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BUILDING OFFSITE RESILIENCE USING CAPABILITY-DRIVEN STAGE GATES

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Abstract: Architecture, Engineering and Construction (AEC) organisations often operate in highly volatile/uncertain environments, with the only constant being that of 'risk'. Given this, several organisations have now started to use offsite delivery platforms to mitigate some of the issues associated with 'traditional' construction challenges, particularly: cost overruns, delays, skills shortages, quality-control, waste (materials/resources), sustainability, health and safety etc. However, migration from 'traditional' thinking to 'offsite' thinking is uniquely beset with its own set of problems, most notably, what organisations need to have in place, ergo skills, resources, people, process, technology etc. Whilst the answers to these questions are not in themselves overly complex, having a detailed understanding of these can help organisations improve their organisational resilience.

This research presents findings from three multinational AEC organisations based in Turkey. These organisations were going through offsite transition, and each faced bespoke challenges associated with 'perception awareness' and division in 'stratified thinking'. To mitigate this, a cross-case study approach was used to evaluate awareness and thinking across three managerial levels (First Line Management; Middle Management; Top Management). Saturation analysis was used to secure representation and collective understanding to support theme discovery. Findings were then mapped into a hybrid offsite transition model, which was based on resilience metrics and capability-driven stage gates. This model provides organisations with clear directions on how to leverage resources, capabilities and intellectual capital - to not only underpin organisational responsiveness and resilience *per se*, but also the stage gates and evidence metrics needed to deliver future offsite exploitation.

Keywords: Offsite; Construction; Maturity; Resilience; Capability

1 INTRODUCTION

Over the last 50 years AEC has been continually challenged to improve. This has been acknowledged as a global problem. Where for example, from a UK perspective, several reports (Farmer, 2016; Nadim and Goulding, 2011; Parliament, 2018) have highlighted this, noting concerns with efficiency, resistance to change, lack of innovation culture, fragmentation, and poor quality. Improvement measures included everything from skills provision, through to improved collaboration, communication, and measures to improve productivity (Banwell, 1964; Latham, 1994; Fairclough, 2002; Farmer, 2016; HM Treasury, 2021). However, over the past 20 years or so, offsite construction (OSC) has increasingly been seen as an innovative approach capable of mitigating some of AEC's long-standing challenges – particularly by moving some of the 'traditional' construction activities into a controlled environment in order to benefit from

advanced manufacturing techniques (Pan, Gibb and Dainty, 2005; Arif and Egbu, 2010). This approach has proven to be particularly effective for addressing inherent inefficiencies most often associated with traditional construction. This areas range from environmental sustainability, carbon, and waste management (Nahmens and Ikuma, 2012; Jaillon et al., 2009), through to quality, process, and performance improvements (Goulding and Rahimian, 2019; Goodier and Gibb, 2005; Blismas et al., 2012; KPMG, 2016; Wang et al., 2020).

Arguably however, the story does not stop there, as several AEC organisations decided to engage with the concepts of OSC without prior thought or due diligence. The concomitant result of which has led to several high-profile failures. These failures have prompted some degree of cynicism, highlighting the need to further examine the subtle nuances of OSC, including the need for a comprehensive understanding of the unique nature of offsite, and the need to develop organisational responsiveness and resilience capabilities aligned to OSC capabilities (Stehn et al., 2021). Given this epoch, this paper proffers that organisational resilience should form the central core (or tenet) for any/all organisations wishing to enter the OSC market. Moreover, that any such transitional arrangements (from traditional to OSC) be evaluated from a "capability" perspective, where organisational resilience can be assessed and evaluated through capability maturity-driven approach beforehand.

2 LITERATURE REVIEW

2.1 Offsite Construction

Whilst Industry 4.0 and 5.0 has sparked increased interest in offsite (Hadi et al., 2023; Marinelli, 2023), OSC as a concept or idea is not new. Early iterations of offsite are commonly associated with mass housing provision after World War II. However, its origins can be traced back to the early 1600s when housing supplies were sent from England to the United States (Arieff and Burkhart, 2003). Since then, various offsite-related terms have been used (often interchangeably) to describe the unique concepts, categories, and typologies of OSC (Jonsson and Rudberg, 2014; Ginigaddara et al., 2019). Where typical terminologies now span issues from: industrialized building systems, modern methods of construction, pod technology, off-site construction/fabrication/production, modular construction, pre-cast panels/foundations, sub-assembly systems; through to volumetric/hybrid construction, and factory-assembled panels, among others. Thus, in order to avoid ambiguity, this study uses "OSC" as an umbrella term for all these different categorisations and typologies.

