



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

Predicting Systems Performance through Requirements Quality Attributes Model

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Abstract

Poor requirements definition can adversely impact system cost and performance for government acquisition programs. This can be mitigated by ensuring requirements statements are written in a clear and unambiguous manner that reflects high linguistic quality. This paper introduces a statistical model that uses requirements quality factors to predict system operational performance. This model is created using empirical data from current major acquisition programs within the federal government. Operational Requirements Documents and Operational Test Reports are the data sources, respectively, for the system requirements statements and the accompanying operational test results used for model development. A commercial-off-the-shelf requirements quality analysis tool is used to determine the linguistic quality metrics for the requirements statements. Following model construction, cross validation of the data is employed to confirm the predictive value of the model. In all, the results establish that requirements quality is indeed a predictive factor for end system operational performance; and the resulting statistical model can inform requirements decisions based on likelihood of successful operational performance.

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

Keywords: Requirements Engineering; Requirements Quality Attributes; Natural Language Requirements; Systems Engineering

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1. Introduction

1.1 Problem Statement

Requirements definition and quality have historically been problematic areas within the systems engineering process; and there is ample research indicating that errors, gaps, and ambiguities in requirements contribute to system deficiencies, incomplete system test plans, and unsatisfactory system performance. Recent technical journal literature^{1,2,3} is replete with discussion describing the need for better natural language requirements quality attributes. In addition, a litany of Government Accountability Office (GAO) reports have been written highlighting the preponderance of poor requirements development and management in government acquisition programs; and, moreover, this has been such a significant issue that the 2009 Weapon Systems Acquisition Reform Act explicitly requires the Department of Defense (DoD) to address and improve its performance requirements. Despite the widespread acknowledgement that poor requirements quality leads to “downstream” issues with defects and performance, the problem remains.

This problem, however, could be better managed if there were a means to predict the probability of successful end-system operational performance following requirements development. This would enable quick identification of deficient requirements needing remedy based on their adverse impact on performance. As such, the focus of this research is to address the hypothesis that end-system operational performance can be determined through use of predictive modeling based on requirements quality factors. While the contemporary literature presents head-to-head comparisons of competing tools or processing techniques for improved requirements analysis^{4,5}, and qualitatively discusses requirements quality impact on defects and the efficacy of various defect prediction methods^{6,7,8}, there is limited discussion on the impact of requirements quality on operational performance. The research presented in this paper is intended to bridge the gap in the prevailing body of knowledge by providing empirical evidence of the predictive relationship between requirements quality and end-system operational performance.

1.2 Approach

The approach presented in this paper describes on-going doctoral research for developing a statistical model of the relationship between requirements quality factors and system operational test results; hence, analysis and results are in progress. The research methodology involves gathering empirical data from current major acquisition programs within two United States government agencies, DoD and Department of Homeland Security (DHS), to support model development and validation. Operational Requirements Document (ORD) Key Performance Parameters (KPPs) and Operational Test Reports from DoD and DHS serve as the data sources, respectively, for the system requirements statements and the accompanying operational test results. A commercial-off-the-shelf requirements quality analysis tool is used to determine the linguistic quality metrics for the requirements statements. The quality metrics for the requirements statements and the associated operational test results are then used to construct the model. Following model construction, sensitivity analysis is performed, and cross validation of the data is employed to confirm the predictive value of the model. In all, the results are expected to establish that requirements quality is indeed a predictive factor for end system operational performance.

1.3 Contributions Summary

This research on the predictive relationship between requirements quality and system performance provides the following major contributions:

- Predictive Modeling Development Methodology – Section 2
- Statistical Significance of Requirements Quality Relationship to System Performance – Section 3
- Additional Areas of Research for Predictive Modeling – Section 4

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