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'Driving' Innovation in Construction Organizations: a Comparative Case Study of the Design and Construction of Motor Racing Venues

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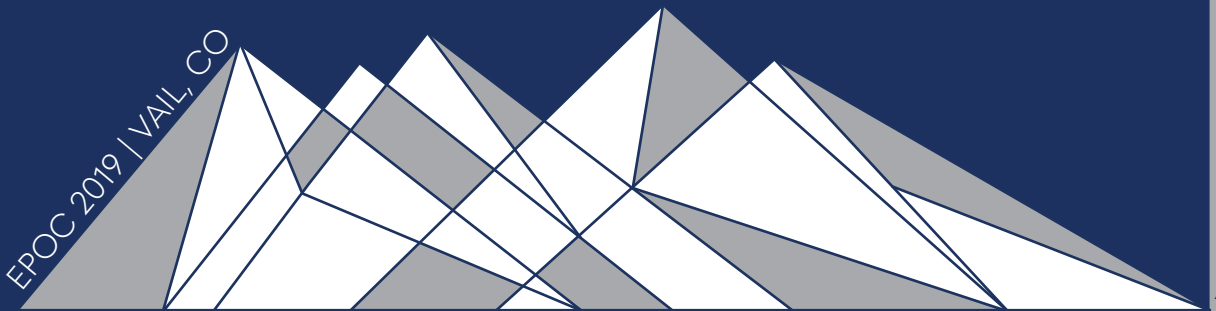

‘Driving’ Innovation in Construction Organizations: A comparative case study of the design and construction of motor racing venues

Abstract:

The culture of high-performance racing, whether Formula One, Nascar, or sports cars represents the continuous push for better performance. The research focuses upon understanding how stakeholders designing and building motor racing venues experience the innovation process through both new and refurbishment projects. This paper will provide a review of the literature relative to the nature of innovations within the construction setting, considering a range of theoretical and methodological approaches. The context of innovative designs and high-performance facilities serves as a novel exploration given that the nature of the facilities seems to attract these innovative solutions. Given this seeming repeatability of pursuit and success in innovation on this project type suggests that the context allows construction firms to successfully mobilize their innovative ideas and construction expertise. Using the captured data from two case study projects; Yas Marina Circuit in Abu Dhabi and the Daytona International Speedway in the USA, we explore the phenomenon around the mobilization of innovation in these contexts. Data is collected through extensive, unstructured interviews with key leadership in both projects to explore the emergent nature of innovation and the evolving facility design, construction, and operations. Innovation is born, resides and lives within a loosely and tightly knit network of stakeholders. We will connect the discursive nature of innovation in such settings and projects back to the innovation literature.

Introduction

> *As soon as you touch this limit, something happens and you suddenly can go a little bit further. With your mind power, your determination, your instinct, and the experience as well, you can fly very high.*
>
> \- Ayrton Senna

The culture of high performance racing, whether Formula One, Nascar or sports cars represents the continuous push for better performance. In motor racing, each season the teams design the cars to the ‘new’ regulations associated with the category of racing and then *through use* over a season the cars evolve and manifest into something better than first designed. Parallels could easily be drawn between the delivery process of a building whereby it is designed; then as it is built, used, understood and technology develops improvements and innovations manifest above and beyond the initial design throughout the life cycle of the building. Fleck (1993) refers to such a process as ‘innofusion’.

Motor racing venues initially emerged in an informal and unstructured manner. Motor racing developments can be traced back to the birth of the motor car.

Venables (2010) acknowledges the earliest motor sport venues, with racing taking place at Ardennes in Belgian in 1902; at Shesley Walsh in 1905 (although this was sprinting rather than circuit racing); at Le Mans in France 1906, and yet it is Brooklands motor racing venue in the UK which *claims* to be the oldest purpose built circuit in the world dating back to 1907. Although not in use today, Brooklands was purpose built with banked corners as seen in many of today's motor racing venues particularly in the USA. Silverstone circuit, perhaps the UK's most famous motor racing circuit with today's generation, was in fact born out of an old WW2 RAF base in 1948 (Hilton, 2010). The 1948 circuit at Silverstone was initially marked out with straw bales and based upon the three runways of the RAF base and its perimeter roads, with the circuit emerging over many years (Hollely and Larsen, 2019). The infrastructure to support the growing interest in all types of motor racing spread rapidly across both Europe and the USA. In the USA, informal racing was already happening when the Indianapolis 'motor speedway' was built in 1909, with the Daytona Speedway being relatively recent by comparison being constructed in 1959. At the time of writing, the UK alone has over 20 motor racing circuits, with a similar story across several other European countries whilst the USA has hundreds of different circuits.

