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# **Performance Workshops and Data Analysis**

Integrated Project/Program Management (IP2M)  
Maturity and Environment Total Risk Rating (METRR)  
using Earned Value Management System (EVMS)

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## **Report No. 5, Annex A**

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**PERFORMANCE WORKSHOPS AND DATA ANALYSIS  
INTEGRATED PROJECT/PROGRAM MANAGEMENT (IP2M)  
MATURITY AND ENVIRONMENT TOTAL RISK RATING (METRR)  
USING EARNED VALUE MANAGEMENT SYSTEM (EVMS)**

**Report No. 5, Annex A**

by

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One of the Deliverables for the U.S. Department of Energy (DOE)-funded Research  
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## **Executive Summary**

The Integrated Project/Program Management (IP2M) Maturity and Environment Total Risk Rating (METRR) is a novel assessment mechanism developed as part of a DOE-sponsored joint research study led by ASU and representing 19 government, industry, and academic organizations. The research team members are 41 individuals with diverse backgrounds including owners, contractors, consultants, academics, and so forth. The list of the research team members is provided at the end of this document. The tool assesses a spectrum of EVMS maturity and environment issues centered around the EVMS Guidelines in the EIA748-D, while also referencing the Project Management Institute's American National Standards Institute (ANSI) standard for EVM (2019) and International Organization for Standardization (ISO) 21508:2018 guidance, and others. By using the IP2M METRR (pronounced "IP2M meter") to assess both the maturity and environment of an EVMS, project leaders and personnel can understand the efficacy of that EVMS to support integrated project and program management, while also identifying opportunities for improvement. The goal of performing this assessment is to assure project and program participants have accurate, timely, and reliable information to manage their work, leading to more successful outcomes.

This research report summarizes the efforts of the research team to test the IP2M METRR on completed projects and programs. It builds on prior research findings that showed EVMS maturity attributes and environment factors can be defined and measured quantitatively with consistent and weighted score sheets. The main hypothesis in this report focuses on the impact of EVMS maturity and environment on project performance. The authors hosted a series of four workshops where 31 industry professionals representing 23 unique organizations (listed in Appendix A), tested the IP2M METRR tool on 35 projects and programs worth \$21.8 Billion USD in installed cost. The participants evaluated 56 maturity attributes and 27 environment factors as applied to each of their reference projects or programs. The collected data was statistically analyzed and used to evaluate the efficacy of the IP2M METRR, and measure the impact of EVMS maturity and environment on project performance. The IP2M METRR was also tested by the authors and research team members on eight additional in-progress projects and programs.

The results validated that the IP2M METRR is an effective and practical tool that has met its original purpose, being capable of measuring the maturity and environment of earned value management systems in an integrated project and program management setting. Also, the IP2M METRR provided a capability to tailor EVMS according to a project or program's specific requirements and needs. This is in contrast to current more traditional industry practices where EVMS is often implemented in a "one size fits all" format. The results also showed statistically significant differences related to both maturity and environment, in terms of cost growth, cost performance index, compliance with EIA-748-D, meeting project objectives and business drivers, and customer satisfaction. These differences were found between the projects and programs that were implementing an effective EVMS versus those that were less committed to EVMS. Moreover, EVMS environment and maturity were found to be strongly and positively correlated with one another, showing that EVMS maturity is a function of environment.

This novel model and framework represents a major paradigm shift from legacy EVMS practices. The IP2M METRR moves away from binary compliance determinations focused entirely on “guidelines”, to a new continuous framework that is on a scale of zero to 1,000 across two different dimensions, centered around management processes and environment. It provides a more useful definition of an EVMS for integrated project/program management and allows to identify gaps and paths forward, as well as associated performance implications.

This document is part of the deliverables for the research project sponsored by the DOE and has been approved by the research steering committee and Arizona State University (ASU) joint team.

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## 1. Background

The *Integrated Project/Program Management (IP2M) Maturity and Environment Total Risk Rating (METRR) using Earned Value Management Systems (EVMS)*, is an assessment mechanism developed as part of a DOE-sponsored Joint Research Study led by the Arizona State University (ASU). The tool can help project/program teams assess the maturity and environment of an EVMS application.

This research report summarizes the efforts of the research team to test the IP2M METRR tool and associated performance impacts. The authors hosted a series of four separate virtual industry workshops where 31 industry professionals evaluated the EVMS maturity and environment of their projects and programs. The list of the 23 unique organizations that these professionals represented are given in Appendix A. The workshop participants provided performance data as elaborated in this report. The data was statistically analyzed and used to assess the impact of both EVMS maturity and environment on project or program performance.

Raw data used to calculate the results shown later in this report, are available upon reasonable request.

The IP2M METRR represents a methodology to evaluate the EVMS maturity and EVMS environment, in two separate but complementary assessments.

The EVMS maturity assessment consists of indicating the maturity level of 56 maturity attributes that make up the ten EVMS sub-processes (organizing, planning and scheduling, budgeting and work authorization, accounting considerations, indirect cost management, analysis and management reporting, change control, material management, subcontract management, and risk management). Each of the attributes can be assessed from level “1” which means that work on this attribute has not yet started, all the way to level “5” which means best-in-class. A template structure of each EVMS maturity attribute that was developed by the research team is shown in Figure 1.

SUB-PROCESS NAME	Maturity Level				
	LOW		MEDIUM		HIGH
	1	2	3	4	5
<b>Attribute name</b> Attribute description.  Items to consider when evaluating this attribute across the five levels: <input type="checkbox"/> Item  The attribute should be integrated with the other specified EVMS sub-processes mentioned here.  <i>References: References to guidelines and standards used to draft the attribute description and the detailed narratives.</i>	<b>Not yet started.</b>	<b>Major gaps. High-level description of level 2.</b>  Detailed narrative of maturity level 2 for this attribute.	<b>Minor gaps. High-level description of level 3.</b>  Detailed narrative of maturity level 3 for this attribute.	<b>No gaps. High-level description of level 4.</b>  Detailed narrative of maturity level 4 for this attribute. Note: at level 4, attribute is compliant with typical standards and guidelines.	<b>Best in class. High-level description of level 5.</b>  Detailed narrative of maturity level 5 for this attribute (above and beyond compliance).

*Figure 1 Template Layout of Each Maturity Attribute*

Figure 1 highlights the fact that each attribute’s maturity can be gauged along five maturity levels, with lower levels indicating there are gaps in the maturity of this attribute. The



maturity levels are additive, meaning a higher maturity level indicates a more mature attribute. When developing this scalable and multi-level maturity assessment method, maturity level “4” was decided by the research team to represent compliance to EVMS guidelines and standards such as those indicated by the EIA748 (NDIA 2020; NDIA 2018; SAE 2019), the Project Management Institute’s American National Standards Institute (ANSI) standard for EVM (PMI 2019) and International Organization for Standardization (ISO) 21508:2018 guidance (ISO 2018). The definition of compliance in this research and report is “The characteristics of an EVMS that ensures the intent of the EIA-748 EVMS guidelines is embodied in the integrated processes and sub-processes of a contractor’s methods of operation that generate accurate and auditable project/program performance data.” (NDIA 2018). Level “4”, representing compliance, is a particular maturity level that provides reliable benchmarking and a common point of comparison versus the lower levels when evaluating each of the maturity attributes applied to a project or a program. Level “5” is an opportunity to go above and beyond compliance for this particular attribute, to surpass a compliance level and be considered “Best in class”. The attribute descriptions were drafted by the research team using collected guidelines and standards that pertain EVMS from the literature (e.g.; DoD 2020; GAO 2020; McGregor 2019; PMI 2019; SAE 2019; DOE 2019; DOE 2018; ISO 2018; NDIA 2019a; NDIA 2019b; NDIA 2018; DoD 2015; DOE 2015; GAO 2015; DoD 2012; OMB M-07-24 2007) and specified in each maturity attribute table under “References”.

The current traditional approach to EVMS implementation leans towards a “one size fits all” system and a binary “Yes or No” approach in EVMS compliance assessment. IP2M METRR shifts this practice in the following ways. First, it allows the user to skip certain attributes when an attribute is not applicable; this approach in IP2M METRR only eliminates certain characteristics of the EVMS, rather than a complete guideline. As such, the IP2M METRR allows EVMS to be tailored based on the project or program’s specific context, requirements, and needs (Bergerud 2017; Gustavus and Hunter 2012; Frahm 2012). Second, rather than a “yes” or “no” compliance approach, it allows the user to locate the attribute into a scale towards “compliance” providing the flexibility of highlighting the gaps in compliance (i.e., levels “1”, “2”, or “3”) for each individual attribute. Third, IP2M METRR distinguishes those attributes that go above and beyond compliance, to recognize success.

