ANALYZING IMPENDING FACTORS AND THEIR IMPACT ON SOFTWARE TESTING ORGANIZATION

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ABSTRACT

This paper is a practitioner’s view of impact of different parameters like Centralization, Offshoring, Productivity Improvement, Quality and other process improvement on Return on Investment calculation for a CTO (Centralized testing Organization). This analysis can help IT QA (Quality Assurance) management to quantify Return on Investment from different parameters of operation and decide on where to invest for optimum benefit.

Return on Investment is one the critical factors that any large / small organization chooses before investing. At all the stages of the project life cycle, Return on Investment calculation is a must - that is at business requirements to design, development, testing and implementation phase.

In today’s world, independent testing has become very important. The organization needs to do a proper due diligence on selecting testing model, process, time to market, cost etc. For these the organization needs to understand the criteria for selecting the right model for testing which gives the maximum return on investment. This study analyses different parameters and their impact on Return on Investment.

This paper does not elaborate on how to establish a CTO. Rather this is an attempt to quantify results after due consideration of various focus areas like - lower cost of operation by offshoring and centralization and savings through Productivity Improvement thru Automated Test Case Execution, savings through Process and tools standardization etc. to implement different parameters within a CTO.

The findings are based on authors’ experience of implementing CTOs for reputed clients and implementing that across big size portfolios. The constraints for pure development projects, product testing projects or open system projects may vary in nature. For example scope and
benefit from automation may be very high for product testing projects or open system projects but not so for legacy mainframe based maintenance projects.

**Keywords:** Centralized Testing Organization, Return on Investment, Productivity Improvement, Offshoring- Sourcing human capital form cost effective locations, Centralization – Consolidating testing activities and resource responsibilities, Standardization- Using common tool/process across the organization.

**Paper Type:** Research Paper

**INTRODUCTION**

General trend in the IT industry is moving towards setting up of dedicated Testing Center for the organization, focusing on maximizing ROI (Return on Investment). Maturity of testing centres that spans from out sourcing for Staff augmentation, Project level testing support to Enterprise or LOB Testing Center of Excellence. Only 5% of the organizations have setup “Centralized Testing Organization”, that provides support at enterprise or LOB (Lines of business) level. Very few organization have achieved full potential of CTO in terms of centralized spending on infrastructure and resources while maintaining consistent objective testing scope of testing.

There are a couple of Critical Success Factors for establishing a CTO. Clarity of objectives viz. short, medium and long term goals should be clearly set up upfront. Also Senior Leadership level commitment and alignment is absolutely essential to percolate the philosophy down. For setting up CTO another important factor is the Amount and Type of Investment which is required. Most important of it all is People – for which hiring/sourcing right set of people to build and deploy the enterprise level QA strategy is required.

For Processes- Sponsorship is required to build a common framework and the consulting effort to deploy it across the enterprise. Infrastructural Investment for labs, test environment, test management and other testing tools is essential. Also necessary is the proper Governance for a Test Management Organization to run and critical funding to be decided. All these post facto things become important after establishing the CTO. However it is of primary importance for the organization in knowing the parameters upfront on the basis of that they can take an informed decision whether to go for it or not and if yes, what kind of return they expect on that. Authors have tried to delve into these practical scenarios after undergoing literature available on the topic.

**LITERATURE REVIEW**

Software Testing Institute, SEI at Carnegie Mellon (www.sei.cmu.edu) is an authority in the field of developing models to judge the capability maturity of a software organization. CMMI® stands for Capability Maturity Model ® Integration and it is a process improvement maturity model that has been developed by the Software Engineering Institute, SEI, at Carnegie Mellon. It is important to note that CMMi defines what processes and activities need to be done and not how these processes and activities are done. In their article related to CMMi and Software Testing (Mar2011)1, they have delved upon the issues related to software test management.
Out of the 22 CMMi Process Areas mentioned below, only two areas Verification and Validation are related to Testing: Validation (VAL) and Verification (VER), (Samuel et al., 2007). CMMI also covers other process areas, such as Process Management, Project Management and Support but only the core Software Engineering development processes are used here by way of example.

It is also interesting to note that SQA (Software Quality Assurance) and SQC (Software Quality Control) are processes defined within CMMI, they are under the Support process area. In CMMI SQA\SQC is defined as Process and Product Quality Assurance. CMMI is an approach to process improvement, in which SQA\SQC play a major but not exclusive role. Everyone in a software development organization takes part in both the CMMI processes and any improvement initiatives for those processes. Each of the main Engineering process areas are now described together with the role that SQA\SQC plays within those areas.

