Ouma, L. A, Leicht, R. M., Messner, J. I. (2025). A target value maturity model for performance target management in the design phase of Lean construction projects. In O. Seppänen, L. Koskela, & K. Murata (Eds.), *Proceedings of the 33rd Annual Conference of the International Group for Lean Construction* (IGLC33) (pp. 199–210). https://doi.org/10.24928/2025/0278

A TARGET VALUE MATURITY MODEL FOR PERFORMANCE TARGET MANAGEMENT IN THE DESIGN PHASE OF LEAN CONSTRUCTION PROJECTS

Lorine Ouma[1], Robert Leicht[2], John Messner[3]

ABSTRACT

Inconsistent application of target value processes limits the achievement of performance outcomes in value-driven Lean design. Current target value practices are also cost-centric, sidelining other aspects of performance value. Maturity models have been used to introduce consistency in Lean practices implementation. This paper presents a target value maturity model (TVMM) that aims to support consistent target value practices. It defines target value functions and processes that drive design toward holistic performance targets beyond cost. The TVMM was developed through a structure maturity model creation methodology. It specifies four maturity functions: value planning, control, alignment, and learning, and further defines fifteen target value attributes. Project teams can assess their maturity across six levels from non-existent, to initial, managed, defined, quantitatively managed, and optimized. The model was internally evaluated through three iterations. Clarity on target value functions presented in the model can support consistent implementation and assessment of target value practices in the design phase of projects. The model can also guide alignment of design efforts with targets. Future work will validate this model with industry experts and a case study project.

KEYWORDS

Lean design, target value design, design management, maturity models, collaboration.

INTRODUCTION

Value in construction projects is measured by the balance of benefits the building delivers and the resources used in its design, construction, and operation. The anticipated benefits and available resources are used to define targets to satisfy the customer's value requirements (Drevland & Lohne, 2023). Lean processes and methods enhance the achievement of value requirements by shifting the focus toward meeting performance target outcomes by pursuing defined value at different phases of project delivery (Nguyen & Akhavian, 2019). Despite the acknowledged capability of Lean to enhance performance outcomes, the implementation of Lean practices related to performance target values is inconsistent. Practitioners and academics alike have linked the limited successful implementation of target value practices to the lack of

1 PhD Candidate, Department of Architectural Engineering, Pennsylvania State University, University Park, PA, USA, lao5206@psu.edu, orcid.org/0000-0002-7572-3284

2 Professor, Department of Architectural Engineering, Pennsylvania State University, University Park, PA, USA, rml167@psu.edu, orcid.org/0000-0001-6705-8141

3 Charles and Elinor Matts Professor, Department of Architectural Engineering, Director, Computer Integrated Construction (CIC) Research Group, Pennsylvania State University, University Park, PA, USA, jim101@psu.edu, orcid.org/0000-0002-7957-1628

sufficient mechanisms to streamline the consistency in characterization and implementation of the practices (Rybkowski et al., 2022).

Limited frameworks exist to align the implementation process with project needs and further support assessment of the level of successful implementation of target value processes. Currently, no framework specific to target value functions and processes exists to support the needed consistency in industry implementation or assessment of improvement in the application of target value driven practices in the design phase of the project. Maturity frameworks proposed to streamline the implementation of Lean practices commonly address enterprise and organizational level consistency in Lean practices (Nesensohn, 2017; Nightingale & Mize, 2002). These Lean maturity frameworks evaluate how well developed, or 'mature,' the social aspects of Lean construction organizations and construction processes are during implementation (Huyser, 2021).

Although efforts have been made to streamline the application of Lean methods through project-level maturity assessment frameworks, the focus is mainly on the construction processes. Detailed construction process maturity frameworks addressing the implementation of Lean practices, such as the Last Planner® System maturity assessment, have been proposed (Asadian, 2023). However, project-level maturity models addressing design processes are scarce. Furthermore, project-specific Lean design maturity models focusing on holistic value generation are lacking (Said et al., 2024).

Assessment mechanisms outside the confines of maturity models have been used to assess value in construction projects. However, these approaches are cost-centric, weighing all performance value from primarily a cost standpoint with assessment of performance target values on target costing as the only value metric (Denerolle, 2013). Practices associated with target costing during the design process have been assessed (Smoge et al., 2020). However, value in projects extends beyond costs (Drevland and Lohne, 2023). Current maturity models adopt a less holistic approach, specifically emphasizing cost-based assessment of value-driven design practices. There are no maturity frameworks guiding the implementation of target value beyond target costing during the design phases of construction projects.