The selection of the maturity level for each attribute gives that attribute’s specific maturity score, with each attribute assigned a different weight depending on its relative importance versus the other attributes. The completion of the EVMS maturity assessment across all the maturity attributes results in an overall EVMS maturity raw score (the summation of all individual maturity attribute scores) with a possible maximum score of 1,000 points; a higher score indicates higher maturity. In the case where not all of the 56 maturity attributes are applicable, the overall maturity raw score is adjusted. Further details on this adjustment are given later in this report. Further details on the impact of EVMS maturity on project and program performance are given in research report #4 (Aramali et al. 2022a).

The EVMS environment assessment consists of assessing the rating level of 27 environment factors grouped under four environment categories (Culture, People, Practices, Resources). The rating level of each factor can be assessed as *Not Acceptable*, *Needs Improvement*, *Meets*

*Some, Meets Most* or finally *High Performing*. Like the EVMS maturity assessment, the completion of the EVMS environment assessment results into a single EVMS environment score with a maximum of 1,000 possible point; a higher score meaning a better environment for EVMS; each factor is assigned a different weight depending on its relative importance versus the other factors. Further details on the impact of EVMS environment on project and program performance are given in research report #3 (Aramali et al. 2022b).

The list of the 56 maturity attributes and the 27 environment factors is given in Appendix B. Further guidance on how the IP2M METRR can be employed is given in a separate report (Gibson et al. 2022a).

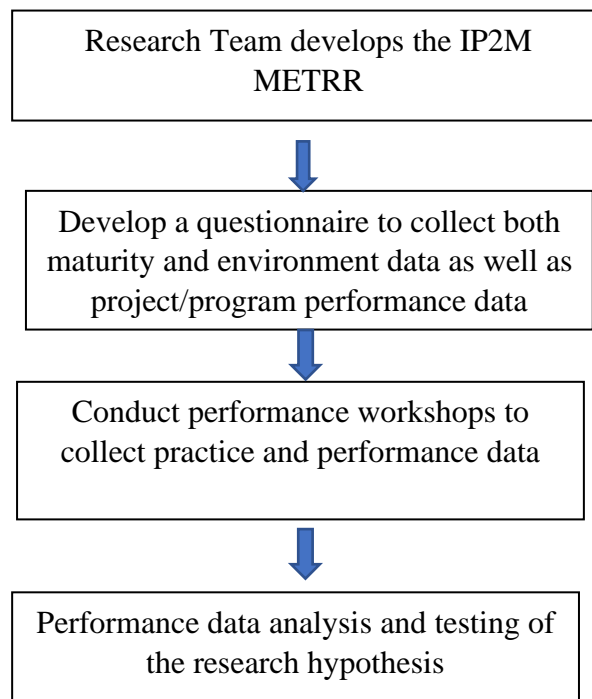
This report summarizes the efforts conducted on the application of the IP2M METRR on 35 projects and programs, with all details shown in the next chapters.

## 2. Objective and Methodology

This report provides information on the testing of the IP2M METRR by providing statistical comparisons of the maturity level of EVMS attributes and the rating level of EVMS environment factors versus their project's or program's performance metrics. This analysis was applied to a collected sample of 35 completed projects and programs worth \$21.8 Billion USD in installed cost. The data from these completed projects was captured after the fact. As such, this report provides quantified substantiation of the impact of EVMS maturity and environment on project performance, at least for this sample.

The research hypothesis tested in this report is: “*Higher maturity and environment scores are positively related to project performance.*” To address this hypothesis, workshops were conducted to collect information from completed projects and programs, and the collected data was analyzed. The overall methodology applied for these analyses is shown next.

Figure 2 provides flow diagram of the research methodology, providing a visual representation of the steps undertaken by the authors.



*Figure 2 Research Methodology Flow Chart*

As mentioned previously, the IP2M METRR tool includes two main sections: EVMS maturity and EVMS environment. The first step undertaken was to develop both of these sections of the IP2M METRR tool. Further details on the IP2M METRR tool development, with its two sections of maturity and environment assessment with their corresponding scoring sheets (weights), as shown in Figure 2, are discussed in separate research reports (Aramali et al. 2022c; Aramali et al. 2022d).

In summary, the authors in conjunction with the research team and using an extensive literature review, developed a set of 56 maturity attributes across ten EVMS sub-processes

to assess the EVMS maturity (the ten sub-processes are: organizing, planning and scheduling, budgeting and work authorization, accounting considerations, indirect cost management, analysis and management reporting, change control, material management, subcontract management, and risk management). The authors then hosted a series of four industry workshops where 56 industry professionals, representing 32 unique organizations, evaluated the maturity attribute names, descriptions, and the narratives of the different maturity levels. The workshop participants provided comments, and weighted (prioritized) the maturity attributes and sub-processes as elaborated in the separate research report (Aramali et al., 2022d). The authors and the research team addressed the comments, and the collected data was statistically analyzed and used to develop weighted score sheets as a mechanism for maturity assessment. An excerpt of the resulting scoresheets is presented in Figure 3, corresponding to sub-process I (Subcontract Management), that has a total of three attributes, out of 56 attributes. For example, the weight/score corresponding to the maturity level 3 of the attribute *I.1 Subcontract Identification and Requirements Flow Down* is 9, reference to Figure 3.

SUB-PROCESS I: SUBCONTRACT MANAGEMENT							
Attribute	Maturity Level					Comments	
	N/A	1	2	3	4		5
<b>I.1. Subcontract Identification and Requirements Flow Down</b>		0	5	9	14	19	
<b>I.2. Subcontractor Integration and Analysis</b>		0	6	11	17	22	
<b>I.3. Subcontract Oversight</b>		0	5	9	14	19	
<b>Column Totals</b>		<b>0</b>	<b>16</b>	<b>29</b>	<b>45</b>	<b>60</b>	

*Figure 3 Excerpt from the Maturity Framework Scoresheets*

In a similar fashion, the authors in conjunction with the research team and an extensive literature review, developed a set of 33 factors to assess the EVMS environment grouped in four categories (Culture, People, Practices, Resources). The authors then hosted a series of four industry workshops where 47 industry professionals, representing 24 unique organizations, evaluated the environment factor names and descriptions and helped narrow the list to 27 most important factors that frame the environment within which an EVMS operates. The workshop participants provided comments, and weighted (ranked) the environment factors and categories as elaborated in this report. The collected data was statistically analyzed and used to develop weighted score sheets as a mechanism for environment assessment. An excerpt of the resulting scoresheets is presented in Figure 4, corresponding to Culture category, that has a total of seven factors, out of 27 factors. For example, the weight/score corresponding to the “Meets Some” rating level of the factor *1a contractor organization is supportive and committed* is 39, reference to Figure 4.

1. <b>Culture:</b>					
Factors for Review	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
1a. The <b>contractor organization is supportive and committed</b> to EVMS implementation, including making the necessary investments for regular maintenance and self-governance.	0	19	39	58	78
1b. The project/program <b>culture fosters trust, honesty, transparency, communication, and shared values</b> across functions.	0	15	30	45	60
1c. The <b>customer organization is supportive and committed</b> to the implementation and use of EVMS.	0	14	27	41	54
1d. Project/program leaders make <b>timely and transparent decisions</b> informed by the EVMS.	0	12	24	36	48
1e. The project/program <b>leadership effectively manages and controls change</b> using EVMS, including corrective actions and continuous improvement.	0	8	16	24	32
1f. <b>Effective teamwork exists</b> , and team members are working synergistically toward common project/program goals.	0	5	11	16	22
1g. <b>Alignment and cohesion exist among key team members</b> who implement and execute EVMS, including common objectives and priorities.	0	5	9	14	19
<b>Column Totals</b>	<b>0</b>	<b>78</b>	<b>156</b>	<b>234</b>	<b>313</b>

*Figure 4 Excerpt from the Environment Framework Scoresheets*

Once the IP2M METRR with its scoresheets was developed and finalized, a questionnaire was formed with the help of the research team who provided inputs based on their long career experiences applying earned value management systems in an integrated project and program setting. The questionnaire was the data collection method enabling industry professionals experienced in earned value management systems test the IP2M METRR on projects and programs and provide information needed for data analysis through a five-hour workshop. The authors used Qualtrics to administer the multi-section survey questionnaire and collect the responses of the workshop participants. The Qualtrics questionnaire included two major sections: (1) a section on EVMS maturity and environment assessment of projects and programs, and (2) a section on project and program performance assessment.

In general, the section where EVMS maturity and environment is to be assessed supported the following important considerations:

- Evaluation of EVMS maturity and environment to the project/program retroactively at a point in time around 20 percent project completion. This 20 percent project completion time was confirmed by the research team as the best benchmarking timeline and a common point of comparison among the collected projects, as they have experienced this as a point in time where EVMS needs to be established and mature. This point in time was also in line with literature sources (e.g., Christensen and Heise 1993; Christensen and Payne 1992). Therefore, the workshop participants were asked to fill out information in the questionnaire by thinking back in time at 20% project completion when assessing each of the maturity attribute and environment factor.

- The 20% project completion is calculated in this study as the CUMULATIVE BCWP/PMB BAC; where BCWP is Budgeted Cost for Work Performed, PMB is Performance Measurement Baseline, and BAC is Budget at Completion.