It is important to note that CMMi defines what processes and activities need to be done and not how these processes and activities are done. Why CMMi is not successful in Testing area is because each of its processes are equally suitable for each process areas as described above. And hence exclusivity of Testing is missing. Because of this reason TMMi (Test Maturity Model Integration, www.tmmifoundation.org) took precedence in testing arena. But TMMi has its own set of issues as described in the next section.

Software Testing Maturity Models (Testing Maturity Model and Software Testing Governance, 2012)2 for assessment includes a measurement of compliance level to measure the progress on the periodic level and provide a framework for planning and conducting appraisals and defining a manageable and traceable improvement. The models are often referred as the bible for users in recognizing and prioritizing processes that need improvement.

The two most prevalent and well documented models are Test Process Improvement Model (TPI) and Test Maturity Model (TMM). However, TPI and TMM models did not get much recognition in the software industry. TMM model faded away as much like CMM in the industry and is overtaken by TMMi framework model which is widely getting accepted in the software verticals.

TMMi framework has implemented the TMMSM3 framework which was initially developed by the Illinois Institute of Technology as one of its major sources and guided by CMMi framework. TMMi is the compilation versions of all the software testing maturity models that support test functions in large, which is not covered or is missing in any of the models mentioned above. TMMi follows a staged representation model which uses predefined sets of process areas to define an improvement path for a Test Organization that are integrated or independent of the Software Development organization.

In TMMi framework which is the most accepted Maturity Model, Software Testing Governance framework consists of the following six components: a) Test Goal – Identify Test Goals b) Test Strategy – Deploy the right Test Strategy c) Test Management – Effectively manage the entire Test Operation and Execution d) Test Measurement – Measure the incidents associated with the Test Operation e) Test Evaluation – Evaluate the risks and incidents reports for the root cause
Test Improvement – Suggest for the prospective Test Improvements to minimize further risks.

None of these specifically talk about Governance in Testing area and the cost benefit analysis therein. The gap in these maturity models is that the efforts to systematically measure the efficiency and effectiveness have been largely appeared as the academic and research exercises, making it difficult to apply in the practical scenario and hence are not practical enough to implement. It becomes necessary for the software organization to evaluate the testing practices for all the key testing responsibilities and functions through a unified lens by using a proper Software Testing Governance Framework at organization level which gives a holistic view of - what kind of Structure is best suited, what kind of Knowledge management is supposed to be undertaken and what would be the ROI against my investment under the framework.

In this well accepted Case Study on Testing Center of Excellence, Margo et al. (2010)3 talks about Testing Governance through Testing Center of Excellence and the best practices followed which includes how to implement testing methodologies related to governance framework. The Vendor brought its own governance controls and adapted them to work with the customer’s proprietary frameworks. The Excellence center improved the maturity of the testing organization by boosting capabilities across key practice areas, including automation, processes, people of tools. For more robust testing governance the vendor designed a phased implementation that included rigorous processes regarding activity and function initiation, sign-offs for quality approval and timeline management.

The case study also talks about reducing the software delivery cost with improved practices such as reducing process duplication and the effort for process completion, reusing testing processes during automation stages and performing static testing. It also talks about several best practices of testing governance like obtaining clear support from the top through executive sponsorship. Establish a champion for the Excellence center, setting up the shop within the company, establishing a strong methodology to drive best practices and adding automation to the testing practices. The study also talks about some challenges in governance in terms of cultural resistance to change, not speaking up in case of conflicts and accommodating too much during conflicts.

The study lacks in its deliberation on how the knowledge management is a key to the governance. It also didn’t explain the current testing methodologies and its deployment. Although it talked about cost of software delivery but the paper is silent on what kind of Return on Investment envisaged upon.

In this much researched article Jha (2012)4 deliberates upon how a Software Testing Governance is important. He also touches upon the various loopholes in TPI and TMM framework. According to him Software Testing Governance is a test discipline for software systems delivery which governs the test management process by the means of applying suitable test strategy, test process improvements, test optimizations and test performance from the project level to Test Organization level to measure and improve the quality of deliverables. It aligns business goals to ensure that information is available during decision making of the management.
The aim of the Software Testing Governance is to provide the transparency of software system measurement and performance assessment to enable the further improvements. Software Testing Governance operates through a set of well defined test organization strategies, strict test management policies, principles and test tools to control and assess the quality and progress of the software system.

