MATTERS AFFECTING CONSTRUCTION PROJECT-LEVEL PLANNING EFFECTIVENESS: A LITERATURE REVIEW

Daniel Musselwhite[1], Barry Gledson[2] and Dave Greenwood[3]

[1] *DLM Consulting (UK) Ltd, 59 Rushy Lane, Nottingham, NG10 5NN, UK*

[1,2&3] *Faculty of Engineering and Environment, Northumbria University, Ellison Building, Newcastle Upon Tyne, Tyne and Wear, NE1 8ST, UK*

Construction project success is often measured based on the adherence to time; cost and quality targets; with Clients and Contractors constantly seeking improvements across these metrics. However, the time predictability of construction projects remains poor; with annually measured 'industry-level' KPIs showing no signs of significant improvement. Access to technological advancements, such as 4D modelling; Artificial Intelligence (AI); and more recently the renewed interest in Off-Site Manufacture (OSM) has indicated opportunities to improve time-predictability; but overall 'industry-level' time performance remains unsatisfactory. As an aspect of time-predictability; insufficient attention is presently focused on exploring 'planning effectiveness'; therefore, the main aim of this work was to review time-predictability and project planning effectiveness at 'project-' and 'activity-' levels via an initial review of subject literature. Following this; a conceptual framework was developed highlighting the key aspects associated with planning effectiveness. These include project environment matters such as complexity and uncertainty; human/cognitive matters such as optimism bias and Parkinson's Law; and the application of available planning techniques or technologies such as Critical Path Method; Last Planner System; Critical Chain Planning; AI and 4D modelling. Whilst 'alternative' planning techniques have shown the potential to improve time-performance; research identifies industry awareness and application of these techniques remains low. As a result of this work, it is considered that planning effectiveness and time predictability can be improved by increasing industry awareness of the constructs identified herein; allowing for the subsequent adoption of available and emerging planning techniques and/or technologies. Subsequent research will explore this; in practice at activity-level; with data obtained from a range of construction schemes to model improvements.

Keywords: planning effectiveness; time predictability; hit-rates; time performance

INTRODUCTION

When reviewing the immediate success of UK construction projects, recognised industry-level Key Performance Indicators (KPIs) measure performance across several categories, with 'time' being one of the primary categories assessed. Failure to achieve set targets within these KPIs are regarded as degrees of project-failure, with industry efforts focussed on improving performance across all indicators. In

[1] dan.musselwhite@dlm-consulting.co.uk

Musselwhite, D, Gledson, B and Greenwood, D (2021) Matters Affecting Construction Project-Level Planning Effectiveness: A Literature Review *In:* Scott, L and Neilson, C J (Eds) *Proceedings of the 37th Annual ARCOM Conference,* 6-7 September 2021, UK, Association of Researchers in Construction Management, 542-551

particular, time-performance is measured against the time-predictability of projects, and despite best efforts, time-predictability in the UK construction industry remains poor. The process of predicting time-targets (i.e., planning a project) can be traced back to the 1800s in modern project management literature, through to the present-day mainstream application of critical path method (CPM) planning and the use of Gantt Charts (bar charts) to communicate intent. In the pursuit to improve time predictability there have been developments in available planning techniques in recent decades, with methods such as critical chain planning (CCP) and Last Planner System (LPS) being utilised in the UK (Winch, 2010), however, current industry-level performance data demonstrates limited improvements. In 2008, to measure time-performance, the Chartered Institute of Building (CIOB) conducted a survey of UK construction projects and identified that as an industry there remained a high demand for robust time-predictability, yet the survey concluded that complex UK construction projects continued to complete, on average, more than six-months behind schedule (CIOB, 2008). Thereafter, despite the collective industry aspiration to improve time predictability, annually reported KPIs recorded only 59% of UK construction projects completed in 2018 achieved completion on-time or early, with a 10-year average between 2009-2018 of 58%, a score that remains unsatisfactorily low (Construction Excellence, 2018). While efforts to improve time-predictability often focus on available or emerging planning techniques and technologies (Gonzalez *et al.,* 2008), it is researched that construction projects encapsulate a variety of complex and uncertain elements, each with the potential to impact time-performance, requiring adequate consideration during project planning (Cohenca *et al.,* 1989; Laufer *et al.,* 1990).

