

ISBSG Software Project Repository & ISO 9126: An Opportunity for Quality Benchmarking

Laila Cheikhi, Alain Abran, and Luigi Buglione

The International Software Benchmarking Standards Group (ISBSG) provides the Software Engineering community with a repository of project data which, up to now, have been used mostly for benchmarking and for estimating project effort. The 2005 version of the ISBSG repository includes data on more than 3,000 projects from various countries, sized with different functional size measurement methods and including a number of quality-related variables. ISO/IEC 9126 (International Organization for Standardization/International Electrotechnical Commission) is a series of ISO documents for the evaluation of the quality of software products: it proposes three quality models (internal quality, external quality and quality in use), together with the ISO taxonomy of quality characteristics and subcharacteristics. ISO 9126 also includes an inventory of over two hundred measures of the quality subcharacteristics. The goal of this paper is to identify whether or not the current ISBSG repository can be of use for benchmarking software product quality on the basis of ISO 9126.

Keywords: Benchmarking, ISBSG, ISO/IEC 9126, Project Data, Quality Models.

1 Introduction

Over the past few years, there has been a growing interest in benchmarking both organizational and project performances across the Information and Communications Technology (ICT) sector. Some of the issues to deal with when looking at the feasibility of a benchmarking exercise are: the availability and size of benchmarking repositories and, obviously, the quality of such data. In the '90s, the International Software Benchmarking Standards Group (ISBSG, <<http://www.isbsg.org>>) was set up to provide a worldwide repository of software projects, all measured with a functional size measurement method. The 2005 version of ISBSG repository [1] contains information on over 3,000 projects and provides data useful for multiple purposes, including comparison of project productivity and building effort estimation models. Such productivity and estimation models can be used to improve overall organizational capabilities in terms of project planning and monitoring [2].

In the pursuit of improved estimation and data analysis capability, repositories such as the ISBSG can help the Software Engineering community to better understand some of the cause-effect relationships by investigating a number of the variables available in the repository fields, as well as trying to figure out which ones contribute the most to the achievement of certain goals (i.e. increased productivity, shorter time-to-market, etc.).

Typically, the ISBSG, as well as other project data repositories, contains a number of descriptive variables, as well as quantitative data from which a number of ratios can be derived. While many of these variables focus on productivity-related issues from multiple viewpoints (project managers, designers, test managers, etc.), what are the data fields that can be of use for quality planning and control? To investigate the availability, as well as the coverage, of quality-related data in the ISBSG, the ISO 9126 series (Internation-

Authors

Laila Cheikhi is a Software Engineering PhD student at the *École de Technologie Supérieure – Université du Québec*, Montréal, Canada. She holds a master degree in Computer Science from University of Montréal. She has over eight years of software experience at the Ministry of Finances of Morocco. Her research interests include software quality engineering, software measurements, ISO Standards for software engineering, including software maintenance. <laila.cheikhi.1@ens.etsmtl.ca>

Alain Abran is a Professor and the Director of the Software Engineering Research Laboratory at the *École de Technologie Supérieure (ETS) – Université du Québec*, Montreal, Canada. He is the Co-executive editor of the Guide to the Software Engineering Body of Knowledge project. He is also actively involved in international Software Engineering standards and is Co-chair of the Common Software Measurement International Consortium (COSMIC). Dr. Abran has more than 20 years of industry experience in information systems development and Software Engineering. He is the co-executive editor of the IEEE project on the Guide to the Software Engineering Body of Knowledge – SWEBOK (ISO TR 19759). <aabran@ele.etsmtl.ca>