Also he suggests that Software Testing Governance framework when applied on the project, provides a crystallized evidence to roll out the product into market with full confidence. For the project, the Software Test Governance framework bridges the gap between requirements control, technical issues and business risks. It emphasizes that the system should comply with the regulatory compliance of the software practice areas and the governing team understands the client’s business domain to get the insight into the workflow process and the operational model. Although the study has been done comprehensively however the study misses many relevant areas like a) What should be the org structure for the governance b) What should be the knowledge retention approach c) What Metrics to look for and it completely misses the most important aspect of articulation of Business value and thereby return on investment to the customer by following the governance framework proposed.

In a well received article Buwalda (2006)5 instead of regarding software testing as a derivate of software development, gives it a central, separate focus and manage it as a key asset of the company. To summarize this thought he uses the term "Test Governance". There is a good case to be made for Test Governance because Testing is a large part of the efforts in IT, typically 30% or more, Good testing is difficult. It takes skilled staff and there is a lot to learn, Testing is usually on the critical path of system development and maintenance, Test automation is a potential solution, but in itself is very hard to do successfully, Testing needs to be organized well, including who is responsible for which tests and how to report results. He recommends additional structures that have an "improvement focus".

Solutions include something "traditional" like a central test support department, or a more "light" solution, like one or more coordinating committees with members from various departments. In addition to formalized structures, he recommends to consider "soft" ones, where staff members meet and discuss matters of know-how and experience. For example one could introduce internal "Special Interest Groups" (SIG's) that have regular informal meetings, typically in the off-hours or at lunch. Members of a SIG share a common interest, for example "test design", "test automation" or "test management" and a meeting is typically structured around a presentation and discussion. SIG's can also run sites on the intranet. All of these activities provide an inexpensive and light way to improve competence, but also help people "find" each other for advice and discussion of matters in projects.

So he talks about the Central Structure to be given to Software Testing in an organization. However his whole solution lacks the decision factor in which a company should take decision what structure to follow and if that structure is followed what kind of return the organization would get.

After going through all the above writings it is very clear that although writings have talked about Testing Center of Excellence and consolidation of the Testing governance the gap comes
out very clearly in terms of giving a result oriented thought based on various parameters like Increasing offshoring, Centralized testing, Increase automation, Standardization of tools, Standardization of test processes and Competency uplift. Based on the above findings the problem definition has been arrived at.

**Problem definition**

Test managers typically do return on investment calculations on different programs and solutions but struggle to show ROI of an entire test organization and more so for getting funds for establishing a CTO. This paper focuses on understanding of different parameters of CTO (Centralized Test organization) that are considered for effort savings and productivity improvements across testing organization leading to better ROI.

Test managers often struggle to identify parameters which should be emphasized for getting the best out of an CTO. The salient features of a CTO which must be considered before developing the most cost effective and result oriented model are listed below in the methodology section to analyze ROI calculation of Centralization of Software Testing Organization based on understanding of parameters and their impact on effort savings and productivity improvement.

**OBJECTIVES OF THE STUDY**

To understand the parameters affecting Centralization and offshoring of testing organization
Impact of the Parameters on effort savings and productivity improvement

**METHODOLOGY**

The primary authors work as senior managers of testing units at leading Indian IT service provider organization, responsible for managing large portfolios for multiple clients. There was direct involvement of the primary authors in software development supervisions, productivity monitoring, quality assurance and testing. This opportunity of corporate exposure enabled in understanding the real scenario and also to collect data on best practices. The current paper is based on firsthand experience of authors in implementing and running CTO for multinational corporations which run world class QA organizations.

Sampling Design: The representative methodology and illustrative numerical figures have been used from the best practices of multiple CTO experiences mentioned in the data collection section below. To present a mathematical model of the problem we needed per unit effort and cost of several parameters which are taken from Industry Standard Reports on testing industry trends. For each parameter simple average for 3 yrs of operations are taken for 4 CTOs running for more than 3yrs. Though the value of individual parameters may vary from organization to organization, the underlying principle of Return on Investment remains same.

Based on literature review, gaps observed and data, it comes out ample clear that following parameters need to be examined for realizing how each of them can contribute to increase in effort savings and productivity improvement. Increasing offshoring-Optimizing effort and cost by moving work to right skilled low cost places
Centralized testing-Maximizing the productivity and synchronization through consolidating various arms of testing existing within the organization. Increasing automation-Scenarios and processes, if automated improve efficiency and productivity across.