When researching time-predictability at project- and activity-levels, Dawood and Sikka (2009) identified construction activity commencement date reliability as a critical success factor (CSF). They subsequently developed a strategy to analyse programme efficiency based on the number of activities within a programme starting and finishing on time. Activities that achieved their planned start and finish dates were recorded as a 'hit', with overall activity 'hit-rates' used to measure the effectiveness and reliability of the programme. In doing so, Dawood and Sikka (2009) were able to associate the efficiency and effectiveness of a construction programme with time-predictability performance. Later research by Dawood (2010) was able to identify improvements in planning efficiency when using 4D modelling to support the planning process, as opposed to just using 'traditional' planning methods such as CPM planning, achieving an improved activity-level hit-rate of 75% versus the industry-level standard of 58% (Construction Excellence, 2018). To further explore the association between activity 'hit-rates', planning efficiency and time-predictability performance, Gledson *et al. (*2018) undertook subsequent research on four UK construction projects and found a reduced hit-rate score of just 38% on traditionally CPM planned projects, a score which was lower than industry-level KPIs and the activity-level analysis by Dawood (2010). The research by Gledson suggested a continued lack of time-predictability improvements at activity-level across the industry despite the increased access to alternative planning techniques and technological improvements. This research subsequently examines the holistic matters affecting 'planning effectiveness' at project- and activity-level through a systematic-type literature review.

RESEARCH METHOD

The literature review carried out was structured to establish a common understanding of the project-planning process and how it has evolved into its current application in the UK construction industry, before exploring constructs impacting planning effectiveness. The research builds upon key theorists in the field of project planning and the wider facet of project 'overruns', recognising commonality between cost and time overruns. The literature review was completed with reference to relevant published textbooks, peer-reviewed journal entries, conference papers and construction industry publications in the field of project management, performance monitoring, critical success factors, project planning, overruns, time-delays and the use of project programmes.

An initial search of peer-reviewed journal entries using keywords "planning", "programme", "overrun", "delay" and "predictability" yielded 3,080 results. No publication date range was set for the initial search. The results were subsequently refined by reviewing article titles and abstracts, with the removal of any obscure results outside the parameters of the research field to obtain a filtered set of 512 entries. After generating the filtered set, recurrent or connected themes were examined, which generated a secondary keyword search for entries associated with the "planning fallacy", "uncertainty", "optimism bias", "Parkinson's Law" and "planning effort", with an additional 622 results. A similar filtering process was applied to the second set of articles, until a set of 107 entries were deemed appropriate, producing a combined result of 619 entries for consideration, as depicted in Fig 1. The peer-reviewed articles were cross-referenced with industry publications and recognised textbooks to ensure sufficient access and consideration of all potential constructs associated with time-predictability and planning effectiveness.

