Assessing an Organization’s Capability to Effectively Implement Its Selected Agile Method(s): An Objectives, Principles, Strategies Approach

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Abstract – Agile methods provide an organization or a team with the flexibility to adopt a selected subset of principles and practices based on their culture, their values, and the types of systems that they develop. More specifically, every organization or team implements a customized agile method, tailored to better accommodate its needs. However, the extent to which a customized method supports the organizational objectives, i.e. the ‘goodness’ of that method, should be demonstrable. Existing agile assessment approaches focus on comparative analyses, or are limited in scope and application. In this research, we present a systematic, comprehensive approach to assessing the ‘goodness’ of agile methods. We examine an agile method based on (1) its adequacy, (2) the capability of the organization to support the adopted principles and practices specified by the method, and (3) the method’s effectiveness. We employ the Objectives, Principles and Strategies (OPS) Framework to guide our assessment process. The Framework (a) specifies objectives of the agile philosophy, (b) identifies principles that support the objectives, (c) designates strategies that implement the principles, (d) defines linkages that relate objectives to principles, and principles to strategies, and (e) prescribes indicators for assessing the extent to which an organization supports the implementation and effectiveness of those strategies. The propagation of indicator values along the linkages provides a multi-level assessment view of the agile method. In this paper, we discuss our assessment approach and substantiation results.

Keywords: Agile Assessment; Adequacy, Capability, Effectiveness; Linkages among Objectives, Principles, and Strategies; Indicators

I. INTRODUCTION

Over the past ten years, we have seen a significant rise in the number of organizations transitioning to agility. However, people in many of these organizations have observed that their agile adoption efforts are not as effective as they should have been, or have often failed to yield the expected results. Agile adoption in an organization is guided by its culture and values. The agile philosophy provides an organization or a team the flexibility to tailor an agile method to better suit its goals and objectives. More often than not, however, the appropriate agile principles, implementation strategies, and practices are not reflected by the customized methods. In effect, these tailored methods may be sub-optimal relative to achieving desired objectives. Also, organizations often lack the supporting environment to effectively employ the adopted practices. As a result, the benefits afforded by agile practices are not fully realized [1]. Hence, we consider it prudent to question the extent to which an agile method or a customized approach satisfies the needs of an organization. In effect, we would question the ‘goodness’ of that approach.

In this paper, we outline a comprehensive agile assessment process that examines people, process, project, and product characteristics within organizations adopting agile methods. Our inclusive approach can be used by organizations to assess their adopted agile method, identify the effective components of their development process, as well as reveal possible inadequacies, and potential enhancements. We also discuss a study that is an application of our approach to measuring the ‘goodness’ of an agile method and the validation of our approach.

Assessing ‘Goodness’

We assess the collective ‘goodness’ of an agile method based on (1) its adequacy, (2) the capability of an organization to provide the supporting environment to implement the method, and (3) the method’s effectiveness. We define adequacy, capability and effectiveness as below (definitions adapted for current context from [2, 3]):

- *Adequacy* - Sufficiency of the method with respect to meeting its stated objectives.
- *Capability* – Ability of an organization to provide an environment supporting the implementation of its adopted method. Such ability is reflected in the characteristics of an organization's people, process and project.
- *Effectiveness* – Producing the intended or expected results. The existence of necessary process artifacts and product characteristics indicate levels of effectiveness.

To guide our assessment process, we provide the Objectives, Principles, and Strategies (OPS) Framework. The OPS Framework is hierarchical and identifies (a) at the first level, objectives of the agile philosophy, (b) principles that govern the achievement of those objectives at the second level, and (c) at the third level, strategies that implement those principles. The core structure of the OPS Framework is illustrated in Figure 1. The Framework includes linkages that signify definitive relationships between identified objectives and principles, and between principles and strategies. In
Figure 1, the arrows between the objectives, principles, and strategies indicate the existence of linkages. These linkages are central to our assessment process. For each strategy, we also define indicators to assess the extent to which an organization supports its implementation and the effectiveness of that strategy.