In contrast, the section where information is requested to be filled out on project and program performance assessment considered the evaluation at a point in time after the project/program has ended (for example, customer satisfaction was assessed by the workshop participants at the end of the project/program). As such, the impact of EVMS maturity and environment on final project performance could be captured and analyzed once all the data was filled-out by the above-mentioned considerations.

The multi-section Qualtrics questionnaire that was used in the workshops is provided in Appendix C. Further details of what was requested from the participants in all sections during the five-hour workshops are given in the following chapter.

Once the questionnaire was ready, the authors organized industry workshops with the support of the research team and invited EVMS practitioners to attend the workshops and participate in testing the IP2M METRR. All the participants of a past large industry survey on EVMS conducted as part of this research (Aramali et al., 2021), and previous workshops (to develop the IP2M METRR as mentioned earlier), as well as participants suggested by the research team based on their EVMS expertise, were invited to voluntarily participate and provide data. Special inclusive efforts were undertaken by the research team to invite practitioners with widely diverse backgrounds and levels of experience. This was monitored iteratively from one workshop to the next, and invitations were sent out to collect additional data from a diverse pool of practitioners. Data was collected from workshop participants using the Qualtrics questionnaire.

The authors, along with help from the research team, conducted four workshops where 31 workshop participants provided data from 35 completed projects and programs. The details of these workshops and workshop process are provided in the next section. The workshops were held online via Zoom for safety measures considering the timing of the workshops during the COVID-19 pandemic. A full account of how these workshops were conducted virtually is provided in a journal article by Gibson et al. 2022b. Summary data for these workshops and the number of projects/programs for which data were collected are shown below:

<u>Date</u>	<u>Workshop #</u>	<u>Workshop Duration</u>	<u># of projects/programs</u>
04/08/21	Performance Workshop #1	5 hours	11
05/19/21	Performance Workshop #2	5 hours	5
06/03/21	Performance Workshop #3	5 hours	11
08/10/21	Performance Workshop #4	5 hours	8

Once data from 35 projects and programs were collected through the four workshops, the authors performed the data analysis and tested the research hypothesis. Further details of what data analysis methods were used are given in the following section.

Summarizing, once the IP2M METRR was developed, workshops were conducted to collect data using a questionnaire created by the authors with the support of the research team. Then, the authors used statistical methods to test the research hypothesis and analyze the data

collected in the workshops. More details about the specific methods and analyses are provided in subsequent sections.

## **2.1. Statistical Tests**

The authors used several statistical methods to analyze the collected data from the workshops. The next paragraphs describe the statistical methods employed by the authors in this report, which are: normality tests, independent sample t-tests, Mann-Whitney U-tests, Kruskal-Wallis tests, correlation analyses, and regressions.

### ***Normality Test***

Statistical analysis methods, such as independent-sample t-tests, assume that a dataset is normally distributed, or symmetric around some central value such as the mean or median of the dataset (Morrison 2009). A normality test checks if the distribution of the data is normal, that is symmetric around the mean, with less dense observations further from the mean (Anderson and Burberg 2015). For each normality test, the null hypothesis  $H_0$  states that data is normally distributed, whereas the alternative hypothesis  $H_1$  states that data is not normally distributed (Royston 1983). P-values less than 0.05 (5% significance level) lead to rejecting the null hypothesis (meaning the data is not normally distributed).

A p-value, here and in this report, represents the “strength of evidence” against a given null hypothesis, with a standard value of 5% (Dahiru 2008); this value is defined as “the probability under the assumption of no effect or no difference (null hypothesis), of obtaining a result equal to or more extreme than what was actually observed. The P stands for probability and measures how likely it is that any observed difference between groups is due to chance. Being a probability, P can take any value between 0 and 1. “Values close to 0 indicate that the observed difference is unlikely to be due to chance, whereas a P value close to 1 suggests no difference between the groups other than due to chance” (Dahiru 2008).

### ***Independent Sample t-test***

In theory, two groups may have the same mean, but the data within those groups may be dispersed differently (Morrison 2009). Groups with a tighter clustering of data points around the mean value will have a higher statistical significance than those groups where the data points are more dispersed (Morrison 2009). Independent sample t-tests are used to determine if the means of two groups of normally distributed data are statistically different from one another (Morrison 2009). In this test, a t-statistic value is calculated. The null hypothesis ( $H_0$ ) is that the mean values of the two groups being tested against each other are equal, or nearly equal (Morrison 2009). The alternate hypothesis ( $H_1$ ) is that the mean values of the two groups being tested against each other are not equal (Morrison 2009). The calculated t-value is tested against a critical t-value, to test if the null hypothesis is to be accepted or rejected (Morrison 2009). The critical t-value is dependent on the degrees of freedom of the samples (Morrison 2009.) Values derived from the t-tests also have an associated p-value, or probability, which is used to determine if the difference between mean values of the groups is statistically significant (Morrison 2009). A confidence interval for the test is stated; the typical confidence interval is 95 percent, which corresponds to an alpha level (or rejection level) of 5 percent (Morrison 2009). If the associated p-value from the t-test is greater than 0.05 (i.e., 5 percent), then there is a greater than 5 percent chance that the mean values of the two groups being compared are equal, or nearly equal, and the null hypothesis

is accepted. If the associated p-value from the t-test is less than or equal to 0.05 (i.e., 5 percent), then there is a less than 5 percent chance that the mean values of the two groups being compared are equal, or nearly equal, and the null hypothesis is rejected.

### ***Mann-Whitney U Test***

Mann-Whitney U Tests are used when comparing the equality mean values of two groups where data within the groups are based on a ranked order scale (Wilcox 2009). An example of a ranked order scale is a Likert scale, which was used for a few metrics in this study. The Mann-Whitney U Test is also similar to the independent t-tests but is used for comparing medians for data differing from a normal distribution and is referred to as being nonparametric (Corder and Foreman 2014; Wilcox 2009; McCrum-Gardner 2008). The test is used to determine if there is a statistical difference between the two groups through the calculation of the p-value. A confidence level for the statistical significance is stated; the typical confidence level is 95 percent, which corresponds to an alpha level (or rejection level) of 5 percent (Wilcox 2009). If the p-value of the test is greater than 0.05 (i.e., 5 percent), then there is no statistical difference between rank-order of the two groups (Wilcox 2009). If the p-value of the test is less than 0.05 (i.e., 5 percent), then there is a statistical difference between rank-order of the two groups (Wilcox 2009).

### ***Kruskal-Wallis Test***

Kruskal-Wallis is a non-parametric test used to compare more than two independent samples (Ostertagova et al. 2014). The null hypothesis ( $H_0$ ) is that the distribution of all the groups being tested against each other is the same (Ostertagova et al. 2014). The alternate hypothesis ( $H_1$ ) is that the distribution of all the groups being tested against each other is not the same (Ostertagova et al. 2014). It specifically compares the mean ranks or medians between the groups. If the associated p-value from the test is greater than 0.05 (i.e., 5 percent; the significance level), then there is a greater than 5 percent chance that the distribution of the groups being compared is the same, and the null hypothesis is accepted. If the associated p-value from the t-test is less than or equal to 0.05 (i.e., 5 percent), then there is a less than 5 percent chance that the mean values of the two groups being compared are the same, and the null hypothesis is rejected. When the Kruskal-Wallis test results are significant, then at least one of the groups is different from the other groups. The test does not identify where the differences occur therefore further tests can be applied to discover that.

### ***Correlation Analysis***

Correlation, commonly denoted as  $r$ , measures the strength of the linear relationship between a set of two quantitative variables (Moore et al. 2010). In this test, aggregated data in the form of dependent (Y) and independent (X) variables are graphed on a scatterplot. Independent variables, or response variables, are graphed based on their position along the Y-axis, and dependent variables, or explanatory variables, are graphed based on their position along the X-axis (Moore et al. 2010). The independent variable is assumed to predict the behavior of the dependent variable (Moore et al. 2010.) The strength of the relationship is determined by how closely the points follow a clear form or direction. The test calculates an  $r$ -value (between -1 and 1). A positive  $r$ -value indicates a positive association between the variables, and a negative  $r$ -value indicates a negative association. An  $r$ -value close to 0 indicates a weak correlation between the variables and a value closer to -1 or 1 indicates a strong correlation (Moore et al. 2010).



## ***Regression***

Building upon the x-y plot in correlation analysis, a simple linear regression model attempts to model the relationship between one independent (X) and one dependent (Y) variable, with the basic assumption that the relationship between these variables behaves linearly (Waissi 2015). The regression model calculates an  $r^2$  value representing the strength of the regression model. The  $r^2$  value denotes how well the regression equation explains the dependency between the X and Y variables. The  $r^2$  value will always be positive, and between 0 and 1. The  $r^2$  value denotes what percentage of the variation in the dependent variable (Y) is explained by the independent variable (X) (Waissi 2015). The regression model is tested to be statistically significant through the calculation of the p-value. The typical confidence level is 95 percent, which corresponds to an alpha level (or rejection level) of 5 percent (Waissi 2015). If the p-value of the regression model is greater than 0.05 (i.e., 5 percent), then a significant portion of the total variability in the data is primarily due to randomness, or error in the model (Waissi 2015). If the p-value of the regression model is less than 0.05 (i.e., 5 percent), then a significant portion of the total variability in the data can be attributed to the relationship between the variables (Waissi 2015). The outcome of the model, if statistically significant, is the relationship between x and y in terms of  $y = ax + b$ , with  $a$  being the slope of the regression line, and  $b$  being the y-intercept.

