Agile Software Quality Metrics

Michelle Maddox
Lockheed Martin
Southern Methodist University
Fort Worth, Texas, USA
michelle.maddox@lmco.com

Sheila Walker
Lockheed Martin
Colorado Technical University
Fort Worth, USA
sheila.walker@lmco.com

***Abstract*— Agile development practices, based on the Agile Manifesto values and principles [1], originated in commercial Information Technology companies starting in 2001. The benefits of Agile development practices have been realized and have led to subsequent widespread adoption of Agile. Agile continues to be adopted in industries and projects that previously dominantly used document-driven Waterfall development practices (for example, Defense Department of (DoD) programs). Sound metrics are key underpinnings of successful software development, and they have matured steadily for traditional software development over the past 30 years. However, Agile quality metrics and practitioner guidance is less mature. This paper explores the current state of Agile development metrics and proposes both a framework for Agile Metrics selection and a foundational Agile Quality Metric "Core Set".**

Keywords—agile, metrics, software quality, software development (*key words****)***

I. INTRODUCTION

Traditional software development metrics have been used in practices for 30 years. In 1992, Booch identified Software Metrics for project management and process improvement [2], and Putman et al. later defined "five core metrics" that "enable software development to operate successfully": size, productivity, time, effort, and reliability [3]. There is no comparable metric standardization or guidance established for Agile metrics. In lieu of identifying specific metrics for assessing development progress or product quality, the Agile Manifesto principles emphasize the continuous delivery of working and valuable software as the primary measure of success [1].

Although Agile development has been practiced in commercial and Information Technology (IT) companies for almost 20 years, the approach has recently been introduced to other domains such as the Department of Defense programs where software development for a major release spans one or more years. For these projects, identifying a way of assessing the software quality for incremental releases is particularly useful.

This paper identifies common Agile metrics, contributions, and current trends related to the topic. It summarizes practical, relevant, and useful metrics that are beneficial to Agile software development projects. The set of Agile quality metrics we recommend are intended to assist new adopters and projects transitioning to Agile. This set of metrics may be used as an aid for the challenging task of selecting and instantiating key metrics to assess overall project progress and software quality. We believe proper metrics are critical for assessing Agile software quality and aid with programmatic and technical decisions that enhance project success rates and increase product quality.

II. RELATED WORKS

The literature search of IEEE Xplore, Engineering Source and Applied Technology and Technology databases yielded 142 papers including the five primary Agile Software Metric papers analyzed for this study – three literature reviews [4]-[6], one survey paper [7], and one paper that combined a literature search, interviews, and a survey [8]. Collectively, these papers researched more than 800 Agile software metric papers and over 390 Agile metric survey responses. Key contributions from the primary research papers are summarized in Table I.

TABLE I. PRIMARY AGILE METRIC LITERTURE

Authors	Agile Metrics Contribution
Kupiainen et al.	High-Influence Agile Software Metrics [4]
Kurnia et al.	Scrum Metrics [5]
Kiš̌ et al.	Agile/Lean Metrics [6]
Sambinelli et al.	Agile Metrics of Customer Value [7]
Padmini et al.	Agile Software Development Metrics [8]

In addition, metrics from the industry reports summarized in Table II are evaluated in this study.

TABLE II. AGILE METRIC INDUSTRY REPORTS

Report	Agile Metric Contribution
Digital.ai (formerly CollabNet VersionOne) State of Agile Report	Measures of Agile Success [9]-[11]
Agile Metrics: Progress Monitoring of Agile Contractors	Basic, Advanced, and Progess Monitoring Agile Metrics [12]
2017 State of DevOps Report	DevOps Metrics [13]

Over 135 Agile metrics were listed in literature and industry reports. Although there are many publications detailing metrics and their respective variants, little formal standardization exists. This study evaluated the listed Agile software metrics further to provide guidance for metric selection and to identify metrics useful for software quality assessment.

2021 IEEE MetroCon | 978-1-6654-0537-9/21/$31.00 ©2021 IEEE | DOI: 10.1109/METROCON54219.2021.9666049

III. RESEARCH SUMMARY

A. Agile Metrics

Software metrics are measurable attributes of a software development process or software product used to [15]:

- Evaluate and analyze software products and processes.
- Monitor and assess risk to cost, time to market, quality, reliability, and customer satisfaction objectives.
- Make informed decisions about the software process and/or product(s).
- Identify where to target process and quality improvement.

Although typical software development business goals have remained the same over time, the transition to Agile software development necessitates re-evaluation of the metrics used to manage the development. Common metrics discussed in Agile research and industry reports are velocity, customer satisfaction, burn-up/burn-down, cost, business value, development time, and lead time, in addition to various metrics related to product size, defects, test, and project performance [4]-[12].