The core underlying principles of OSC are predicated primarily on moving construction-related tasks (which are traditionally carried out on-site), to a highly 'controlled environment' - one which is not directly exposed to external events such as the weather. This controlled environment is typically a manufacturing facility, factory, or special premises dedicated exclusively to OSC (Gibb, 2001; Arif and Egbu, 2010). This requires organisations to think differently, to embrace a new way of thinking – ergo towards a more "manufacturing-oriented" approach. In doing so, this brings several benefits, such as; faster delivery, better quality of the final product, reduced costs, improved Health and Safety and much lower on-site labour requirements (KPMG, 2016; Nadim and Goulding, 2011; McKinsey, 2017). However, this new way of thinking requires careful thought, especially in the remits of: planning (materials/resources); robotics and automation; level of OSC expertise available; product variety; strategic direction; platform strategies etc. Moreover, dereliction of this can often hinder OSC transition, and in some instances lead to "avoidable and/or intelligent" business failure (Green, 2022; Rabeneck, 2021).

2.2 Organisational Responsiveness

In volatile and unpredictable markets such as AEC, risk and uncertainty often go hand in hand. So many issues need to be contemplated, from energy, through to inflation rates, supply chain and labour challenges. All these impinge on organisational resilience; where it is proffered here that organisations should take extra care to develop their abilities to withstand (and recover) from rapid changes, disruptive events and crises (Banahene et al. 2014; Bhamra et al. 2011). On this theme, the concept of organisational 'resilience'

was defined by Kuntz et al. (2017) as "…system agility and robustness, essential to survival and thriving in increasingly challenging contexts". In essence, it involves the capacity to embrace and learn from challenges while also preparing for and responding to new obstacles (Duchek, 2020; Giustinianoetal, 2018; Vogus and Sutcliffe, 2007). In a similar vein, the term 'responsiveness' was defined by Holweg (2005) as the ability of a manufacturing system or organisation to respond to customer requests; whereas, Catalan and Kotzab (2003) included the ability to respond quickly and efficiently based on real-market signals; where Chen et al., (2021) included the need recover from change, and Malik (2013) included the need to include organisational sensing – which resonates with Barclay et al., (1996) to include significant events, opportunities, or threats. However, for the purposes of this paper, the term 'responsiveness' follows the definition of Sharifi and Zhang (1999), as "the ability to identify changes and respond quickly to them, reactively or proactively, and to recover from them." Collectively therefore, understanding the components of 'resilience' and 'responsiveness', can not only help support company survival, but also improve overall competitiveness.

2.3 Capability Maturity Modelling in Architecture, Engineering and Construction

One of the key challenges organisations tend to face in volatile businesses sectors such as Construction, is that of continued survival. Cognisant of this, many things need to be carefully evaluated, balanced, and operationalised, ranging from competitor analysis, through to portfolio/platform analysis and accompanying risk management strategies. In this respect, several tools can be used to help with some of these variables (far too many to mention here); but typically, these embrace such issues as: resource management, process control, planning solutions, through to customisable solutions proffered through strategy tools such as GAP/SWOT/PESTLE and proprietary offerings provided by Porter/McKinsey/Ansoff etc. However, one of the often-overlooked solutions is that of Capability Maturity Modelling (CMM). The origins of CMM can be broadly traced back to concepts discussed by Crosby (1979), where solutions were seen as being particularly good for evaluating and improving the maturity and effectiveness of business processes. These were later codified by the Software Engineering Institute (US Defense Department) at Carnegie-Mellon University into a formalised Capability Maturity Model for Software (Paulk et al., 1993). This new approach was subsequently adopted in many different sectors and industries, paving the maturity-based organisational assessment.

The use of CMM's within organisational settings are based on the concepts of scaled 'levels of maturity', where each level represents a level of maturity and corresponding level of organisational capability. The most common format of CMM is based on five levels of increasing maturity, typically covering: Level 1 [Initial] very basic systems and processes; Level 2 [Repeatable] some repeatable processes; Level 3 [Defined] some semblance of standardisation and synergy; Level 4 [Managed] engages performance measures to structure integration; and Level 5 [Optimizing] represents the highest level of achievement (Figure 1). The rationale behind this is to provide organisations with a "to-do-list" for them to migrate from one level to another, ergo to make improvements and move up the levels of the framework. The stage gates (between maturity levels) have accompanying progression criteria, where progression is only permitted subject to meeting prequalification requirements. The Stage Gate approach (Cooper, 1988) provides a particularly useful approach for managing process-driven operations, especially construction (cf. Process Protocol).