We assess the adequacy of an agile method by traversing the linkages in a top-down fashion. That is, given the set of objectives enunciated by the agile method, we follow the linkages downward to ensure that the appropriate principles are identified, and that the proper strategies are expressed. In addition to a top-down examination, the capability of an organization to implement its adopted method, and the method’s effectiveness, are assessed using a complementary bottom-up traversal of the linkages. This begins, however, by identifying people, process, project, and product properties that attest to the use of particular strategies. Then, by following the linkages upward from the strategies, we can infer the use of proper principles and the achievement of desired objectives.

Our assessment process is comprehensive. That is, we examine an agile method from three perspectives: adequacy, capability, and effectiveness. However, due to page constraints, we will focus this paper on how to assess the capability of an organization or a team to support the implementation of its adopted agile method(s).

**Substantiating the OPS Framework and Assessment Process**

Currently, our substantiation of the OPS Framework and the assessment process has been a three-pronged process:

- **Substantiating the components of the OPS Framework**: Online survey to gather the feedback from agile practitioners about the core components of the OPS Framework. The results show that the identified objectives, principles, and strategies are consistent with the practitioners’ views of the agile philosophy and development paradigm.
- **Applying the Adequacy assessment process**: Assess the adequacy of three Agile methods – eXtreme Programming (XP), Feature Driven Development (FDD), and Method A which is a tailored instance of XP. Applying our adequacy assessment process, we have determined that (a) XP is better at supporting its objectives than either FDD or Method A, and that (b) Method A is more effective (or adequate) in supporting its objectives than FDD.
- **Substantiating the assessment methodology**: Onsite examination and assessment of agile methods adopted by Organization Z in Blacksburg, Virginia, U.S.A. Based on our observations recorded during the three-month onsite study at Organization Z, we have assessed the adequacy, capability, and the effectiveness of agile methods adopted by four agile teams. Results (see Section VI) show that the OPS based assessments are consistent with the perceptions of Organization Z employees, and the Subject Matter Experts (SMEs).

Preliminary results from our substantiation of the components of the OPS Framework and the adequacy assessment of XP, FDD and Method A can also be found in [4].

This paper is organized as follows. Section II provides background information and briefly discusses some of the existing agile assessment approaches. In Section III, we describe the OPS Framework and our approach to assessing capability. Sections IV, V and VI outline the details of the study at Organization Z and the substantiation results. Our ongoing efforts and future directions are detailed in Section VII. Section VIII summarizes our work.

**II. BACKGROUND**

The agile manifesto states that agile practitioners value “working software over comprehensive documentation” [5]. This value, in conjunction with the agile principle that states, “our highest priority is to satisfy the customer through early and continuous delivery of valuable software” [5], have been the mantra for guiding extant agile assessment procedures and supporting metrics [6]. Consequently, most assessment approaches have focused primarily on the product. For example, the number of bugs reported [7], the number of tests written for maximum code coverage [8], the team velocity that indicates the number of story points delivered during each iteration [6], earned business value [9], etc. are typical product metrics used by agile teams.

While essential to assessing agile methods, product metrics alone are insufficient to support a comprehensive approach to assessment. Software Engineering involves people, process, project, and product (the 4 P’s) [10]. Hence, metrics used in the assessment of agile methods should incorporate characteristics of the 4P’s. The OPS Framework presented in this paper is designed to incorporate the 4P’s. In this section, we review some of the current agile assessment approaches that have motivated our research.
A. Agile Assessment Checklists

As a rule, agile teams are constantly being asked: “How agile are you?” To assess the agility of their process, many teams rely on checklists to determine the presence or absence of practices that are considered “agile”. Some checklists commonly used by agile practitioners are (1) the Nokia Test [11] for Scrum, (2) How Agile Are You (42-Point Test) [12], (3) the Scrum Master Checklist [13], and (4) the Do It Yourself (DIY) Project Process Evaluation Kit [14]. The DIY Project process Evaluation Kit is a generic checklist that can be adapted for use with any agile process. These checklists, however, focus primarily on practices, and largely ignore the underlying agile principles and objectives, as well as the effectiveness of an agile method. Moreover, most of these checklists are tailored to one or more specific agile methods.

