Strategic QA

Steps to Effective Software Quality Assurance

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Overview

The paradox of quality assurance is that, although “quality” is a key value for every organization, the actions taken to ensure it are often left until late in the lifecycle when budgets are scarce, time is short and there is high pressure to deliver to the market. Software quality is particularly challenging as teams generally have little idea at the start of the project how much testing and debugging will be needed to produce a release that is “acceptable.”

The challenge of quality assurance may be overcome by applying a bit of process and discipline, as organizations can collect data on previous projects and learn from experience what fault levels to expect. By capturing information such as fault origin, diagnosis and cost, software QA managers can pinpoint weak process areas and focus improvement budgets with measurable benefits. Quality assurance becomes part of a real corporate plan with objective focus and accountable results – which we call Strategic QA.

Two best practices help implement Strategic QA. First, enterprise-wide fault data collection is facilitated by rolling out an Enterprise Change Management solution, which enables all teams to easily submit the right data through a Web interface, assists in analysis and generates the metrics and reports. Organizations should also standardize on common process and lifecycle rules so that data is consistent and the improvement initiatives are effective.

This paper details the challenges and solutions available for organizations wishing to improve their software development process, reduce costs, improve quality and increase reliability of planning. It also presents examples of companies that have successfully implemented Strategic QA and, as a result, have become more competitive.

The Quality Assurance Paradox

Customers expect software quality to be very high, and yet we frequently hear in the news about bugs or design errors that cost time, money or worse – lives. As software development becomes more complex, innovative, and created by distributed teams, delivering quality is increasingly difficult.

Quality assurance (QA) generally focuses on testing the software in the final stages of a project, when budgets are scarce and the pressure to deliver the product is high. To ensure quality, project managers must balance quality assurance with time-to-market.

How Much Testing is Enough?

Software engineers have a motto: “There is always one more bug.” The amount of testing needed to ensure quality is hard to quantify. Very few project teams are able – or are willing – to predict how many bugs there will be in a release. Testing and fixing until all bugs have been found would be a very expensive task, if it were possible. And is it reasonable? Most organizations prefer to deliver a product on time, with a few unimportant defects, rather than to deliver it six months late. Needless to say, each industry has a different level of acceptable quality, for instance, word processors versus aircraft systems.
What Part of Your Process Needs to be Improved?

Many organizations often limit QA to testing the final software. Functional testing may be outsourced to low-cost countries, which makes ensuring quality “somebody else's problem.” In fact, this activity is quality control – checking after the fact that quality levels are met. On its own, quality control doesn’t help teams build better software, a fact that can be very frustrating for the QA manager, as he is confined to the role of inspector of other people's work.

In order to provide correct budget and schedule estimates, QA managers need the means to predict fault levels.

Analyst reports indicate that the cost of fixing a defect increases dramatically the later it is found in the lifecycle – the cost of correcting a fault detected during final system testing can be up to 200 times more than if it is found during in the requirements phase. Very few organizations can confidently pinpoint the weakest links of their process, those where their budget would have the most impact. Without objective process performance indicators, QA managers cannot focus quality improvement initiatives where they are necessary or where they will have the best return on investment, let alone prove their efficiency.

Predicting Defects and Errors in the Software Development Lifecycle

Metrics for Strategic QA

Strategic QA helps organizations track faults across the software development lifecycle, providing QA managers with the insight necessary to predict fault levels, testing budgets and, more importantly, allows them to focus process improvement budgets in an efficient way with provable benefits. Strategic QA not only helps organizations become more competitive, it also reaffirms the value of the QA manager in the project team and the organization.

Defects and errors can be introduced and found during the different phases of the Software Development Lifecycle (SDLC). The practices described in this paper are easily applied to all types of processes (waterfall, iterative…) with different phase names. In this document, we will consider the following phases:
• Requirements analysis
• Design
• Implementation / Coding
• Unit Testing
• Integration testing
• System testing
• Customer usage (maintenance)

The industry uses multiple terms and different standards to name software problems. In this article, we will use the following as articulated by Daskalantonakis within Motorola:

• “Errors” are problems detected in the phase they were created in
• “Defects” are problems detected after the phase they were created in
• “Fault” is the generic term for a defect or an error

For instance, if during the design phase of a project, ten faults were introduced, seven of which were caught but three were in the design specification given to the developers to code from, then this phase had 7 Defects and 3 Errors.

