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Considering the systems engineering leading indicators to improve project performance measurement

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Abstract: With a long history in project management practices, project performance measurement (PPM) offers a wide range of methods and good practices which help project managers to effectively monitor the project and evaluate project progress and results. However, several critical issues remain, such as an unbalanced development of KPIs types or a limited availability of leading Key Performance Indicators (KPIs). On the other hand, systems engineering measurement (SEM) is a more recent discipline, with practices and theories that appeared with the emergence of the systems engineering discipline. Moreover, SEM has been much more developed with some practical research results published in several standards and guides. In particular, SEM does not only use lagging indicators, used to track how things are going but defines methods to promote leading indicators, used as precursors to the direction where the engineering is going; indeed, 18 leading indicators (LIs) were recently proposed, validated, and finally engineered in a practical guidance. Our goal being to improve project performance and success rate, one mean is to improve the project performance measurement, on which decisions rely for project management. To achieve this goal, this paper proposes to extend the project performance measurement of indicators by considering how performance is measured in systems engineering.

Keywords: performance measurement; leading indicators; lagging indicators; KPIs.

1. INTRODUCTION

Project performance measurement (PPM) is receiving wide focus from both academy and practitioners (Lauras et al., 2010; Zheng et al., 2016) and some remarking methodological results have been achieved, such as earned value project management (Anbari, 2003; Lipke et al., 2009), performance measurement of engineering projects (Guo and Yiu, 2015), or benchmarking project performance management (Barber, 2004; Kim and Huynh, 2008). Even though these results have great contributions to the economic development and enterprise competitions, it seems that most studies are based on the outcome project performance measurement with a wide variety of lagging indicators, used to track how things are going and can confirm that something is occurring or about to occur (Zidane et al., 2015; Kakar and Thompson, 2010). Relatively few studies focus on prediction-based PPM with leading indicators (Juglaret et al., 2011; Mearns, 2009). These types of indicators signal future events; they are input oriented, hard to measure and easy to influence.

What has become clear over years of research is that a combination of leading and lagging indicators results in enhanced business performance overall: a lagging indicator without a leading indicator will give no indication as to how a result will be achieved and provide no early warnings about tracking towards a strategic goal, a leading indicator without a lagging indicator may make you feel good about keeping busy with a lot of activities but it will not provide confirmation that a business result has been achieved. A 'balance' of leading and lagging indicators is required to ensure the right activities are in place to ensure the right outcomes.

On the other hand, systems engineering measurement (SEM) is related to more recent practices and theories, which appeared with the emergence of the systems engineering discipline (Wilbur, 1995); however SEM offers very deep developments, published in several standards and guides (Wilbur, 1995; INCOSE Measurement Working Group, 2010; Roedler et al., 2010). In particular, it is also important to note that SEM does not only use lagging measurement but defines methods to promote leading measurement (Rhodes et al., 2009) recently; therefore, as a result, 18 leading indicators were recently proposed, validated, and finally engineered in a practical guidance (Roedler et al., 2010).

The purpose of this paper, therefore, is to broaden the path of PPM through applying the SE leading indicators based on a mapping and integrating approach. A case study demonstrates that it is possible to find appropriate positions in PPM for the SE leading indicators and SE leading indicators can also integrate well with existing performance measurement methods and processes in the context of the specific project.

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Next two sections review literature in PPM and SEM. Section 4 presents a mapping approach transferring SELIs into PPM. Section 5 presents results from the case study. Section 6 concludes on the achievement of our research objectives and gives perspectives about further research.

2. RESEARCH BACKGROUND OF PPM

PPM plays a key role in project management by helping project managers to effectively evaluate project progress and results. Generally, in the PPM there are two kinds of indicators, which are lagging indicators and leading indicators. The lagging indicators measure performance data already produced during or after a project; they are described as the outcomes that result from previous actions (Mearns, 2009); a classical example in the occupational health and safety (OHS) management is "the frequency rate of accidents and illness" (Juglaret et al., 2011). Prediction-based PPM uses the leading indicators and is regarded as a precursor to the direction something is going. A leading indicator is defined as something that provides the users information to achieve desired outcomes or avoid unwanted outcomes (Mearns 2009), and a related example in the OHS management is 'progress of completed audits' that helps to identify the work that remains to be done (Juglaret et al., 2011).