In addition, the following DevOps Research and Assessment (DORA) metrics are becoming more common for projects that integrate software development and Information Technology (IT) operations (DevOps) in automated, continuous integration, continuous delivery (CI/CD) environments [13]:

- Deployment frequency
- Lead time for changes
- Mean time to recover (MTTR)
- Change failure rate

There seems to be some commonality across the top/popular metrics. This evidence suggests that industry best practices are generally converging. However, no framework for identifying Agile metrics was identified. While there is no clear evidence that industry-wide standardization is taking place, there is a clear positive trend given the explosive growth and adoption of Agile development practices.

B. Agile Software Quality Metrics

Software product customers expect delivered products to perform the required functions (i.e., fit for use), and to perform the functions reliably [14]. Failure to effectively manage software defects typically leads to increased development cost, schedule, and project execution risk, as well as decreased quality [15].

Of the many Agile metrics identified in literature and industry reports, the goal of this research is to identify the set of metrics for Agile software quality assessment. Basili's Goal Question Metric (GQM) approach provides a structured method to determine which metrics to use [16]. Candidate metrics are identified in Table III.

TABLE III. ASSESS SOFTWARE QUALITY GOAL-QUESTION-METRIC

Question 1	**Question 2**
How much of the testing is complete?	What is the quality of the completed software product(s)?
Candidate Metrics	
Test Metrics	Defect Metrics
Tests/Test Cases Test coverage Test-growth ratio Test cases passed Test cases failed Test cases executed Test cases not executed Test Efficiency[a]	Defect Count Defect Density Defect Removal Efficiency Defect Severity Defect Slippage Defect Trend Indicator Defect Resolution Production Escape Percentage Change Failure Rate

[a] Defects discovered in test / (Defects discovered in test + production escapes) *100

The majority of the candidate metrics also apply to traditional software development approaches [4]. We offer and recommend the following "Core Set" of metrics as a useful subset for Agile software quality assessment: test efficiency, defect removal efficiency, production escape percentage, and change failure rate represented in Fig. 1, Fig. 2, Fig. 3, and Fig. 4, respectivley. The test efficiency, defect removal efficiency, production escape percentage metrics are traditional software metrics, so applying the metrics to Agile projects should be relatively easy due to the the history of practical use. The change failure rate is a DORA metric that is emerging in DevOps development environments.

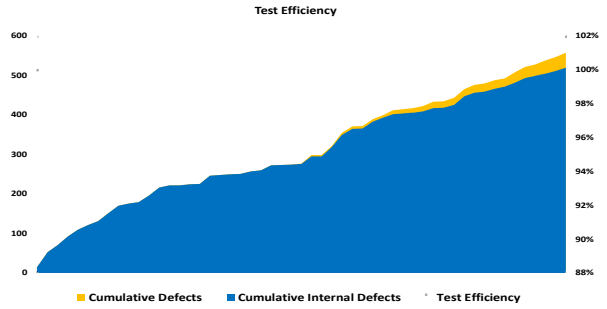

Fig. 1. Test Efficiency

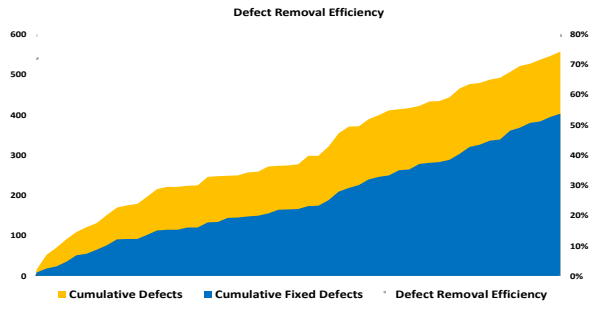

Fig. 2. Defect Removal Efficiency

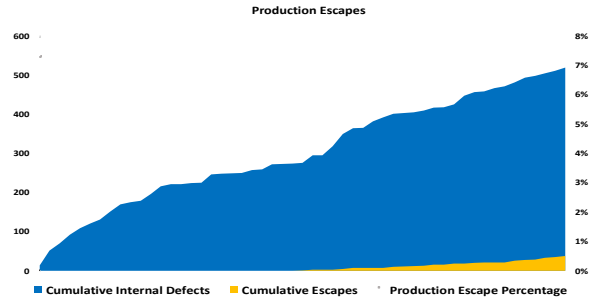

Fig. 3. Production Escapes Percentage

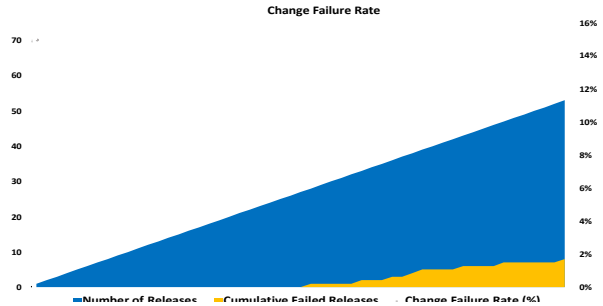

Fig. 4. Change Failure Rate

When evaluated as a set, these four metrics provide valuable insight on Agile test effectiveness and software quality. In addition, each of these metrics can be automated in DevOps pipelines. The source data used to generate the metrics depicted in the figures is a subset of the Data.gov consumer complaint data [17] extracted as a raw data and manipulated in Excel to integrate test information as representative data.