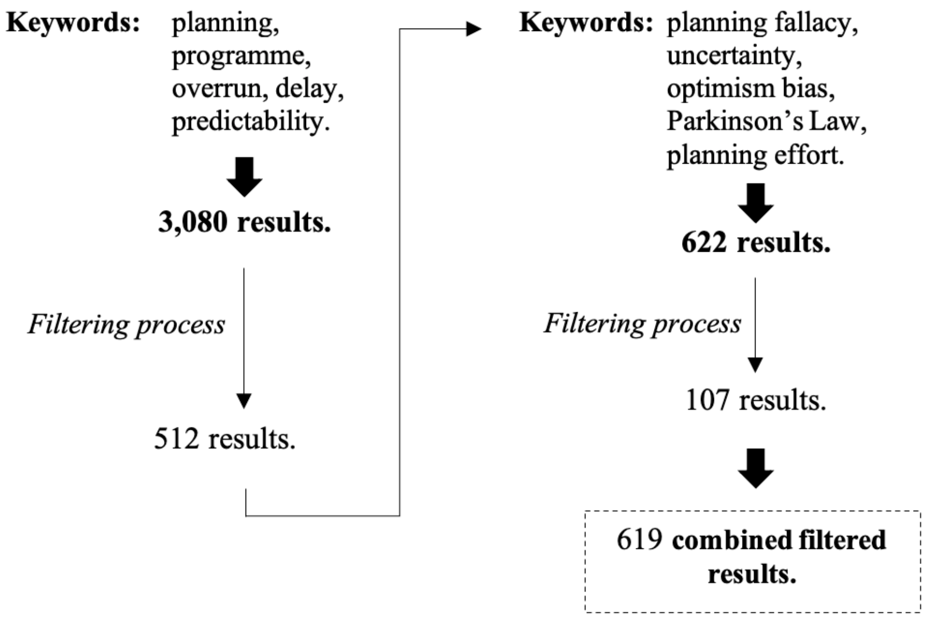

Fig 1: Literature Review

The research identified a relatively consistent understanding of the planning 'process'; albeit undertaken in a multitude of different ways, its modern-day placement within project delivery and its association with time-performance. When considering matters affecting planning effectiveness and time-predictability, it identified constructs that can be placed into three high-level classifications of 1) project environmental aspects, 2) human nature/cognitive matters, and 3) available planning techniques, technologies and effort; leading to the summarised findings discussed below and the development of an initial conceptual framework.

DISCUSSION AND FINDINGS

The Planning 'Process'

To measure time-predictability, one must set targets from which to measure performance against. The process of establishing time targets is derived from the development of a 'plan' or 'programme', which in the context of construction can be defined as the design and construction of a building or infrastructure project (Baldwin and Bordoli, 2014). When considering the tool for communicating said plans, the Gantt Chart (bar chart) is the commonly recognised method in the industry, which can contain data regarding historic and planned activities (CIOB, 2008). However, project planning goes far-beyond the issuance of graphical representations and is 'a decision-making process performed in advance of action which endeavours to design a desired future and effective ways of bringing it about' (Ackoff, 1970). The planning 'process' must include not only consideration of time, but also consideration of cost, quality, health and safety, design, production and risk (Baldwin and Bordoli, 2014). The method of deriving at the project plan necessitates a planner apply considerable use of heuristics based on judgement and experience-based learning, in an environment laden with uncertainty (Winch and Kelsey, 2005). It is the matters affecting the effectiveness of this planning 'process' which have been the focus of this research.

Project Environment Factors

Construction projects involve the interaction of a high number of activities, with inter-dependencies, opposing priorities and diverse constraints, emanating in highly complex project environments. Planning comprises of arranging the activities into a robust and accurate schedule, with construction programmes regarded as complex systems. The complexity of construction projects is recognised as a difficult aspect of the project planning process and a recurrent factor contributing to project failure, adversely influencing time-predictability (Gidado, 1996; Flyvbjerg *et al.,* 2003; CIOB, 2008).

Gidado (1996) identifies three factors of task complexity; 'technical complexity' which captures new tasks which are understood in principle, but not yet undertaken; 'analysability' which captures new tasks that are not yet understood and will require increased effort to plan; and 'task difficulty' which captures known tasks that are being completed in new environments. Each complexity factor requires consideration by the planner (or project team) in the preparation of the plan, with the 2008 CIOB survey (CIOB, 2008) reporting 'the more complex the project, the less likely it is that it will be completed either on time or shortly after the completion date'. An aspect contributing to complexity in construction projects alongside the interdependencies of activities, is 'uncertainty'. This includes uncertainty in end-goals / objectives, uncertainty in the method of reaching the goal, uncertainty in the performance of others and uncertainty of potential change (Hagan *et al.,* 2011). Gidado (1996) contextualises uncertainty in the construction environment as incomplete specifications, unfamiliarity with project inputs or the surrounding environment, lack of uniformity of work and the unpredictability of the environment. Related research by Howell *et al. (*1993) identifies that construction projects frequently start with significant uncertainty; however, it is exactly at this time when planners are expected to make project-wide time predictions. Uncertainty in 'how' works are to be undertaken is found to reduce as the final objectives become clearer. In construction this can be associated with uncertainty decreasing as works progress, specifications develop and methods for completing the works become clearer. For project planning, the first programme iteration is frequently prepared with a high level of uncertainty. Fig 2 below illustrates the correlation between certainty ('how' and 'what') and a typical project timeline, with certainty increasing as the project progresses and time elapses (adapted from Howell *et al.,* 1993).