Two metrics are of particular interest to track and understand quality in the SDLC:

• **Phase Containment Effectiveness (PCE)** is the ratio of faults captured in a phase (represents how effective the process is at preventing problems from becoming defects)
• **Phase Screening Effectiveness (PSE)** is the ratio of prior escaped defects captured in each phase

In our previous example, the PCE is 7/10. If later on in the process, out of the 20 faults present in a release delivered by the coding team and after unit testing, 14 were caught by Integration Testing and six were still present in the version delivered for System Testing, the PSE for the Integration Testing phase would be 14/20 or 70%.
Figure 3. Phase Containment Effectiveness metric

\[ PCE = \frac{7}{7+3} = 70\% \]

Figure 4. Phase Screening Effectiveness metric

\[ PSE = \frac{2}{5} = 40\% \]
Predicting Faults Throughout the SDLC

By capturing fault data on projects, organizations can estimate Fault Density (FD) - the number of faults present in a work product per size, where size is defined accordingly for each phase. Requirements and Design Fault Density may be expressed by Faults per Page, while Coding Fault Density may be measured by Faults per Line of Code (LOC) or by Faults per Function Point.

Phase effectiveness metrics quantify the organization's capability to find and fix defects closer to their origin, before the cost of rework becomes too important. By implementing strategies to improve these metrics, organizations reduce the number of released defects and avoid project delays, improving customer satisfaction and cost of maintenance.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Fault Density</th>
<th>PCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements</td>
<td>0.4</td>
<td>70.0%</td>
</tr>
<tr>
<td>Design</td>
<td>0.3</td>
<td>80.0%</td>
</tr>
<tr>
<td>Code</td>
<td>0.015</td>
<td>90.0%</td>
</tr>
</tbody>
</table>

*Table 1. Example values for Quality Prediction Metrics*

Historical project data should be collected to calculate these metrics for organizations. With FD, PCE and PSE values, the QA manager can statistically predict faults, errors and defects for each phase, based on the estimated size of the current release.

With the metrics above, a QA manager can produce reliable fault estimates for a project. The table below shows example estimates if the scope of the project is planned as 250 pages of requirements, 900 pages of design documents, and 40,000 lines of code. The PSE metrics also help predict where these coding defects will be found.
Historical fault data provides quality assurance teams with the information necessary to accurately predict fault levels across the SDLC. With objective fault graphs, QA managers can analyze the performance of their quality process within the company as well as benchmark this performance against other companies.

By implementing Strategic QA, organizations can produce reliable schedules and testing plans as well as allocate testing resources in the most efficient way, for the highest impact.
Process Improvement and the CMMI

Leading organizations have successfully attained return on investment (ROI) for process improvement initiatives by adopting the Software Engineering Institute’s Capability Maturity Model® Integration (CMMI®). Of the 878 organizations assessed by the SEI in 2005, two-thirds reported a clear increase in productivity, and half of them reported an increase in quality. When asked to measure ROI, the mean value reported was nearly 5-to-1, with some organizations reporting an ROI of up to 27-to-1.

One of the fundamental principles of the CMMI is the implementation of a standard set of processes across the organization, which are continually improved based on objective measured feedback. In particular, the CMMI recommends the key practice of Causal Analysis and Resolution. When implementing this practice, organizations identify causes of defects and errors and take action to prevent them from occurring in the future. Causal Analysis and Resolution improves quality and productivity by proactively preventing the introduction of defects into a product.

Strategic QA at Renesas

Renesas Design France, a subsidiary of Renesas Technology Corporation, a joint venture between Hitachi and Mitsubishi Semiconductors, is one of the world’s leading semiconductor system solutions providers. Renesas Design France deployed Telelogic Change™, an Enterprise Change Management solution, to manage all change requests and bug reports, as a key step of the process improvement initiative.

For each bug report, Renesas Design France captures the development phase in which the error was found and, upon resolution, also indicates the phase in which the error could have been avoided. This causal analysis enables the company to identify the process areas where improvement will deliver the highest return on investment. Metric history allows development staff to predict the number of bugs a program will have based on the number of requirements, before design even takes place.

“Strategic QA is an example implementation of Causal Analysis and Resolution and should be considered by all organizations aiming for CMMI level 3 certification (and above).”

“This level of insight would be impossible to implement in most other tools,” Stéphane Thomas, Quality Manager, Renesas Design France, said. “With Six Sigma metrics on Defect Containment Effectiveness and Defect Screening Effectiveness, Renesas Design France is able to continually improve its organizational development process.”
Enterprise Change Management solutions produce the forms, processes, metrics, reports and graphs necessary to capture, summarize and analyze the data for Strategic QA. They enable organizations to view which links of their process are the weakest and where to focus process improvement budgets.

Moving to Strategic Quality Assurance

Capturing Error and Defect Data Across the Organization

The data necessary for the QA metrics mentioned previously must be captured when faults are identified. This process is facilitated by the roll-out of an Enterprise Change Management (ECM) solution for consistent fault tracking. Web-based ECM solutions provide customizable forms to collect the relevant data for each fault. By providing a user-friendly interface with drop-down list boxes, organizations can ensure that quality feedback is easy for users to provide.