Therefore, a framework for maturity assessment to align the implementation of target value processes beyond target costing could help benefit the implementation of target value methods. This paper introduces a framework for assessing the implementation of target value functions performed while managing performance targets in the design phase of construction projects.

LITERATURE REVIEW

Design consists of a series of processes that transform specific inputs into outputs for the downstream construction process. The implementation of such processes needs to be evaluated to support process improvement. Maturity models have been used to evaluate process or practices and provide a framework for improvement. The models are structured in stages representing different growth levels (Poppelbus & Roglinger, 2011). Maturity models from other domains, specifically business and software product development, have been previously adapted to generate Lean-specific improvement maturity models (Zanon et al., 2021). Successful application of these Lean maturity models has been demonstrated mainly at the organizational, enterprise, and construction process levels.

The Business Process Maturity Model (BPMM) (Object Management Group, 2008), Capability Maturity Model, and the Capability Maturity Model Integration (CMMI) (Carnegie Mellon University SEI, 2001), originating from the software development domain, are commonly referenced in the development of maturity models across different fields of study (Nesensohn et al., 2016). Capability maturity models advance process improvement and standardization within projects and firms by enabling assessment of current state and providing a path to potential improvements.

Maturity models vary across domains; therefore, adaptation of existing models or the creation of new models is required to achieve the desired domain-specific process alignment and improvement. Each maturity model should, therefore, specify the application domain to prevent confusion. Maturity models are also used for different purposes: to evaluate the current state of a process, assess potential future improvements, or compare the current state against industry standards. The purpose and use of the model should be clear (Poppelbus & Roglinger, 2011). Further, the stages of maturity, often ranging from a level of inconsistent or ad hoc practices to an optimized level, should be specified according to the domain terminology.

The process of maturity model development requires a stepwise approach initiated by identifying domain-specific literature on the dimensions to be assessed. The best practices identified from literature informed the process of model design, evaluation, and application (Mettler, 2011). Designing and refining the model attributes, maturity level, and maturity descriptions with guidance and feedback from domain experts improves its internal validity and reliability (Salah et al., 2014). The final assessment of the model entails validating accuracy and applicability though a case study to support continuous domain use (Maier et al., 2012).

MATURITY MODELS IN LEAN CONSTRUCTION ORGANIZATIONS

Lean practices have dominated the construction industry for more than two decades. Since the inception of the Lean project delivery system, the construction industry has actively pursued the application of Lean processes, methods, and tools (Vaagen & Ballard, 2021). However, inconsistencies in the application of Lean practices and a lack of methods for assessing progress in implementation have resulted in the need for resources, such as maturity models, in the Lean construction domain (Nesensohn et al., 2016).

A maturity roadmap developed by Nightingale and Mize (2002) determined that Lean enterprises require the right leadership, tools, and infrastructure, as well as a long-term plan for Lean processes to mature in their Lean journey. According to this Lean enterprise maturity roadmap, getting started requires planning for a long-term vision for Lean and establishing learning mechanisms to support organizational growth in Lean practices.

The application of maturity models in Lean construction organizations have been used to capture the growth in Lean implementation at the organization level (Nesensohn et al., 2014). The study exploring this Lean construction-specific maturity model adopted the CMMI approach to maturity model development, proposing a five-stage approach to Lean Construction Maturity Assessment, dubbed the Lean Construction Maturity Model (LCMM). This model categorizes Lean organizational practices into five stages, from zero to four (level 0 to level 4), ranging from uncertain, awakening, systematic, integrated, and challenging. The model assesses social and technical aspects of Lean maturity. A follow-up study on the LCMM developed a self-assessment tool for measurement of maturity in Lean leadership within organizations (Nesensohn, 2017).

Some assessment tools have been further developed to guide traditional organizations initiating their Lean journey where no Lean practices exist. Cherrafi et al. (2021) developed a Lean green model for preparing organizations to implement Lean and sustainable design within construction projects. This research recommended a five-level model that guides organizations in assessing their preparedness in undertaking Lean practices. Although social aspects are important, technical practices such as planning, and measurement of outcomes also play a significant role.

These studies show that success in Lean implementation depends on having the right leadership to support the technical processes. Several studies have, therefore, advanced Lean management and leadership maturity in construction organizations (Huyser, 2021; Urban, 2015). However, limited models extend the process management practices beyond Lean organizational leadership into the technical Lean processes.

PROJECT-LEVEL LEAN MATURITY MODELS

Best practices have been defined for extending Lean practices beyond the enterprise level. Construction teams are aggressively implementing Lean during the design and construction processes. Therefore, consistency in implementing and improving these practices at the project level was identified as necessary. Studies have extended different Lean organizational models to define Lean maturity at the project level.