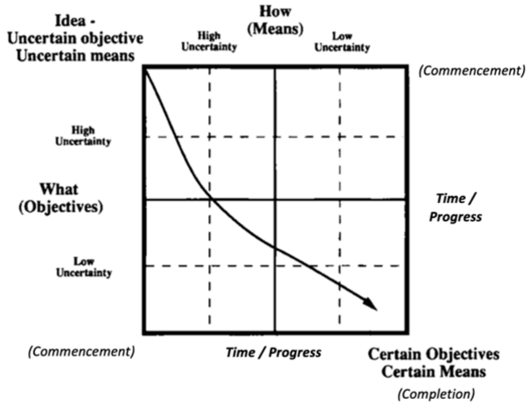

Fig 2: Certainty: Time/Progress

To alleviate uncertainty and complexity affecting time-predictions there have been developments in available planning techniques and improved access to technological advancements. In particular, 4D modelling has shown to improve visibility of complex situations allowing for improved time-predictions (Dawood, 2010; Gledson and Greenwood, 2014) and AI has shown to improve the accuracy of estimate predictions by performing simulations of chance, however, uptake of these technologies remains low across the industry.

Aside from technological advancements, the 'rolling wave' planning technique also seeks to address inaccurate time-predictions by adjusting the level of detail included within a programme depending on the proximity to the date and end-goal. As an alternative to estimating entire projects with uncertainty, this method provides detailed planning only as far ahead as known information exists, with high-level planning utilised to populate the balance of the programmed period. The process is repeated during the lifespan of the project at appropriate intervals, with certainty improving at each iteration.

Regardless of the technology applied or method used to assist the planning process, complexity and uncertainty within construction is identified as a long-standing factor influencing time-predictability and must receive adequate attention to avoid setting inaccurate time predictions.

Human Nature / Cognitive Matters

Given that project planning is completed in advance of action, and recognising complexity and uncertainty in construction, a planner is faced with the difficult task of estimating activity durations in a programme at the outset of a scheme. Estimations come with risk, and various planning methods are available which seek to assist and improve estimate reliability, such as programme evaluation and review technique (PERT), probabilistic network evaluation technique (PNET), narrow reliability bounds (NRA) and Monte Carlo simulation (MCS) (Dawood, 1998). Despite the range of deterministic and probabilistic critical path network analysis methods available to assist with planning estimations, a significant cause of construction programme overrun can be found in unrealistic baseline plans (Flyvbjerg *et al.,* 2003), that is, the original estimated activity durations were too ambitious with a bias towards being overly optimistic (i.e., optimism bias).

Optimism bias can result in insufficient 'float' being allocated within a construction programme, leading to failure to achieve activity targets and project time-overrun, a tendency known as the 'planning fallacy' (Kahneman and Tversky, 1979). Estimating the duration of activities, especially considering uncertainty, is one of the most difficult aspects of project planning, balancing the need to ensure the plan is both competitive and realistic (Baldwin and Bordoli, 2014). Recent industry KPI time-performance scores suggest programmes continue to be overly competitive and optimistic, more-so than realistic.

To counteract the planning fallacy, research by Buehler *et al.,* (1997) found a correlation between motivation and prediction accuracy, recognising that if prediction accuracy was the primary motivator over speed (or programme competitiveness), then predictions can become more accurate. Therefore, on the face of it, if there was a collective drive for 'accuracy' over 'speed', then project and activity estimates could improve, and the planning fallacy could be eliminated. However, removing the incentive for speed can result in a deterioration of performance, even when the baseline position is overly optimistic at the outset (Buehler *et al.,* 1995), a behavioural phenomenon best described as Parkinson's Law. Parkinson's Law manifests that work expands to fill the time available, with a relationship between the level of performance and the goals set; the higher the goal (the more competitive the programme), the higher the performance (Gutierrez and Kouvelis, 1991). In the context of construction planning, if too mindful of the planning fallacy (and surrounding risks), one may set a pessimistic goal and the project duration would inevitably grow to fill the extra time made available, taking longer than necessary to deliver the works, ultimately becoming less competitive. Ultimately, human behaviour dictates that if we have longer to complete an activity than necessary, then the level of effort assigned is tailored to complete the task in the time made available. For construction programmes, this can result in accelerated target programmes naturally expanding to fill contracted periods because of reduced effort allocations. Research by Peters *et al. (*1984) reiterates the correlation between targets-set and effort assigned but was mindful to identify that whilst efforts may increase under time pressure targets, this does not guarantee desired results. Increasing effort to meet an ambitious target may improve an otherwise poorer result, but it could still fall short of achieving the set target.

The planning process therefore requires a delicate balance between establishing sufficiently competitive plans to combat activities growing to fill the time made available (Parkinson's Law) and falling foul of setting overly ambitious targets which are unattainable (Planning Fallacy); both of which can affect planning effectiveness and time predictability.