Luigi Buglione is an Associate Professor at the *École de Technologie Supérieure (ETS) – Université du Québec*, Montreal, Canada, and is currently working as a Software Quality Engineer in the Quality Dept. at Atos Origin (formerly SchlumbergerSema) in Rome, Italy. Previously, he worked as a Software Engineer at the European Software Institute (ESI) in Bilbao, Spain. Dr. Buglione is a regular speaker at international Conferences on Software Measurement and Quality and is the co-ordinator of the Software Measurement Committee (SMC) of the Italian Software Metrics Association (GUFPI-ISMA). He developed and was part of ESPRIT and of Basque Government projects on metric programs, EFQM models, the Balanced IT Scorecard and QFD for software and was a reviewer of the SWEBOK project. He received a PhD in Management Information Systems from LUISS Guido Carli University (Rome, Italy) and a degree in Economics from the *Università degli Studi di Roma "La Sapienza"*. <luigi.buglione@computer.org>

tional Organization for Standardization) [3] on software product quality measurement has been selected as the baseline reference for this analysis.

Section 2 provides an overview of the quality models of ISO 9126-1, and Section 3 describes the ISBSG organization and gives an internal view of its repository of project data through an analysis of its data collection questionnaire. Section 4 presents a comparative analysis of the ISBSG questionnaire and ISO 9126. Finally, opportunities for using ISO 9126 and the ISBSG repository for benchmarking software product quality are identified in Section 5.

2 ISO 9126 – An Overview

The ISO 9126 series of documents consists of four parts under the general title "Information Technology – Software Product Quality". The first part (ISO 9126-1) specifies the ISO software product quality model. The other three parts provide an inventory of candidate "metrics" that can be used to evaluate the characteristics and subcharacteristics of the quality model. The software product is defined in ISO 9126 as "the set of computer programs, procedures, and possibly associated documentation and data. Products include intermediate products, and products intended for users such as developers and maintainers" [3].

The ISO 9126-1 quality model is defined as "a framework which explains the relationship between different approaches to quality" [3], and distinguishes three views of software quality: internal quality, external quality and quality in use (Figure 1):

- **Internal quality** corresponds to the "totality of the characteristics of the software product from an internal viewpoint", which can be achieved by measuring the internal properties of the software product without executing it.
- **External quality** corresponds to the "totality of characteristics of the software product from an external viewpoint", which means that the quality of the software product can be evaluated during its execution by measuring its external properties.
- **Quality in use** represents the "user's view of the quality of the software product when it is used in a specific

environment and a specific context of use". It corresponds to the use of the software during the operation and maintenance phases, and is not related to its intrinsic properties.

The set of ISO 9126 quality views in Figure 1 is based on the belief that internal quality has an impact on external quality, which in turn has an impact on quality in use. Therefore, the achievement of quality in use depends to some extent on the achievement of external quality, which in turn depends on the achievement of the internal quality of the software product itself.

The internal and external quality models share the same hierarchical structure, with two levels. The first level has six characteristics, which are broken down into 27 subcharacteristics (Figure 2) in the second level. A set of internal and external measures approved by the ISO to specify and quantitatively assess these quality characteristics is provided in ISO 9126 Technical Reports, Part 2 [4] and Part 3 [5]. The quality in use model has only one level, and includes four characteristics (Figure 3) with a set of measures provided in ISO 9126 Technical Report, Part 4 [6]. These technical reports are not intended to give an exhaustive set of measures for all the characteristics; they provide only those measures for which there is a consensus within the ISO.

In Software Engineering, it is expected that a proper and exhaustive identification of project specifications and goals early in the development phases decreases the risk of rework and delay and of being over budget. Similarly, it is expected that evaluating the internal and external quality of the software product before delivery provides an opportunity to correct errors, to implement required changes and to decrease the risk of expensive rework and unforeseeable costs.