Of course, much has changed since these early motorsport venues were built, especially around views upon cars and the built environment. Naziman (2010) champions leadership in energy and environmental design (LEED) in the importance of environmentally sustainable designs as the new millennium sees an explosion in the design and development in new motor racing venues as countries sought to gain a slice of the revenues associated with sports tourism. This increase in the number of global motor racing venues means there is increased competition between the venues to hold racing events (Larsen, 2016). It is argued that this competition has manifested into ever more elaborate and innovative motorsport venues being designed and constructed. Given the innovativeness within the design of racing cars, readers may be forgiven for assuming that the processes used when designing and constructing motor sport racing venues also value innovation and draw upon innovative approaches. This research will offer comment to explore how the culture within motor racing extends into the construction of motor sports venues. However, the central aim of the research is to understand innovation uptake associated with the design and construction of motor racing venues.

The paper is structured as follows. Whilst rehearsed by many already, an incumbent critique of the innovation uptake literature is presented, emphasizing the need to be sensitive to the contextual settings and their network of stakeholders. Understanding of this contextual setting, the design and construction of racing venues, is then mapped out leading to specific points of departure for the research and its aim. This is followed by a justification of the research methodology and the emergent research design mobilized. Analysis and discussion focus upon telling the stories of innovation uptake, seeking resonance between the data and the body of knowledge regarding the unique interaction in how the network needed for the innovative solutions for each project is mobilized. The paper concludes with a summary of contributions set against weaknesses and directions for future research.

Background

There are extensive studies into the nature of innovations within the construction setting, adopting a range of theoretical positions and methodological approaches. Much work seeks to reduce the dynamic complexities surrounding innovation and uptake into a dichotomy of barriers and drivers (e.g. Hakkinen and Belloni, 2011; Suprun and Stewart, 2015). We argue such a reductionist approach is overly simplistic and fails to represent the reality of the innovation process experienced by stakeholders over time. We consider the literature, across organizations as well as specific to innovation in construction, but find the phenomenon around motorsports construction as an anomaly in the potential uptake of innovation within construction that is not well addressed in current literature

Damannpour (1999), in his review of determinants and moderators of innovation, identified four organizational factors: type of innovation, stage of innovation, scope of innovation and type of organization. Downs and Mohr's (1976) explored innovation-decision design, distinguishing organizational, social, and individual variables that emerge when studying innovation at the project level. However, the research into the construction industry paints a different picture, often noting the procurement and contractual models across firms as keys to enabling innovation (Blayse and Manley, 2004). Egan (1998) emphasized the trends, such as design-build and supply chain management, as drivers for new levels of innovation in the construction industry. These are potential methods for overcoming the organizational fragmentation Henisz et al (2012) presented, cutting across the vertical, horizontal, and longitudinal arrangements within the construction supply chain. The question arises, then, how are some projects able to overcome this fragmentation in the pursuit of innovative processes, technology, and engineered solutions?

Lieberman and Montgomery (1988) outline the idea of speed to market in innovation or new products providing first-mover or second-mover advantages. Innovation speed refers to "accelerating activities from first spark to final product, including activities that occur throughout the product-development process," (Kessler and Chakrabarti 1996). Similarly, research into the spread and management of innovation within construction demonstrate the messy pathways by which innovation is adopted into use, linking the managerial and contextual factors specific to the construction industry (Harty, 2008). Ozorhon (2013) identified the role of the owner as a champion as a key differentiator to the successful adoption of innovations for sustainable solutions, yet such a conceptualization often struggles to find resonance within construction as owners tend to consist of many constituent stakeholders.