### 3. Performance Workshop Process

The authors facilitated each of the workshop sessions hosted online using the Zoom platform. The authors sent information packets electronically to all confirmed workshop participants prior to each session; these included background information about the research study and the purpose of the workshop itself. Similar information packets were sent out prior to all workshop sessions. Potential workshop participants were asked to review the "pre-read" information prior to the workshop sessions, which included familiarizing themselves with the IP2M METRR, workshop instructions, and the workshop presentation. The presentation included an agenda for the session, instructions for using the IP2M METRR, including what information is needed to submit during the workshop.

Each session began with a Microsoft PowerPoint presentation (a sample presentation is included in Appendix D) that briefly introduced the objectives of the workshop, background of the research project, background of the IP2M METRR, and instructions for using the IP2M METRR. Participant and research team introductions were made during the introduction of the session.

During that presentation, participants were provided a Qualtrics URL link and then collectively guided through how to fill it out (Appendix C). The steps 1 to 9 (shown in Figure 5) were followed for each participant during each workshop, with each of the steps elaborated next.

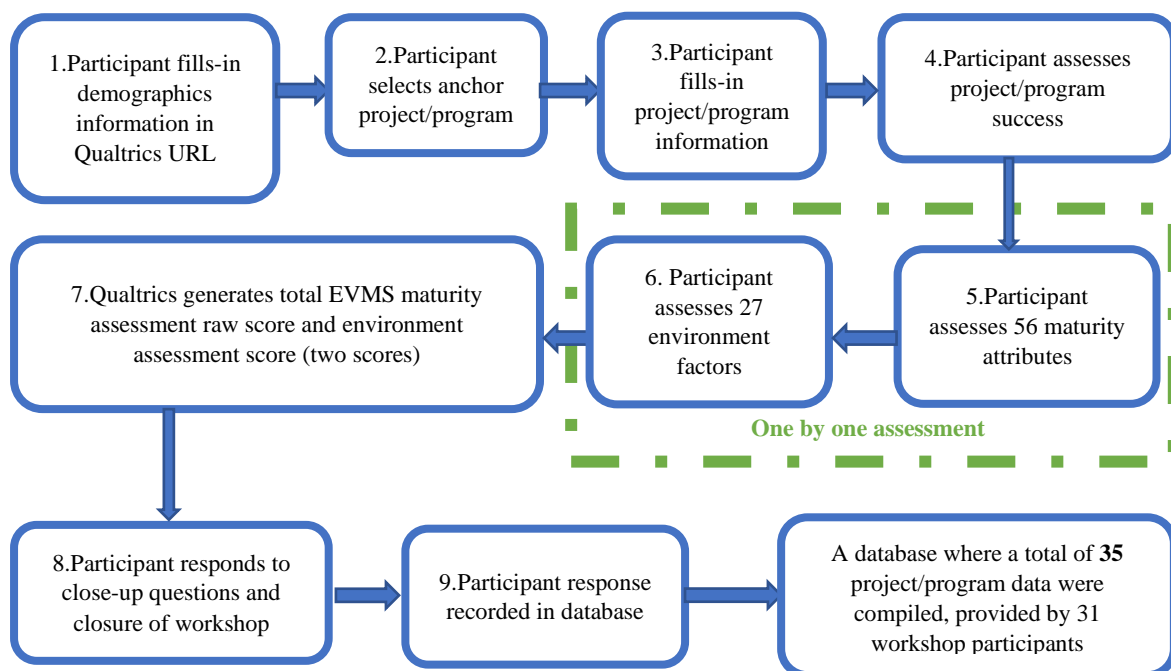


Figure 5 Workshop Data Collection Process

*Step 1:* The participants were asked to open the Qualtrics URL link and fill in their demographic information (e.g., name, email, phone number, organization name, employer type, employment role, and years of EVM experience in total).

*Step 2:* The participants were asked to select a completed project or program (typically before the session started), which is a sample project or program they have worked on

previously that would be used as a reference throughout the workshop session, to test the IP2M METRR. This project/program was henceforth referred to as the “anchor” project/program.

*Step 3:* Next, the participants were asked to use the Qualtrics and input their anchor project or program information into the questionnaire. The header question requesting this information stated: “*Think of an EVMS application on a recently completed project/program that you were involved with. You will use this project/program as your anchor while assessing its EVMS maturity and environment. Note: if any values cannot be shared, please write N/A.*” The specific questions and an example of the response received by a given participant to this request during the workshop are provided in Figure 6 (Please note that the information is slightly modified to retain confidentiality). It is important to note here that the last question in Figure 6 requested that workshop participants inform the researchers about their project/program’s EVMS compliance with NDIA EIA-748 at the point in time at 20% project completion. The response to this specific question was deemed useful in the statistical analysis described later in this report.

- Please provide the name of the project/program (e.g., USS Enterprise): \_\_XYZ\_\_
- Briefly describe the scope of the project/program (e.g., this project was a major cleanup facility to process high-level nuclear waste): \_\_Facility construction\_\_
- Please provide the primary location of the project/program (i.e., Nevada, Alabama, India): \_\_Tennessee\_\_
- Initial Performance Measurement Baseline (PMB) Budget (\$M): \_\_\$200M\_\_
- Final Project/Program Cost (\$M) (if you provided N/A for PMB, please provide % of cost underrun (-X%) or overrun (+Y%) versus baseline): \_\_\$180M\_\_
- Initial Baseline Project/Program Duration (Months): \_\_50\_\_
- Final Project/Program Duration (Months) (if you provided N/A for baseline duration, please provide % of schedule underrun (-X%) or overrun (+Y%) versus baseline): \_\_57\_\_
- Please explain any changes that impacted the initial baseline cost or schedule by more than 5%. If not, please write N/A. \_\_N/A\_\_
- Budgeted owner contingency above the PMB (\$M or a % of PMB): \_\_\$20\_\_
- Final Cost Performance Index (CPI): \_\_0.90\_\_
- Absolute value of change orders (\$M or a % of PMB): \_\_\$1M\_\_
- Feel free to use this box to explain anything unusual in this project/program: \_\_N/A\_\_
- Was the anchor project/program used in your evaluation compliant with NDIA EIA-748 at the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC, where BCWP is Budgeted Cost for Work Performed, PMB is Performance Measurement Baseline, and BAC is Budget at Completion)? \_\_YES\_\_

*Figure 6 Example Project/Program Information Response*

*Step 4:* In the following section of the questionnaire, the project/program performance is evaluated. In this case, the following question in Qualtrics, stated “*Reflecting on your perspective, rate the anchor project/program using a scale of 1 to 5, as shown below.*”, where the participants selected a level between 1 and 5 to three given statements as applied to their project/program, shown in Figure 7. In this question, the three statements were evaluated by the workshop participants at the end of the project/program, and the answers were filled out accordingly. For example, when the customers were somewhat satisfied with the results of the project once the project has ended, then the workshop participant would assess the customer satisfaction statement as “somewhat successful.” An example of a complete response received by a participant during the workshop is also provided in Figure 7.

Statement	1 very unsuccessful	2 unsuccessful	3 somewhat successful	4 successful	5 very successful
The project/program met its objectives and business drivers.			X		
Customers were satisfied with the results of the project/program.				X	
The EVMS helped to proactively manage the project/program.					X

Figure 7 Example Project/Program Success Statements Response

Step 5: After that information was provided, each of the 56 EVMS maturity attribute tables in IP2M METRR was then reviewed, one by one (the tables were developed and presented previously in research report #4, Annex A by Aramali et al. (2022d)) in relation to this anchor project at 20% project/program complete. An example of the maturity attribute table for A.1 (Product-Oriented Work Breakdown Structure (WBS)) is shown in Table 1.