B. Agile Adoption Frameworks

Organizations require a tangible approach to adopting agile methods. More specifically, before transitioning to agility, they need specific guidance on which practices are best suited for their requirements. Agile process improvement frameworks such as the Sidky Agile Measurement Index (SAMI) [15, 16] and Agile Adoption and Improvement Model (AAIM) [17] guide an organization’s agile adoption and improvement efforts. Both frameworks describe levels of agility modeled on similar concepts found in the Software Capability Maturity Model (SW CMM) [18] and Capability Maturity Model Integration (CMMI) [19]. That is, a set of practices is to be adopted at successively higher levels in order to be ‘agile’ at that level. The primary disadvantage of these frameworks is that a set of practices is ‘forced’ on an organization at defined levels, which compromises the flexibility offered by agile methods. We do recognize, however, that these approaches are not intended to assess the ‘goodness’ of an agile method, but instead, to guide an organization’s transition toward an agile software development paradigm.

C. Agility Measurement Approaches

After transitioning to agility, most organizations are concerned about how ‘good’ has their agile adoption been - that is, are they achieving identified goals by employing the agile approach? Organizations are also interested in identifying problem areas and issues, and taking adequate steps to solve them. Retrospective meetings at the end of each iteration or release cycle help an organization or team assess their progress, and ‘fine-tune’ their agile approach. In addition to retrospection, teams can employ external consultants or tools to help assess their agile process.

Comparative Agility [20] and the Thoughtworks Agile Assessment survey [21, 22] are two independent agile assessment tools that can be used by agile practitioners to assess the agility of their adopted method. These tools are intended to assess the extent to which an organization or a team is successful in adopting and using agile methods. Close examination, however, reveals that these tools help determine only the presence or absence of practices in an organization, and not degree to which those practices are used. The Agile Usage Model [23] has been designed to measure the post-implementation effectiveness of agile methods. Agile effectiveness is measured based on productivity in and quality of the development process, and customer satisfaction [23]. Although this approach recognizes that existing agile assessment processes do not assess the effectiveness of agile methods, and attempts to mitigate this problem, it does not assess the extent to which an adopted agile method helps achieve organizational objectives or the degree to which the organization is capable of supporting the implementation of that method.

Summary

The checklists, the agile process improvement frameworks, and the agile assessment approaches discussed in this section are all distinct tools. Individually, each assesses in part, different aspects of an agile method. They are, however, somewhat limited in scope and application. Hence, there is a need for a more comprehensive approach to assessing agile methods. We present three criteria or perspectives for assessing the ‘goodness’ of agile methods, namely adequacy, capability, and effectiveness. The OPS Framework guides assessment based on three perspectives, which combine to provide a more comprehensive approach. We discuss the OPS Framework, its components, and our approach to assessing capability in the next section.

III. THE OPS FRAMEWORK AND ASSESSMENT METHODOLOGY

We have designed the Objectives Principles and Strategies (OPS) Framework to assess the collective ‘goodness’ (adequacy, capability, and effectiveness) of agile methods. In this section, we present the core components of the OPS Framework and (because of page limitations) our approach to assessing only the capability of organizations to support the implementation of their adopted agile methods.

A. The OPS Framework

The agile manifesto provides four focal values and twelve principles that define the agile philosophy. Using the manifesto as a guide, we have evolved the OPS Framework (see Figure 1) to reflect the viewpoint that each agile method should

- strive to achieve an enunciated set of desirable objectives,
- embrace process principles that support the achievement of those objectives, and
- employ accepted agile strategies to implement those principles.

In addition to the objectives, principles, and strategies, the Framework also identifies definitive linkages that establish the relationships between these core components. The linkages are fundamental to our assessment approach. They bind specific
The OPS Framework identifies five objectives that are reflective of the agile philosophy, nine principles that govern the development process supporting the achievement of those objectives, and 17 strategies that help implement those principles (see Figure 2).

An objective is something aimed at or striven for [3]. We contend that each agile method embodies a set of objectives, which are supported by a set of underlying principles. The OPS Framework identifies objectives that are reflective of the agile philosophy (Figure 2). These objectives provide a more definitive description of the values articulated in the manifesto. They are common themes that underlie agile software development methods.