The nature of construction procurement often finds construction firms in the need to quickly mobilize their innovative approaches and solutions to win projects. The context of innovative designs and high-performance facilities seems to attract these innovative solutions. Not only are these project outcomes successful in meeting client requirements but are often such that the firms involved extort the approaches and successes through extensive marketing and conference venues to disseminate their efforts (and brand). Given this seeming repeatability of pursuit and success in innovation on this project type suggests that the context allows construction firms to successfully mobilize their innovative ideas and construction expertise. Dhanasai and Parkhe (2006) argue that innovation networks, in the orchestration of innovations, leverage knowledge

mobility, innovation appropriability, and network stability. The suggestion that it is fundamentally how firms act to pursue, exploit, and manage network knowledge that is instrumental in the balancing both the network structure and the roles of the individual players within the network.

Certainly, motor racing venues are in competition with one another, as they complete to host a limited number of races each year. The race series organizers will choose the race venues with the best facilities, which in turn offer the best financial returns through ticket sales and commercial advertising. Motor racing venues owners will therefore use innovation associated with their built facilities to gain a competitive advantage over. This places a great deal of pressure upon the construction sector, as their solutions can determine the success or failure of a motor racing venue. Further, the research is timely as there remains a dearth of research associated with innovation uptake within motor sport venues, with just a handful of exceptions (cf. Alnaser et al., 2007; Larsen and Hughes, 2012; Larsen, 2016, Hollely and Larsen, 2019, Leicht et al., 2015). Construction management research only seems to notice sports venues as an important contextual setting for research every 4 years, during world cup football or Olympic projects. It is exactly the ability of construction firms to mobilize seemingly novel solutions for these challenging projects that stands out, specifically the context of motor racing venues which seem uniquely successful in the uptake of design and construction innovation.

As a point of departure before introducing the methodology, it is perhaps helpful to remind readers of the aim of the research based upon the critique of the literature above. The research seeks to understand how construction companies mobilize innovation uptake (through knowledge and innovative solutions) regarding the design and construction of motor racing venues.

Methodological justification

The research design focusses upon developing case studies (acknowledging their longitudinal nature) for two motor sport venues. Regarding the sample population, one venue was selected to be part of the new breed of circuits built from a blank canvas and the other a more traditional established circuit being refurbished and modernized. The motor sport venues chosen include the UAE within Abu Dhabi (Yas Marina Circuit - hosting F1 and sports cars racing) and the other from the USA within the state of Florida (Daytona International Speedway - hosting Nascar but also sports car racing). Whilst geographically separated, the venues are also separated through time with the Yas Marina motorsport venue being almost brand new in comparison to the Daytona speedway which has been holding racing since the 1950s. However, today, both are household names within the global motorsport community and hold can hold the same category of racing, closed wheeled sports cars.

The research design is aligned with a multimethodology, drawing upon a wealth of primary data, secondary data and grey literature (Mingers and Gill, 1997). The primary data comes in the form of co-created narratives between the researchers and the stakeholders from the AEC firms undertaking the design and construction of these motorsport venues. The secondary data consists of formal reports and documents provided from the stakeholders associated with the venues,

together with the grey literature available in the public domain offering further commentary. The data was interrogated to understand the themes of innovation uptake through the discourses mobilized (both by human actors and within the documents mentioned).

Aligned with this methodological stance, the research design and methods used therefore acknowledge that different stakeholders will mobilize different narratives of innovation uptake. Stakeholders historically socially construct their identities associated with innovation uptake through the discourse they mobilize both in practice and certainly when in discussion academic researchers (Sergeeva and Green, 2019; Ulutas et al., 2018).

Case Study Projects:

Case study 1 - Yas Island and the Yas Marina motorsport venue

The story around the development of Yas Island and the Yas Marina F1 motorsport venue, is one of a highly complex and innovative design. These characteristics in turn led to an AEC firm having to develop an innovative approach to designing what was to be built and how it was built. Since the year 2000, new F1 motor sport venues typically form part of a larger redevelopment plan for a region within a country and have a range of firms contributing. Yas Island in Abu Dhabi is a case in point, with total development cost of the whole Yas Island estimated to be in the region of $40 billion. This included a large deserted area of the country being turned into the Yas Marina F1 motorsport venue and includes; Yas Mall (blue chip shopping, 300,000 m^2), world-class links golf course, water theme park, residential units and the Ferrari theme park. It also includes the Yas 5-star hotel and the construction of a new port suitable for mega yachts (Mortimer, 2009). The client for this undertaking was the Abu Dhabi's Ministry of Works and Housing. The Yas Marina circuit was built by main contractor Cebarco-WCT WLL with Aldar Properties acting as the developer (Mortimer 2009). The stakeholders involved were truly international, ranging from Buro Happold, Tarmac, Ridge, PKE-Siemens (MEP), Able-Middle East (earthworks), Hamilton International and RMD Kwickform.