Table 1 Maturity Attribute A.1 Table (Example)

SUB-PROCESS A: ORGANIZING	Maturity Level				
	LOW		MEDIUM		HIGH
	1	2	3	4	5
<b>A.2. Work Breakdown Structure (WBS) Hierarchy</b>					
<p>The Work Breakdown Structure (WBS) scope is arranged in clear and logical groupings and is inclusive of all authorized contract and project life cycle work efforts regardless of the entity performing the work. The WBS is decomposed from a high-level “system” and de-constructed into sub-systems and components to ensure a hierarchy that helps effectively manage the project/program. There is clear vertical integration traceability between the WBS hierarchy and the authorized work scope.</p> <p>Items to consider include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Statement of Work (SOW)/Statement of Objectives (SOO)</li> <li><input type="checkbox"/> Work Breakdown Structure (WBS)</li> <li><input type="checkbox"/> ...and so on</li> </ul> <p>References: NDIA EVMS EIA-748-D Intent Guide GL 1; ISO 21508:2018(E); ANSI PMI 19-006-2019 and so on.</p>	<b>Not yet started.</b>	<p><b>Little vertical integration exists between the WBS hierarchy and authorized work scope.</b></p>	<p><b>Vertical integration exists between the WBS hierarchy and authorized work scope, with only minor gaps or errors.</b></p>	<p><b>Complete vertical integration exists between the WBS hierarchy and authorized work scope.</b></p>	<p><b>Vertical integration between the WBS hierarchy and authorized work scope reflects all authorized changes within a reporting period of the change.</b></p>
		<p>The process to maintain a logically grouped WBS has started, with hierarchical integration of all authorized scope that accurately reflects the products, services, and deliverables required to complete the program. ...and so on</p>	<p>Most of the process to develop and maintain a logically grouped WBS has been defined, with limited open items. The process includes hierarchical integration of all authorized scope that accurately reflects the products, services, and deliverables required to complete the program. ...and so on</p>	<p>The process to develop and maintain a logically grouped WBS has been defined, documented, and approved. ...and so on</p> <p>Note: The attribute at this level 4 is compliant with standards and guidelines.</p>	<p>All authorized WBS elements and groupings are consistent and have clear vertical integration that is 100 percent traceable. They reflect any contractual changes, and this process is repeatable from month to month, including changes and additions to the WBS. WBS elements are clearly specified for external reporting and are traceable to authorized work scope. ...and so on</p>

The facilitators addressed any questions posed by the workshop participants as the attributes were individually reviewed. Adequate time was provided for participants to read the attribute descriptions and maturity level narratives and indicate the level of maturity of the given attribute, but not enough time to “over think” the attributes, keeping a consistent flow and timing throughout the session. Following the review of the descriptions of each attribute and narratives for each maturity level, the participants inserted the maturity level of the attribute into the Qualtrics questionnaire when thinking back to the point in time of 20% project completion (from maturity level 1, meaning the work on the attribute has “Not Yet Started”, to 4, meaning compliant to EVMS guidelines and standards (e.g., PMI 2019; ISO 2018), and 5, which is the highest maturity level beyond compliance (explained earlier in the background section). For example, the question on the Organizing sub-process stated “*This question is focused on the attributes that make up the Organizing Sub-Process (Sub-Process A). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each attribute’s maturity at that point in time, where BCWP is Budgeted Cost for Work Performed, PMB is Performance Measurement Baseline, and BAC is Budget at Completion.*” An example of the response received by a given participant to this question during the workshop via Qualtrics is given in Figure 8.

Attribute	Maturity Level					
	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
A.1 Product-Oriented Work Breakdown Structure (WBS)				X		
A.2 Work Breakdown Structure (WBS) Hierarchy					X	
A.3 Organizational Breakdown Structure (OBS)						X
A.4 Integrated System with Common Structures					X	
A.5 Control Account (CA) to Organizational Element				X		

*Figure 8 Example Organizing Sub-Process Assessment Response*

Upon each maturity level selection, the project/program gained the corresponding attribute maturity score. For example, the scores gained by evaluating the attributes A.1 to A.5 in the way presented in Figure 8, lead to the following scores shown in Figure 9 (scores gained are shown in bold). Note that the IP2M METRR also allows the participants to indicate those attributes deemed not applicable to the project/program, in that case, they could select “N/A” and thereby the attribute gained no point (0 score).

Attribute	Maturity Level					
	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
A.1 Product-Oriented Work Breakdown Structure (WBS)	0	5	11	<b>16</b>	22	0
A.2 Work Breakdown Structure (WBS) Hierarchy	0	5	10	14	<b>19</b>	0
A.3 Organizational Breakdown Structure (OBS)	0	4	7	11	14	<b>0</b>
A.4 Integrated System with Common Structures	0	6	11	17	<b>23</b>	0
A.5 Control Account (CA) to Organizational Element	0	4	9	<b>13</b>	18	0

*Figure 9 Example Maturity Scores Gained based on Assessment Response*

*Step 6:* Similar to step 5, 27 environment factor tables provided in the IP2M METRR were then reviewed and evaluated one by one for the anchor project (the factor names and factor descriptions were developed and presented previously in research report #3, Annex A by

Aramali et al. (2022c)) in relation to the anchor project at 20% project/program complete. An example of the factor name and description for 4e (*Data are readily available to populate EVMS tools supporting analyses for decision-making*) is shown in Table 2.

Table 2 Environment Factor 4e Table (Example)

Factor name	Description
4e. Data are readily available to populate EVMS tools supporting analyses for decision-making.	Data are readily available and accessible in a consistent and timely manner according to the business rhythm. It should be shared effectively and efficiently, and support analyses to properly manage the project/program. These data are current, accurate, complete, repeatable, auditable, and contextualized to aid understanding which leads to effective, timely, and informed decision-making at all levels. Data also meet applicable EVM reporting requirements, such as file type, format, and so on.

At the end of each factor review, the participants were asked to rate the factor (either *Not Acceptable*, *Needs Improvement*, *Meets Some*, *Meets Most*, or *High Performing*) as applied to their projects and programs at 20% project/program completion and provide the rating in the Qualtrics questionnaire. For example, the question on the Organizing sub-process stated “*This question is focused on the factors that make up the **Resources Category** (Category 4). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each environment factor at that point in time.*” An example of the response received by a given participant to this question during the workshop on Qualtrics is given in Figure 10.

Factor	Factor Rating Level				
	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
4a. Adequate technology/software and tools are integrated and used for the EVMS.			X		
4b. Sufficient funding is committed and available for implementing and executing the EVMS.				X	
4c. The team that implements and executes the EVMS for the project/program is adequate in size and composition.					X
4d. Sufficient calendar time and work-hours are committed and available for implementing and executing the EVMS.				X	
4e. Data are readily available to populate EVMS tools supporting analyses for decision-making.			X		
4f. The project/program utilizes an appropriate periodic cycle for executing the EVMS effectively and efficiently.			X		

Note: the meaning of each factor rating level is given below:

- Rating a factor *Not Acceptable* indicates that the factor’s criteria are consistently below expectations and current performance is unacceptable. The ability to effectively manage the project/program cannot be achieved in this current state and actions are required to improve.
- Rating a factor *Needs Improvement* indicates that the factor’s criteria are not consistent in meeting project/ program expectations and without improvement, the ability to effectively manage the project/program is at risk. Substantial action is required to meet expectations.
- Rating a factor *Meets Some* indicates that the factor’s criteria are partially met and without improvement, the ability to effectively manage the project/program could be in jeopardy.
- Rating a factor *Meets Most* indicates that the factor’s criteria are consistently met and understood, with minor gaps, leading to effective management of project/program.
- Rating a factor *High Performing* indicates the factor’s criteria are fully met within the context of their respective category (e.g., culture, people, practices, or resources).

*Figure 10 Example Resources Category Assessment Response*

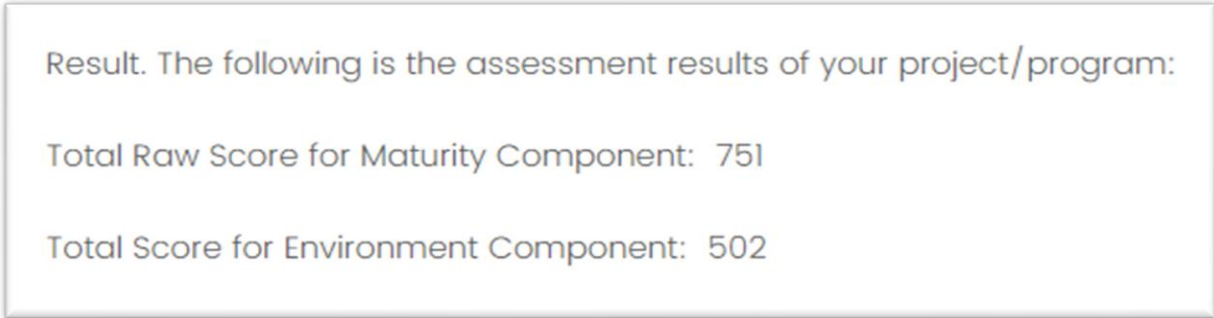
Upon each factor rating level selection, the project/program gained the corresponding environment factor score. For example, the scores gained by evaluating the attributes 4a to 4f in the way presented in Figure 10, leads to the following scores (scores gained are shown in bold) shown in Figure 11.

