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Benefits and Challenges of Measuring Software Size: Early Results in a Large Organization

Abstract

Turkcell, a leading telecommunications and technology company in Turkey, has decided to initiate a project utilizing COSMIC to measure their software products and to use functional size of the software as an input parameter in their development and procurement processes. This paper explains the steps we have taken and the difficulties we have faced towards being a quantitatively measured organization as well as the early results from this approach.

Keywords: COSMIC functional size measurement, process change in a large organization

1. Introduction

Considering its role as a main input for effort and schedule estimation, it is undeniable that measuring software size accurately is crucially important for organizations in their software project management activities. One of the most widely used size measures for software has been functional size[6] since introduced to the world by Albrecht[7]. Its ability to be used reliably and accurately in early phases of the software development is the main advantage of functional size measurement (FSM).

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6 ISO/IEC 14143–1, *Information Technology – Software Measurement – Functional Size Measurement – Part 1*, Definition of Concepts 1998, updated in 2007.

7 A.J. Albrecht, *Measuring Application Development Productivity*, Proceedings of IBM Application Development Symposium 1979, pp. 83–92.

One of the most common FSM methods is COSMIC[8] which is accepted by ISO[9]. After IFPUG[10], COSMIC is the most commonly used method and it suits well for automated measurement as shown in previous works[11].

Considering all the benefits of using functional size measurement methods, organizations should integrate them into their software development processes. It might be easier for a start-up organization to structure their processes considering the need for a measurement approach, it may also be easy for a small scale organization to integrate functional measurement methods into existing processes. However, for a large organization some problems arise to integrate a functional measurement approach into their software processes.

Turkcell has decided to utilize the COSMIC Functional Size Measurement method as part of the main size measure in software processes[12]. The main motivation was to establish size based procurement processes, however, we also wanted to use the measurements to evaluate the productivity and efficiency of our internal development teams, to benchmark their performance against the international information and communications technology sector, to improve the quality of artifacts (requirements analysis, technical design, etc.) produced during a project and to identify improvement opportunities in the processes, technologies and organization.

Turkcell, considering the difficulties in managing a process change in a large organization, has decided to use a personalized approach during the implementation. In this paper the approach, the challenges, and preliminary results are discussed.

The 2nd section summarizes the related research, the 3rd section explains the measurement program and gives details about the benefits and challenges, and the 4th section gives the conclusion of the paper.

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8 A. Abran, J.-M. Desharnais, S. Oligny, D. St-Pierre, C. Symons, *COSMIC Method Measurement Manual Version 3.0.1.*, The Common Software Measurement International Consortium 2009.

9 ISO/IEC 19761, *Software Engineering – COSMIC: A Functional Size Measurement Method 2011*.

10 *OVERVIEW of Function Points*, *Total Metrics* 2013, http://www.totalmetrics.com/function-point-resources/what-are-function-points

11 A. Abran, *Automating Functional Size Measurement – A Survey*, UKSMA/COSMIC Conference 2011–22nd Annual Conference on Metrics and Estimating: hosted in collaboration with COSMIC 2011.

12 S. Bağrıyanık, A. Karahoca, E. Ersoy, *Selection of a Functional Sizing Methodology: A Telecommunications Company Case Study*, "Global Journal of Technology and Optimization" 2015, no. 7, pp. 98–108.

2. Literature review

Since its introduction by Albrecht[13], FSM has been a widely used measurement in both academic and industrial organizations. Beginning from its introduction, FSM received criticism about the possible inconsistencies between the measures of different specialists[14]. In his work in 1992 Kremer stated that the reliability of FSM can be increased by improving some factors[15], he also stated that "both the inter-rater and inter-method reliability of functional processes (FP) are high"[16].

Türetken showed with a case study that the set of base functional components in COSMIC (like FUR, OOI, etc.) might be defined differently because of different interpretations of the users[17]. Ungan and Top classified common errors found in student measurements[18]. They built two main groups of errors; the first group includes errors resulting from misapplication of the rules, the other group includes errors resulting from misinterpretation of the software artifacts by the users. These results are also in line with the classification given in COSMIC Guideline for Assuring the Accuracy of Measurements[19].

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[13] A.J. Albrecht, *Measuring Application Development Productivity*, Proceedings of IBM Application Development Symposium 1979, pp. 83–92.

[14] C. Kemerer, *Reliability of Function Points Measurement: A Field Experiment*, "Communication of the ACM" 1993, vol. 36, no. 2; C.F. Kemerer, B.S. Porter, *Improving the Reliability of Function Point Measurement: An Empirical Study*, "IEEE Transaction on Software Engineering" 1992, vol. 18, no. 11, pp. 1011–1024; S. Abrahao, G. Poels, O. Pastor, *Assessing the Reproducibility and Accuracy of Functional Size Measurement Methods Through Experimentation*, International Symposium on Empirical Software Engineering 2004, pp. 189–198.