The motorsport venue was designed incredibly quickly and took just 31 months to construct. At its peak the Yas Marina F1 construction project reportedly had 45,0000 operatives on site, working day and night shifts (Mortimer, 2009). The significance and global audience attention surrounding the construction of such a prestigious motor sport venue calls for innovative solutions and makes this an interesting contextual setting to understand innovation uptake. Due the enormous scale of the construction work undertaken on the Yas Island development as a whole or even just the Yas Marina motorsport venue the data analysis focuses mainly upon the Yas Marina Hotel, which is a land mark feature in a stunning location spanning the race track of the motorsport venue whilst also abutting the new marina area.

Figure 2: Yas Marina F1 motor racing construction site – Yas hotel and its' grid shell

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Case study 2 – Daytona Speedway – Daytona Rising

The Daytona International Speedway, in Daytona Beach Florida, USA, is best known as the home of the Daytona 500 – considered by many the most prestigious race of the NASCAR circuit (Bennett, 2009). The speedway was originally construction in 1959, using banked designs for the race track itself that provided both higher speeds for the cars, as well as better views for fans observing from the stands. While several renovations have occurred to the speedway since the original construction, previous efforts focused on the midfield, installation of lights, and track re-paving. However, the fourth renovation, unveiled in January 2013, offered a significant re-shaping and redevelopment of the 'front stretch' of the main stadium seating (Reed, 2013).

Figure 1: Daytona Speedway - showing partial demolition of the 'frontstretch' seating.

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The renovation offers a substantial addition, as well as a renovation of the current seating and infrastructure of the speedway. The demolition of the majority of the existing 'front stretch' of seating

and supporting structure steel, foundations and existing 'Spring Tower' were replaced with 103,500 seats, as well as new food concessions, vendors, upgraded fan amenities and experiences, and new boxes. In addition to the extensive scope, the project had to maintain speedway operations to accommodate annual races, including the Daytona 500, while the stadium was under construction over a more than two-year period. Rossetti Architects developed the design and then collaborated with Barton Malow Company through a novated Design-Build arrangement. The project broke ground in July of 2013 and was completed in 2016 and cost $400 Million.

Analysis/Results

Focusing on the adoption of new processes of design and production, the research draws upon innovative approaches to support the design, planning and construction of these two, large, complex, and expensive motorsport venues. The first section will present the key findings for the analysis of the Yas Marina data set, followed by the Daytona speedway. The discussion will then consider the comparison between the two motorsport venues and how they resonate with key themes from innovation uptake literature.

Yas Marina

With the construction sector currently in the midst of a digital revolution (often termed Industry 4.0); with building information modeling (BIM), GPS, and RFID), wearable robotics, the automation and electrification of site plant the Yas Marina motorsport venue acted as a catalyst for innovative ideas and the uptake of an innovation in the form of 3D tools. The data points toward the timely development of a new 3D visualization tool, called LocusEye. This enabled the winning of the contract in the first instance, together with the design of the temporary works in order to enable the construction of the Yas Marina Hotel. The need for such innovation was driven by the nature of the design, with a bespoke glass paneled grid shell hanging over the physical structure of the hotel (this is shown in Figs 1 and 3). This grid shell featured a lighting system, which could alternate in color offering an additional dimension, which can also be seen in Figure 3. The design meant that each of the 900 grid shell segments was bespoke and therefore needed a bespoke node point in space for support it. The contractor noted that;

> *"this was made more difficult due to the grid-shell's location, connecting to the hotel which also incorporated a man-made marina. This meant some of the grid-shell had to be supported on dry land and other parts from the much deeper marina"*

