the individual phases. The case studies demonstrated the need to ensure that the innovation was aligned with the overall strategic objectives of the project. The grass roof case study illustrated this alignment as it was integral to the buildings design and was symbolic for the progressive vision of the client for social housing. In the context of the passive ventilation system, it was apparent that the innovation was less significant than other higher profile design features and as a result the client (responsible for this layer) was able to instruct the design team to drop the innovation. The alignment of an innovation with the project's wider objectives is important and this layer is necessary to provide an overview of the innovation process in the context of the wider needs of the project. The research observed that the selection process was an activity undertaken at the project level ensuring a supportive mindset for innovation.

Tailoring a management response- the research acknowledges the challenge of developing a model that is responsive to the variations in innovation and project attributes. Analysis revealed that it was not the attributes which influenced the success or failure of the innovation process, but the ability of management to accommodate for their implications. For example, whether the innovation was radical or incremental was not significant, but rather it was management's ability to accommodate for varying levels of understanding or a perception of risk within the team. As a result, the model aims to avoid prescribing a management response, but instead aims to provide a framework which allows management to identify and develop a response appropriate for the context. Thomson (2006) developed similar models for system and process innovations, and explored the implications of managing the influence of the different attributes and the need for tailored responses.

CONCLUSIONS

The research outlines the emerging structure of an innovation process model developed to aid the understanding of practitioners in the management of component innovations within the construction project environment. The model displays a need for practitioners to observe and understand the activities required to satisfy three decision gates that punctuate the process and form the boundaries to four recognizable phases. A tailored management response delivered through two layers of management that respond to both the strategic needs of the overall innovation process, as well as the specific needs of the individual phase. Key factors identified were the role of the innovation champion in leading the process during particularly the early phases; the need to support the innovation process; provision of information and evidence of the innovation potential; and the need to ensure that the innovation is aligned with the

overall project objectives. Further research will examine the dynamics of the emerging model against three dominant innovation modelling styles (i.e. stage gate, emergent and cyclical) to consider potential gaps and to further consider the apparent iteration and feedback between the activities within a phase, and the different phases.

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