Planning Techniques

As noted, when considering construction project planning, the most commonly generated output is the Gantt Chart (Winch and Kelsey, 2005; CIOB 2008; CIOB 2021). The chart is used as the mechanism for communicating the planned intent of future activities and rose to prominence in the 1900s. The use of Gantt charts evolved in the 1950s when it was identified that static charts needed to reflect inter-relationships between activities to cope with ever-growing project complexity, resulting in the development of deterministic critical path method (CPM) planning techniques (Baldwin and Bordoli, 2014). CPM planning assists planners and project managers determine the 'longest irreducible sequence of events' on a project, calculating the overall programme duration, and became the industry-standard approach to planning in the 1970s. To improve the accuracy and time-performance of deterministic CPM planning, probabilistic techniques evolved, however the industry uptake of these remains low, with deterministic network-linked programmes communicated via Gannt charts continuing to be the industry 'go-to'; recognised as 'traditional planning' (CIOB, 2021). CPM planning has been criticised for its lack of capacity to deal with complexity resulting from uncertainty of information and the dynamic environment of a construction site, its lack of wider-team involvement and the failure to adequately consider resource availability (Shikhrobat *et al.,* 2019). As a consequence, several alternative holistic planning and project control methods have developed, such as critical chain planning (CCP) and Last Planner System (LPS); and more recently, technological advancements have become accessible to support the planning process, such as 4D modelling and the use of AI; recognised as 'modern planning' methods (Al Nasseri *et al.,* 2016).

LPS was developed from 'lean' concepts and takes a collaborative and process-orientated approach to planning, encouraging a wider team-input to take account of constraints, complexity, and uncertainty. The correct application of LPS is intended to force a proactive approach to dealing with the unknown but has been criticised for being time-consuming and requiring unrealistic buy-in from external parties (Al Nasseri *et al.,* 2016). As an alternative, CCP uses a network-based set of activities with dependencies (as with CPM planning), but with levelled resources and an alternative approach to 'buffer management'. CCP 'pools' programme float and has been praised for avoiding some of the human behavioural issues in planning such as 'activity padding', but critics argue the inserted buffers can unnecessarily prolong programmes because of Parkinson's Law (Al Nasseri *et al.,* 2016). CPM, LPS and CCP all seek to address the common concern of uncertainty in project planning and have each shown the potential to improve planning effectiveness when deployed correctly. To further support the planning process, technological advancements have also shown the potential to improve planning effectiveness by improving visibility of complex situations using 4D modelling, determining probabilistic scenarios using AI or increasing control of the project environment by increasing the use of OSM. The application of technological advancements does not require the use of a specific planning technique and in appropriate scenarios have shown to contribute to improved planning efficiency and increased activity 'hit-rates' (Dawood, 2010).

Planning Effort

The literature demonstrates that 'traditional' and 'modern' methods of planning can influence planning effectiveness, with each method addressing recognised difficulties in the planning process. Regardless of the chosen technique, research has also found a correlation between planning 'effort' and time-performance. Faniran *et al. (*1994) found that by moving ones focus onto 'planning' (development of construction strategies) as opposed to 'project control' (monitoring progress and actioning deviations), planning effectiveness can improve. The research demonstrated that increasing time spent and effort on the planning process had a direct correlation in reducing time-predictability variance. This hypothesis validates preceding analysis by Cohenca *et al. (*1989) where they identified that planning efforts should be adjusted to suit the complexity and uncertainty of a scheme, with the level of 'effort' applied during the planning process expected to directly impact planning effectiveness.

Overall, the literature demonstrates that available planning methods have evolved since the widespread use of deterministic CPM in the 1950s, with technological advancements providing the capacity to further assist the process, and if deployed appropriately, with sufficient effort assigned, an improved method-selection could provide a route to improved planning effectiveness and time-predictability improvements. The matters identified in the literature as influencing planning effectiveness and time-predictability have been synthesised into a conceptual framework below for application in practice. The framework recognises that each of the concepts researched can influence planning effectiveness, which can be measured in activity 'hit rates'. The techniques, technology and effort assigned can influence the impact of the project environmental and human behavioural matters, with relationships between the concepts.