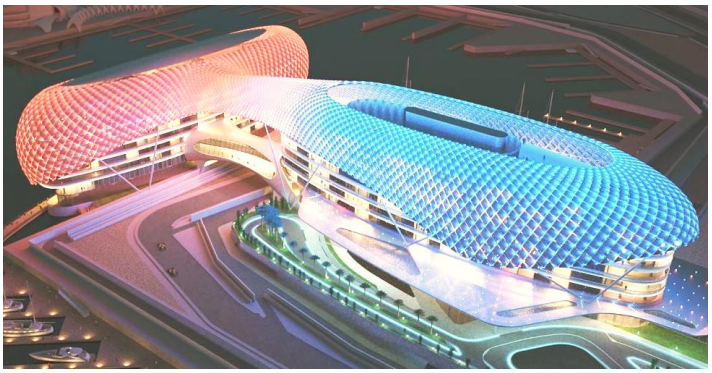

Figure 3: Yas Marina hotel spanning the F1 racing track – cloaked with an electrified grid shell with changeable lighting capability

The in-house developed new 3D tool, called LocusEye, was far more than a visualization tool. Locus Eye can draw upon a wide choice of in-house temporary works systems and then automate highly realistic rendered 3D models. The choice of temporary works system can then be changed at the press of a button in order to understand the options available. These 3D models offer flexibility and can be viewed on a PC, iPad or mobile phone, providing stakeholders with a realistic model of how any solution looks on site.

Figure 4: Example of 3D design, chosen system and sizing.

The 3D tool allows for changes to be made instantly and for solutions to be re-examined in real time. The functionality goes even further, with a built-in range of features in order to connect it to pricing data, in-house temporary works systems, material product schedules and resources, as well as being suitable for engagement with other contractors regarding interface and safety issues and with clients.

In addition, the tool enabled the wearing of an immersive virtual reality head mounted display (see Figure 5) to walk through the temporary works design, enabling the forecasting of on-site challenges including clash detection, loadings, system selection and access.

Figure 5: Example of 3D design viewed through Oculus Rift head set

At the turn of the millennium, RMD Kwikform were just beginning to think about working in 3D and looking for the right opportunity to develop that capability in house;

> *the 3D capability had sprung from the early ideas that he had, I don't believe we had worked in 3D before this project*

The development of this bespoke innovative 3D tool did not occur in isolation, there were knock affects to the practices of the professionals, the engineers but also on the need for innovative construction equipment needed to actually build such designs;

> *It certainly was not an off the shelf solution in terms of equipment (this is the construction equipment needed to build the design)*

The Yas Marina F1 motorsport venue was designed to be spectacular and world class in every way, with almost no expense sparred. The vision of the hotel spanning the motor racing track (see Figs 2 and 3) demanded innovative solutions to be able to design and construct it, as traditional methods would simply not work;

> *We released that the only way to successfully deliver this project was through 3D and being able to work in 3D.*

However, it is argued that the timing and opportunity need to coincide in order for innovation uptake to occur, according the interviews the Yas Marina project had both whereby;

> *we were able to demonstrate a certain level of capability that we were beginning to develop*

Yas Marina, there are certain projects within the scope of what we do that really lend themselves to be marketed. A certain amount of marketing you can make

There was also an amount of innovation work that went into the working out how to support the individual sections of the grid shell

The Yas Marina F1 motorsport venue was undoubtedly a major achievement by all concerned and should be praised. Alsono (2009) noted that there "*was always something to do"* on track, thus being positive for drivers and spectators alike. Yet, Raikkonen (2009) saw things slightly differently, stating "*the first few turns are quite good, but the rest of it is shit*". Tilke (2017), the lead designer and architect, noted that through feedback offered, additional lessons had been learnt meaning that they *"were considering making changes to the track to present more overtaking opportunities*" but said less about the other built facilities.

Daytona Rising

The adoption of Building Information Modeling was similarly both challenging and impactful in the delivery of the Daytona International Speedway. The contractor, Barton Malow, targeted their use of BIM specifically around the need to support production. As noted, the project had a massive scope, challenging timeline to complete it, and in addition the need to maintain speedway operations led to very specific sequencing and production challenges to be able consistently hit construction schedule dates needed to meet the owners demands. The project team developed a BIM Execution Plan soon after the selection of Barton Malow as the builder. The process laid out in the BIM Execution Planning document highlights the targeting of model uses that focus on the challenging and interdisciplinary aspects of planning the project's intense production schedule.