The identification of a small set of Agile quality metrics is consistent with Lew's suggestion to keep the identification of metrics simple by starting with a "handful of metrics" [18]. Since Agile metrics are collected during each development increment, the frequent cadence results in increased transparency, enables more proactive project monitoring, and provides feedback to support decisions throughout the development lifecycle.

IV. CONCLUSIONS

The key to a successful metric strategy is to "identify the right set of metrics that provide the information to act" and support decision making [19]. This paper contributes a survey of recent, popular, and published Agile software development metrics, with results and insights intended to be useful and relevant to practitioners, project managers, and early adopters. The results and application example metrics provide a quick reference guide that distills the results into a focused summary. In addition, the work intends to assist DoD software development efforts, which have traditionally been slower in adopting commercial software industry paradigms.

Over 135 Agile unique metrics identified in literature and industry were examined in this Agile metric review. One key finding is that there are no industry-wide standards or associated Agile metric commonality initiatives.

Of the software quality metrics identified in the study, this paper focused on those most useful for Agile software quality assessment: test efficiency, defect removal efficiency, production escape percentage, and change failure rate. Based on research results, the authors conclude that the Agile Quality "Core Set" of metrics are meaningful, practical, and may be automated and applied effectively throughout the Agile development lifecycle. The authors recommend these metrics as the starting point for quality assessment in Agile development efforts.

REFERENCES

[1] K. Beck., M. Beedle., A. Bennekum.,A. Cockburn, W. Cunningham., M. Fowler, et. al., "Manifesto for Agile software development," 2001. Retrieved from http://agilemanifesto.org

[2] [2] G. Booch, "Practical Software metrics for Project Management and Process Improvement," Prentice Hall, 1992.

[3] L. Putnam and W. Myers, Ware. "Five Core Metrics : The Intelligence Behind Successful Software Management," Dorset House Publishing, 2003.

[4] E. Kupiainen, M V. Mäntylä, and J. Itkonen. 2015. "Using Metrics in Agile and Lean Software Development – A Systematic Literature Review of Industrial Studies." Information & Software Technology 62 (June): 143–63.

[5] R. Kurnia, R. Ferdiana and S. Wibirama, "Software Metrics Classification for Agile Scrum Process: A Literature Review," 2018 International Seminar on Research of Information Technology and Intelligent Systems (ISRITI), Yogyakarta, Indonesia, 2018, pp. 174-179.

[6] F. Kišš and B. Rossi, "Agile to Lean Software Development Transformation: A Systematic Literature Review," 2018 Federated Conference on Computer Science and Information Systems (FedCSIS), Poznan, 2018, pp. 969-973.

[7] F. Sambinelli and M. A. F. Borges, "Survey on Strategies to Increase Customer Value in Agile: A Survey of Brazilian Software Industry", 14th Iberian Conference on Information System and Technologies, 2019.

[8] K. V. J. Padmini, H. M. N. Dilum Bandara and I. Perera, "Use of software metrics in Agile software development process," 2015 Moratuwa Engineering Research Conference (MERCon), Moratuwa, 2015, pp. 312-317.

[9] Digital.ai, "14th Annual State of Agile Report," https://stateofAgile.com

[10] VersionOne, "13th Annual State of Agile Report," https://stateofAgile.com

[11] VersionOne, "12th Annual State of Agile Report," https://stateofAgile.com

[12] W. Hayes, S. Miller, M.A. Lapham, E. Wrubel, and T. Chick. "Agile Metrics: Progress Monitoring of Agile Contractors," 2014.

[13] Puppet and DevOps Research and Assessment (DORA), "2017 State of DevOps Report." Retrieved from https://puppet.com/resources/report/2017-state-devops-report

[14] J. Tian, "Software Quality Engineering: Testing, Quality Assurance, and Quantifiable Improvement", John Wiley & Sons, Inc, 2005.

[15] M.S. Rawat and S.K. Dubey, "Software Defect Prediction Models for Quality Improvement: A Literature Study," International Journal of Computer Science, Vol. 9, Issue 5, No. 2, September 2012.

[16] V. Basili, G. Caldiera, and H.D. Rombach, "Goal Question Metric Approach," Encyclopedia of Software Engineering, pp. 528-532, John Wiley & Sons, Inc., 1994

[17] Data.gov, Consumer complaint database, 2020. http://catalog.data.gov/dataset/consumer-complaint-database.

[18] P. Lew, "Agile Testing Metrics: Quality Before Velocity," Software Quality Professional, June 2016.

[19] Department of Defense, "Agile Metrics Guide, Strategic Considerations and Sample Metrics for Agile Development Solutions", Version 1.1, 23 September 2019. Retrieved from https://www.dau.edu/cop/it/DAU%20Sponsored%20Documents/Agile%20Metrics%20v1.1%2020191122.pdf