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Project complexity assessment and management tool

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Abstract

Project Complexity Assessment and Management (PCAM) Tool was developed to help project teams identify, assess, and manage project complexity. This Excel-based tool was designed with a "Complexity Measurement Matrix" comprising of the indicators that are statistically significant to project complexity. The weight factors of these complexity indicators were developed based on the expert ranking result from a subject matter workshop. These factors function as the multipliers to place greater emphasis on the stronger complexity indicators. The comprehensive reports from the tool present the overall project complexity level, a series of radar diagrams describing the most important indicators, and associated management strategies. The outputs help project teams formulate a management plan for the most important contributors with sufficient flexibility to be deployed at multiple project stages and for different project sizes.

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1. Instruction

Project engineering researches often study complexity as one of many variables. Most of these studies focus on the theoretical background of the topic and describe a broad definition of project complexity. Cicmil et al. [4] identified complexity as a factor that helps determine planning and control practices, hinders the identification of goals and objectives, or a factor that influences time, cost, and quality of a project. There is a crucial need of

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integrated complexity studies in order to identify, assess, and manage the complexity of a project and an efficient complexity tool to help project practitioners facilitate this process. One of the downsides of the completed studies was that while significant number of studies that assess complexity, there is no integrated study that defines the project complexity, introduces its attributes, and proposes a methodology to measure the level of complexity of each project.

For the topic of project complexity, scholars have focused on the identification of complexity attributes more than any other aspects. Studies in this area have evolved significantly over the past twenty years. Baccarini [1] identified two major attributes of complexity including organizational complexity and technical complexity. Organizational complexity reflects the view that a project is a task containing many interdependent elements. Technical complexity deals with complexity related to the transformation processes, which convert inputs into outputs. Generally, the number of project components, degree of activeness within each component, degree of interactions between project components, and interactions of the project with entities outside of the project were frequently considered as the attributes that create complexity of a project.

Global Alliance for Project Performance Standards [5] developed a project manager standard in 2007 with a comprehensive project management complexity measurement tool called CIFTER (Crawford-Ishikura Factor Table for Evaluating Roles). The tool provides a seven factor model on which the project management complexity of projects can be assessed. Lebcir and Choudrie [6] introduced four driving factors of project complexity based on previous studies: infrastructure size, infrastructure interconnectivity, infrastructure newness, and project uncertainty. The impact of these factors on the project life cycle has been modeled using system dynamic method. Vidal et al. [7] developed a method to measure the complexity level of a project using Delphi and Analytic Hierarchy Process (AHP) methods. The authors have identified seventy possible complexity factors. Then, using the Delphi method, 18 essential factors have been selected as the most influential factors on project complexity.

The PCAM tool presented in this paper was developed on the basis of a complexity measurement matrix comprising of the complexity indicators that have been proven significant to project complexity. The measures of complexity were developed based on the data set collected from the historical projects. The importance of each complexity factors on the overall complexity level of a project was allocated based on the expert ranking results. A project team can use PCAM Tool to assess the current complexity level of project at a particular point in the project life cycle. The tool can be used for different phases of a project and for any industry projects including industrial, infrastructure, or buildings with different project sizes.

2. Project Complexity Measures for PCAM Tool

One research supported by Construction Industry Institute has identified the complexity attributes and indicators deemed to measure the associated attributes. The statistical analysis of this research finally resulted in 37 significant indicators measuring 23 associated complexity attributes. Table 1 presents two sample category of the significant complexity attribute and indicator. These 37 complexity indicators were statistically significant in differentiating low complexity projects from high complexity projects. These indicators were used as the input for PCAM Tool.

3. Complexity Indicator Measurement Scales

The PCAM Tool was designed with a Complexity Measurement Matrix comprised of 37 complexity indicators each with a 3x3 measurement scale with separate low, medium, and high measurement ranges. These measurement scales were generated by normalizing the factual data collected from the past projects on each complexity indicator. The survey data collected for each indicator was used as a basis for setting the nine-point range. Typically, the mean from the survey data for the indicator was used to set the medium score (4-6). The low range from the survey data was used to set the low score (1-3) and the high range from the actual survey data was used to set the high score (7-9). When a complexity score for an indicator is assessed depending on the impact level of that indicator on the project, a numeric score from 1 to 9 is assigned to each measurement range with 1 being lowest through 9 being highest score (i.e., most complex). The complexity scores of each indicator function as the complexity-impact level of that indicator to the project.

Table 1. Significant Complexity Indicators.

Attribute	Complexity Indicator (CI)
Stakeholder Management:	
1. Strategic importance of the project	CI-1_Influence of this project on the organization's overall success (e.g., profitability, growth, future industry position, public visibility, and internal strategic alignment).
2. Project impact of local social and political groups (stakeholders)	CI-2_Impact of required approvals from external stakeholders on the original project execution plan.
	CI-3_Impact of required inspection by external (regulatory) agencies/entities on original project execution plan.
Legal:	
9. Permitting and regulatory requirements	CI-10_Number of total permits to be required.
	CI-11_Level of difficulty in obtaining permits.
	CI-12_Difficulty in obtaining design approvals.
10. Legal	CI-13_Impact of external agencies on the project execution plan.