Standardization of tools- Synchronizing the silos which increased the presence of amplitude of tools for the same kind of work

Standardization of test processes- Various LOBs/functional areas using their own set of processes which can be standardized

Competency uplift- In the knowledge based industry, retention, reuse and distribution of knowledge is of paramount importance which can add to every aspect of efficiency within

DATA COLLECTION AND ANALYSIS

The benefit measurements are taken from data observed and collected for the four major implementations done for CTO by the authors. They are customers for the authors for more than 5 years. The implementations were for major insurance, healthcare and banking clients spread across the globe. All these were major transformation programs for the clients who have budget of more than 100 MUSD for IT every year. Each of these clients are having more than 1000 person months budgeted every year only in testing. Their offshoring percentage vary in the range of 30% to 80%. The productivity, process, automation and tool related data are consolidation of 151 projects across 17 portfolios for the period 2009 to 2012.

After shortlisting the four cases discussions were held with senior managers and delivery managers for the clients and the respective projects for revalidating the data points.

As mentioned above the portfolios and projects were fairly large and the size of applications developed was more than 1000 Function Points for each project. The criteria was essential to ensure that projects were characteristically similar so that all the interpretations and analysis were based on those results. The profile of clients for the data collected for four primary CTOs under study are outlined below.

The first company for which data has been collected is of one of the leaders in healthcare insurance in USA which provides coverage for medical, dental, pharmacy, group life, and disability insurance. Currently it operates in 50 states in USA to provides a full spectrum of healthcare insurance products and services to more than 31 million members. Also has overseas operations in UK, Saudi Arabia and China. It has done pioneering work on various programs like as case management, disease management and patient safety programs to provide best in class services at affordable cost. Currently it is a leading player in adopting ICD10 procedure and diagnosis codes for all its operations and establishing Accountable Care Organization in USA.

As vendor partners authors have been leading testing portfolio of the above mentioned health insurance provider with total IT budget more than 300M USD. The organization runs a s Quality Assurance organization for more than 15 years which has been converted to an CTO with current budget close to 100M USD. Authors have been part of the CTO for more than last 5 years and have direct supervision and control of around 45% project under entire CTO. On an average 50
projects and 200 small enhancements are executed by authors team (peak team size 480) in a year. The projects were executed in global delivery model which has more than 80% effort offshored and achieved defect removal efficiency more than 95%. As the authors parent organization operates at CCMi Level 5, a fair number metrics are collected in granular detail for all projects.

Starting form effort spent by individual resources on each project to size of the project in terms of no of Test cases and Test Unit, % of cases automated are systematically recorded and reported at various level of management. Organization maintains detail account all employees’ domain experience and trainings attended to look at the project quality in light of resource quality. As projects were executed under a fixed price contract the vendor organization has flexibility to closely evaluate the staffing need based on centralized staffing model. For bench marking the results of various parameters under study in this paper authors have evaluated the project and metrics reports of 50 large projects in 2011-2012 with minimum 1000 FP. The outliers which had results at either extreme end were removed from calculating average and bench marking the results.

The other company for which data has been collected is part of a European based Insurance Group, which is a global financial institution with 112,000 employees providing services to 60 million clients in over 50 countries. The Client provides retail and institutional clients with products and services in retirement services, annuities, life insurance, employee benefits, mutual funds, financial planning, reinsurance and institutional markets. It also offers a broad array of financial products and services in insurance, asset management and direct banking through a wide variety of products, from traditional equity and fixed income to alternative assets. The Client holds top 10 rankings in its major product lines and serves more than 14 million customers across the USA.

CTO has been successfully implemented in the company which has peak size of more than 100 testing personnel with approx 80% of offshoring. The IT budget of the company exceeds 100 MUSD and has more than 1100 PM of testing work every year. They could increase their Automation percentage to 30% and maintained more than 6% Productivity improvement year on year. Their major focus was to optimize Testing Governance through synchronization of their shared services. The spread was through their four portfolios and more than 35 projects were in execution.

The third data point was taken from one of the largest direct provider of life insurance in USA. They work in various technology areas including Mainframe., Unix, Java, Dot Net, Data warehouse, IBM DB2, 3rd Party products like Siebel, JDE, 3rd Party testing tools. They receive the best possible insurance financial strength ratings from the all major companies that rate insurance providers: A.M., Best Ratings, Standard & Poor's Moody's Investors Service. This reflects their financial strength, overall operations efficiency, claims-paying ability and the soundness of their investments.