Conceptual Framework

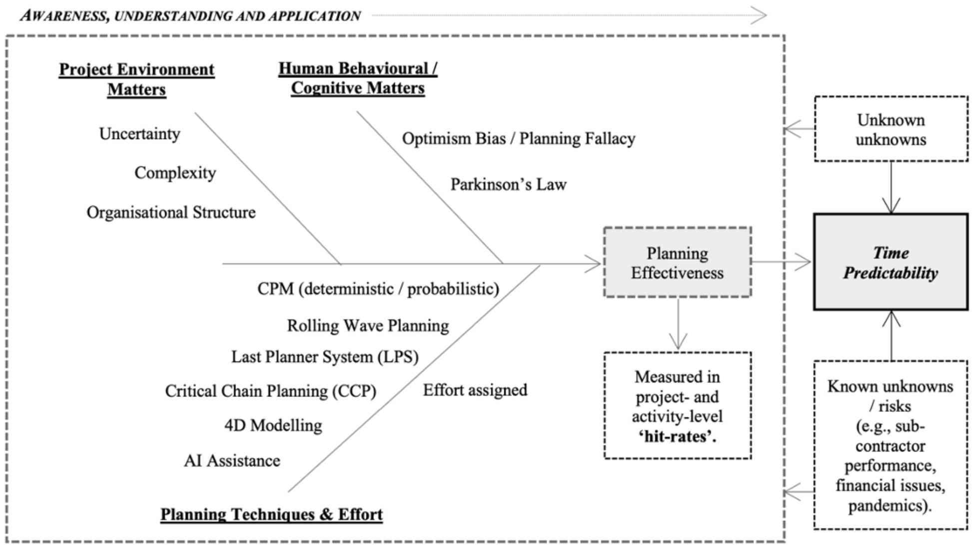

Fig 3: Conceptual Framework

CONCLUSION

It is recognised that construction time performance is measured annually using industry-level KPIs based on the accurate time-predictability of project programmes, with performance failing to exhibit significant improvements. To establish robust time predictions effective planning is necessary, which the literature identifies is influenced by a range of constructs. These include project environment matters, such as the complexity of the project and the uncertainty associated; human behavioural matters such as the planning fallacy and Parkinson's Law; and planning techniques and emerging technologies, such as CPM planning, LPS or 4D modelling, as demonstrated in the conceptual framework. Recognised industry bodies, such as the Project Management Institute, Association for Project Management, and the Lean Institute synthesise similar concepts as influencing time-performance, with common understanding on performance affecting inputs, however, this theoretical awareness fails to translate into industry-wide time performance improvements. Recent industry engagement with senior managers continues to highlight limited awareness of the performance influencing concepts in practice, with efforts often focussed on specific software usage (to produce Gantt charts) and a perceived shortfall in a planner's skillset, as opposed to the application of the wider planning process. Similarly, in the latest planning protocol issued by the CIOB in 2021 (CIOB, 2021), advice continues to focus on 'how' to plan a project from a technical and technique basis, with no mention of time-predictability or the wider constructs affecting planning effectiveness, demonstrating the need to alter the focus of the industry to align with the concepts identified to realise the potential for time performance improvements.

Collating concepts (i.e., inputs) associated with planning effectives and time-performance is not distinct from surrounding work, however, this research provides an opportunity to analyse the collated concepts in a unique manner by seeking to understand the relationships between the concepts and planning effectiveness at micro-level on recent and current projects. The 'hit-rate' work described by Dawood and Sikka (2009) provides a distinct opportunity to expand activity-level research in practice to analyse how activity-level performance translates to overall time-predictability, and how specific attention to the researched concepts can alter performance.

Accordingly, using the conceptual framework established from this research, a series of research instruments are to be developed to analyse the relationships between the concepts and activity 'hit-rate' performance on recent and live construction projects to seek improvements in planning effectiveness and time-predictability. The research instruments will be developed to explore performance variances after increasing consideration of the concepts, with it hypothesised that activity-level 'hit-rates' can improve with directed focus. The subsequent research has the prospect of increasing activity 'hit-rates', thus improving planning effectiveness, reducing the theory-practice gap in the field of time-performance, with the potential to yield overall improvements in time-predictability.

REFERENCES

Ackoff, R, 1970 A concept of corporate planning, *Long Range Planning*, **3**(1), 2-8.

Al Nasseri, H A, Widen, K and Aulin, R (2016) A taxonomy of planning and scheduling methods to support their more efficient use in construction project management, *Journal of Engineering, Design and Technology*, **14**(3), 580-601.

Baldwin, A and Bordoli, D (2014), *A Handbook for Construction Planning and Scheduling 1st Edition*, Wiley-Blackwell, Oxford, UK.