[15] C.F. Kemerer, B.S. Porter, *Improving the Reliability of Function Point Measurement: An Empirical Study*, "IEEE Transaction on Software Engineering" 1992, vol. 18, no. 11, pp. 1011–1024.

[16] C. Kemerer, *Reliability of Function Points Measurement: A Field Experiment*, "Communication of the ACM" 1993, vol. 36, no. 2.

[17] O. Turetken, Ö. Top, B. Özkan, O. Demirörs, *The Impact of Individual Assumptions on Functional Size Measurement*, Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) 2008, vol. 5338 LNCS, pp. 155–169.

[18] Ö. Top, O. Demirors, B. Ö zkan, *Reliability of COSMIC Functional Size Measurement Results: A Multiple Case Study on Industry Cases*, 35th Euromicro Conference on Software Engineering and Advanced Applications 2009, pp. 327–334; E. Ungan, O. Demirörs, Ö. Top, B. Özkan, *An Experimental Study on the Reliability of COSMIC Measurement Results*, International Conferences IWSM 2009 and Mensura 2009 Amsterdam, 4–6.11.2009, pp. 321–336.

[19] *Guideline for Assuring the Accuracy of Measurements Version 1.0.*,The Common Software Measurement International Consortium (COSMIC) 2011.

Even though there are suggested methods to increase the reliability of an FSM measurement with automated software tools, like the preventive tool suggested by Salmanoglu[20] or the defect detection approach proposed by Yilmaz[21], given studies show that most of the errors can be prevented by increasing the knowledge and experience of the measurers. Mert et al. show that including most common error types into a course schedule helps to decrease observed errors in student measures[22].

Considering the results of previous studies, training is the factor number one for the quality of functional size measurement. This paper describes the methodology, and its preliminary results, used in a large industrial organization in Turkey to train participants as functional size measurers, to change software processes to include software functional size as the main measure used in development and procurement processes. In the next section the applied measurement program is given in detail.

3. The Measurement Program & Its Benefits and Challenges

Turkcell is one of the largest telecommunications and technology providers in Turkey. The company web site[23] states that "Turkcell is a regional leader by being the market leader in five countries out of nine it operates in. Turkcell's shares have been traded on the Istanbul (IMKB) and New York Stock Exchanges (NYSE) since July 11, 2000, and it is the first and only Turkish company ever to be listed on the NYSE". The short time to market cycles and the sustainability of the service quality are the key components for the success of the company. ICT (Information and

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20 M. (METU) Salmanoglu, O. Demirors, O. Demirörs, *Exploration of an Error Prevention Model for COSMIC Functional Size Measurement Method*, The Joint Conference of the 22nd International Workshop on Software Measurement (IWSM) and the 7th International Conference on Software Process and Product Measurement (Mensura) 2012, p. 7.

21 G. Yilmaz, S. Tunalilar, O. Demirörs, *Towards the Development of a Defect Detection Tool for COSMIC Functional Size Measurement*, The Joint Conference of the 23rd International Workshop on Software Measurement (IWSM) and the 8th International Conference on Software Process and Product Measurement (Mensura) October 2013, pp. 9–16.

22 A.M. Ertugrul, G. Yilmaz, M. Salmanoglu, O. Demirors, *The Effect of Highlighting Error Categories in FSM Training on the Accuracy of Measurement*, The Joint Conference of the 24th International Workshop on Software Measurement (IWSM) and the 9th International Conference on Software Process and Product Measurement (Mensura) 2014, pp. 152–156.

23 Company Overwiew – History 2015, http://www.turkcell.com.tr/en/aboutus/company-overview/history (16.05.2015).

Communications Technologies) play an important role in this success since the services are developed, introduced to customers and operated within this department of the company. ICT delivery departments develop solutions that serve Turkcell's individual and corporate customers, and internal business groups. Some of the business lines of Turkcell are: marketing solutions, billing and charging solutions, business intelligence solutions, customer relationship management solutions, enterprise resource management, network and infrastructure management solutions. Turkcell's ICT department supports development of portfolios of this wide spectrum of business customers with 800 analysts and developers, and 28 service provider companies.

3.1. The Motivation for Measurement

Software development projects are classified into two main groups in Turkcell ICT:

- **Project**: New business products or solutions are developed within projects. This type of projects has complex integration and development requirements. Their software development effort and/or other costs are large. The duration goal for a typical project is 180 days.
- **Fast Track (FT)**: FTs are small scale projects. Their goal is generally extending the existing products or services by adding some new features or modifying the existing functionality. They are completed within 45 or 90 days depending on their size.