The project team extended the 4D model (3D geometry plus time of construction form the schedule) into detailed steel sequencing to allow for the construction engineering and temporary bracing associated with the complex steel demolition and replacement schedule (Figure 6). In addition, line of balance production analysis was performed based upon the 4D schedule to limit potential production conflicts across trades and areas of the project. The model, in addition to being used for visualization, was then able to be leveraged to balance the structural analysis associated with the temporary bracing needs during the demolition and re-construction, as well as communicating that sequencing clearly to the erection crews to ensure safe and productive placement of steel.

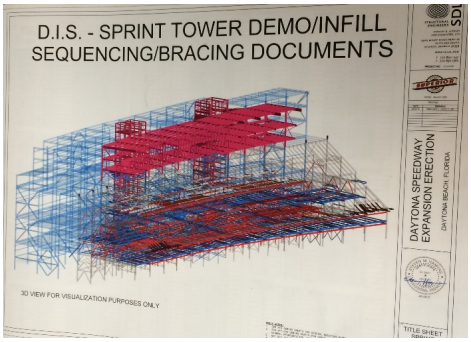

Figure 6: Model derived steel sequence drawings.

The model was developed to a high level of detail, targeting model use for direct to digital fabrication and prefabrication strategies. These included CNC fabrication of rebar cages, constructability / buildability analysis, and prefabrication of offsite panelized wall systems (Figure 7) for the interior structures, such as the concessions. The steel model was used for supply chain tracking, from milling, to fabrication, to galvanization, and finally to delivery and erection on site. Beyond simply tracking the schedule, the information was provided to the owner to support monthly invoicing for steel production.

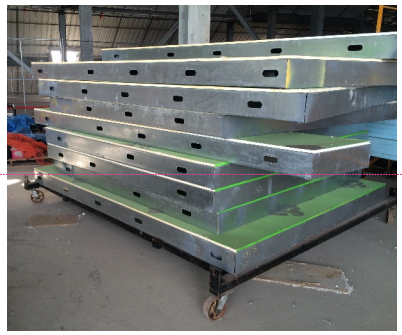

Figure 7: Prefabricated wall panels ready to be erected.

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The use of operation and maintenance software was selected to support the tracking and organization of the model-based information for transfer to the owner for operations. The pursuit of the detailing and offsite fabrication of the metal framed walls was one example that stood out regarding the team's approach. The Daytona structure has 88 smaller structures housed within the structural steel frame, such as the restrooms, concessions, and amenity spaces. When these framing contracts were tendered, there was a wide range of bid pricing, all of which came in higher than budgeted. Rather than work with one of the trade contractors, the project manager chose to hire a full-time engineer to model the studs and self-perform the offsite fabrication and erection of the panelized walls. The first of the structures took approximately 22 days to erect, but after that they averaged 7 days to be installed. The outcome was that this scope came in under budget and further improved the firms modeling and prefabrication capabilities.

The project manager referred to the approach as 'model-enabled project management' wherein he focused on leveraging the model as the central resource for project information, wherever and whenever feasible. The extension of detail and model data was intended to move the process closer to the automotive approach to manufacturing;

"Automakers know and model what is going into a car down to 1/8" washers, whereas in construction we typically model anything over two inches,"

They went on to say they tried to pursue the more detailed representation unless it was clearly an added onus that could not be tied back to the project management process.

The project team did experience turnover from personnel that were unable to adjust to the culture and support of this approach to project management and level of technology adoption. Further, the team tried to embed modeling as a competency that needed to support every role within the project team – there was not a designated model person, everyone was expected to engage with and use the model for their tasks. In addition, they felt the timing of their selection within the design-build novation approach limited some of the model uses that they might have otherwise pursued.