Information to be collected for each error or defect should include:

- Fault description
- Category
- The phase in which the fault was found (Requirements, Design, Code, Unit Testing, Integration Testing, System Testing, Customer, not classified)
- How the fault was found (peer review, visual inspection, design model simulation…)

Extra information can either be provided by the submitter or later in the process, when the fault is verified and analyzed.

- The phase in which the fault was introduced (Requirements, Design, Code, not classified, Prior release, 3rd party)
- The phase in which the fault should have been detected
- The cost of the fault

Deploying Enterprise Change Management Across the Enterprise

To successfully improve the way they produce software, organizations need to capture error and defect data in a consistent, centralized fashion. Enterprise Change Management, the cornerstone for sustainable compliance as well as causal analysis and resolution, enables organizations to implement a repeatable, documented and reliable process for capturing both fault data and change requests of all types, on software and hardware, from customers and the internal teams, urgent and minor. By offering a Web interface, ECM solutions ensure ease of adoption across the enterprise.
Naturally, an organization wishing to deploy and enforce an Enterprise Change Management solution must verify that it is scalable to its needs and flexible enough to implement a process that reflects the corporate culture and solves the identified challenges. The solution must also be capable of providing a common, consistent process across the organization. Products that provide out-of-the-box, industry-proven processes are a natural choice for low-risk deployment.

**Enterprise Change Management at Philips**

Philips, one of the world’s largest electronics companies and a global leader in designing and manufacturing high-quality technology products for consumers and businesses, identified the lack of change management as one of its main inhibitors to fast product delivery. Its software development process was often delayed because of numerous rounds of code changes, bug fixes and enhancements prior to final product release.

Philips deployed Telelogic Change, an Enterprise Change Management solution, across the organization, bringing together software, electronics and hardware teams across the globe, from the Netherlands, US and UK to India, Singapore and Taiwan. Philips now have a consistent generic process model for change requests, problem reports and implementation requests, designed for scalability to thousands of users, that has significantly decreased change throughput times and reduced the effort managing changes. This process is packaged and provided by Telelogic as the Enterprise Change Process and has received multiple certifications, including CMM level 3 and KEMA.

**Telelogic Solutions for Strategic QA**

Telelogic Change is a Web-based, workflow and change management solution for Enterprise Change Management that simplifies the change management process, enabling organizations to consistently track defects and errors. With Telelogic Change, organizations respond systematically to all types of change. This improves communication and collaboration throughout the development lifecycle and across the enterprise, allowing organizations to react to continuous change and improve their productivity and time-to-market.

- Enterprise Change Management enables organizations to respond quickly to change from both internal and external sources.
- Out-of-the-box forms, workflows, reports and metrics support best practices such as Strategic QA, Requirements Driven Development, and process improvement initiatives such as CMMI and Agile.
- The Enterprise Change Process, Telelogic’s ready-to-use process package co-developed with Philips, used by over 900 users across over 30 sites world-wide, unifies software, electronics and hardware teams within a common workflow. This process has been certified for CMM level 3 usage.
- Migration facilities from existing bug tracking tools, both home-made and commercial, to Telelogic Change.
- Lifecycle change management allows you to coordinate all your development and management lifecycle tools, including Telelogic DOORS®, Telelogic Synergy™, HP Mercury Quality Center and IBM® Rational ClearCase, for traceability throughout the entire development lifecycle.
References


About Telelogic

Telelogic® is a leading global provider of solutions for automating and supporting best practices across the enterprise—from the powerful modeling of business processes and enterprise architectures to the requirements-driven development of advanced systems and software. Telelogic’s solutions enable organizations to align products, systems, and software development lifecycles with business objectives and customer needs to dramatically improve quality and predictability, while significantly reducing time-to-market and overall costs.

To better enable our customers’ drive towards an automated lifecycle process, Telelogic supports an open architecture and the use of standardized languages. As an industry leader and technology visionary, Telelogic is actively involved in shaping the future of enterprise architecture, application lifecycle management, and customer needs management by participating in industry organizations such as INCOSE, OMG, The Open Group, Eclipse, ETSI, ITU-T, the TeleManagement Forum and AUTOSAR.

Headquartered in Malmö, Sweden, with U.S. headquarters in Irvine, California, Telelogic has operations in 20 countries worldwide. Customers include Airbus, Alcatel, BAE SYSTEMS, BMW, Boeing, DaimlerChrysler, Deutsche Bank, Ericsson, General Electric, General Motors, Lockheed Martin, Motorola, NEC, Philips, Samsung, Siemens, Sprint, Thales and Vodafone.

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