The choices of indicators for PPM differ from project to project. But evidently, the lagging indicators have got a wider focus compared with the leading ones. Some models or methods, typically like the earned value project management (EVPM) and its extensions, have been identified as efficient tools for cost and schedule prediction (Anbari, 2003; Lipke et al., 2009; Pajares and López-Paredes, 2011; Chen et al., 2016). However, both the traditional EVPM research and studies on extensions and applications of EVPM concentrate on cost and time rather than other important performance measures like customer satisfactions, team performance and so on, which couldn't be apt to the more complex projects in challenging environments. Some researchers have proposed a web-based project performance monitoring system which can provide project managers timely signalling of project problems (Cheung et al., 2004). Obviously, the prediction-based PPM with leading indicators have not been implemented to a substantial degree and its benefits like risk indication haven't received wide attentions (Kueng et al., 2001).

Indeed, a set of balanced indicators are needed for measuring different aspects of project performance, and especially the balance of leading indicators and lagging indicators is important to ensure the right activities are in place to ensure the right outcomes. The dominance of outcome-based PPM based on the lagging indicators should be modified by the efforts of the academic and the practice. Systems engineering, as one of its related disciplines, is experiencing a remarking development with a shift from outcome measurement to predictive one, which has provided many available guides and standards for measurement, particularly its advance in leading indicators.

3. RESEARCH BACKGROUND IN SEM

In our literature review, only directly SE-related measurement guidebooks are chosen (see Fig.1). Metrics Guidebook for Integrated Systems and Product Development, published in 1995, includes thousands of metrics as candidates. In this guidebook: 1) it presented only lagging indicators; 2) no detailed guide about how to aggregate the collected data with models or functions. INCOSE SE Measurement Primer version 2.0 (INCOSE Measurement Working Group, 2010) helps: 1) to define the basic concepts behind measurement and measurement programs; 2) to provide requisite background knowledge. However no information is about how to realize a construct of a SE leading indicator (Rhodes et al., 2009). Technical measurement, version 1.0 (Roedler and Jones, 2005) developed collaboratively by PSM, INCOSE and Industry, is a set of measurement activities used to provide the stakeholders insight into progress in the definition and development of the technical solutions. It presents the ongoing assessment, mainly for risks and issues associated with technical aspects. These three guidebooks have been applied in SE practical activities and got general recognition; however, all these are still for outcome measurement with lagging indicators, as to how to predict potential risks and issues has only been referred as a concept. For overcoming the limitations in the lagging indicators, the INCOSE organization collaborated with others, having published systems engineering leading indicators guidance, version 1.0 (Roedler and Rhodes, 2007) with defining thirteen indicators which have been extended to 18 indicators (Roedler et al., 2010). Such measurement practices have brought SE measurement stepping into a new milestone—shift from only outcome measurement to the combination of both outcome and predictive ones.

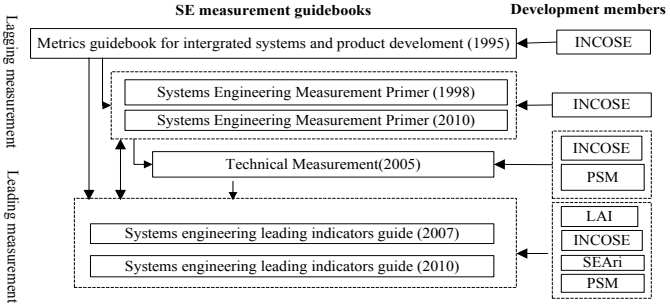

Fig. 1. The systems engineering measurement evolution

From the development and characteristics of SEM, some of its advantages could be summarized as following: 1) The history of systems engineering measurement has experienced the shift from lagging indicators to the "balance" of lagging and leading indicators; 2) The leading indicators align well with pre-existing measurement references, and the specification of leading indicators has been engineered.

The application of SE leading indicators has been conducted by NAVAIR (Naval Air Systems Command) on some aircraft development programs (Roedler et al., 2010. There are also some studies pointing that the benefits of applying the SE leading indicators for each technical review and audit defined in the United States Defence Acquisition Guidebook