Discussion

The two case studies presented here offer a range of issues in connection with the current body of knowledge surrounding innovation uptake. The data points toward these capabilities being key; but for success the AEC firm needs to separate itself from competition regarding the capability at that time;

"I'm not sure anyone else could have delivered what we did at the time"

Early, the unique nature and scale of the Yas Island was outlined in financial terms, meaning that meant that considerable resources were available, estimated to be $40 billion in total (Mortimer, 2009) and some $400 million for Daytona. As such, the AEC firms saw;

"a very large revenue opportunity"

It is argued that it was this revenue opportunity which encouraged the AEC firms to engage in innovation uptake and the associated risk and uncertainly when looking at how to tackle the challenging construction processes, such as the Yas Marina hotel structure or the complex Daytona sequencing, thus giving the right timing and opportunity. In line with Dhanasai and Parkhe (2006), the 'appropriability' of the knowledge and investment return had to match the project opportunity. In turn, it is argued that with a lesser financial reward, the innovation uptake may never have occurred, and this is what perhaps separates prestigious motor sport venues from other projects. The discourses mobilized around innovation uptake as it unfolded were varied and changed. The findings resonate with Bijker and Pinch (1983), whereby stakeholders migrate around different interests, mobilize different agendas at different times and change interests, essentially 'seeing' innovation differently whereby;

"Directors and the commercial people they sort of cheer and think 'great we won that job', then from the point of view from the engineering staff etc, examining their in trays thinking oh shit how are we going to do this job, how are we going to do all this"

It is out of this situation that innovation is borne. The scale of motor sport venues and the number of stakeholders involved will generate a highly diffuse set of narratives with a range of different interests and perspectives on the innovation. It is argued that understanding these is essential in order to gain an adequate picture of the innovation uptake process.

The prestigious nature of the Yas Marina F1 and Daytona projects continued to play a role in the success of the innovation uptake for the AEC firms, with a range of reasons. It is argued that influenced the narratives mobilized by firms, their approach to innovation development and uptake as the stakes are exponentially more than a 'regular' project. Once a solution was offered then;

we have got to deliver on this promise now. We promised we could do this and now we have to deliver. If we don't succeed and we don't deliver it going to be a whole lot worse than if we had not won the job, internally, for us as people and for the company because suddenly we are into a claim situation

The ‘crisis’ created needs to balance the challenges of the project with the contractor’s confidence in their capabilities. So, the nature of these motor racing venue projects, their prestige and their global agency directly shapes the innovation uptake process meaning that for the engineers of the AEC;

their job and their reputation is all on the line

It is the seriousness of these needs that innovation is stimulated (job, reputation, promises and the risk of a claim situation) that helps stimulate the appetite of AEC firms toward innovation and thus the discourse they mobilize;

From that need (to deliver) comes a good deal of innovation

Despite the drivers for innovation on such projects, the AEC firms still mobilize a sensitive and staged process of uptake, thus not trying to run before they can walk;

“The conversion from designing in 2D to 3D tools is a gradual process (transition process, managing people through change). So, they gradually take ownership of the software and the software becomes their software because it is tailored to suit their comments (software for users by users). So, they become enthusiasts within the team and we use them to teach other people”

A common theme running across all the stories was timing. The relevance of timing relates to the construction project, how developed the innovation already is and the capabilities of the stakeholders. As the Project Manager from the Daytona project noted, the decision to self-perform the modeling and prefabrication of the panelized wall systems arose out of the high bid-pricing that was submitted for the framing packages. There was a need to find an innovative solution.

“So, you are introducing it at an optimal time”

Reflecting on the process of innovation uptake, the emphasis for AEC firms seems to be represented as a journey of evolution and not revolution, and on carefully and sensitively managing the stakeholders through what can be a painful period in order to get from point A to point B;

The challenge is managing the people through change and it’s a continual journey and it is not without pain

Defining innovation uptake is problematic, both within academia and it seems industry practice. When can we say uptake has occurred or has been successful is highly contestable? For the AEC firm operating with digital 3D tools for use on motor sport venues they view this as;

We have around 80% uptake (of the 3D design tools)

Finally; thinking about the future and the strategic needs of designing and constructing motor sport venues, there is an acknowledgement that the construction sector and firms within it could and indeed should be doing more and thinking more strategically about the innovative approaches needed;

> *Wouldn't it be great if there was a team within our business that just 'tracked' these large projects and built relationships with the major stakeholders of these project, acting as an international team that was specializing in delivering mega projects (F1 projects)*

Such strategic thinking is already happening with some AEC stakeholders such as Ridge LLP, Tilke and Populous. In summary, innovation uptake on one project is admiral and welcomed. However, for the construction sector to enact sustainable long term change as championed by the like of Nazimah (2010) then it needs to move beyond the stereotypes of being slow, traditional and innovation averse. One method for overcoming these stereotypes is better marketing through high profile global innovative projects such as the Yas Marina F1 motorsport venue and the Daytona Speedway and AEC stakeholders recognize this.