At the project level, Lean methods enable effective design and construction processes. Maturity in the use of these Lean methods is critical for the achievement of process goals. Asadian (2023) developed a model for assessing projects that are highly mature in implementing the Last Planner® System (LPS). This model adopted the five levels proposed in the BPMM and the CMM to evaluate the maturity of ten key attributes exhibited during LPS implementation meetings. The key attributes to be associated with high level of LPS maturity include training, coaching, participant engagement in the meetings, level of participants' readiness, the commitment of the team, identification, and removal of constraints, the level of team collaboration, use of visual tools, and measurement of progress toward goals. However, this study focuses on the construction phase of the project.

Lean design management practices in construction projects have also been assessed across different angles such as a five-staged assessment levels (Herrera et al., 2020). With this model, the lowest stage represents traditional Lean design management, while the highest represents developed Lean design management. These five levels can be evaluated against four main attributes: design planning, design control, decision-making, and stakeholder management. Although this model focuses on Lean design management at a high level, the attributes provide a basis for developing the dimensions for assessment of application of Lean processes and methods during the design process.

TARGET VALUE PROCESSES MATURITY MODELS

In the value-driven lean design domain, very limited studies have explored the maturity of processes that drive the design toward performance target outcomes. Smoge (2020) and colleagues explored the maturity of target value design (TVD) practices in construction projects in Norway based on post-process documents and participants' reflections on the process. The maturity assessment adopted a four-scale tool that evaluated the level of implementation of target value design practices drawn from TVD literature. The scale of assessment ranged from no implementation at level zero to full implementation at level three (Smoge et al., 2020). However, the assessment criteria used in the study model only consider cost-centric target value practices in the case study projects. The stages defined in the maturity assessment are vaguely grounded on Lean maturity model development literature, reducing the clarity on the growth trajectory in target value practices during the design process.

There is a need for a maturity model to objectively assess the implementation of performance target value management practices beyond the existing cost target focus. To fill this identified gap, this study proposes a maturity framework for assessing target value functions in the design phase of Lean construction projects.

METHODOLOGY

This paper is part of a larger IRB-approved study that aims to define a target value system integrating Lean functions, processes, and methods driving the design development process toward performance targets. In the first part of the study, we defined a framework outlining the key functions, processes, and methods for managing project target value outcomes. In this specific study, we aim to develop a model for assessing the maturity of the target value functions and processes defined as part of the system. We adopt a pragmatic view that focuses

on the research problem as the primary driver of the research design and the methods used in the study. The development of this maturity model is achieved in four steps: target value system definition, maturity model design and internal evaluation, expert evaluation, and model validation. This paper focuses on the maturity model design and evaluation process. The expert evaluation and validation through a case study will be presented as part of a future publication.

TARGET VALUE SYSTEM (TVS) DEFINITION

A two-phase process was adopted to develop the target value maturity model. The first phase involved defining a target value system for management of performance targets within the collaborative Lean design processes. The defined target value system integrates Lean functions, processes, and methods enabling the performance targets management. This framework was developed using theoretical Lean and target value design literature prior to refinement and validation by subject matter experts (Lasrado et al., 2015).

The functions and processes defined in the first phase were used as the dimensions and attributes of assessment in developing the maturity model. Four dimensions are specified for the target value function: value planning, decision-driven target value control, team alignment, and process-based learning. A set of processes required for successful fulfillment of each function were also generated.

The second step adopted the functions and processes from the target value system framework as assessment dimensions and attributes respectively. The four functions defined the model's dimensions, while the processes were refined to align with maturity model attributes. The development of attribute descriptions and ideal statements at each level of maturity were guided by a critical review of existing literature on Lean maturity models and model development literature (Utah State University, 2012).

MODEL DESIGN

The model's design was initiated by a critical review of existing literature on maturity models, emphasizing Lean design and construction models. The literature review focused on publications from scientific and peer-reviewed sources, specifically the Compendex, Web of Sciences, ASCE, Lean Construction Journal, and the International Group for Lean Construction (IGLC) conference proceedings. Publications related to maturity models in general, Lean maturity models, and design maturity models relevant to collaborative design processes were included in the analysis. Relevant studies identified from reference lists from the first sources were further analyzed to inform the process of maturity model development.

The literature findings provided guidelines for defining the dimensions and attributes of the maturity models, the levels of maturity, and determining the ideal statements for the attributes. We further used the findings from the literature to refine the descriptions of the attributes and processes included in the maturity model.