4. Complexity Indicator Weighting Factors

A panel of subject matter experts who had many years of experience in project management was assembled in a workshop to develop the weighting factors for the complexity indicators. The experts were asked to select 15 complexity indicators and rank these indicators in importance order from 1 to 15. A score was automatically assigned to each ranked indicator depending on its rank order. The assigned scores of each indicator from all workshop participants were then added up to generate the total ranking score of that indicator. The total ranking score was used as a basis for weighting the complexity indicators in developing the assessment tool. A forced weight factor of 1.9 was assigned to the top ranked indicators and a weight factor of 1.2 was assigned to the lowest ranked indicators. These factors in the form of a multiplier were used in PCAM tool to place greater emphasis on those indicators that were considered stronger indicators of project complexity based on their ranking.

5. PCAM Tool Application

The purpose of PCAM tool is to identify the key project complexity indicators, assess their potential impact on a project, and design a plan to manage the potential impacts of the complexity indicators. The tool was designed to be flexible enough to deploy in many different ways and at multiple stages of project development and delivery. The project timeline shown in Fig. 1 indicates possible uses of the process relative to the CII Front End Planning (FEP) and Project Execution gates with the four phases as reference points.

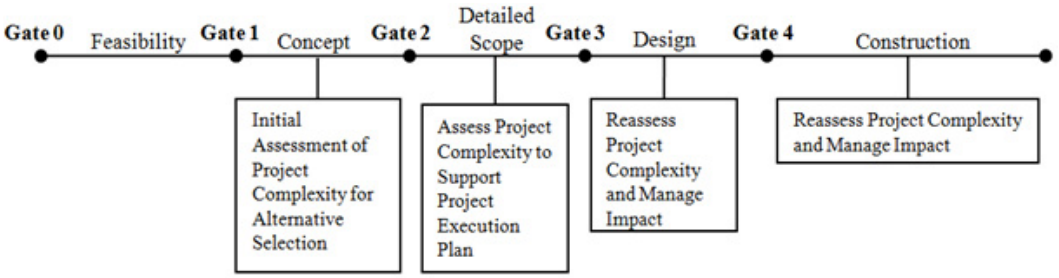

Fig. 1. Project Time Line with Tool Uses.

5.1. PCAM Tool Structure

PCAM tool has eight different worksheets including Introduction, User Guide, Project and Evaluator Information, Complexity Input, Complexity Output, Complexity Management Strategies, Detailed Report, and Executive Report. To select the input for the PCAM Tool, project teams should understand exactly where the project is at the time of assessment of the level of complexity. PCAM Tool requires the project team to analyze the complexity indicator to quantitatively assess and measure the impact of each indicator, determine its measure, and then score the indicator based on the decided measure. The measurement level and score for each complexity indicator is selected from a drop down menu based on the team's experience and input. A numeric value from 1 to 9 will be assigned to each measurement indicator with one being lowest through nine being highest complexity. Fig. 2 shows an example of the drop down menu for each indicator with the measurement scores and other measurement information.

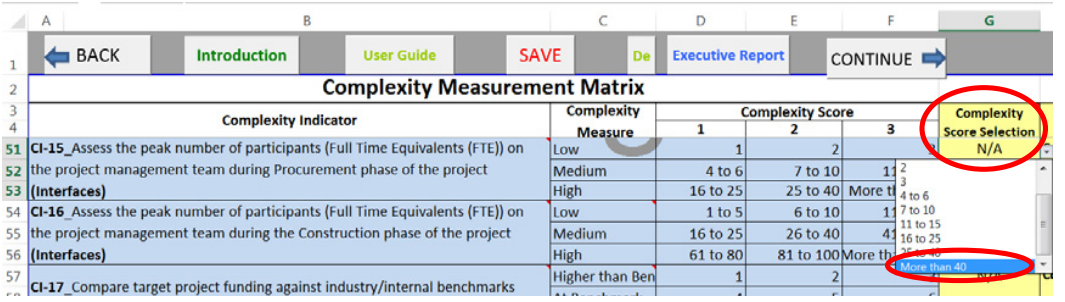

Fig. 2. Selection of Measurement Score for Each Complexity Indicator.

After assessing all 37 complexity indicators and assigning an appropriate measurement score to the corresponding indicator, the complexity output is generated with four radar diagrams (Fig. 3) and one overall complexity level dial chart. The 37 complexity indicators are arranged into four diagrams based on their relationship with other indicators by groupings previously referenced. On each diagram, users can see which indicators are located in the high complexity area, meaning that those indicators may have a substantial contribution to project complexity. On the diagrams, users can identify the indicators that have substantial contribution to the overall complexity of project, and then focus on managing these indicators.