**Principles** govern the process by which one achieves the desired objectives [3]. The agile manifesto presents twelve principles that underlie the agile software development process. To a large extent, the principles outlined in the manifesto overlap to preserve the different styles offered by the various agile methods. However, in order to provide a more concise view of the agile software development paradigm, the OPS Framework embodies a complementary set of nine principles (Figure 2).

**Strategies** are implementations of the principles, i.e., they are ‘plans of action’. Agile methods provide practitioners with strategies, which are more tangible concepts, to help implement the touted principles. The OPS Framework identifies 17 such accepted strategies. Figure 2 depicts the set of objectives, principles, and strategies that are defined by the OPS Framework and reflective of the agile philosophy. We recognize, however, that the list of strategies shown in Figure 2 is neither necessarily exhaustive nor complete; we do expect that it will change over time.

We have derived the objectives, principles, and strategies based on our understanding of the agile philosophy, our experiences and observations, existing literature [5] [24-26] [17, 27] [28], and interactions with industry experts. The substantiation results published in [4] indicate that the objectives, principles, and strategies, which we have identified, are consistent with practitioners’ views of the agile philosophy, its values, principles, and effective strategies.

**Linkages**

Because the OPS Framework is intended to support an assessment process, it also defines a set of linkages that (a) connect objectives to supporting principles and (b) bind principles to strategies used to implement them. These linkages provide an assessment path binding the use of process principles to the achievement of stated objectives, and the use of strategies to the implementation of specific principles.

The linkages are fundamental to the assessment process. Consider, for example, ‘Maximal Adaptability’, an objective of agility identified by the OPS Framework. Our working definition for ‘Maximal Adaptability’ is *maintaining (a) the flexibility to support change and (b) the freedom to choose among appropriate strategies*. We have substantiated through the work of others that one of the principles which supports the attainment of Maximal Adaptability is ‘Accommodating Change’. Subsequently, as shown in Figure 3, there exists a linkage between the objective ‘Maximal Adaptability’ and the principle of ‘Accommodating Change.’ To help implement this principle, we have also identified (or linked) a corresponding set of appropriate strategies (also shown in Figure 3), they are *evolutionary requirements, iterative progression, incremental development, continuous feedback, and retrospection.*
Although linkages between the objectives, principles, and strategies have not been explicitly enunciated in the existing literature, our research efforts have enabled us to definitively identify, document, and substantiate their existence [29] viz-a-viz independent sources.

**Indicators**

We define strategies at the lowest level of the OPS framework; our assessment of capability and effectiveness is initiated at this level. To determine if the organization has the supporting environment to effectively implement a strategy, or if the strategy has produced the intended results, we measure properties that attest to the existence or use of that strategy. These properties are observable characteristics of the people, process, project, product, and environment, and are specific to each strategy. Because of this intentionally-formed and undeniable relationship, we consider each strategy and property pair to be an indicator.

Indicators are directly measurable and are tailored to assess the strategies. Currently, the OPS Framework identifies 80 indicators tied to the 17 strategies.

<table>
<thead>
<tr>
<th>Property: Minimal Big Requirements Up Front and Big Design Up Front (Process)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is it expected</td>
</tr>
<tr>
<td>• That only the high level features be identified upfront?</td>
</tr>
<tr>
<td>• An evolutionary approach to architecting the system be followed as opposed to creating the architecture upfront?</td>
</tr>
</tbody>
</table>

**Property: Just In Time Refinement (Process)**

Is it expected that the requirements be determined and refined just-in-time?

**Property: Requirements Reprioritization (Process Artifacts)**

Are the features reprioritized as and when new features are identified?

Consider the strategy: Evolutionary Requirements. Our working definition for this strategy is “Allow the features/requirements to evolve over the development lifecycle”. By analyzing the mechanics of implementation for Evolutionary Requirements, we identify the observable properties given in Table 1. Associated with each property, is a set of questions that help measure the extent to which the property is supported or achieved. These questions are separate measures of the indicators, i.e., the (strategy, property) pairs. For each question, the corresponding measurement scale can be subjective, objective, binary, or range values. In Table 1, the measurement scales used are binary and subjective.