3 Overview of The ISBSG

3.1 ISBSG Organization

The ISBSG is a not-for-profit organization created in 1994 "to develop the profession of software measurement by establishing a common vocabulary and understanding of terms" [7]. It groups together national associations on

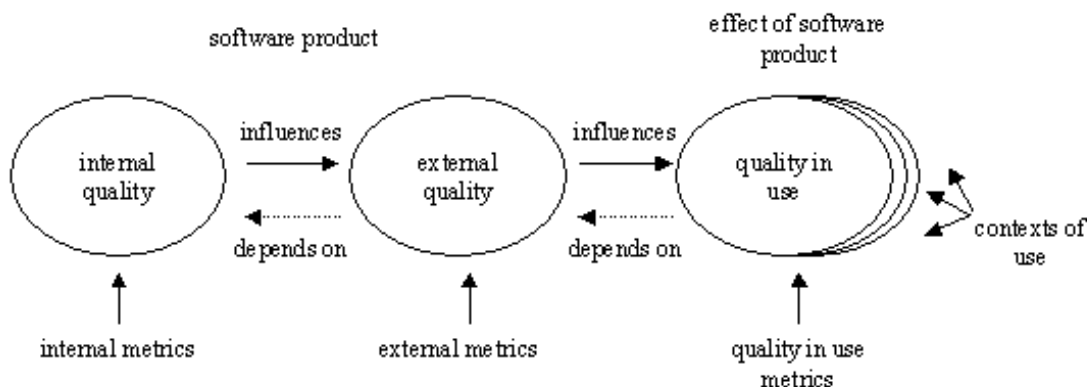


Figure 1: Quality along the Software Life Cycle (ISO/IEC 9126-1) [3].

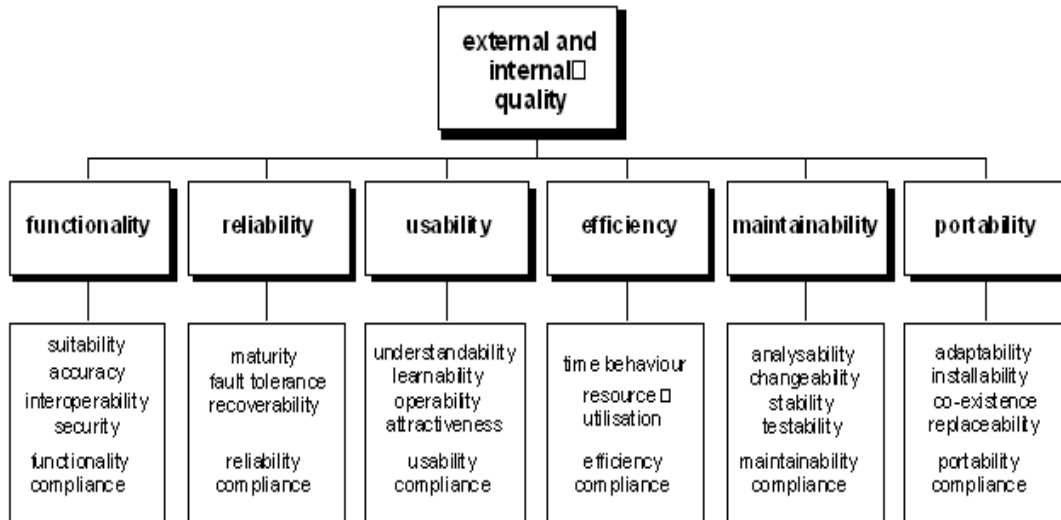


Figure 2: Quality Model for External and Internal Quality (ISO/IEC 9126-1) [3].

software measurement, currently representing 13 different countries. The ISBSG software project repository provides "software development practitioners with industry output standards against which they may compare their aggregated or individual projects, and real data of international software development that can be analyzed to help improve the management of IT resources by both business and government" [8].

To achieve these goals, the ISBSG makes available to the public a questionnaire to collect data about projects, including software functional size measured with any of the measurement standards recognized by the ISO (COSMIC-FFP functional size – ISO 19761, etc.). Thereafter, the ISBSG assembles this data in a repository and provides a sample of the data fields to practitioners and researchers in an Excel file, referred to hereafter as the ISBSG MS-Excel data extract (Figure 4).