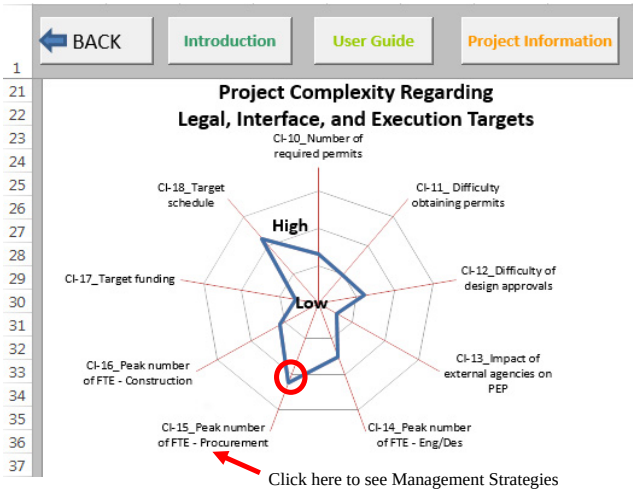

Fig.3 Complexity Radar Diagrams and Links to Management Strategies.

5.2. Complexity Management Strategy

For each complexity indicator, a set of management strategies has been identified to help direct a project team to take appropriate action. These complexity management strategies have been developed and refined by experienced subject matter experts. Depending on the availability of resources at the project team's disposal, one or more management strategies may be implemented. After identifying the indicators that have high impact on project complexity and clicking on those indicators on the diagrams (Fig. 3), users will be linked to the recommended strategies for managing the potential impact of each indicator (Fig. 4).

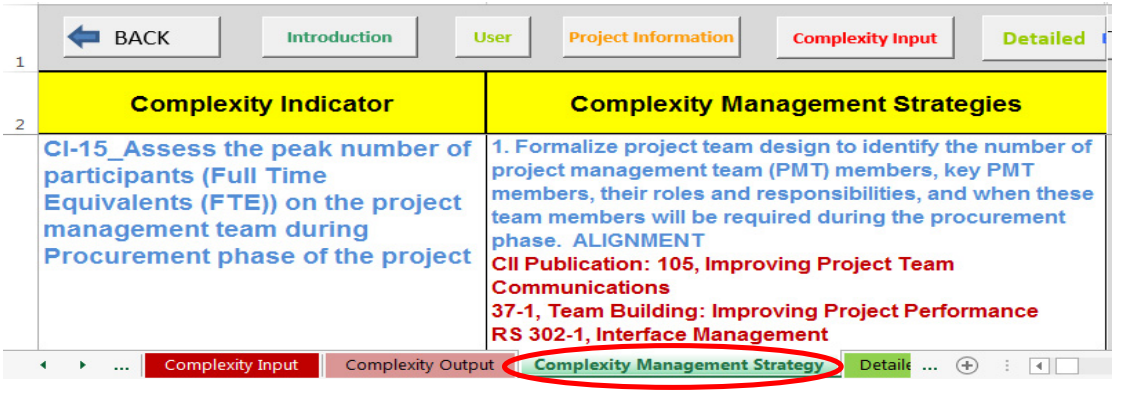

Fig. 4. Recommended Strategies for the Pointed Indicator.

Many companies have their own management procedures so by no means is the list intended to be exhaustive. After a project team has selected one or more management strategies to implement, they should incorporate them into their project execution plan.

5.3. Reporting

In order to help a project team in summarizing the complexity assessment process, PCAM tool provides the report function that includes a Detailed Report and an Executive Report. The Detailed Report provides a comprehensive report with inputs and outputs from the tool. This report presents top 10 ranked complexity indicators (CIs) and associated management strategies that are selected among 37 CIs based on their relative complexity score. It also presents an overall complexity chart to help the project team assess the overall complexity level of the project. The Executive Report presents a complexity output with respect to an executive level focus that includes only the top four complexity indicators, associated management strategies, and the overall complexity chart. In addition to the recommended management strategies for the highest complexity indicators, project management staff can also provide their own additional strategies based on their perspective and experience from other projects to manage project complexity effectively.

6. Conclusion

The PCAM Tool provides a process to evaluate the complexity of a project in which a set of complexity indicators that have been statistically verified. It also identifies the relative importance of these indicators to the project, enabling a project team to focus on implementing mitigating strategies that facilitates managing those complexity indicators to ensure project outcome objectives are met. In addition, the tool also provides the strategies to be incorporated into the project execution plan to manage a project's complexity. Organizations using this tool can differentiate between projects' complexity, they can measure complexity anywhere along the life-cycle of a project, and they can employ some of the strategies chosen to manage complexity and then re-test the project to determine the impact of employing the strategies.

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