The CMM approach has been widely adopted, with initiatives including: SPICE (Sarshar et al, 1999; 2000), the People Capability Maturity (Curtis et al., 2009), the Organizational Project Management Maturity Model (PMI, 2003) and the Business Motivation Model (Object Management Group, 2008). One of the main advantages of using CMM is that this approach is particularly useful for assessing organisational ability (through well-defined maturity levels). These five CMM levels identify areas for improvement, but perhaps more importantly, provide the organisation with precise metrics for achieving higher levels of maturity. This is not too dissimilar to other tools such as the Balanced Scorecard (Kaplan and Norton, 1992) or EFQM Model (EFQM, 2024). In summary, this approach was adopted in this paper as a vehicle for exploring organisational challenges through a maturity-driven approach which more purposefully captures skills,

resources, people, process, technology etc. to not only provide clearer pathways to support organisational suppleness, but also identify the resilience metrics and capability-driven stage gates needed to underpin transitional maturity progression.

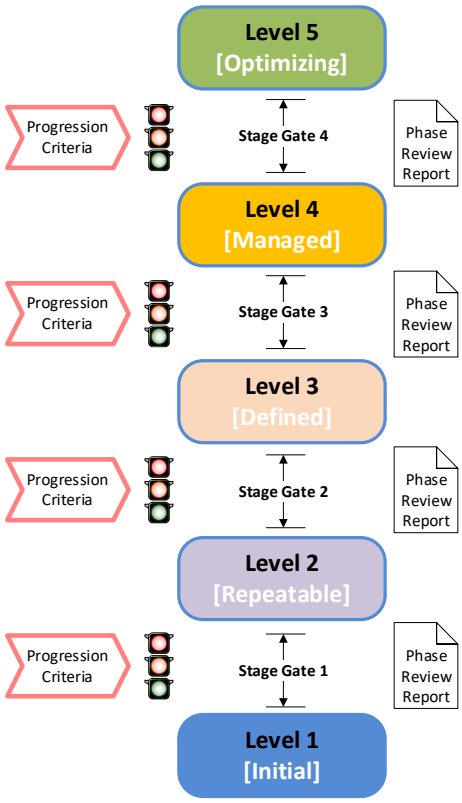

Figure 1. Five Stages of Capability Maturity

3 RESEARCH METHODOLOGY

In order to appreciate the nuances required to support organisational 'resilience' and 'responsiveness' for AEC companies wishing to enter the OSC market, the capture instrument needed to be aligned to organisational need in order to propose a new approach – where the solution guided their transition (from traditional construction to OSC).Given this, an interpretivist approach was adopted for capturing respondents' views. The observational lens (Hawking and Mlodinow, 2010), used outputs from previous research on organisational capabilities, which was refined and distilled to incorporate 'responsiveness capabilities'. From this, a case study approach (Yin, 1994) was adopted. This engaged three similar companies (cf. literal replication approach) from Turkey, to secure in-depth understanding of the socio-technical phenomena and constructs underpinning thinking and decision-making. Threse three case study companies were well-known international contractors, all of which had various degrees of experience in OSC. In order to capture a balanced (representative) view of the different managerial levels in the organisation, interviews captured the views from three different levels (first-line management, middle management, and top management) for all three case study organisations. In this regard, eight interviews were conducted in each organisation, providing a total of 24 respondents across these three companies (Table 1). Each interview took an average of 60 minutes. All interviews were recorded and analysed using content analysis.

Table 1: Respondents' experience by management level

Management Level	Experience (Years)					TOTAL NR*
	0 - 5	6 - 10	11 - 15	16 - 20	21 -	
Top Management (TM)	-	-	-	1	5	6
(Board of Directors, Chief Executive Officer, General Manager, Managing Director, President, etc.)						
Middle Management (MM)	-	-	4	2	3	**9**
(Department Heads, Branch Managers, Junior Executives, etc.)						
First Line Management (FLM)	4	5	-	-	-	**9**
(Engineers, Architects, Surveyors, Technicians working under the middle management)						
TOTAL	4	5	4	3	9	**24**

*NR = Number of respondents

4 FINDINGS AND DISCUSSION

Findings from these interviews were ranked and scored using the Relative Existence Index (REI), the results of which can be seen in Table 2.