The association of author with their testing services group has helped in revalidating the parameters in discussion for CTO. The company has more than 150 MUSD of IT Budget. 46 Projects across their 5 portfolios had more than 125 testing professionals. More than 1500 PM of
testing effort per year was being budgeted. With 70% of offshoring they had various areas of improvement in terms of cost savings through CTO. After implementation they maintained 7% of Productivity improvement and could achieve 30% of automation apart from going deep into standardization of Processes and Tools.

The other company considered for analysis is a leading wealth management company with more than 3.4 million customers and 3,500 employees in Australia and New Zealand. It provides services in the area of Wealth Management: Retail Superannuation, Corporate superannuation, Pensions/annuities, Retail investment, Fixed term annuities, Wealth Protection / Insurance: Group risk, Individual risk, Lifetime annuities, Mature and Banking: Mortgages and Deposits. Also helps in Capital Investment through investment in Australian equities, International equities, Fixed interest, Infrastructure, Private equity and Property. In Australia it is #1 in Superannuation business, #2 in Retirement Income management and #3 in Retail Managed Funds.

The company has implemented Centralized Testing organization. The IT spend of the company is 125 MUSD. They have more than 100 folks working for their testing services. They run more than 20 large Projects simultaneously in 3 portfolios with their large transformation program. They involved TPI for their Testing Center of Excellence assessment. After the implementation their savings percent went as high as 20% which included increasing their offshoring percentage from 30% to 60% and implementing standard tools and knowledge management practices across their testing organization.

ANALYSIS OF CTO PARAMETERS

Increase Offshoring

To mitigate risk in the cost, logistics and availability of expertise at the onshore location it’s essential to increase offshoring of testing projects. For this a proper pre-planning, process alignment, research of the local economy, finding the right vendor, inspection of the infrastructure, customization of training on cultural differences need to be considered. Across clients we have seen the maximum offshore resource ratio increase up to 80% of the total testing resource in the organization.

The cost advantage of offshore billing gives significant benefit to the overall cost of operation. To bring out maximum benefit from vendor the various contracting methods followed for e.g. Time and Material, Fixed Price, Managed Service or Shared Service contracts and lately output based contracts.

Onshore/offshore Demand Planning leads to cost reduction due to low cost of offshore resources. The savings can be calculated based on following simple formula.
Savings= Total Effort*(Targeted Offshore%- Current offshore%)*(Onsite billed rate-offshore billed rate)

The offshoring percentage in many situations can go upto as high as 90%.
Centralized Testing

Maximum utilization of test resources can be achieved by centralization of the resource pool testing and managing assignments efficiently. From our experience the cost benefit of centralization seemed to achieve saturation at one level and its benefit has been capped at 10%. In our view mainly specialized roles can be considered for centralization, SMEs roles are found not suitable for this as they are typically less in number. Specialized roles like configuration lead and infrastructure lead could be reduced to an extent based on overall numbers. Some amount of reduction in non-specialized roles is also considered and is applied in the proper order – Tester, Test Analyst and Project manager.

It has been observed that Cross utilization of resource to optimize resource utilization leads to the savings in the range of 6 to 10%.

Note: Offshoring and Centralization need to go hand in hand. The number of full time employees deployed by the organization which are optimized by offshoring needs to be further analyzed from centralization perspective. The vendor offshore roles are the ones that need to account for offshoring additions (from offshoring view) and adjustments owing to reduction in the centralization view. The offshore vendor count and non-specialist roles like project manager, test analyst and tester are calculated using an optimized ratio (in the span of 1 is to 10).

Increased Automation

Primary aim of Automation is reducing manual effort and increasing quality by removing human errors. It’s important to do a thorough feasibility and Return on Investment study of automation proposal before investing in any technology or human resource in automation. Automation can be considered for both new script development and maintenance of existing scripts.

In our experience regression test bed were found to be more suitable for automation to achieve substantial saving and increasing confidence. The major bottle neck faced in the projects are i) Maintaining data consistency in different regions of testing and different testing cycle ii) Stability of the targeted application, core applications which undergoes frequent changes are not suitable for automation. It’s observed that an agile or accelerated automation approach could be taken for dynamic and new application but the cost benefit analysis doesn’t look promising.

This leads to savings in terms of Reduction in Test Scripting Effort, which ranges from 2% to 5% of overall scripting effort. Also Reduction in execution effort is in the range of 10% to 40% of overall test execution effort. These two combined together come in the improvement range of 2%-4% of overall testing effort.