**B. Assessment Methodology**

Using the OPS Framework described above, we assess the ‘goodness’ of an agile method by assessing (a) its adequacy, (b) the capability of the organization to provide the supporting environment to implement the method, and (c) the effectiveness of that method. As mentioned previously, we focus this paper only on the capability component of our assessment process. For more information about assessing adequacy and effectiveness, see [4, 29, 30]. In this sub-section, we only describe our capability assessment process.

We define the capability of an organization as its ability to provide the supporting environment conducive to the implementation of an agile method. In assessing the capability of an organization, we focus on the characteristics of its *internal environment*. The internal environment of an organization is primarily composed of its resources and competencies. More specifically, in an organization, the characteristics of its people, the process that it adopts, its environment, and its projects are reflective of the characteristics of its internal environment. Hence, we use observable properties of the environment, people, process and project in our assessment of capability. For example, the presence of open physical environments in an organization is *indicative* of the organization’s capability to foster face-to-face stakeholder communication and collaboration at any given time.

As discussed previously, a set of questions is associated with each indicator to measure that indicator (see Table 1). The complete set of the objectives, principles, strategies, properties, and questions with the linkages and associations among them, form a multi-level hierarchical structure that we refer to as the *indicator hierarchy*.

Guided by the indicator hierarchy, we initiate the capability assessment by seeking answers to the questions linked to each property. Those answers are recorded as numeric values using a pre-defined scale. A property value is then computed as a weighted average of its linked scores. In turn, values for each strategy are computed as an average of its associated property values. Following the same weighted average process, values are propagated from the strategies level, through the principles level, and up to the objectives level. For the computations, we have assigned equal weights to all the elements. Using this process, we have assessed the capability of four agile teams in Organization Z.

**IV. THE STUDY AT ORGANIZATION Z**

We recognize that in order to effectively substantiate our assessment process, and determine the viability of our approach, the OPS Framework and assessment methodology must be applied within an organization that adopts agile methods. We worked with Organization Z, which is located in Blacksburg, Virginia to substantiate our work. Organization Z delivers web-based applications to businesses around the world. Started in the late 1990’s, it has since grown to serve an extensive customer base. The company employs about 4500 (full-time + part-time) personnel.

**A. Study Objectives and Benefits**

This study has been designed to be mutually beneficial to Organization Z and the authors. It provides Organization Z with insights concerning its approach to Agile Software
We answer the questions, assign scores based on the scale given in Table 2, compute weighted averages, and finally propagate those scores to the higher levels in the indicator hierarchy. At the intermediate and root levels of the OPS hierarchy for Capability, we compute a score on a five-point scale. The final scores obtained at each hierarchical level are interpreted using the scale given in Table 3 below:

<table>
<thead>
<tr>
<th>Score Range</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5 – 5.0</td>
<td>Maximal</td>
</tr>
<tr>
<td>3.5 – 4.4</td>
<td>Considerable</td>
</tr>
<tr>
<td>2.5 – 3.4</td>
<td>Moderate</td>
</tr>
<tr>
<td>1.5 – 2.4</td>
<td>Somewhat</td>
</tr>
<tr>
<td>1 – 1.4</td>
<td>Marginal</td>
</tr>
</tbody>
</table>

For example, if the Capability score for Team X is 3 at the root level, we can conclude that the team is Moderately Capable of supporting / implementing the strategies, principles, and objectives of its adopted agile method.

B. Scoring Sources

In this paper, we include three sets of scores. In addition to the OPS-based scoring, we include scores assigned by Subject Matter Experts (SMEs) and Organization Z personnel. The authors of this paper are the SMEs. These additional scores are recorded for both capability and effectiveness. This section provides an overview of each of the three scoring sources.

Scores derived from OPS Computations

The scores derived from the OPS computations are indicator based (see Section III.B). A set of questions is associated with each indicator to help measure the associated OPS strategy. We then propagate the scores from the strategies level to the objectives. Recall that at each level of the hierarchy, we compute the weighted averages of the scores at the level below it. In our computations, all the linkages and associations in the OPS Framework are assigned equal weights. The OPS-based scores are labeled “Computed Scores” in the Results section.