FT and Project numbers are used in the outsourced software development services procurement, productivity analysis and performance goal setting. In 2014, more than 350 projects and 5000 FTs were completed and delivered to users. The FT and Project number approach is effective as long as FT and project scopes are of similar size. However, this assumption may not hold across ICT teams and causes subjectivity. Therefore, a need for a generally accepted, objective method has arisen. A proof of the concept study is conducted to assess the state-of- the-art functional software measurement methods used in the software industry. As a result, COSMIC Function Point is selected as the most appropriate method for the company since it satisfies all the company measurement requirements. Additionally, it is simpler, it can also be used for requirement quality enhancement and it is compatible with the current software engineering technologies, models and practices[24].

[24] S. Bağrıyanık, A. Karahoca, E. Ersoy, *Selection of a Functional Sizing Methodology: A Telecommunications Company Case Study*, "Global Journal of Technology and Optimization" 2015, no. 7, pp. 98–108.

3.2. Measurement Initiative

A measurement program has been commenced in the company just after the selection of COSMIC Function Point. In order to apply the CFP method, requirements engineering artifacts are essential. Business analysts who work in the ICT delivery departments, document requirement analysis outputs into analysis documents (AD). Design, technical implementation, and testing activities are based on AD documents for both in-house developed or outsourced projects. ADs contain functional and non-functional requirements such as use cases, modified business and application services, high level solutions, quality and performance requirements etc. As the first step of the program, an assessment of AD documents revealed important information regarding the measurement maturity level, it was quite difficult to identify data movements correctly in the same level of abstraction from the old version of the AD as they either include a very brief description of the project, or technical details in the design level. This difference in the abstraction level suggests that the documents may be written by the analysts after the design or even development phase. It is determined to change the template of the AD to let all documents be created at the same abstraction level. This gap analysis has guided the improvement activities in the processes and documentation standards within ICT delivery teams. A common problem of the companies in the technology sector is the deviation from their well-defined and structured business processes over time in order to cope with dynamic market conditions and competition. This situation is described in a recent study conducted in the company as follows: "A semi – formal requirements modelling approach is preferred by the analysts in the company. Considering the competitive environment as well as quality and regulation requirements, this situation is understandable. Agility is a must for them and the easiest way to model requirements seems to use free format typing. On the other hand, quality and knowledge management is another important factor and this brings a balance of semi formalism"[25]. The production transformation speed frequently exceeds the process transformation speed in these fast service delivering companies. This is a very critical trade-off which must be managed carefully since introducing new processes and the application of new methods rapidly may lead organizational resistance against change. Considering these

[25] S. Bağrıyanık, D. Karahoca, *System Analyst Expectations from Requirements Engineering Tools: A Human Computer Interaction Perspective*, "Global Journal of Computer Science and Technology" 2014, vol. 4, no. 1.

factors, it would be a surprise to find the majority of the existing documentation suitable and mature enough for the measurement.

Although the referenced work products were not immediately mature enough for measurement, the expectation from the project was to create the measurement baseline as fast as possible. To comply with these needs, we developed a growing measurement program with frequent demonstrations of the benefits.

The main steps for the measurement program are:

1. Preliminary measurement and setting program goals,
2. Presentation of the results to the top management,
3. Application of the measurement method to a limited domain in the field,
4. Presentation of the first benefits to the top management,
5. Dissemination of the method to the whole field.

Preliminary Measurement and Setting Program Goals

In the first step, documentation quality and suitability for the CFP measurement has been examined by selecting a representative Project and FT set using random sampling. 450 project and FT documents are included in the sample set. These documents are measured using COSMIC. Size and effort correlation and average productivity rates (Effort/CFP) are also computed for all the ICT units. The most important finding is that 51% of 450 projects have been found appropriate for measurement. The criteria used to determine that were the measurements of the expert measurers with no domain expertise. The rest of the analysis documents were either too brief for measurement or contained only detailed technical explanations, which cannot be interpreted without domain knowledge. Another interesting finding was the observation of the diseconomies of scale effect, as represented in **Fig. 1** the number of hours spent on each CFP are higher in both very small and very large projects. Following goals are determined using the preliminary results and company needs.

