Available online at www.sciencedirect.com

ScienceDirect

Procedia Computer Science 28 (2014) 71 – 80

Procedia Computer Science

Conference on Systems Engineering Research (CSER 2014)

Eds.: Azad M. Madni, University of Southern California; Barry Boehm, University of Southern California; Michael Sievers, Jet Propulsion Laboratory; Marilee Wheaton, The Aerospace Corporation
Redondo Beach, CA, March 21-22, 2014

Systems Approach to the Development and Application of Technical Metrics to Systems Engineering Projects

Dawn Gilbert[a]*, Mike Yearworth[a], Les Oliver[b]

[a]*Systems Centre, The University of Bristol, Merchant Venturers Building, Woodland Road, Bristol. BS8 1UB. UK*
[b]*Thales UK, 2 Dashwood Lang Road, Bourne Business Park, Addlestone, Surrey. KT15 2NX. UK*

Abstract

Thales UK employs around 3,000 engineers, over half of which are systems engineers, delivering solutions from transport systems and secure transactions to integrated communications, naval sensors, and air defense systems. The Systems Engineering (SE) function within Thales UK seeks to minimize the impact of, or eliminate problematic SE projects. Here, problematic projects are defined as ones where the SE group on a project was expected to deliver certain characteristics against cost/time constraints arising from the problem context, however the project did not, or will not meet expectations by a significant margin. A traditional view is that the impact to the Company of problematic projects can be minimized by early detection and subsequent intervention by SE leadership. As such, Thales UK seeks to implement an approach that will alert SE staff and leadership to the presence or development of problematic projects, such that appropriate interventions can be made.
Literature regarding SE technical metrics explores the development, and less frequently, the use of metrics to provide information to project teams to support judgments about current versus desirable positions. No literature has been identified that describes how SE technical metrics could be used en-masse to provide insight in to the performance of a diverse portfolio of SE projects. Thales UK has mandated the collection of a set of SE technical metrics on all SE projects, and understands that the reported data requires interpretation and relation to context. The context of each project is different and dynamic. This presents a challenge when attempting to use this data to draw conclusions regarding the health of all projects across an enterprise, and the health of the operation of an entire engineering function.
This paper describes a quasi-experiment with SE leaders and project technical metrics from a range of domains within Thales UK to test whether expert judgment can determine if a project is problematic or not from metric data alone. A separate research

* Corresponding author. Tel.: +44-789- 424-0500; fax: +44-117-331-5719.
E-mail address: cedpg@bristol.ac.uk

Selection and peer-review under responsibility of the University of Southern California.
doi:10.1016/j.procs.2014.03.010

activity is then presented which moves toward a theory of how a metrics approach could be structured for use across a diverse range of SE projects to detect characteristics of problematic projects

Selection and peer-review under responsibility of the University of Southern California.

Keywords: Metrics; systems engineering; leading indicators; methodology; qualitative analysis

1. Introduction

Stakeholders who would benefit from improving the reliability of Systems Engineering (SE) project delivery are numerous, and spread across the globe. Thales UK is one of these stakeholders, as an organisation that at any one time has many active SE projects across a range of domains in its project portfolio. Thales UK seeks a method by which the occurrence of problematic projects can be reduced, and the early awareness of problematic projects by SE leadership can be increased. This paper first presents a literature review of methods to measure and forecast the current and future position of SE projects. It then describes two discrete research activities. The first research activity is a quasi-experiment which investigates whether SE technical metrics, whose collection had been mandated for all SE projects in Thales UK, provided enough information to reliably alert SE leadership of whether a SE project was, or was becoming, problematic. This research activity used a positivist paradigm. The second research activity is a qualitative study towards a theory of what metrics could be used to alert SE leadership to problematic projects. The qualitative study asked the question 'how do people find out what they need to know?' and used an interpretivist paradigm.

This research was carried out by the author as part of the University of Bristol Engineering Doctorate (EngD) in Systems. The Systems EngD seeks to embed research in industry; it seeks to solve real-world industry-based problems while also performing doctoral level research as described by Godfrey [1]. The strength of an interpretivist paradigm is in its ability to help understand the problem, but it is weaker in guiding us towards robust validation of the success of actions taken to address the problem. A positivist paradigm is weaker in helping us develop a robust understanding of the problem, but if we were to develop and implement a solution, it would be able to tell us clearly whether or not the action had solved the problem as we understood it.

Faced with this dilemma, this EngD seeks to take the best from both worlds, via a critical realism approach. Within the critical realism paradigm, the day-to-day industrial interactions combined with formal learning requirements of an EngD drives an action-research approach, which iterates through the steps of Plan-Act-Observe-Reflect. The critical realism paradigm that provides the context for the action research loops that are executed within the EngD ensures philosophical consistency and rigor of the whole research endeavor, while allowing suitable adoption of varying philosophies for specific activities, tasks, or elements [2,3,]. An understanding of this philosophy is key when considering the coherence of methods used here, understanding if or when insights, approaches, or results from this research could be generalized, and the applicability of various bodies of literature to this research [4,5,6].

2. Early determination of SE project health

2.1. Literature Review

The key publication that suggests it is possible to monitor variables during SE project technical development, such that warning signs could be detected and then successfully acted upon, is the System Engineering Leading Indicators Guide [7]. The current guide, version 2.0 builds upon an earlier release from 2007, and like its predecessor, garners input from industry, academia, and government. The document presents and describes the use of 18 SE leading indicators which 'support the effective management of systems engineering by providing visibility into expected project performance and potential future states'[7]. Application of the leading indicators by NAVAIR [7], on an Alpha Systems avionics project [8],and on a number of high speed sled testing programs within one organization [9] represent the total body of literature covering application of systems engineering leading indicators described in [7]. NAVAIR initially developed their Advanced Leading Indicator (ALI) approach by making use of a substantial