Factor	Factor Rating Level				
	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
4a. <b>Adequate technology/software and tools are integrated and used for the EVMS.</b>	0	12	<b>23</b>	35	47
4b. <b>Sufficient funding is committed and available for implementing and executing the EVMS.</b>	0	9	18	<b>28</b>	37
4c. The team that implements and executes the EVMS for the project/program is adequate in <b>size and composition.</b>	0	9	18	26	<b>35</b>
4d. <b>Sufficient calendar time and work-hours are committed and available</b> for implementing and executing the EVMS.	0	8	17	<b>25</b>	34
4e. <b>Data are readily available</b> to populate EVMS tools supporting analyses for decision-making.	0	8	<b>17</b>	25	34
4f. The <b>project/program utilizes an appropriate periodic cycle</b> for executing the EVMS effectively and efficiently.	0	7	<b>14</b>	20	27

*Figure 11 Example Environment Scores Gained based on Assessment Response*

*Step 7:* After the participant completed the EVMS maturity and environment assessment on their anchor project/program, Qualtrics automatically summed up the overarching scores resulting from the assessments and generated the total scores for both maturity and environment. An example output of the assessment completed during the workshops is shown in Figure 12.





*Figure 12 Example Project EVMS Maturity and Environment Score Response*

*Step 8:* The workshop participants contributed to final discussions on their perspective of the overall workshop process and their project/program assessment results. The authors were thankful for the provided information, and the facilitated workshop was concluded.

*Step 9:* Through this process, a database of 35 completed projects/programs was formed and used to perform the analyses discussed in the next section of this report. It should be noted that the information in the database was provided by 31 participants, with four participants providing information on four additional projects/programs subsequent to the workshops.

The authors have made every effort to keep confidential any personal or proprietary information collected from individuals who provided data to support the research effort with each sample project/program given a unique. The authors also have made every effort to analyze the responses objectively, by anonymizing respondent information during the course of the analysis.

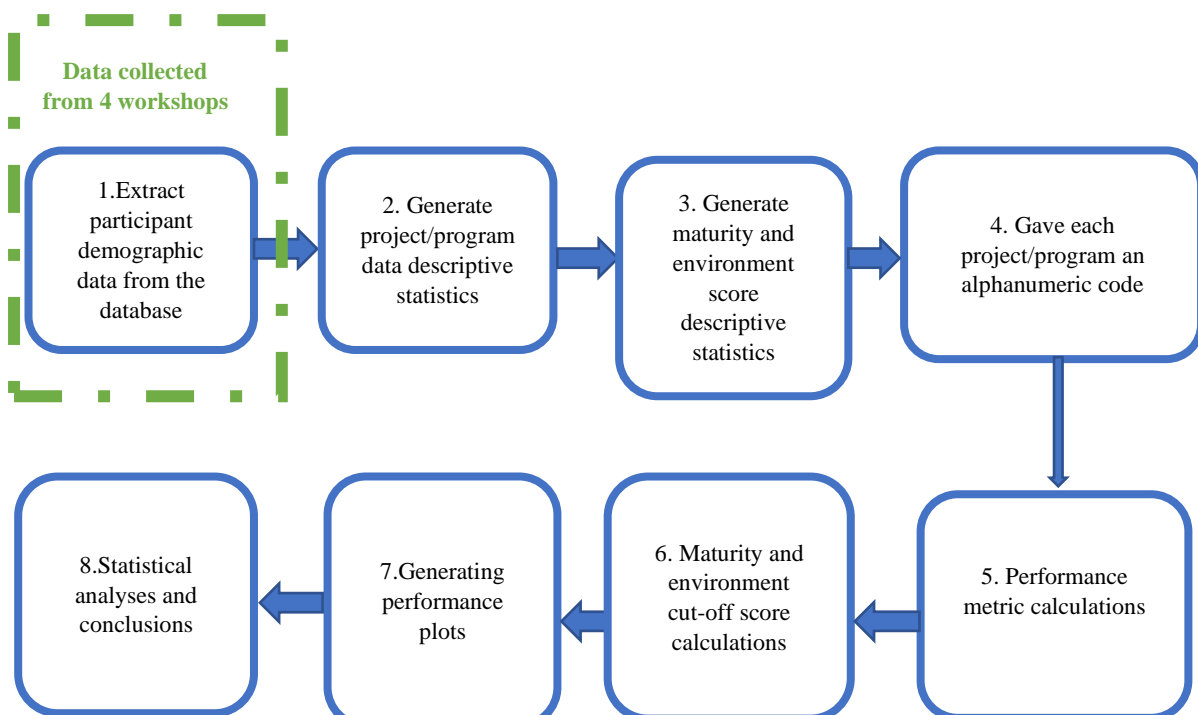
The workshops were successful in both collecting data and receiving insights from experienced industry professionals on the value and use of the IP2M METRR. They also allowed the researchers a means to effectively and efficiently collect data to test the research hypothesis.

## 4. Analysis and Results

This chapter outlines the results of data obtained during the performance workshops, and how input obtained from these workshops was used for further quantitative analyses. This section includes brief participant demographic information and data descriptive statistics, along with an overview of the data analysis process.

The authors used Microsoft Excel and SPSS to perform the tasks for screening the data, calculating the descriptive statistics (e.g., mean, median, standard deviation, variance, skewness) of the data, and statistical data analysis. Statistical analysis allowed the authors to interpret the data and provided a basis for the authors to offer recommendations for the improvement of integrated project and program management. The next few sections describe the calculation results and the statistical methods employed by the authors, including t-tests, Mann-Whitney U-tests, Kruskal-Wallis, correlation analysis, and regression analyses.

In general, the authors followed the processes shown in Figure 13 to analyze the database consisting of the 35 projects and programs provided by the 31 industry practitioners, as discussed earlier.



*Figure 13 Data Analysis Process*

### 4.1. Workshop Participant Demographics

This section presents the data characteristics or demographic information of the participants in the performance workshops. They include the participants' employer type, employment role, and number of years of EVM experience in the industry.

Overall, 31 industry professionals, representing 23 unique organizations as listed in Appendix A, tested IP2M METRR on 35 projects and programs. The representation of the participant demographics is given in the following three figures.

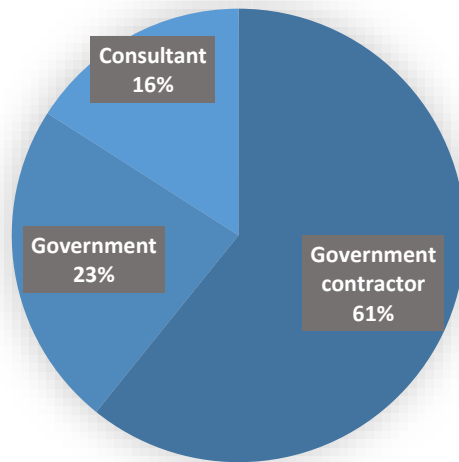


Figure 14 Employer Type – N=31

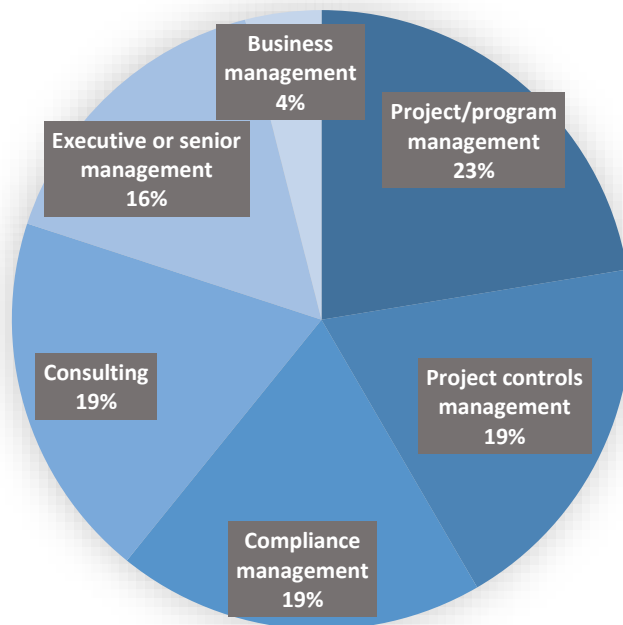
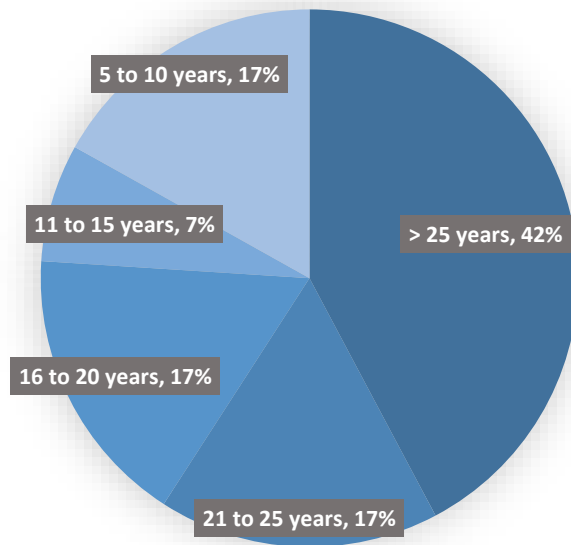


Figure 15 Employment Role – N=31



*Figure 16 Years of EVM experience – N=31*

The workshop participants had an average of 19 years of EVM experience. Overall, as shown, the data was collected from a pool of participants with diverse employment roles from government agencies, contractors, and consultants.