The maturity model development process considered existing maturity models and their applicability in the Lean design management context. Commonly used maturity models, such as the Capability Maturity Model Integration (CMMI) and the Business process Maturity Model (BPMM), were reviewed in depth to determine the key components of robust maturity models. The Capability Maturity Model Integration (CMMI) version 1.1, developed by the Carnegie Mellon University Software Engineering Institute (Carnegie Mellon University SEI, 2001), was used to guide the development of the maturity model presented in this study.

The CMMI provides a versatile approach for assessing maturity and capability to improve integrated product and process development. It also captures both the maturity model and capability maturity components. The CMMI has also been adapted in the development of maturity models in the Lean construction domain. Case example is the common Lean construction maturity model (LCMM) (Nesensohn, 2017). Using an extensively validated

maturity measurement framework enhances the chances of accurately measuring the attributes being assessed. The CMMI assessment levels and scales have been extensively used, validated, and proven to be applicable in the Lean construction domain .(Huyser, 2021; Nesensohn, 2014). A similar approach to adapting the CMMI to this context was therefore considered and deemed suitable. From the CMMI, this study drew the definition of the different capability maturity levels and the generic characteristics of practice maturity across the different levels of growth. A six-stage maturity model was created for the target value functions derived from the target value system.

INTERNAL MODEL EVALUATION

Maturity models are often subjected to evaluation and verification to confirm the validity and reliability of the attributes. This evaluation process ensures that the components accurately capture all the requirements of the processes to be assessed. The first step in the evaluation process is often conducted internally, based on the development team's understanding of maturity models and process domain requirements. This process enhances the accuracy of the model and is used as the initial improvement before approaching external experts (Helgesson et al., 2012).

In developing the maturity model dimensions, attributes, and maturity level practice descriptions, the authors conducted an internal evaluation in three iterative cycles. In the first cycle, an in-depth review of the model was performed by analyzing the suitability and accuracy of the maturity dimensions, attributes, and attribute descriptions. The consistency of maturity level descriptions was evaluated based on the existing literature and content in lean construction community research. Feedback from the first cycle was used to enhance the accuracy and completeness of the model. Prior to the first cycle of review, most of the attribute descriptions were unclear, and therefore, revisions were made by reference to literature requirements for each of the processes.

The second cycle of internal evaluation included further review of the accuracy, completeness, consistency, and relevance of the dimensions, attributes, and maturity level components in target value management processes. After the second review cycle, the redundancies and overlaps in the target value control mapping and partitioning attributes were eliminated. The revisions from the third cycle emphasized the succinctness of the attribute's maturity level descriptions. Final revisions from this third cycle were used to generate this final version of the model to be shared with the subject matter experts.

EXTERNAL SUBJECT MATTER EXPERT EVALUATION

Individual interviews with ten subject matter experts were conducted for further evaluation of the maturity model with parties outside the model design context. These experts were identified through a multi-criterion expert sampling method (Nyimbili & Nyimbili, 2024) from within the US construction industry's leading Lean construction network. Request emails were sent to the potential participants based on referrals from the network's research committee. Two main criteria were used in determining suitability for participation in the study: previous involvement in more than one project implementing target value practices and experience with developing, disseminating, and implementing target value content at the industry or organizational level.

Four target value trainers and six Lean coaches and directors with more than five years of experience implementing Lean and target value practices were included in the maturity model evaluation. Each interview session followed a structured presentation of the target value maturity model dimensions, and an example of the maturity level practices presented to the subject matter experts. Semi-structured questions were asked to seek the expert's opinions on the relevance, completeness, and clarity of the maturity model components (Salah et al., 2014).

Summary notes taken from the interview sessions were used to determine the recommended areas of improvement and suggested revisions.

FUTURE FOCUS GROUP AND CASE STUDY VALIDATION PLAN

Applicability of a maturity model in the targeted domain requires external review from process experts outside the model development team. These experts analyze the accuracy and completeness of the model based on their expertise (Helgesson et al., 2012). The model validation will be done through a focus group with Lean and target value experts. Further a case study project will be used to demonstrate its application and improve the contents. These steps achieve two goals; first, they determine the accuracy in descriptions of the level of maturity of the processes to facilitate improvement. They also help the maturity model development team identify the model's strengths and weaknesses when applied in the processes of interest (Poppelbus & Roglinger, 2011).

RESULTS

Maturity models differ across domains. The structure of the models varies depending on domain requirements and the process it is applied (Frick et al., 2013). Given the robustness and longstanding use and adaptation of the CMMI to many domains, this study adapted the CMMI capability maturity model. The Target Value Maturity Model (TVMM) aims to support assessment of current state and future improvements.