Table 1: Respondents' Ranking and REI Scores

Capability	TM		MM		FLM		**TOTAL**	
	Rank	REI	Rank	REI	Rank	REI	**Rank**	**REI**
[MR] Monitoring and Reporting	9	0.883	7	0.756	8	0.789	**8**	**0.800**
[CA] Connectivity Awareness	3	0.783	4	0.733	5	0.733	**3**	**0.746**
[RA] Risk Analysis	7	0.817	5	0.744	4	0.711	**4**	**0.750**
[SV] Strategic Vision	8	0.867	8	0.800	9	0.833	**9**	**0.829**
[KM] Knowledge and Information Management	4	0.800	1	0.700	7	0.767	**5**	**0.750**
[DM] Responsive Decision Making	1	0.717	3	0.711	2	0.667	**2**	**0.696**
[AN] Assessment of Recovery Needs	4	0.800	9	0.811	3	0.667	**7**	**0.754**
[RP] Recovery Plan Development	6	0.800	5	0.744	5	0.733	**6**	**0.754**
[RO] Reorganisation	2	0.733	2	0.700	1	0.600	**1**	**0.671**

Key: TM-Top Management, MM-Middle Management, FLM-First Line Management; REI-Relative Existence Index

These findings provided a useful point of departure for solution generation. Some of the main discussion points centred around the following issues:

Active Scanning (Day, 1994). The capability of detecting, (sensing, perceiving, and anticipating) changes and risks in the market [MA]. This aligns with the findings of Chowdhury et al. (2020).This includes the importance of horizon scanning and forecasting capabilities to create and support organisational awareness [external], as well as understanding the organisation's resource levels (people, processes, and technology) [internal] as equally important requirements for strategy formulation.

Agility and Responsiveness (Bernardes and Hanna, 2009). Being aware of how different dynamics are linked, and how they affect each other, both within the organisation and the market [CA]. An interesting point to note here was a difference in perception between the lower levels of management and top management awareness of these links. This disconnect and lack of awareness, cohesion and interaction resonate with forces of change and market dynamics (cf. Osunsanmi, Aigbavboa and Oke, 2018; Ebrahimi, 2019).

Risk and Dependencies (Volkoff et al., 2007; Hanelt et al., 2021). Respondents reaffirmed the need to assess (and predict) potential risks and consequences [RA]. First line management differed slightly to that of middle management and top management, insofar as they needed to be convinced that this process fully incorporated the type and nature of production in this assessment.

Reaction to Change (Kritchanchai and MacCarthy, 1999; Sawyerr and Harrison, 2020). The need to be aware of, and accommodate future needs after change was seen as especially important. It was acknowledged that this was more likely to occur if supported by a clear strategic vision and outcome expectancy [SV]. This requires appropriate information and knowledge management [IM] and, devolved and responsive decision making [DM]. These issues also align with findings by Chowdhury et al., (2022) on employee engagement with Artificial Intelligence and Structural Equation Modelling.

Communication (Scholz, 1987; Yun et al., 2020). This was seen as the most important aspect, as it (inter alia) influenced any subsequent reorganisation [RO]. All three case study organisations supported this. It was also recognised that on some occasions the ‘voice’ of first line managers did not seem to be ‘heard’. This affected employee empowerment/engagement (cf. is equally important to include first line management, provided information on the companies` strategic focus, which was confirmed to have been developed to meet the quality accreditation requirements. However, respondents from lower management levels, also raised their concerns about the lack of their ‘voice’, awareness and sense of belonging – supporting the findings of Scholz (1987) and Yun et al. (2020).

Information Flow and Decision-Making (Veen et al., 2020; Mouzelis, 2017). Respondents emphasised the importance of seamless information flow both horizontally and vertically, as this was seen as being crucial for making quick and effective decisions. One of the challenges highlighted was that of bureaucracy, which in turn affected the approval process (cf. Jeyaraj and Sabherwal, 2008). Issues of delegation, power, responsibility and control all seemed to be interlinked.

Recovery and Resilience (Allen and Toder, 2004; Stuart, 1996; Chen et al., 2021). It was acknowledged that organisations needed to be better prepared for recovery, and that this formed the basis of their organisational resilience. This coalescence should not only include the core capabilities needed, but those supporting the recovery needs [AN]. This requires a recovery plan that addresses priority areas and steps to be followed [RP], including the plan for returning the organisation back to the required state [RO].

