

1 **An Assessment Tool to Measure the Lean Construction**
2 **Maturity Level**3 Ahmed Helmy Mohamed¹4 ¹ Integrated Solutions Consultancy, London, UK
5 a.helmy@iscoglobal.com6 **Abstract.** The past two decades have witnessed a rapid increase in construction
7 projects within developing countries in the Middle Eastern Gulf region. Despite
8 this, construction companies still face many challenges, including completing
9 projects on time and within budgets. The negative impact of these challenges has
10 been confirmed through (1) data collected from documents concerning completed
11 construction projects in which the author has been professionally involved; (2)
12 the author’s experience in the field of construction project management in the
13 Middle East and risk management in particular; and (3) extensive study of the
14 literature in this domain.15 To that end, the objective of this study is to create a Lean Construction
16 Assessment Tool. To achieve this objective, the research work (a) investigates
17 the linkages between Lean and risk management; (b) reviews the concept of Lean
18 and its application to the construction industry in developing countries (c)
19 analyses the barriers and success factors; and (d) identifies the benefits of Lean
20 Construction within construction organizations in developing countries.21 Among the main findings of this research is the lack of future strategic plans for
22 the construction industry in terms of managing waste and risks in general and
23 specifically in developing countries. It is hoped that the outcomes of this research
24 study will have theoretical and practical significance for successful Lean
25 implementation in construction organisations in developing countries.26 **Keywords:** Developing Countries, Lean Construction, Mega-Construction, and
27 Risk Management.28 **1 Introduction**29 Prior to a successful Lean implementation, a Lean assessment should be conducted to
30 identify gaps in knowledge that need to be addressed. The Lean implementation
31 assessment consists of all the observed categories of Lean implementation. The
32 researcher believes that Lean assessment should be applied before implementing the
33 Lean Construction method. The researcher considered two tools for conducting Lean
34 assessment: (1) The Lean Enterprise Self-Assessment Tool (LESAT); and (2) The
35 Highways Agency Lean Maturity Assessment Toolkit (HALMAT).

36 2 Proposed Lean Construction Assessment Tool (LCAT)

37 The researcher proposes a Lean Construction Assessment Model to evaluate the level
38 of Lean awareness in organisations which can measure the gap between their current
39 state of maturity and the position they want to reach. The researcher reviewed some of
40 the previous assessment tools and adopted two approaches, LESAT and HALMAT, as
41 guidance and then tailored an assessment tool to be adopted for assessing the level of
42 Lean awareness in construction companies in the Middle East. The rationale behind
43 choosing these two tools is that the two approaches are easy to use and will be relevant
44 to the Middle East construction industry. Highways England (2012) developed a step-
45 by-step route to completion, and abiding by the following steps is highly recommended
46 [3].

47 2.1 Lean Construction assessment steps

48 The researcher mainly followed the steps of the assessment tool mentioned in the
49 HALMAT section because, from experience, it is more applicable to construction
50 projects. The road map has been created to implement an actual assessment for the
51 organisation that undertakes the management of the ongoing Mega-construction project
52 [4]. The following are the steps that should be abided by and followed by the road map
53 (see Figure 1):

54 **Step 1:** Decide the limit of the assessment, whether to include a whole organisation,
55 a particular division or a department of an organisation.

56 **Step 2:** Determine individuals qualified to participate in the assessment process:

57 **Step 3:** Appoint a facilitator

58 Explanation: A facilitator should have sufficient knowledge of Lean principles so as
59 to be able to guide participants on interpretation; should be an independent individual;
60 and should not be one of the leaders of the organisation, in order to avoid any conflict
61 of interest.

62 **Step 4:** Determine the mission, vision, value and strategic aims of the organisation.

63 Explanation: The Company's mission, vision, value and strategic aims should be
64 considered in the questions posed to assess the level of company awareness regarding
65 Lean.

66 **Step 5:** Hold an initial meeting to set the ground rules of the assessment.