TARGET VALUE MATURITY LEVELS

Improvements in any process require understanding the potential directions that the process can take to move from one state or maturity level to another. Maturity models provide this possibility by defining a staged path through which an organization or a team can adjust to grow from a lower to a higher level of practices that deliver improved outcomes (Poppelbus & Roglinger, 2011). However, the stages of growth should be presented consistently to prevent disconnects between the stages and the representation of each stage as an endpoint.

The capability maturity model integration (CMMI) defines six levels of capability maturity, ranging from zero to six, where zero represents the lack of process practices and six represents well-implemented and continuously improving processes. By applying the capability maturity model approach to the target value process maturity, we aim to align client and team-defined value being pursued with project design processes.

Therefore, the six levels of maturity were adapted to align with target value processes during the project's design phase, as captured in Figure 1 and 2. The definition of practices across the different levels of maturity has been adapted from the CMMI (Carnegie Mellon University SEI, 2001).

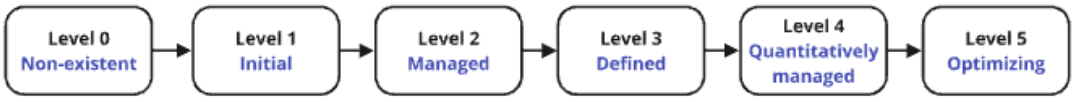

Figure 1: Maturity levels in the target value maturity model

KEY

Level 0: No formal target value processes in place
Level 1: Target value processes are ad hoc
Level 2: Target value processes are planned but vary across project scopes
Level 3: Target value processes are standardized across scopes
Level 4: Target value processes are quantitatively controlled
Level 5: Target value processes are continuously improved

Figure 2: Generic maturity practices of target value processes at different levels of maturity

Level 0 – Non-existent: The minimum maturity level where the target value processes are not explicitly implemented. Little to no documentation exists.

Level 1 - Initial: At this level, the practices exist but in an inconsistent pattern with minimal, inconsistent documentation.

Level 2 - Managed: The team establishes standardization of some of the different functions.

Level 3 - Defined: The team has consistent practices that are structured and standardized across all working groups. The processes' documentation is well-defined and understood.

Level 4 - Quantitatively managed: Measurable indicators are defined for the standardized work procedures, and the practices are applied to all relevant scopes of work.

Level 5—Optimizing: Through reflections and evaluations, measurable practices are consistently improved. Improvement measures are implemented, and results are tracked for changes in processes or products.

TARGET VALUE MATURITY DIMENSIONS AND ATTRIBUTES

Maturity dimensions specify process-specific constructs under assessments. The constructs were generated deductively through literature and inductively through in-depth engagement with subject matter experts (Lasrado et al., 2015). These dimensions summarize the main categories of practices, embodying the principles within the process (Chiera et al., 2021). A specific number of process practices are defined for each dimension. These attributes provide a precise level of detail on the steps and procedures involved in the process (Huyser, 2021). In the refinement with ten subject matter experts, the changes in Table 1 were proposed, resulting in four main dimensions, and 15 attributes, as presented in Table 2.

Table 1: Revisions made based on input from ten subject matter experts

Maturity attribute	Source	Change proposed	Reason for change
Feedback	SME	Combine progress measurement and feedback	Occur concurrently in most cases
Error reduction	SME	Include in the feedback aspect	Occurs during root cause analysis in the measurement and feedback process
Team health assessment	SME	Introduce the process of identifying team-related issues impacting the pursuit of targets	Behavioral aspects of the team are an important component
Roles and responsibilities	SME	Introduce a process on aligning roles and responsibilities	Aligning participants on their required contribution toward the achievement of targets
Scopes and timing definition	SME	Capture a process of linking target value milestones are to handoffs	Linking target value milestones and handoffs is important in delivering to target

The descriptions in Figure 3 show examples of practices for some of the attributes in the model.