1. **Improving Quality:** Measurement activity expected to provide an overall quality improvement in many activities (requirements analysis, development, test) during the project life cycle. It functions as a review mechanism for the Project scope. For example, missing and inconsistent information in requirements becomes visible during the measurement activity. Normalized defect density (Defect count/CFP) can be monitored in all the phases of the project. Scope creep can be measured.
2. **Improving Efficiency, Productivity:** Cost per CFP is computed and may be used as a guidance for the improvement opportunities in technology,

processes or people. Productive or non-productive application design and architectural patterns, programming frameworks, development methodologies may be determined. Training needs for the analysts and developers may be identified.

3. **Outsourcing Software Development Projects**: Outsourced software development procurement is simplified by measuring and determining the scope using the CFP method. Contracting can be done easily using unit CFP costs. Performance measurement of the vendors may be compared more objectively.

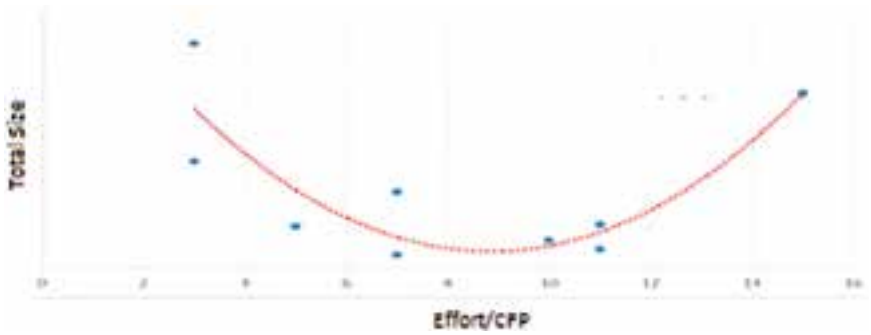

Figure 1. Representation of Diseconomies of Scale
Source: the authors' own study.

Presentation of the Results to the Top Management

Presenting the preliminary findings, potential benefits and program roadmap to the top management is very important for the future of the measurement initiative. Management support and sponsorship is crucial for the success of the program. The main presentation has included the quality and measurement maturity level of the documents, early results over scale in terms of CFP per project & FT, rough efficiency results in terms of the consumed effort per CFP and the examples in diseconomies of scale. The statistical analysis of the samples and benchmarking the results with the historical data in the sector were the main tools used to discover the opportunity to improve.

Table 1 presents a sample of the data that has been presented to the upper management. The average person-hour spent on each CFP is calculated for several projects, and for different technologies used in these projects, and compared with the industry data obtained through ISBSG[26]. This comparison helps the

[26] ISBSG Dataset Release 11, www.ISBSG.org

management to evaluate their efficiency level according to the industry average. If the numbers are higher than the industry average, the results of this situation should be analyzed and necessary improvements should be planned accordingly.

Table 1. Sample of Data Presented to the Top Management; Efficiency Comparisons with Industry Data (real values are confidential and not given)

Module	Technology	Past Effort/CFP	Industry Effort/CFP
Modul-1	Java	3,1 × Hrs./CFP	14,5 Hrs. /CFP
	.Net	2,7 × Hrs. /CFP	14 Hrs. /CFP
Modul-2	PLSQL	2,1 × Hrs. /CFP	11,3 × Hrs. /CFP

Source: the authors' own study.

Application of the Measurement Method to a Limited Domain in the Field

The Kaizen approach which means continuous improvement or "change for the better"[27] suggests that the success of a new method strictly depends on the acceptance of it in the field (Gemba[28]) where the method is put into practice. A method that is not well accepted according to Gemba, will fail sooner or later. Many transformations require a cultural change and a measurement program is no exception. It requires an intensive communication management, a detailed roadmap and patient champions in the organization. The following activities have been planned in order to disseminate the change in the field:

- Determining program sponsors,
- Creating a CFP committee composed of team leaders from every development team,
- An expert from every team is selected as a COSMIC representative,
- Informative meetings with small teams organized by the representatives,
- Introductory COSMIC seminars organized for large groups,
- Workshops, in which real projects are measured, organized for large groups,
- Measurements are reviewed by expert CFP instructors,
- Regular coaching activities and supportive training are organized to eliminate erroneous measurement practices.

For a sustainable measurement activity, processes should also be extended accordingly. The measurement timing within the Project life cycle should be determined. In Turkcell ICT, the end requirements analysis, end acceptance test,

[27] Kaizen 2015, http://en.wikipedia.org/wiki/Kaizen (16/05/2015).
[28] Gemba 2015, http://en.wikipedia.org/wiki/Gemba (16/05/2015).

and Project closure are the project milestones at which COSMIC measurements will be taken. The rationale behind a three phase measurement is to make the scope creep visible for the quality and agreement on follow up costs with vendors. Measurement activities have been incorporated into the existing company processes. Also templates of AD documents, which are used as requirements analysis documentation, have been changed to simplify the measurement and to include CFP measurement results. The new template requires the user to identify and specify all data movements in each use case and calculate the total size of each use case while creating the documentation.