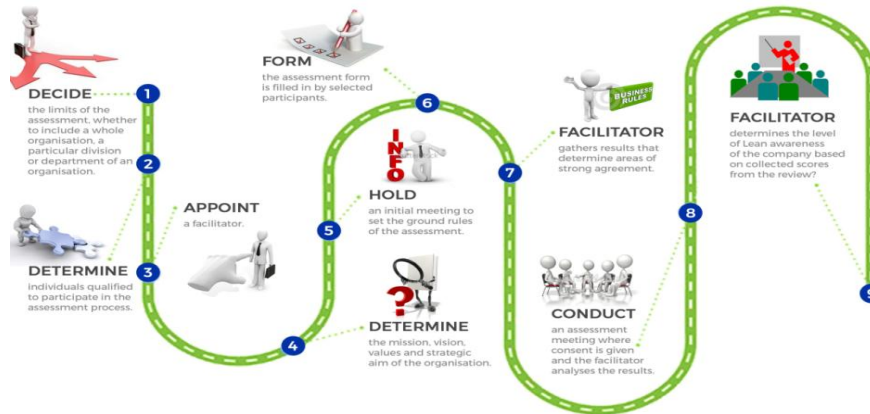
67 Explanation:(1) Ensure that the participants fully understand the assessment tool as
68 well as the application method; (2) Confirm that they understand the limits of
69 assessment clearly; (3) Arrive at an agreement on the timetable for completion and
70 collation of individual scores; (4) Set a date for the assessment meeting.

71 **Step 6:** The assessment form is filled in by selected participants

72 **Step 7:** Facilitator gathers results that determine areas of strong agreement

73 **Step 8:** Conduct an assessment meeting where consent is given and the facilitator
74 analyses the results.

75 **Step 9:** Facilitator determines the level of Lean awareness of the company based on
76 collected scores from the review.



77

78

Fig. 1. Lean Construction assessment roadmap.

79

2.2 Areas of coverage of the assessment tool

80

Before developing the assessment tool questions and determining the key assessment elements, the researcher held a brainstorming session with the workers involved in the selected ongoing Mega-Construction project. This session aimed to tackle the main Lean Construction principles as well as the quantitative evaluation of such principles within construction projects through site visits. Attempting to cover all Lean Construction aspects, the researcher chose the following assessment elements based on the reviewed literature and previous assessment tools, as well as key findings from data collected from both the conducted survey and the researcher's experience in developing countries [1]. These areas of coverage are verified in the validation process, and if any other area is suggested by the participants, the research will consider it:

90

- Lean policy and strategy: this element identifies the extent of Lean principles incorporated in the strategic and planning processes of organisations and assesses the company policy deployment in order to determine the company's position in the future.
- Lean philosophy: this element identifies the scope of an organisation's target for creating more value for customers and focuses on its key processes to continuously increase it.
- Lean leadership and structure: this element indicates how the organisation's leaders are active in encouraging and mentoring the introduction of Lean and examines the companies' degree of structuring their organisations to maximise team working and employee empowerment [2].
- Lean principles and drivers: this element evaluates the organisation's usage of the five principles of Lean and ensures that companies are following the overall organisational strategy and that they are constantly and consistently delivering value to their customers through the constant review of their processes.

100

101

102

103

104

105

- 106 • Eliminating waste and continuous improvement: this element identifies the
107 organisation's plan for defining and managing the generated waste in order to
108 achieve continuous improvement.
- 109 • Lean techniques and tools: this element aims at evaluating the usage of the
110 Lean techniques and tools to support the adoption of Lean principles.
- 111 • Delivery of value: this element identifies the level of value maximisation in
112 the organisation through the analysis of the key processes which deliver end
113 customer value.
- 114 • Built-in quality: this element identifies whether the organisation avoids quality
115 issues through the quality assurance processes.
- 116 • Process flow: this element assesses the degree to which processes are being
117 designed to encourage flow and balance resources.
- 118 • Lean impact (barriers and success factors): this element identifies the
119 organisation's understanding of Lean's impact on its performance and defines
120 the process of assessing the impact of Lean on final project success [4].

121 **2.3 Assumptions for assessment tool**

122 The researcher made two assumptions for proposing the assessment tool: 1) LCAT
123 weighting and overall scoring system; 2) evaluation of the outcome of the assessment
124 tool (reading results). The main basis for those two assumptions was an expert's
125 judgment, reviewed literature and the researcher's experience in the Middle East.

126 In order for the researcher to develop the tool, a brainstorming session with four of the
127 selected participants, two from top management (the CEO and Project Management
128 Office Director) and another two from site workers (project manager and construction
129 manager) was held to discuss the main Lean Construction principles and how they can
130 be quantitatively evaluated within construction projects in the Middle East.

131 The researcher considered the HALMAT scoring spreadsheet developed by the
132 Highways Agency (2012) as a basis for the first assumption (weighting and overall
133 score system). The questions' weights are given, tailored to the company's areas of
134 weaknesses and strengths [3]. Therefore, the researcher and experts during the
135 brainstorming session agreed to weight the twenty (20) questions provided in the
136 assessment tool equally at 5 per cent each and have a minimum score (1) and maximum
137 score (5).