PROJECT-SPECIFIC TARGET VALUE MATURITY ASSESSMENT MODEL								
Target Value Attribute		Description	Capability Maturity Levels					
			Level 0 Non-existent	Level 1 Initial	Level 2 Managed	Level 3 Defined	Level 4 Quantitatively managed	Level 5 Optimizing
Dimension 1 - Value Planning								
A1	Define value	Define client's value requirements, constraints, and allowable outcomes for the design, construction, and operation scope of the project.	No value requirements, constraints, or allowable outcomes are defined.	Allowable outcomes are vague or generic to resource constraints (e.g. 'on budget').	Some client-desired requirements are defined for some portion or single phase of the project, such as construction.	Value requirements, constraints, and allowable outcomes are clearly defined across phases, e.g. design, construction, operation.	Value requirements, constraints, and allowable outcomes are defined with measurable indicators for each phase of the project.	The team regularly revisits the value requirements, indicators, and outcomes to ensure alignment with the current project needs.
A2	Validate performance outcomes	Evaluate feasibility of meeting allowable outcomes and establish expected performance outcomes.	No validation study is conducted.	Allowable outcomes are assumed as expected outcomes.	Some reviews of design are used to establish expected outcomes, primarily cost, based on client value and program.	Detailed analysis of design and production to meet client value is used to establish expected outcomes for design and construction.	Detailed analysis of design and production is considered using measured comparison of expected outcomes against client's value across portfolio.	Validation is considered in the measured comparison of expected outcomes to drive improvement across client's portfolio and best in class performance.

Figure 3: Example of project-level target value practices across six levels of maturity

Table 2: TVMM dimensions, attributes, and attribute characteristics

Function Dimension	Process attribute	Process attribute characteristic
1. Plan	Define value	Identifying the client's project-specific goals or value statements, determining constraints, and establishing expected performance outcomes based on goals and constraints.
	Validate value	Evaluating design, construction, and operational performance outcomes based on a detailed analysis of the design and production process.
2. Align team	Engage the team	Engaging the client and all key construction specialists early in the design phase and creating alignment on responsibilities and expectations of participants around performance target value.
	Define roles and responsibilities	Creating alignment across team member roles and responsibilities related to meeting team expectations and project targets.
	Streamline communication	Providing an environment for the exchange and sharing of information related to project target values and for the project team to converge and address issues impacting target value outcomes.
	Provide training and support	Improving the team's understanding of lean and target value practices and promoting behaviors that align the design and production planning process with target value outcomes.
	Assess team health	Evaluating the alignment of participants when working toward the target value. Identifying and addressing issues impacting team collaboration
3. Control Target Value	Set target value defaults	Defining minimum targets for design, construction, and operational performance. Establishing incentives (contractual or non-contractual) for achieving target value defaults.
	Establish scopes and timing	Establishing project milestones and using pull principles to align task timing and handoffs.
	Partition decision process	Categorizing decisions impacting target value outcomes in clusters to minimize decision overload. Establishing target value milestones and pulling key decisions from the defined milestones.
	Map decisions impact	Evaluating decisions against multiple criteria and linking alternatives to their impact on target value outcomes. Approving decisions based on analysis results.
	Analyze progress and feedback	Measuring and tracking progress toward targeted performance outcomes. Identifying causes of variations and constraints to performance target achievement.
	Track risks and opportunities	Identifying uncertainties and alternative ideas that may impact the achievement of defined performance target outcomes.
4. Learn	Conduct reflective learning	Evaluating practices and procedures to identify and document lessons learned for improvement of target value outcomes in subsequent processes. Revisiting and applying lessons learned to improve the process outcomes.
	Evaluate processes and methods	Documenting team processes, planned methods, or procedures that support the teams' collaboration in achieving targets.

Additionally, 90 ideal statements for process practices across all six levels of maturity were defined and included in the complete maturity model accessible here. The assessment of the process attributes is based on observable practices that the project team exhibits during collaborative design processes. The maturity attributes are characterized differently, in an ascending pattern as the process improves from one level to the next (Nesensohn et al., 2016). The model should be implemented from the project's pre-design planning through all the design stages. The dimensions, attributes, and maturity level descriptions will be further validated through subject matter expert focus groups and a case study project.

DISCUSSION AND CONCLUSION

Construction teams have improved performance outcomes through the application of Lean processes, methods, or tools in projects. Target value design is used across the industry to manage the process of aligning design to performance targets in construction projects. However, its application is inconsistent across the industry. These inconsistencies in the application of target value processes have resulted in inconsistent results across the industry. Maturity models have been used to achieve process and method implementation consistency within the Lean construction domain. Nevertheless, the models do not sufficiently address the alignment in target value-driven Lean design processes.

This study addresses the gap by defining a maturity model for assessing target value practices in construction projects to achieve industry consistency. The Target Value Maturity Model (TVMM) presented in this paper, specifies four target value functions and fifteen target value processes necessary for managing performance targets during the design process. This model also provides project teams with a framework for driving the design process toward defined target outcomes where no practices exist. The Model extends the definition of target value beyond the current cost-centric view, allowing target value management beyond the target costing. An internal evaluation and refinement resulted in a final model with six levels of maturity across the four functions, fifteen processes. Further 90 ideal practices are defined in the maturity model.