It is important to communicate these changes to the organization efficiently to reduce calculation errors. In order to reduce calculation errors and eliminate manual measurement efforts, there is also an ongoing project that aims to automatize the manual measurement process. The results of this research project will be published in the future as well.

On the other hand, although a self-measurement of the organization is designed, a controlling mechanism should be built to assure the accuracy of the CFP measurements and effort (timesheet) data. Particularly in CFP based outsourcing contract cases, the agreement and audit mechanism becomes a commercial necessity. Measurement results should be audited by an independent third party as shown in **Fig. 2**. Audit may be conducted for all projects or for a random sample of all projects.

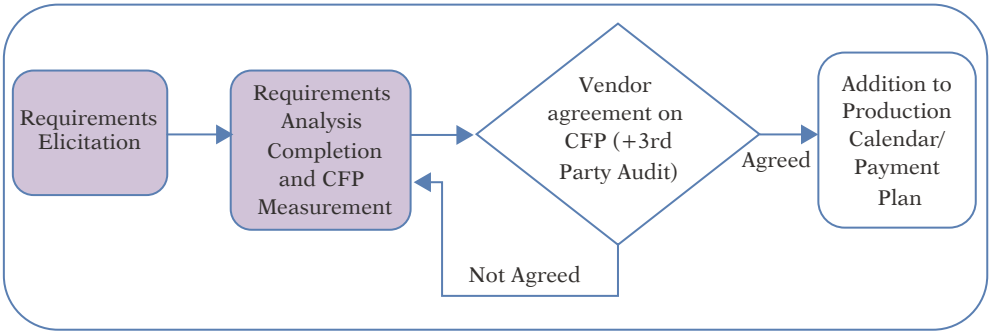

Figure 2. CFP Measurement in the Procurement Process

Source: the authors' own study.

Presentation of the First Benefits to the Top Management

The presentation of the progress and benefits to the sponsors and top management has increased motivation and support for the initiative. The presentation included the use of the CFP method in the procurement of outsourced services and the benefits of the new buying model. On the other hand, the enhanced quality was obvious in documentation, which will lead to improved efficiency and productivity in the long run. The additional budget and resource support for the program is enabled to achieve the goals faster.

Dissemination of the Method to the Whole Field

After the proof of the concept application in the field, the methodology, good practices, lessons learnt, process changes, and roadmap are identified and accumulated. Therefore, disseminating this valuable experience and knowledge is possible by replicating good practices in other departments in the organization. We are currently at the stage of dissemination. Up to now, over one third of Turkcell's ICT delivery departments including managers, analysts and developers, and co-operating employees of the vendors have become measurers. By the end of 2015, all the ICT and related ecosystem was planned to be measuring, planning and operating according to the CFP method. Best practices and lessons learned from the pilot run will be useful in performing the dissemination program.

4. Results

Implementing process improvement activities in large and well-established organizations, like Turkcell, is not expected to be an easy procedure. The main challenge has been the resistance from the stakeholders against this complex change; the determination of the upper management and in depth training with detailed workshops have helped the participants to accept the change. After they started to measure their own projects, they have had other difficulties like measuring data warehouses and data cubes. With the help of COSMIC specialists and in depth discussions with the project teams, the measurement procedures for specialized domains are determined.

As one of the expected benefits of this project is to manage outsourced software developments and contracts with the outsource partners, the concerns

raised by software development service providing partners should also be eliminated. After organizing special training sessions with the contractors, special meetings are arranged to let the contractors and company analysts meet and discuss their disagreements on both measurement practices and evaluations methods of the results. At the end of these meetings common rules are determined and accepted as guidelines.

Although it is a challenging experience, knowing the necessities of a process change in the software size measurement approach, Turkcell has embraced this challenge.

This paper summarizes the early findings of a process change in which the COSMIC functional size measurement method is being implemented in software development and procurement processes. The results are promising considering the acceptance among the process participants, support from the upper management, and improvement in the quality of the process outputs.

After the dissemination phase is completed as described in this paper, Turkcell will continue collecting quantitative data and analyzing them to determine:

- Functional size distributions of the projects,
- Productivity ratings for the development groups and contractors,
- Groupings among the projects according to the productivity measures,
- Process improvement opportunities to increase productivity.

The research that is started with this paper is expected to be continued to include the findings of the follow-up phases, until the continuous process improvement fed by quantitative efficiency data becomes an embraced unobtrusive company practice.

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