138 The second assumption is the outcome/results of the assessment tool which will be
139 used to calculate an overall weighted score for the organisation's Lean maturity.

140 **2.4 LCAT weighting and overall scoring system**

141 The adopted maturity levels for the development assessment are based on the approach
 142 of Nesensohn et al., (2014). The researcher applied a scoring system based on a 5-point
 143 scale for each question. Ratings are in whole numbers only (no decimal ratings). The
 144 assessment tool is based on a numerical scoring system on a scale that ranges from 0 to
 145 4, where 0 represents the state of Uncertainty and 4 represents the Challenging state.
 146 The researcher used the same maturity levels utilised for the maturity assessment. Table
 147 1 identifies the maturity levels used for Lean Construction assessment [5]:

148 **Table 1.** Maturity level definitions.

Level	Maturity level	Definition
0	Uncertain	Knowledge about the system is present but there is lack of interest in implementing it
1	Awakening	System is present but lacks concentration and guidance in the implementation
2	Systematic	System is implemented and company is adjusting to the system
3	Integrated	System is implemented and company is reaping the benefits while adjusting to new challenges encountered during the process.
4	Challenging	Knowledge about the system is present but there is lack of interest in implementing it

149 Lean Construction principles were presented in questions applicable to the reality of
 150 construction sites. However, the Lean principles included in the assessment tool were
 151 split into ten main categories, covered by 20 questions, for applicability reasons. These
 152 ten main categories are: 1) Lean policy and strategy; 2) Lean philosophy; 3) Lean
 153 leadership and structure; 4) Lean principles and drivers; 5) waste elimination and
 154 continuous improvement; 6) Lean techniques and tools; 7) delivery of value; 8) Built-
 155 In Quality; 9) process flow; and 10) Lean impact (barriers and success factors). Each
 156 of the 20 questions has an equal weighting, with a rating value that ranges from 0 to 4.
 157 Table 2 illustrates the weighted scoring for each section and subsection (questions).

158

Table 2. Weighted scoring system – assumptions.

Section	Sub-section	Sub-section Weighting	Section Weighting	Min Score	Max Score
1.0 Lean Policy and Strategy	1.1	5.00%	15%	1.00	5.00
	1.2	5.00%		1.00	5.00
	1.3	5.00%		1.00	5.00
2.0 Lean Philosophy	2.1	5.00%	10%	1.00	5.00
	2.2	5.00%		1.00	5.00
3.0 Lean Leadership and Structure	3.1	5.00%	10%	1.00	5.00
	3.2	5.00%		1.00	5.00
4.0 Lean Principles and Drivers	4.1	5.00%	10%	1.00	5.00
	4.2	5.00%		1.00	5.00
5.0 Eliminating Waste and Continuous Improvement	5.1	5.00%	15%	1.00	5.00
	5.2	5.00%		1.00	5.00
	5.3	5.00%		1.00	5.00
6.0 Lean Techniques and Tools	6.1	5.00%	10%	1.00	5.00
	6.2	5.00%		1.00	5.00
7.0 Delivery of Value	7.1	5.00%	5%	1.00	5.00
8.0 Built-In Quality	8.1	5.00%	5%	1.00	5.00
9.0 Process Flow	9.1	5.00%	5%	1.00	5.00
10.0 Lean Impact (Barriers and Success Factors)	10.1	5.00%	15%	1.00	5.00
	10.2	5.00%		1.00	5.00
	10.3	5.00%		1.00	5.00
Weighting Check		100%	100%	20.00	100.00

159

160 3 Evaluation and outcome of the assessment tool

161 There are several necessary prerequisites for conducting the application of the LCAT
 162 adequately. Project and company information should be gathered beforehand in order
 163 to provide time for the assessment, which is conducted through an interview and needs
 164 to be well prepared through a site/company visit. In order to reduce bias and to facilitate
 165 observation and questioning, site visits and interviews should be conducted with ten or
 166 more people. The evaluation model should not be filled out during the site visit and
 167 questioning, in order to provide better observation and maintain confidence between
 168 the facilitator and interviewee. In order to rate the project or company according to the
 169 LCAT, based on a trial that has already been conducted, the researcher asked two of
 170 the participants to fill in/answer the assessment questions prior to the actual assessment.
 171 It has been found that one hour of site visit is considered enough. The results of the
 172 assessment are then compared, discussed and merged in order for the interviewers to
 173 agree on a final version. For the sake of gaining more experience and a clearer rating
 174 notion, the same researchers are advised to apply the LCA-Tool to as many projects as
 175 possible. This will also help in minimising bias.