The model considers four main functions during the management of performance target values. First is value planning. The project team needs to define the value aspects to be pursued in the project. During the actual design processes, performance targets need to be established (Hamdan et al., 2018). Second, the achievement of these targets can be realized through controlling the decision environment, justifying the decision-based value control function. The Lean community acknowledges that collaboration is key when advancing design toward target outcomes (Tommelein & Ballard, 2016). If the team also pursues continuous learning and product-process improvement during this process, the outcomes are likely to be achieved. The model, therefore, defines team involvement and process-based learning as the third and fourth target value functions.

The functions defined in the TVMM maturity model are heavily structured around design decisions, project timing, and implementation of Lean methods enabling systematic value management. Future work will focus on evaluating the model's components with subject matter experts through focus groups. Case studies will also be used to validate the model and characterize the practical application in projects.

ACKNOWLEDGMENTS

The authors would like to thank all industry experts who participated in the interviews in this study. We also thank the Lean Construction Institute (LCI) and the Partnership for Achieving Construction Excellence (PACE) for the financial support.

REFERENCES

Asadian, E. (2023). The Impact of Lean Methods Implementation on Construction Team Dynamics. *PhD Dissertation, The Pennsylvania State University*. https://etda.libraries.psu.edu/catalog/23149eza234

Carnegie Mellon University SEI. (2001). Capability Maturity Model ® Integration, Version 1.1 *CMMI SM for Systems Engineering, Software Engineering, and Integrated Product and Process Development* (CMMI-SE/SW/IPPD, V1.1).

Cherrafi, A., Garza-Reyes, J. A., Belhadi, A., Kamble, S. S., & Elbaz, J. (2021). A readiness self-assessment model for implementing green lean initiatives. *Journal of Cleaner Production*, *309*. https://doi.org/10.1016/j.jclepro.2021.127401

Chiera, M., Lupi, F., Rossi, A., & Lanzetta, M. (2021). Lean maturity assessment in eto scenario. *Applied Sciences (Switzerland)*, *11*(9). https://doi.org/10.3390/app11093833

Denerolle, S. (2013). The application of Target Value Design to the design phase of 3 hospital projects. *Project Production Systems Laboratory, University of California, Berkeley*. https://digicoll.lib.berkeley.edu/record/205877?v=pdf

Drevland, F., & Lohne, J. (2023). Clearing the Fog: Demystifying Value and Values in Lean Construction. In *Lean Construction Journal.* pp 82-99 https://doi.org/10.60164/l2ttv6484

Frick, N., Küttner, T. F., & Schubert, P. (2013). Assessment methodology for a maturity model for interorganizational systems - The search for an assessment procedure. *Proceedings of the Annual Hawaii International Conference on System Sciences*, 274–283. https://doi.org/10.1109/HICSS.2013.106

Hamdan, S. B., Barkokebas, B., Alwisy, A., Bouferguene, A & Al-Hussein, M. (2018). Improved Target-Value Design Approach through the Integration of Environmental Performance and Reliability Theory. *Proceedings of the Construction Research Congress 2018*. https://ascelibrary.org/doi/epdf/10.1061/9780784481301.057

Helgesson, Y. Y. L., Höst, M., & Weyns, K. (2012). A review of methods for evaluation of maturity models for process improvement. In *Journal of software: Evolution and Process* (Vol. 24, Issue 4, pp. 436–454). https://doi.org/10.1002/smr.560

Herrera, R. F., Mourgues, C., Alarcón, L. F., & Pellicer, E. (2020). An assessment of lean design management practices in construction projects. *Sustainability (Switzerland)*, *12*(1). https://doi.org/10.3390/su12010019

Huyser, A. (2021). Development of a lean leadership maturity model. *Master Thesis, North-West University*. http://hdl.handle.net/10394/37667

Lasrado, L. A., Vatrapu, R., Normann Andersen, K., & Allan, L. (2015). Maturity Models Development in IS Research: A Literature Review. *Selected Papers of the IRIS, Issue Nr 6 (2015)*. 6. https://aisel.aisnet.org/iris2015/6

Lee, J., Lee, D., Kang, S., Lee, J., Lee, D., & Kang, S. (2009). vPMM: A Value Based Process Maturity Model. In *Computer and Information Science 2009, SCI 208, pp. 193–202*. https://doi.org/10.1007/978-3-642-01209-9

Maier, A. M., Moultrie, J., & Clarkson, P. J. (2012). Assessing organizational capabilities: Reviewing and guiding the development of maturity grids. *IEEE Transactions on Engineering Management*, *59*(1), 138–159. https://doi.org/10.1109/TEM.2010.2077289

Mettler, T. (2011). Maturity assessment models: a design science research approach. *International Journal of Society Systems Science*, *3*(1/2), 81. https://doi.org/10.1504/ijsss.2011.038934

Nesensohn, C. (2014). An Innovative Framework for Assessing Lean Construction Maturity. *Liverpool John Moores University*. https://doi.org/10.24377/LJMU.t.00004320

Nesensohn, C. (2017). A Lean Construction Maturity Model for Organizations. *Proceedings of the 25th Annual Conference of the International Group for Lean Construction, 357-364.* doi.org/10.24928/2017/0293.