Buehler R, Griffin D, Ross M (1995) It's about time: Optimistic predictions in work and love, *European Review of Social Psychology*, **6**(1), 1-32.

Chartered Institute of Building (CIOB) (2008) *A Research on Managing the Risk of Delayed Completion in the 21st Century*, Bracknell, UK: CIOB.

Chartered Institute of Building (CIOB) (2021) *Planning Protocol 2021 (CIOB Pp21)*, Bracknell, UK: CIOB.

Cohenca, D Laufer, A and Ledbetter, W (1989) Factors affecting construction planning efforts, *Journal of Construction Engineering and Management*, **115**(1), 70-89.

Constructing Excellence (2018) *UK Industry Performance Report 2018 Based on the UK Construction Industry Key Performance Indicators*, Watford, UK: Constructing Excellence.

Dawood, N (1998) Estimating project and activity duration: A risk management approach using network analysis, *Construction Management and Economics*, **16**(1), 41-48.

Dawood, N and Sikka, S (2009), Development of 4D based performance indicators in construction industry, *Engineering, Construction and Architectural Management*, 16(5), 438-458.

Dawood, N (2010), Development of 4D-based performance indicators in construction industry, *Engineering, Construction and Architectural Management*, **17**(2), 210-230.

Faniran, O O, Oluwoye, J O and Lenard, D (1994) Effective construction planning, *Construction Management and Economics*, **12**(6), 485-499.

Flyvbjerg, B, Holm, M K S and Buhl, S R L (2003), How common and how large are cost overruns in transport infrastructure projects? *Transport Reviews*, **23**, 71-88.

Gledson, B J and Greenwood, D (2014) The implementation and use of 4d BIM and virtual construction. *In:* Raiden, A and Aboagye-Nimo, E (Eds.), *Proceedings 30th Annual ARCOM Conference*, 1-3 September 2014, Portsmouth, UK, Association of Researchers in Construction Management, 673-82.

Gledson, B, Williams, D and Littlemore, M (2018) Construction Planning Efficiency and Delivery Time Performance: Analysing Failure in Task-Level 'Hit Rates'. *In:* Gorse, C and Neilson, C J (Eds.), *Proceedings 34th Annual ARCOM Conference*, 3-5 September 2018, Queen's University, Belfast, UK. Association of Researchers in Construction Management, 627-636.

Gidado, K (1996) Project complexity: the focal point of construction production planning, *Construction Management and Economics*, **14**(3), 213-25.

Gonzalez, V Alarcon, L F and Mundaca, F (2008) Investigating the relationship between planning reliability and project performance, *Production Planning and Control*, **19**(5), 461-474.

Gutierrez, G J and Kouvelis, P (1991) Parkinson's law and its implications for project management, *Management Science*, **37**(8), 990-1001.

Hagan, G, Bower, D and Smith, N (2011) Managing complex projects in multi-project environments, *In*: C A L Egbu, ECW (Chair), *Symposium Conducted At the Meeting of the 27th Annual ARCOM Conference*, Bristol, UK.

Howell, G, Laufer, A and Ballard, G (1993) Uncertainty and project objectives, *Project Appraisal*, **8**(1), 37-43.

Kahneman D and Tversky, A (1979) Intuitive prediction: Biases and corrective procedures, *TIMS Studies in Management Science*, **12**, 313-327.

Laufer, A and Cohenca, D (1990) Factors affecting construction-planning outcomes, *Journal of Construction Engineering and Management*, **116**(1), 135-156.

Peters, L H, O'Connor, E J, Pooyan, A and Quick, J C (1984) The relationship between time pressure and performance: A field test of Parkinson's Law, *Journal of Occupational Behaviour*, **5**(4), 293-299.

Shikhrobat, M B, Kabiri, S and Flanagan, R (2019) Project Planning and Scheduling Using System Dynamics for Dealing with Complexity on Construction Projects. *In:* Gorse, C and Neilson, C J (Eds.), *Proceedings 35th Annual ARCOM Conference*, 2-4 September 2019, Leeds Beckett University, Leeds, UK Association of Researchers in Construction Management, 689-698.

Winch, G.M and Kelsey, J, 2005 What do construction project planners do? *International Journal of Project Management*, **23**(2), 141-149.

Winch, G (2010) *Managing Construction Projects: An Information Processing Approach*, Ames, Iowa: Blackwell Publishing.