Standardization of tools

Use of different tools by different vendors for the same purpose in different parts of the organization increases overhead and total cost of operation significantly. It is very important to select the tools at organization level that will be used in the various lifecycle stages of the project. Typical tools that can be used in a testing project are available from various vendors for
Test Management, Automation, Configuration Management, Performance testing etc. The primary benefit of having standardized tools across organization is it reduces redundancy of tools training, purchase/license cost maintenance, data storage and retrieval and report reformatting. This can help in increasing the ROI significantly.

The observation in number of projects shows that the effort reduction on overall testing effort due to deployment of tools (Test Management, Automation, Configuration Management, Performance testing etc.) is from 3% to 5% due to reduction in rework and increased reuse across all stages of test life cycle.

**Standardization of test processes**

Well defined entry exit criteria and detailed process for all lifecycle stages of testing reduces communication overhead and minimizes error. Defined metrics for Quality and productivity improvement makes it easier to track progress and benefits of the project.

There are various best practices which come out very clearly in terms of defining document template for all artifacts (e.g. Building skeletal scripts for each LOB-Lines of Businesses- helps a lot in reducing scripting effort), defining estimation model for e.g. SMC(Simple/Medium/Complex)/TUM(Test Unit Method)/FP(Function Point) etc., Establishing Early Validation Processes (Early Defect detection will result in significant cost savings in terms of relative cost of fixing defects 1:10:100-Design:Test:Production), defining Data Strategy and also Risk Based Testing approach can be done significantly through Orthogonal Array Approach to achieve maximum code coverage with optimum number of test cases.

**RESULTS AND LIMITATIONS**

Though theoretically optimization up to 100% is possible for any parameter, out of experience we cap the benefit of offshoring and centralization to max 25%. Productivity improvement is capped at 11%-19% in 3 yrs. As these figures have been observed practically, it can be recommended as a base to run through what kind of benefits companies can observe if the guidelines are followed. This was a major gap observed by authors while implementing multiple CTOs.

There are some factors which might limit the amount of improvement desired. The cost of standardization of Tools and Processes depend on a lot of factors like organizations current state and readiness, the technology and nature of project constraints and the test manager’s ability to exploit full potential of CTO. For example automation tools for projects involving latest technology may not be available. Projects which are compliance (compliance to Govt. laws) in nature sometime cannot be offshored or outsourced. All these parameters have to be considered holistically before putting the numerical figures to calculate Return on Investment and calculate impact of any parameter.

**PRACTICAL IMPLICATIONS**
Till now there are still many IT organizations (more than 50%) which do not have centralized testing organizations. While attempting to implement CTO there is need to understand the different parameters impacting it and their current state and their impact to overall benefit in terms of Return on Investment. The study above will help the organization to attack different parameters individually and model their own CTO for deriving maximum benefit from the investment done in CTO. It is of immense importance because cost reduction and efficiency are the burning needs for Software arm of any entity and testing being almost one third of the cost of Software Development life cycle need to work through the measures elaborated above.

FUTURE SCOPE OF WORK

Senior Management in Testing Organizations of a company can further analyze their operations more at microscopic level on the mentioned parameters to have better insight into issues and further detailed calculation of ROI. Few parameters which every CTO must study in detail are – Savings due to improved quality (reduced defects) and time (reduce time to market). The factors that will be considered to evaluate quality are overall Defect Injection Rate in terms of effort, defect injection Rate in terms of size, Defect Removal Effectiveness (Pre Production), total Number of Defects Injected per year, Total UAT Defects (Identified by business client), total Number of Defects escaped(Post production escaped defects).

Another area of study which could result from this study is to analyze on similar lines the synchronized effort of Development, Testing and Production support work and how processes and knowledge in various domains can be optimized with the above approach for reducing cost and increasing productivity. There can be feasibility of Centralized Development Organization and Centralized Production Support Organizations on similar lines as above. Removing inefficiencies of Agile working is another area where similar analysis can be undertaken.

SUMMARY

Outcomes of this paper can be used by the software testing governance team as performance benchmark while planning on developing CTO (Centralized testing Organization) for their organization or showcasing the business value of testing to their Executive leadership thru Productivity and savings calculations. More importantly this paper gives an insight in to impact of multiple factors on the decision for establishing an optimized testing value for the organization, when all the factors are worked upon together or separately, like offshoring and centralization done together, making productivity improvement decisions, maximizing their automation effort and making informed investment decisions on standardizing tools and processes.

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