Nesensohn, C., Bryde, D., Ochieng, D. E. G., & Fearon, D. (2015). Maturity and Maturity Models in Lean Construction. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2622152

Nesensohn, C., Bryde, D., Ochieng, E., & Fearon, D. (2014). Maturity and Maturity Models in Lean Construction. *Australasian Journal of Construction Economics and Building, 14 (1) 45-59.* https://search.informit.org/doi/10.3316/informit.200742815970454

Nesensohn, C., Bryde, D., & Pasquire, C. (2016). A Measurement Model for Lean Construction Maturity. *Lean Construction Journal*. https://doi.org/10.60164/e6a4i1b1i

Nguyen, P., & Akhavian, R. (2019). Synergistic Effect of Integrated Project Delivery, Lean Construction, and Building Information Modeling on Project Performance Measures: A Quantitative and Qualitative Analysis. *Advances in Civil Engineering*, *2019*. https://doi.org/10.1155/2019/1267048

Nightingale, D. J., & Mize, J. H. (2002). Development of a Lean Enterprise Transformation Maturity Model. In *Information Knowledge Systems Management* (Vol. 3). https://dl.acm.org/doi/10.5555/1234203.1234204

Nyimbili, F., & Nyimbili, L. (2024). Types of Purposive Sampling Techniques with Their Examples and Application in Qualitative Research Studies. *British Journal of Multidisciplinary and Advanced Studies*, *5*(1), 90–99. https://doi.org/10.37745/bjmas.2022.0419

Object Management Group. (2008). Business Process Maturity Model (BPMM). Version 1.0. http://www.omg.org/spec/BPMM/1.0/PDF

Poppelbus, J., & Roglinger, M. (2011). What makes a useful maturity model? A framework of general design principles for maturity models and its demonstration in business process management. *ECIS 2011 Proceedings. 28* http://aisel.aisnet.org/ecis2011/28

Rybkowski, Z. K., Arroyo, P., & Parrish, K. (2022). Assessment of current target value design practices: consistencies and inconsistencies of application. *Construction Management and Economics*, *40*(7–8), 598–617. https://doi.org/10.1080/01446193.2022.2037146

Said, J., Abotaleb, I., & El-adaway, I. (2024). Construction Lean Scoring and Benchmarking System. *Canadian Society of Civil Engineering Annual Conference* 563–578.

Salah, D., Paige, R., & Cairns, P. (2014). An Evaluation Template for Expert Review of Maturity Models. PROFES 2014, LNCS 8892, pp. 318–321, 2014. https://link.springer.com/book/10.1007/978-3-319-13835-0

Smoge, G. Y., Torp, O., & Johansen, A. (2020). Maturity of tvd implementation in Norwegian public building projects. *Proceedings of the 28th Annual Conference of the International Group for Lean Construction (IGLC28)*, 385–396. https://doi.org/10.24928/2020/0087

Tommelein, I., & Ballard, G. (2016). Target Value Design Introduction, Framework, and Current Benchmark. Version 1.7. *Project Production Systems Laboratory, University of California, Berkeley. https://escholarship.org/uc/item/29m7163g*

Urban, W. (2015). The Lean Management Maturity Self-assessment Tool Based on Organizational Culture Diagnosis. *Procedia - Social and Behavioral Sciences*, *213*, 728–733. https://doi.org/10.1016/j.sbspro.2015.11.527

Utah State University. (2012). *The Shingo Prize for Operational Excellence™. Model and Application guidelines.* Jon M. Huntsman School of Business, Utah State University.

Vaagen, H., & Ballard, G. (2021). Lean and flexible project delivery. *Applied Sciences (Switzerland)*, *11*(19). https://doi.org/10.3390/app11199287

Zanon, L. G., Ulhoa, T. F., & Esposto, K. F. (2021). Performance measurement and lean maturity: congruence for improvement. *Production Planning and Control*, *32*(9), 760–774. https://doi.org/10.1080/09537287.2020.1762136