3.2 ISBSG Internal View

The internal view of the ISBSG data repository corresponds closely to their data collection questionnaire, with some additional fields added by their repository manager. The data collection questionnaire includes a large amount of information about project staffing, effort by phase, development methods and techniques, etc. Moreover, the ISBSG provides a glossary of terms and measures [7] to facilitate understanding of the questionnaire, to assist users

at the time they collect data and to standardize the data-gathering process.

The ISBSG data collection questionnaire includes 7 sections subdivided into several subsections (Figure 5):

A. **Submitter Information:** in this section, information is collected about the organization and the people filling out the questionnaire. Such information is kept confidential by the ISBSG.

B. **Project Process:** in this section, information is collected about the project process. The ISBSG provides well-defined terms to describe this section, offers a simple structure to gather data and allows precise comparisons to be made among projects. The information collected here is structured along the various phases of a software life cycle (SLC): planning, specification, design, programming, test and implementation.

C. **Technology:** in this section, information is collected about the tools used for developing and carrying out the project. For each stage of the software project, the ISBSG questionnaire proposes a list of tools.

D. **People and Work Effort:** three groups of people are considered in this section: development team, customers and end-users, and IT operations. Collected here is information about the various people working on the project, their roles and their expertise, and the effort expend for each SLC phase.

E. **Product:** in this section, information is collected

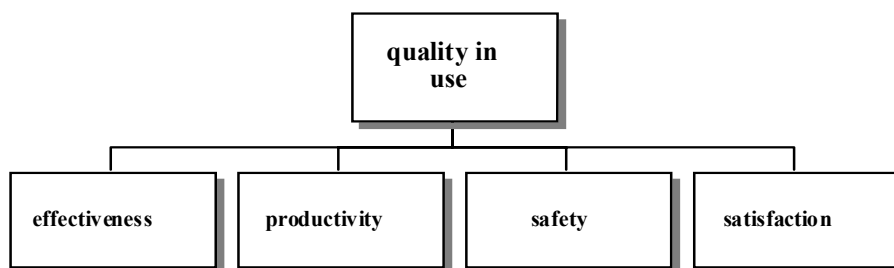


Figure 3: Quality model for Quality In Use (ISO/IEC 9126-1) [3].

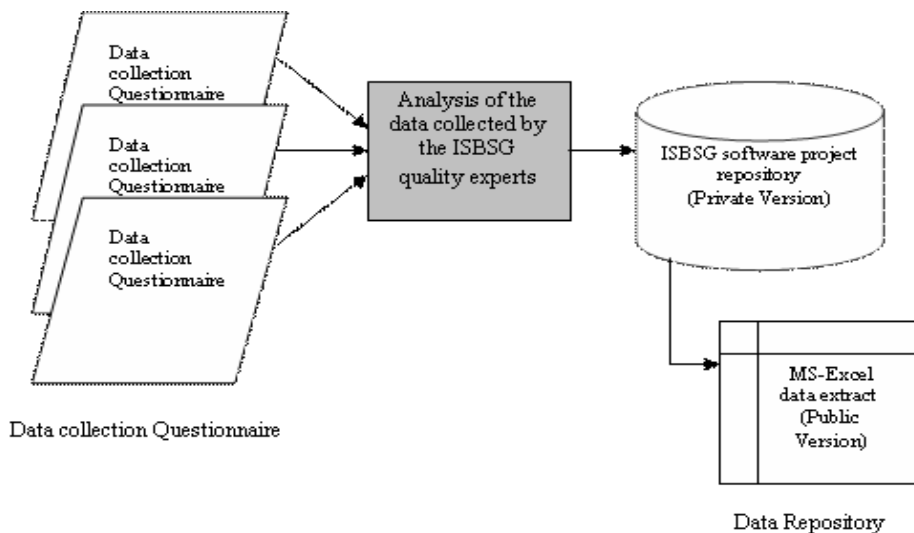


Figure 4: ISBSG Organization.

about the software product itself (e.g. product description, application type and deployment platform, such as client/server, etc.).