The projects demonstrate the agency surrounding this type of projects and the contextual setting they create regarding innovation uptake. Larsen (2016) noted the *niche market* network of stakeholders engaged with the design and construction of motorsport venues, being very inward looking, with high barriers to entry, a small number of key actors acting as innovation gatekeepers. There are a small number of AEC firms repeatedly undertaking the work on such projects. Granovetter (1979) would hardly see this as a recipe for innovative ideas and uptake.

Ultimately, the innovation is shaped by and through the process of 'uptake' and 'enactment' on the projects, by the relevant stakeholders and their agendas and interests (which are themselves not fixed). That, in-turn, leads to the 'firm' considering its best practices, processes and the planned processes used on future projects. The innovation starts to be 'rolled' out in stages through a period of timely consultation on other projects. Whereby the success and high profile of the motorsport venue project is mobilized as part of a diverse marketing strategy. All of which resonates with process schools associated with innovation uptake (cf. Pettigrew et al., 2001), as well as viewing construction firms as networks (cf. Dhanasai and Parkhe 2006). The nuance comes from the 'hubs' of the networks, are they project teams, are they departments or are they offices, or all of them? The blurring of innovation and uptake and the notions of technology being socially constructed (cf. Bijker and Pinch 1983 and Fleck 1999) takes on unique shape within the dynamic organizational and contextual settings of engineering project organizations. Such stories of innovation uptake typically go unheard; which in part explains why many continue to claim (very few have a theoretically robust argument based upon empirical data) that the sector is not innovative. Basically, many researchers and commentators may simply be 'looking' in the wrong place and employing the inappropriate methodological tools.

Conclusions

AEC stakeholders mobilize different discourses regarding the projects. Some seeing it as a financial goldmine, others a marketing opportunity, others a significant technical challenge requiring innovative solutions. This research set out to understand innovation uptake set within the context of design and construction of motor racing venues. Central to this was ensuring the contextual setting (motorsport venues) was seen as a variable with potential agency, rather than a static playing field upon which innovation uptake take place. This enabled an argument to be developed around motorsport venues having a unique appetite for innovative solutions and uptake.

Timing plays a central role to the innovation uptake process and thus also has agency. Several themes coincided within a given timeframe including; the projects themselves together with their fixed end date, the digital agenda across the construction sector, the AEC firms choosing to bid and developing the specific technical capabilities to undertake such projects, giving an opportunity for innovation uptake to occur. Thus, for innovation uptake to occur to any significant degree then it *needs* these elements to be aligned. Caveating this claim, it is important to note that there is an iterative relationship between the themes noted above.

The project type provides a powerful contextual setting for innovation uptake – because it is and will be in competition with other motorsport venues, it needs to impress through innovation, and is extremely well resourced financially. Furthermore, the project type provides a suitable contextual setting for innovation as the AEC firms attempt to meet a very strict project end date. The potential adverse publicity and litigation costs of failing provide a unique and sizable motivator. Perhaps most important is the manner in which these project types provide a contextual setting suitable for innovation – because failure will be far too costly publicly and contractually.

Innovation uptake is viewed as a journey, thus resonating with the work of Van de Ven *et al.,* (1999). AEC stakeholders are effectively managed through a period of change, not without pain, being consulted, given ownership of the innovation, asked to champion it and encouraged to adapt to their needs. Whilst this journey is not without pain, it also gets the innovation uptake to 80-90%. The notion of a unitary voice either within a firm or about innovation across and between AEC firms working on a project is challenged. Instead the findings align with Dhanasai and Parkhe (2006) view of networks of innovation. However, their instantiation within the engineering project organization domain changes the context from inter-organizational networks to the intra-organizational networks that make-up AEC firms.

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