Scores determined by Subject Matter Experts

As mentioned previously, the authors of this paper are the SMEs. Examining the objectives, principles, and strategies from a capability perspective, we (SMEs) assigned scores for
the above-mentioned three components. These scores, labeled “Expert Scores”, were determined independently of the scores computed using the indicator hierarchy and those elicited from the Organization Z personnel.

For each team, the SMEs have determined the extent to which the organization provides resources, expertise, and appropriate knowledge-base to that team to support the (a) implementation of strategies, (b) adherence to principles, and (c) achievement of objectives. The expert scores are assigned using the scale given in Table 4 before analyzing the gathered data and computing the OPS-based scores.

We have included these scores when presenting the results in Section VI. In most cases, we found that (a) the differences between the computed scores and our expert scores are negligible, and (b) the two sets of scores follow similar trends.

Table 4. Scale used for assigning Expert scores

<table>
<thead>
<tr>
<th>Answer</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximally</td>
<td>5</td>
</tr>
<tr>
<td>Considerably</td>
<td>4</td>
</tr>
<tr>
<td>Moderately</td>
<td>3</td>
</tr>
<tr>
<td>Somewhat</td>
<td>2</td>
</tr>
<tr>
<td>Marginally</td>
<td>1</td>
</tr>
</tbody>
</table>

Scores elicited from Organization Z personnel

As mentioned previously, during the course of our on-site study, we administered surveys about perceptions of the current processes. We also interviewed key personnel from the four teams. From the surveys and interviews, we have gathered information about the capability of the teams to implement the strategies. Based on our discussions, interviews, and observations of the development processes, we have inferred the capability of the teams to support the implementation of each strategy. We have used the scale shown in Table 4 to record the scores.

The objectives and the principles are at higher levels of abstraction than the strategies. Consequently, it is difficult for the practitioners to assign scores for those components. Strategies, on the other hand, are more tangible concepts that are better understood by practitioners. Hence, we primarily focused on strategies when eliciting scores from Organization Z personnel. They are labeled “Organization Z scores – numeric” in the results section below.

VI. RESULTS

People are valued more than the processes and tools.
- They work towards maximizing value to all the stakeholders involved.
- The teams are adaptable to varying degrees with respect to accommodating changes to requirements, fine-tuning their process, work estimates, schedules, etc.
- The organization provides an open physical environment.
- Refactoring is strongly encouraged. However, they find it difficult to refactor legacy code.
- Open communication is encouraged.
- All the teams hold a stand-up meeting everyday.
- Cross team collaboration is encouraged.
- The developers work in pairs on an as needed basis.
- The teams manage risk by deploying software in stages.

In the remainder of this sub-section, we present detailed capability assessment results for Team A; because of page constraints, we present a summary of the results for the other three teams.

Prior to assessing the capability of these teams, we assessed the adequacy of their adopted agile methods. Following the adequacy assessment process outlined in [4, 29, 30], we found that all four agile methods were deemed adequate with respect to achieving their stated objectives.

A. Team A – Capability Assessment

Team A develops financial applications that are intended for internal use. It has adopted a Scrum-like process. Software is built iteratively and incrementally. Each iteration lasts for two weeks. More often than not, at the end of an iteration, the team deploys a software increment. Retrospective meetings are held at the end of each iteration. Team A schedules one release planning meeting to ‘kick-off’ each project. During this meeting, they identify the scope of the project, the release milestones, and anticipated delivery dates. Though this requires considerable amount of work to be completed upfront, this helps the team understand the project vision, scope and requirements. The team is self-managing. Table 5 outlines Team A’s profile.