F. COSMIC Project Functional Size: in this section, information is collected about the functional size of the project and a few other variables related to the context of the functional size measurement. The ISBSG COSMIC questionnaire includes, for example, tables for collecting quantitative information about data movements (ENTRIES, EXITS, WRITES and READS) for each type of project:

new development or redevelopment software, or enhancement software. Again, some information is collected about the expertise of the software functional size measurer.

G. Project Completion: this last section of the questionnaire provides an overall picture of the project, including project duration, defects, number of lines of code, user satisfaction and project costs, including cost validation.

This data collection questionnaire consists of 134 questions within the seven data groups; some of these questions may contain a number of sub-questions. Therefore, the

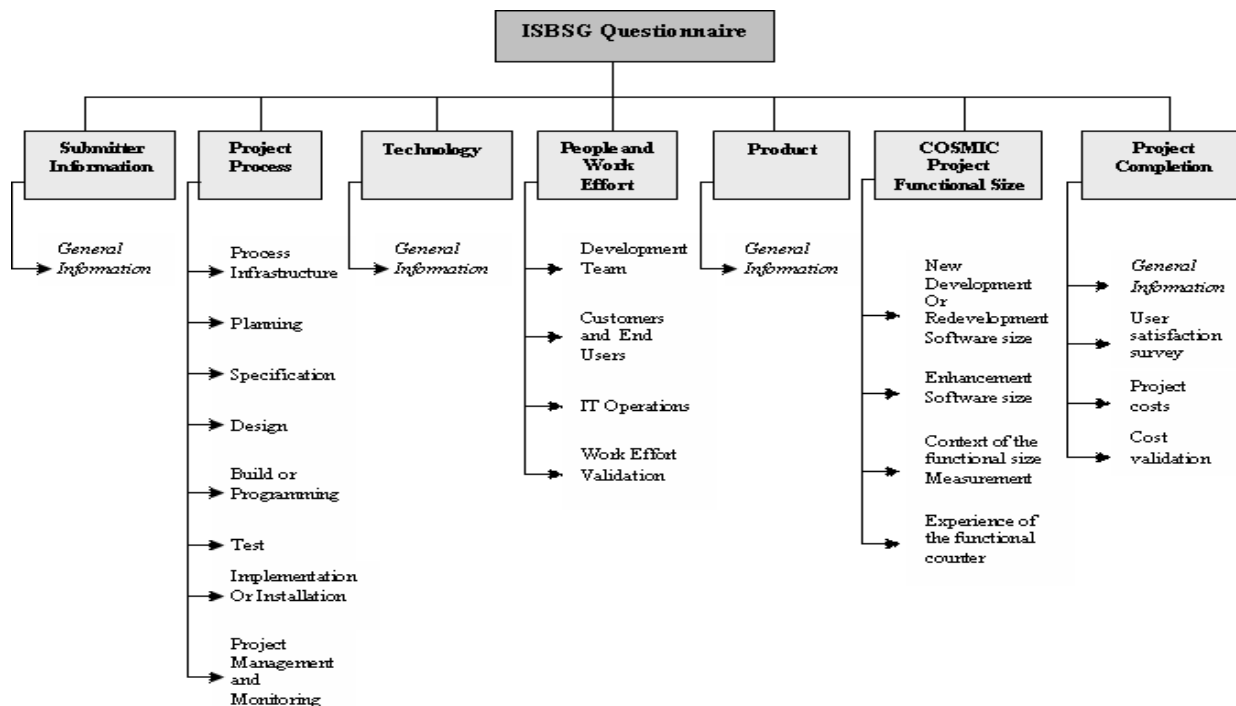


Figure 5: Structure of The ISBSG Data Collection Questionnaire.