Given the above findings, a conceptual Organisational Responsiveness Capabilities and Maturity Level model was developed for discussion. This highlights the organisational forces at play. Whilst at this stage dominant drivers are not discussed; it presents organisations with a starting point (Figure 2). This starting point requires all nine core areas [MR,CA,RA + SV,KM,DM + AN,RP,RO] to be evaluated across five maturity levels [Level 1-5], where the collective findings from this assessment is then evaluated at the macro level in order to determine the overall capability maturity assessment of the organisation – ergo, it’s standing and effectiveness in the OSC sector.

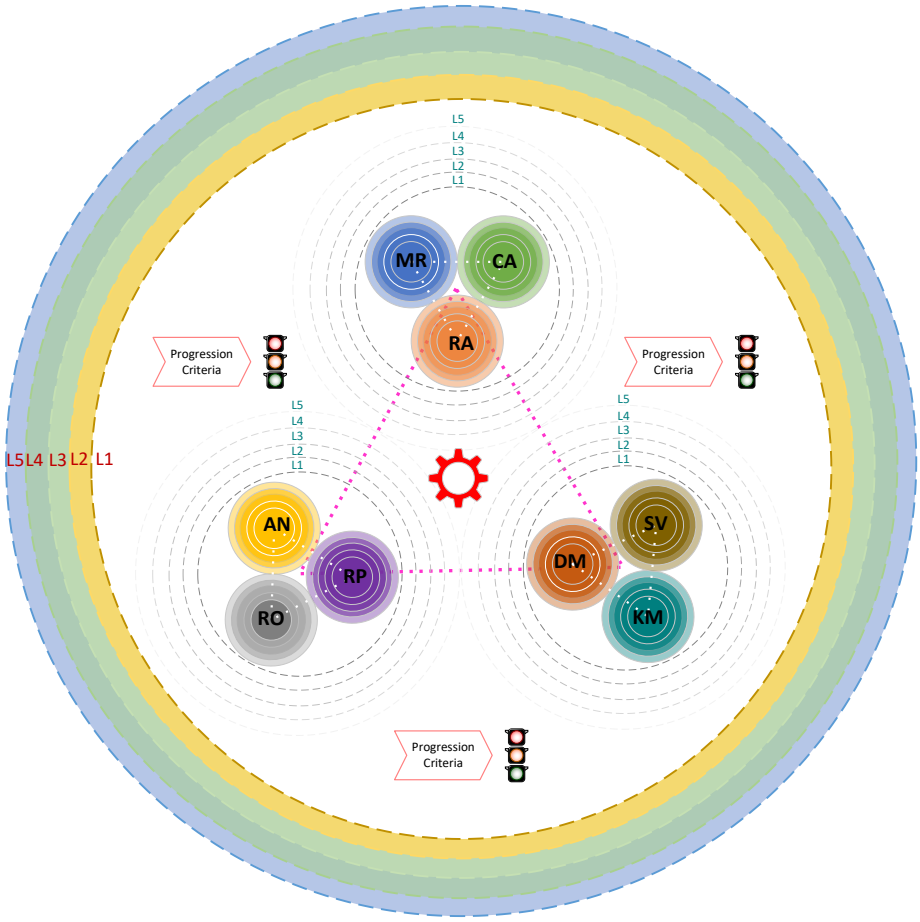

Figure 2: Capability Maturity and Organisational Responsiveness

5 CONCLUSION

This research originated from the need to provide AEC organisations wishing to enter the OSC market with specific guidance - as far too many business failures have occurred is testament to this. The challenge therefore, was to evaluate current thinking and practice against “best in class” hermeneutics on theory and methodology interpretation across a number of areas, not least: resilience, recovery, responsiveness; and perhaps most of all, organisational capacity to thrive, be competitive and operate as viable business concerns (in the OSC market). In doing so, three case study organisations based in Turkey were purposefully sampled for analysis. A total of 24 respondents were engaged in this study, spanning three levels of management. All respondents were asked the same questions on OSC, the content of which was then used to evaluate perception on their organisation and its ability to operate in the OSC market. From this, a Capability Maturity and Organisational Responsiveness model was developed for discussion. The rubrics of this model uses the principles of Capability Maturity Modelling to assess organisational readiness across five maturity levels. This is the first step of ongoing work. As such, this can be seen as an initial phase for developing detailed constructs and stage gates (using resilience metrics and capability-driven criteria) for future operationalisation

In summary, it was encouraging to note that organisational awareness was clearly evident across all three case study organisations, including the need embrace a different mindset to that of 'traditional' construction. However, from a research methodological perspective, it is equally important to note that all three companies used in this study were categorised as large organisations (>249 employees), and that scalability, context (Turkey), and cognate market interplay could all (directly/indirectly) affect generalisability and repeatability from a replication perspective.

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