Table 5. Team Profile – Team A

<table>
<thead>
<tr>
<th>Team Size</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roles</td>
<td>Scrum Master (1)</td>
</tr>
<tr>
<td></td>
<td>Product Owner (1)</td>
</tr>
<tr>
<td></td>
<td>Development Manager (1)</td>
</tr>
<tr>
<td></td>
<td>Developers (5)</td>
</tr>
<tr>
<td></td>
<td>Quality Engineer (1)</td>
</tr>
<tr>
<td>Development Process</td>
<td>Scrum</td>
</tr>
<tr>
<td>Velocity</td>
<td>Currently, they have been able to deliver about 30 story points in two weeks. They are still trying to establish their velocity.</td>
</tr>
<tr>
<td>Iteration length</td>
<td>2 weeks.</td>
</tr>
</tbody>
</table>
Based on our OPS observations and assessments, the overall Capability score for Team A is 4.227. Using Table 3 to interpret this score, the value falls in the “Considerable” range (3.5 – 4.4). Hence, Team A is considerably capable of implementing its adopted agile method.

**A Strategies Level Assessment**

Figure 4 shows the Capability Assessment results for the strategies. At the strategies level, we present three sets of scores – Computed OPS, Expert, and Organization Z. As shown in Figure 4, all three sets of scores show similar trends.

This team identifies all the requirements upfront during their release planning meeting. By design, the features and stories are minimally allowed to evolve over time. Hence, the scores for the strategy Evolutionary Requirements are lower (see Figure 4). Support for Test-first Development and Continuous Integration is marginal. From Figure 4, we observe that all three sets of scores are lower for those strategies as well.

To validate the computed OPS values at the strategies level, we have determined the Pearson correlation coefficient between the sets of values for (a) the Computed OPS and SMEs, and (b) the Computed OPS and Organization Z.

**Pearson Correlation At the Strategies Level**

**Computed OPS and Expert:**

\[ r = 0.88427, \quad N = 16, \quad p-value = 0.00001, \quad \text{two-tails} \]

**Computed OPS and Organization Z:**

\[ r = 0.86828, \quad N = 16, \quad p-value = 0.00001, \quad \text{two-tails} \]

In both cases given above, the correlation is positive. Additionally, the results are statistically significant. Hence, we can conclude that the similarity in trends exhibited by the three sets of values is not by random chance. That is, the observed correlation between the Computed and Expert scores, and the Computed and Organization Z scores is significant, and not a chance occurrence.

**A Principles Level Assessment**

As mentioned previously, we have elicited scores from Organization Z personnel only for the strategies. Hence, for both principles and objectives, only the computed and the expert scores are presented.

As shown in Figure 5, the Computed and Expert scores predominantly follow similar trends. Recall that all the linkages in the OPS Framework have been assigned equal weights. In Figure 5, we observe that there is a substantial difference in the two sets of scores for the principle:

**Accommodating Change:** With Team A, we have observed that the development team is minimally receptive to accommodating changes to the requirements. The Expert score weighs this aspect more with respect to the principle Accommodating Change. Hence, the difference in the two sets of scores.

**Pearson Correlation At the Principles Level**

**Computed OPS and Expert Values**

\[ r = 0.36664, \quad N = 8, \quad p-value = 0.37167, \quad \text{two-tails} \]

From the Pearson’s correlation coefficient for the two sets of scores, we cannot conclude that the results are statistically significant. However, the trend lines are similar and, with the exception noted above, the differences in the two sets of scores are negligible.

We conjecture that our inability to prove statistical significance stems from the fact that we initially assume equal weights, and therefore, as we propagate the scores up the
indicator hierarchy, the impact of the individual scores is reduced.

![Capability Assessment: Principles](image)

**Figure 5. Team A - Capability Assessment: Principles**

**An Objectives Level Assessment**

Figure 6 depicts the assessment results with respect to the objectives. Similar to the results obtained for the principles, we observe differences in the Computed and Expert scores. According to the Pearson Correlation factors shown below, the r and p values do not indicate any significant correlation. We conjecture that, as with the values assessed for principles, the significance and distinction of the contributing indicator values were minimized as each individual value was aggregated upward in the OPS hierarchy. That “minimization effect” was not a factor in assigning the SME scores.