ISBSG	ISO 9126		
	Internal Quality	External Quality	Quality In Use
ISBSG Data Collection Questionnaire	<ul style="list-style-type: none"> • Specification • Design • Build or Programming (Review/Inspection) 	<ul style="list-style-type: none"> • Build or Programming (Unit Testing) • Test • Implementation or Installation 	<ul style="list-style-type: none"> • Project completion <ul style="list-style-type: none"> ○ General information ○ User satisfaction survey ○ Project costs

Table 1: Comparison of The ISBSG Questionnaire Phases with The ISO 9126 Quality Models.

number of data fields collected by the questionnaire is actually larger; while a few of these data fields are mandatory, most are optional.

4 Comparison of ISBSG and ISO 9126

The ISO 9126 quality model refers to three types of quality shown in Figure 1 (internal quality, external quality and quality in use) covering the various phases of the SLC. The ISBSG questionnaire for project data collection is available on their Web site, and has been used as the key input to analyze whether or not the ISBSG repository contains the appropriate information for using ISO models of software quality.

The comparison of the ISBSG questionnaire phases with the ISO 9126 quality models is presented in Table 1; it can be observed, in particular, that there is full coverage at the high level of comparison.

At a more detailed level, the ISBSG questionnaire collects information for most of the SLC phases, and the ISBSG questions can be mapped to the three ISO 9126 views of software quality (internal, external and quality in use). More specifically (Table 2):

- the Project Process section can be mapped to two of the three views: internal and external;
- the Project Completion section can be mapped to the quality in use view;
- the remainder of the sections, Technology, People and Work Effort, Product and COSMIC Project Functional Size, cannot be mapped directly to any of the three ISO 9126 quality models (Table 2). However, information from these other sections can be of use to normalize the information about quality (for instance, using functional size) or to analyze causal relationships with various variables.

The ISBSG data collection questionnaire collects information related to the *project* entity with its various characteristics, whereas standard ISO 9126-1 focuses on *part* of this entity, that is, the quality of the software product. Since standard ISO/IEC 9126 is taken as a tool for the analysis, the study conducted in this paper is restricted to the quality of the software product within the software projects in the ISBSG repository. A set of quality related data fields are presented in Table 3.

- 1 Build or Programming (Review/Inspection)
- 2 Build or Programming (Unit Testing)

5 Conclusion

In recent years, there has been a growing demand in ICT companies for the performance of quantitative analysis on software projects, including benchmarks (from an external viewpoint) and performance and productivity assessments (from an internal viewpoint). While the principles of total quality management (TQM) and software process improvements (SPI) are becoming better known and accepted in industry, there has up to now been a lack of structured, historical databases on internal projects in most organizations. To address this specific issue of the availability of data for benchmarking purposes, the ISBSG has designed, developed and deployed its Project Data Repository, which now contains information on more than 3,000 projects. This repository is becoming the reference database for such analyses and studies, in particular for those interested in projects sized using a Functional Size Measurement (FSM) method.

In this paper, we have investigated the availability, as well as the coverage, of quality-related data in the ISBSG repository using the ISO 9126 series on software product quality measurement as the baseline reference for this analysis. The ISBSG repository has been compared with the three ISO models of software quality (internal quality, external quality and quality in use) using the ISBSG data collection questionnaire. This comparison indicates that, based on the definition of its data fields, the ISBSG repository contains many of the fields required to collect information on the three views of the ISO models of software quality. The results of this analysis documented here can be very useful:

- to industry, in analyzing the availability of quality-related information in the ISBSG repository;
- to industry and researchers looking for information to analyze and implement ISO models of software quality;
- to the ISBSG organization, in studying how to improve the alignment of their software quality-related data collection standards to the ISO software quality models;
- to the ISBSG organization, in promoting their re-