176 The reading of results is based on the overall score of the ten categories of the
 177 assessment. The results are considered to be the company's level of Lean Construction

178 awareness; this is represented as a score between 20 and 100. The researcher has
 179 assumed a weighting score system such that the minimum score for each question is
 180 1.0 and the maximum is 5.0, whereby results are based on the overall score of the ten
 181 categories of the assessment. It is assumed that the score range represents each level of
 182 maturity [6].

183 INITIATION (score range: 20.0 – 30.0): your company urgently needs to improve
 184 these aspects

185 PLANNING (score range: 31.0 – 45.0): your company needs to address the gaps in
 186 its knowledge

187 EXECUTION (score range 46.0 – 60.0): your company has moderate capability and
 188 maturity and scope for improvement

189 MONITORING AND CONTROLLING (score range 61.0 – 75.0): your company
 190 has high capability and maturity

191 CLOSING (score range: 76.0 – 100): your company needs continuous improvement

192 **4 Conclusions**

193 The development of an assessment tool was employed to allow construction companies
 194 in the Middle Eastern Gulf region to assess the maturity level of Lean Construction
 195 prior to implementing the Lean Construction method. The nine steps of Lean
 196 Construction Assessment and the ten areas of coverage of the assessment tool are
 197 provided. The ten areas have twenty questions to help organisations evaluate the level
 198 of awareness of the Lean Construction method among their workers. Based on the
 199 conducted process of the validation of the assessment tool. Fifteen participants (100 per
 200 cent) agreed that the proposed Lean Construction Assessment Tool could assess the
 201 awareness of Lean in construction organisations/projects. In addition, the experts
 202 interviewed also gave positive comments on the overall assessment tool, such as “the
 203 proposed assessment tool is really well-designed”. Moreover, an assessment tool was
 204 employed to allow construction companies in the Middle East to assess the maturity
 205 level of Lean Construction prior to implementing the Lean Construction method.

206 **References**

- 207 1. Casey, J.: A lean enterprise approach to process improvement in a health care organization.
 208 Submitted to the System Design and Management Program, pp. 1-100. Massachusetts
 209 Institute of Technology, Massachusetts: Cambridge (2007).
- 210 2. Engineers Australia,
 211 http://www.engineersaustralia.org.au/sites/default/files/shado/Divisions/Western%20Australia%20Division/Technical%20Presentations/lean_construction_august_2012.pdf, last
 212 accessed 2014/06/16.
- 213 3. Highways England, [http://assets.highways.gov.uk/specialist-information/lean-](http://assets.highways.gov.uk/specialist-information/lean-halimat/Highways%20Agency%20Lean%20Maturity%20Toolkit%20%28HALMAT%29%20version%2021.pdf)
 214 [halimat/Highways%20Agency%20Lean%20Maturity%20Toolkit%20%28HALMAT%29](http://assets.highways.gov.uk/specialist-information/lean-halimat/Highways%20Agency%20Lean%20Maturity%20Toolkit%20%28HALMAT%29%20version%2021.pdf)
 215 [%20version%2021.pdf](http://assets.highways.gov.uk/specialist-information/lean-halimat/Highways%20Agency%20Lean%20Maturity%20Toolkit%20%28HALMAT%29%20version%2021.pdf), last accessed 2016/05/07.
 216

- 217 4. Massachusetts Institute of Technology,
218 [https://dspace.mit.edu/bitstream/handle/1721.1/84694/PRD_LESAT_2_Facilitators_Guide](https://dspace.mit.edu/bitstream/handle/1721.1/84694/PRD_LESAT_2_Facilitators_Guide_Feb2012.pdf?sequence=1)
219 [_Feb2012.pdf?sequence=1](https://dspace.mit.edu/bitstream/handle/1721.1/84694/PRD_LESAT_2_Facilitators_Guide_Feb2012.pdf?sequence=1), last accessed 2016/05/06.
- 220 5. Nesensohn, C., Bryde, D., Ochieng, E., Fearon, D., & Hackett, V.: Assessing Lean
221 Construction maturity. In: The 22nd Annual Conference of the International Group for Lean
222 Construction, pp. 1157-1168. IGLC and Akademikaforlag, Oslo, Norway (2014).
- 223 6. Nightingale, D., Mize, J.: Development of a Lean enterprise transformation maturity model.
224 *Information, Knowledge, Systems Management* 3(1), 15-30 (2012).