<table>
<thead>
<tr>
<th>Pearson Correlation At the Objectives Level</th>
<th>Computed OPS and Expert Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>r</strong> = 0.21885, <strong>N</strong> = 5, <strong>p-value</strong> = 0.72359, two-tails</td>
<td></td>
</tr>
</tbody>
</table>

In summary, at the strategies level, the sets of scores exhibit predominantly similar trends whose correlations among them are statistically significant. We conjecture that the differences in scores and trends at the principles and objectives levels can be attributed to the lack of weighted linkages in the OPS Framework and the “minimization effect” as values are propagated up the indicator hierarchy. Based on the insights gained from the on-site study at Organization Z, we plan to refine the OPS Framework accordingly. As a first step, we envision assigning weights to the linkages and associations in the OPS Framework.

**B. Capability Assessment results for Teams B, C, and D**

Due to page constraints, we are unable to fully present the assessment results for the remaining three teams. In this subsection, we summarize the assessment results for Teams B, C, and D. All three teams focused primarily on building web-based applications that are intended for external customers and users.

Teams B and C follow Continuous Flow and Kanban, respectively. By design, Continuous Flow and Kanban minimally advocate the concepts of building software iteratively and retrospection. Hence, the strategies Iterative Progression and Retrospection have been excluded in the capability assessment of Teams B and C. Team D’s process is Scrum-like and is almost identical to that of Team A. The iterations last one week. Table 6 below shows the computed overall Capability scores for Teams B, C, and D.

![Capability Assessment: Objectives](image)

**Figure 6. Team A - Capability Assessment: Objectives**

<table>
<thead>
<tr>
<th>Team</th>
<th>Capability Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>4.395</td>
</tr>
<tr>
<td>C</td>
<td>4.214</td>
</tr>
<tr>
<td>D</td>
<td>4.257</td>
</tr>
</tbody>
</table>

From Table 4, we see that the scores for all three teams given in Table 6, fall in the ‘Considerable’ range (3.5 – 4.4). That is, Teams B, C, and D are considerably capable of implementing their adopted agile methods.

Like Team A, all paired scores at all OPS levels for Teams B, C and D follow a similar trend line. Again, similar to Team A, the scores computed at the strategies level for each team are found to have statistically significant correlations.

**C. Summary**

Based on the OPS computations, all the four teams are ‘Considerably’ capable of supporting the implementation of their adopted agile methods. Predominantly, all three sets of scores (computed, expert, and Organization Z) show similar trends. Though the numeric values are not identical, the differences in the values are more often than not, negligible. The scores obtained at the strategies level are statistically
significant. With respect to the principles, and objectives, though the observed correlation is positive in most cases, we are unable to conclude that the results are statistically significant. We conjecture that this can be attributed, at least in part, to the fact that the computed OPS based scores are not weighted, and hence, as the scores are propagated up the OPS hierarchy, the impact of the scores at the strategies level is minimized.

VII. FUTURE WORK

In addition to assessing the capability of the four agile teams at Organization Z, we have also assessed the effectiveness of the methods adopted by those teams. Our more immediate goals are to elicit additional feedback concerning the computed scores for Capability and Effectiveness from Organization Z personnel. The intent is to further validate our work.

Assessing effectiveness is a longitudinal process. Since the duration of the on-site study at Organization Z was only three months, our effectiveness assessment results are preliminary. A more long-term goal is also to design and implement a longitudinal study to validate the OPS Framework and its assessment process as it relates to evaluating the effectiveness of an instantiated agile method. Also, we plan to refine the OPS Framework and assessment methodology based on our findings and feedback gathered at Organization Z.

VIII. CONCLUSIONS

Our research is motivated by the need for a comprehensive approach to assessing the ‘goodness’ of agile methods. We assess ‘goodness’ by examining (a) the adequacy of a method, (b) the capability of an organization to provide the supporting environment for implementing the method, and (c) the effectiveness of that method. To guide our assessment, we present the OPS Framework. The Framework identifies objectives, principles, and strategies. Definitive linkages between the components have also been established to support the assessment process. We recognize that the Framework must evolve based on future research findings. Currently, we have substantiated the components of the OPS Framework and our approach to assessing the ‘goodness’ of agile methods. We have also facilitated a study of Organization Z, located at Blacksburg to assess the ‘goodness’ of their agile methods and to compare the findings with the perceived reality. The results attest to the validity of our work.

REFERENCES