ISBSG Questionnaire Sections		Quality Views	Internal Quality	External Quality	Quality in Use
Subsections					
Submitter Information	<i>General information</i>				
Project Process	Process infrastructure				
	Planning				
	Specification	X			
	Design	X			
	Build or Programming	X	X		
	Test		X		
	Implementation/ installation		X		
	Project management and monitoring				
Technology	<i>General information</i>				
People and Work Effort	Development Team				
	Customers and End Users				
	IT Operations				
	Work Effort validation				
Product	<i>General Information</i>				
COSMIC Project Functional Size	New development or redevelopment software size				
	Enhancement software size				
	Context of the functional size measurement				
	Experience of the functional counter				
Project Completion	<i>General information</i>				X
	User satisfaction survey				X
	Project costs				
	Cost Validation				

Table 2: ISO 9126 Quality Views in The ISBSG Data Collection Questionnaire.

pository as (partially or fully) aligned with ISO quality standards.

This study has been limited to the comparison with ISO 9126-1. Further work is being carried out to analyze the alignment of the ISBSG quality-related data fields to the inventory of over 200 measures proposed in Technical Reports 2 to 4 of the ISO 9126 series on software quality evaluation. The next steps taken will involve a detailed comparison of the ISBSG repository and the ISO 9126-1 models of software quality, through a high-level mapping of the ISBSG questionnaire to the three ISO quality views (internal, external and quality in use), followed by a detail-level mapping for each view.

References

- [1] ISBSG, ISBSG R9 Database, International Software Benchmarking Standards Group, 2005.
- [2] D. Déry, A. Abran. Investigation of the effort data consistency in the ISBSG repository, Proceedings of the 15th International Workshop on Software Measurement (IWSM 2005), 12-14 September 2005, Montréal (Canada), Shaker Verlag, ISBN 3-8322-4405-0,, pp. 123-13.
- [3] ISO/IEC, IS 9126-1, Software Engineering - Product Quality - Part 1: Quality model, International Organization for Standardization, Geneva, 2001.
- [4] ISO/IEC, TR 9126-2, Software Engineering - Product Quality - Part 2: External Metrics, International Or-

Categories	Phases	Quality-Related Data Fields Collected
Project Process	Specification	-Number of defects recorded in the documents and other work products of this phase -Resolution/rework effort
	Design	-Number of defects recorded during design -Resolution/Rework effort
		Number of change requests made during design
	Build or Programming	-Number of defects (minor, major, extreme or total) recorded and resolved during this activity. - Resolution/Rework effort
		Number of change requests made during build
	Test	-Number of defects (minor, major, extreme, or total) recorded during this activity -Resolution/rework effort
		Number of change requests made during testing
	Implementation or Installation	-Number of defects (minor, major and extreme or total) recorded during this activity -Resolution/rework effort
		Number of change requests made during implementation
	Project Completion	<i>General Information</i>
-The lines of code generated by this project. - The percentage of these lines of code that are not program statements		
User Satisfaction Survey		-Did the project meet the stated objectives? -Did the software meet business requirements? -Quality expectations for the software? -Quality expectations for the user documentation? -Ease-of-use requirements for the software? -Was sufficient training or explanation given? -Schedule for planning & specification? -Schedule for design, build, test & implement?

Table 3: ISBSG Quality-related Data Fields.

ganization for Standardization, Geneva, 2003.

- [5] ISO/IEC, TR 9126-3, Software Engineering - Product Quality - Part 3: Internal Metrics, International Organization for Standardization, Geneva, 2003.
- [6] ISO/IEC, TR 9126-4, Software Engineering - Product Quality - Part 4: Quality in Use Metrics, International Organization for Standardization, Geneva, 2004.
- [7] ISBSG, Glossary of Terms, version 5.9, International Software Benchmarking Standards Group, 01/03/2005.
- [8] ISBSG, Data Collection Questionnaire New development, Redevelopment or Enhancement Sized Using COSMIC-FFP Function Points, version 5.9, International Software Benchmarking Standards Group, 24/05/2005.