#### **4.2. Project/Program Data Characteristics**

The collected data came specifically from 28 projects and 7 programs with approximately \$21.8 Billion USD in installed cost, and located in 17 U.S. states and territories indicated below:

- Alabama
- California
- Florida
- Idaho
- Illinois
- Indiana
- Louisiana
- Missouri
- New Mexico
- New York
- Pennsylvania
- South Carolina
- Tennessee
- Texas
- Virginia
- Washington
- Washington DC

The types of projects/programs they represent are provided in Table 3.

Table 3 Types of Projects/Programs – N=35

Type of projects/programs	Number of projects/programs
Construction	12
Defense	9
Environmental	6
Software	3
Aerospace	3
Science	2
<b>Total</b>	<b>35</b>

Thirty-one (31) industry practitioners participated in the four performance workshops, however not all of them provided all the information requested from their projects and programs through the Qualtrics questionnaire. The participants were allowed to fill in data as “N/A” for the information that they did feel comfortable sharing, allowing them to keep their organizations’ data confidentiality in many cases. For example, a participant from the fourth performance workshop, filled in “N/A” for the requested value for change orders. In total, information on change orders were missing from seven questionnaire responses, leading to a sample size of N=28 for the metric measuring the value of change orders. Therefore, the number of responses *N* (sample size) providing data may be a little different for each of the studied variables, depending on whether there was any missing information. The filled-in data was also converted to a consistent numerical format to perform analysis. The descriptive statistics, with their corresponding sample sizes, for the collected project and program data is given in Table 4.

Table 4 Project and Program Data Descriptive Statistics

	N	Avg.	Median	Std. Dev.	Min	Max
Initial Performance Measurement Baseline (PMB) budget (in \$M)	33	473.4	112.0	976.9	3.1	3,981.0
Final project or program cost (in \$M)	33	662.1	150.0	1,491.2	4.8	7,500.0
Final Cost Performance Index	35	0.94	0.98	0.12	0.60	1.1
Budgeted owner contingency above PMB, including Management Reserve (MR) (in \$M)	28	159.1	13.6	601.0	0.0	3,200.0
Absolute value of change orders (in \$M)	28	37.5	11.0	61.6	0.0	266.0
Initial baseline project/program duration (in months)	32	50.3	48.0	20.7	8.0	96.0
Final project/program duration (in months)	32	56.0	48.5	25.8	20.0	132.0
Meeting business objectives (1-5 scale)	35	4.1	4.0	1.1	1.0	5.0
Customer satisfaction (1-5 scale)	35	4.1	4.0	1.1	1.0	5.0
EVMS helped proactively manage the project (1-5 scale)	35	3.5	4.0	0.9	1.0	5.0

### 4.3. EVMS Maturity and Environment Scores

As mentioned earlier, the EVMS maturity and environment assessments that the workshop participants conducted, resulted into two scores per each project and program. The first one is the EVMS maturity raw score, and the second one is EVMS environment score. A total of 35 maturity raw scores, and 35 environment scores were collected. Out of the 35 projects/programs, only four projects had the complete list of the 56 maturity attributes applicable to their projects (in other words, for their project/program all attributes are applicable). Therefore, the majority of the project/program maturity raw scores were converted over a scale of 1000 for the purpose of valid comparison between one project versus the other. The conversion is explained next.

#### *Adjustment of Maturity Raw Scores*

Since each project/program had a unique set of N/A attributes, the maturity raw scores were adjusted in order to have a consistent comparative data analysis between the different projects/programs. In effect, the overall score is not penalized based on N/As, but instead it is treated as a relative score. The following equation shows how the collected raw maturity scores were adjusted for data analysis.

Equation (1):

$$Adjusted\ Score = \frac{Raw\ Score}{Maximum\ Possible\ Score} \times 100$$

With,

- Raw Score: maturity score of a project/program, provided by participant
- Maximum Possible Score: total possible score a project/program can achieve (1,000 points minus the level 5 scores of the attributes which are Not Applicable (N/A))

Figure 17 gives an example of equation (1) application: calculating the raw score for maturity of a project.

Project P10 received a raw maturity score of 575 and had 5 N/A attributes (C.2, C.11, G.6, H.4 and H.5).

The level 5 scores of C.2, C.11, G.6, H.4 and H.5 are 6, 11, 12, 12, and 8, respectively.

The maximum possible score is 951, which is 1000 – sum of level 5 scores of these 5 attributes = 1000 – (6 + 11 + 12 + 12 + 8).

Therefore, the adjusted maturity score is 575/951 x 1000 which equals 604.6, rounded to 605.

*Figure 17 Adjustment of Raw Maturity Score Example*

Refer to research report #4 (Aramali et al. 2022a) for more details on this conversion. Information on the collected scores from the 35 projects and programs is shown in Table 5.

*Table 5 Maturity and Environment Scores – N=35*

	N	Avg.	Median	Std. Dev.	Min	Max
Raw Maturity Score (collected by the workshop participants)	35	616	629	176	57	887
Maturity Score (out of 1,000, adjusted by the authors)	35	657	703	182	78	898
Environment Score (out of 1,000, collected by the workshop participants)	35	657	686	158	200	897

Next, each project and program was given an alphanumeric code based on the order in which the EVMS maturity and environment assessment was done, in order to protect confidentiality and limit bias from the researchers. For example, P1 stands for the project/program # 1, with the last digit (1) denoting that it was collected first.

The adjusted maturity scores and the environment scores for P1 to P35 in the P (x, y) format are plotted in Figure 18, with x denoting the environment score and y denoting the maturity score. When this form of scatter is observed visually, it is anticipated to find a linear correlation between the x and y variables. This type of relationship is tested later in this report.



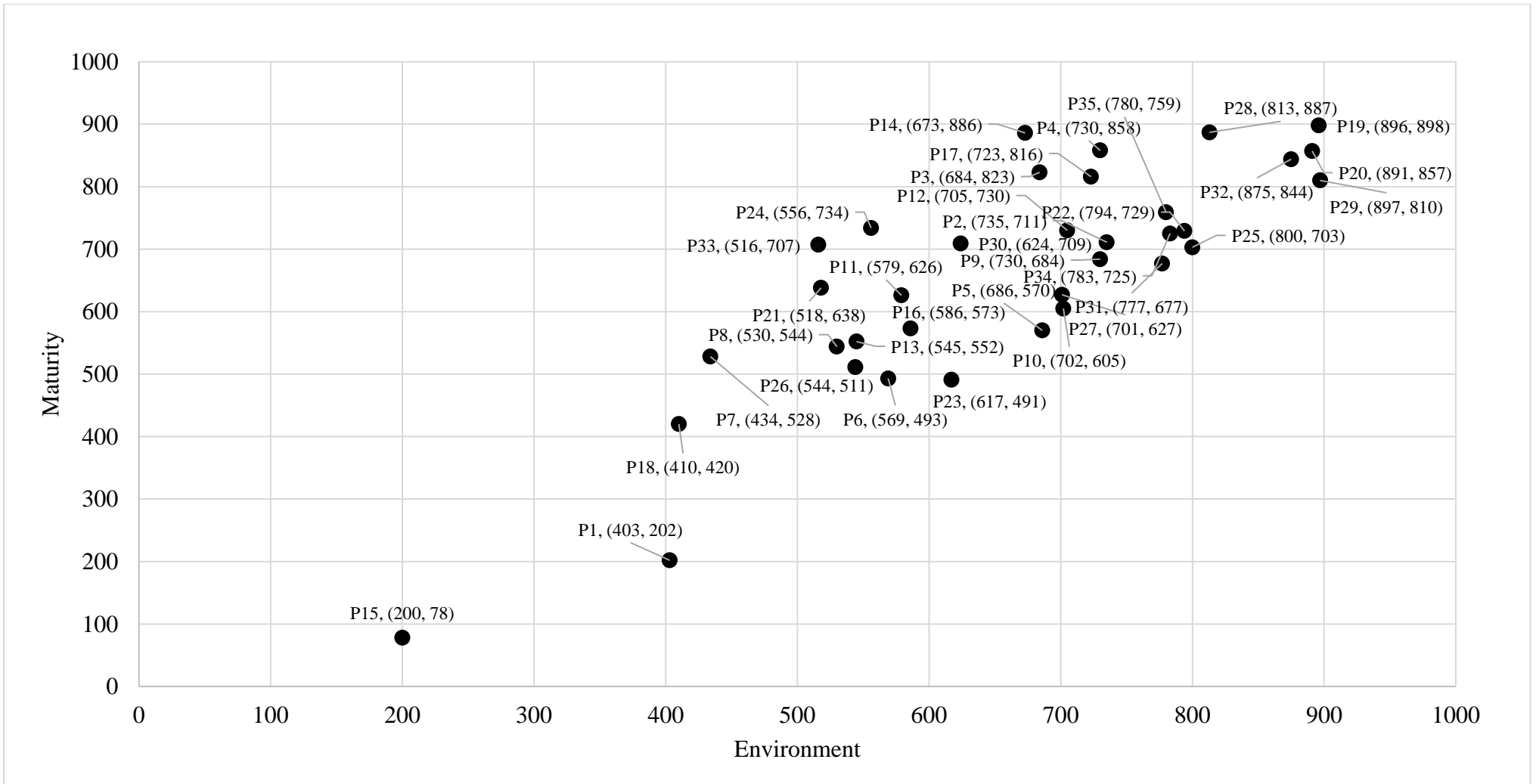


Figure 18 Maturity and Environment Matrix – N=35

#### 4.4. Performance Metric Calculations

The authors calculated the cost growth, the cost growth excluding change orders, the schedule growth, the absolute value of change orders, and contingency used on the projects and programs in the sample, using the following formulas:

Equation (2):

$$\text{Cost Growth (\%)} = \frac{\text{Final Project Cost} - \text{Initial PMB Budget}}{\text{Initial PMB Budget}} \times 100$$

Equation (3):

$$\begin{aligned} & \text{Cost Growth without Change Orders (\%)} \\ = & \frac{(\text{Final Project Cost} - \text{Absolute Value of Change Orders}) - \text{Initial PMB Budget}}{\text{Initial PMB Budget}} \times 100 \end{aligned}$$

Equation (4):

$$\text{Schedule Growth (\%)} = \frac{\text{Final Project Duration} - \text{Initial Baseline Duration}}{\text{Initial Baseline Duration}} \times 100$$

Equation (5):

$$\text{Change Absolute Value (\%)} = \frac{\text{Absolute Value of Change Orders}}{\text{Initial PMB Budget}} \times 100$$

Equation (6):

$$\text{Contingency (\%)} = \frac{\text{Budgeted Owner Contingency}}{\text{Initial PMB Budget}} \times 100$$

The results of the performance metric calculations in the sample are shown in Table 6.

*Table 6 Performance Metric Calculation Results – N=35*

	N	Avg.	Median	Std. Dev.	Min	Max
Cost Growth (in %)	34	+56.1	+13.0	121.4	-13.8	+537.9
Cost Growth, excluding Change Orders (in %)	29	+9.9	+0.0	36.7	-51.6	+147.1
Schedule Growth (in %)	34	+17.8	+2.1	46.6	-20.0	+250.0
Change Absolute Value (in %)	30	53.3	13.8	122.2	0.0	537.9
Contingency (% of PMB)	30	+34.8	+10.7	103.8	+0.0	+572.7

Figure 19 shows the list of the overall performance metrics in this research study scope, including the five calculated performance metrics segregated by variable type (continuous, or discrete). Note that these performance metrics are deemed important when applying earned value management systems based on the input of the research team. The variables are divided into continuous and discrete variables to apply the appropriate statistical tests, as described later in the report.

<u>Project/Program Performance Metrics:</u>		
Variable Type:	Continuous	Discrete
<u>Collected Data:</u> (through workshops via Qualtrics survey)	<ul style="list-style-type: none"> <li>Final Cost Performance Index (CPI)</li> </ul>	<ul style="list-style-type: none"> <li>Meeting business Objectives (1-5 scale)</li> <li>Customer Satisfaction (1-5 scale)</li> <li>EVMS Helped Proactively Manage (1-5 scale)</li> <li>Compliance (Yes/No)</li> </ul>
<u>Calculated Data:</u> (calculated by the author using data collected through workshops)	<ul style="list-style-type: none"> <li>Cost Growth (in%)</li> <li>Cost Growth, excluding change orders (in %)</li> <li>Schedule Growth (in %)</li> <li>Change Absolute Value (in %)</li> <li>Contingency (% of PMB)</li> </ul>	

*Figure 19 List of Ten Performance Metrics*

## 4.5. EVMS Maturity and Environment Cut-off Scores

### *Setting the Maturity Cut-off Score*

The authors investigated the data to establish a cut-off maturity score or a threshold value, which is defined as the maturity score above which the projects and programs statistically outperformed those projects and programs that have lower scores than the threshold value. This means that when separating the projects/programs into two subsets using the threshold value, it is expected to have statistically significant differences in performance between the two different groups of projects/programs.

In order to establish this threshold value, which was later used in the statistical testing, one alternative was adopting the stepwise sensitivity analysis approach used in the topic of Front-End Engineering Design (Yussef et al. 2019; CII 2018; El Asmar et al. 2018) and apply it to this research.

As such, the stepwise sensitivity analysis was performed by ordering the maturity scores from lowest to highest and successively comparing cost growth data starting with the lowest maturity score and stepping up to the very next maturity score. This operation was performed for the sample of 34 projects and programs that had available cost growth data (one project did not have cost information available, therefore the authors excluded it from this analysis). This process generated a p-value for each successive cost comparison. As defined earlier, the p-value is the measurement of the probability of obtaining the observed results when the null hypothesis is true, and a p-value of 0.05 or lower is considered statistically significant. In each comparison, the null hypothesis ( $H_0$ ) considered is that the cost performance of the two groups being tested against each other is the same (Morrison 2009). If the resulting associated p-value is less than or equal to 0.05, then the null hypothesis is rejected, and therefore significant differences in performance are found between the projects being compared. The lower the p-value, the higher the confidence in rejecting the null hypothesis (Figueiredo Filho et al. 2013). The p-values for each set of comparisons in the sample were then plotted versus the maturity score to establish a threshold value for the EVMS maturity assessment tool. The resulting output of the stepwise sensitivity analysis is shown in Figure 20.

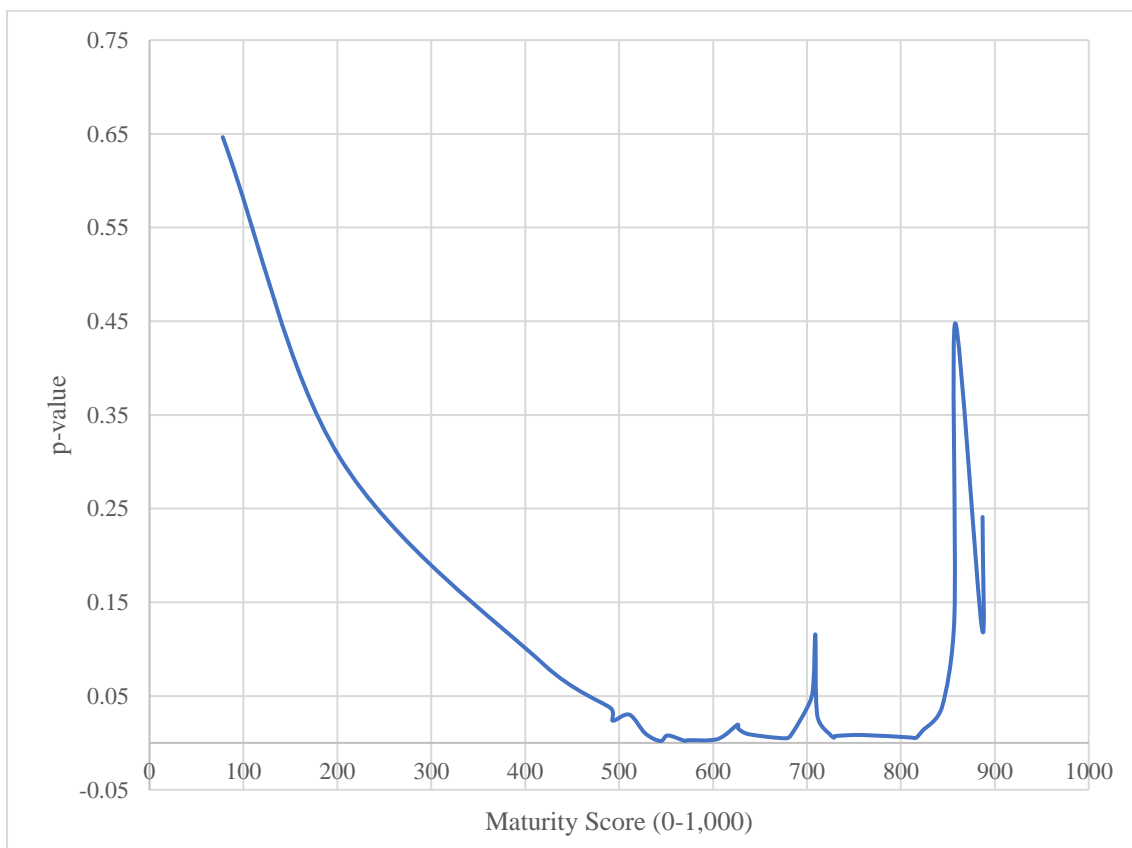


Figure 20 Stepwise Sensitivity Analysis Results – Maturity Scores

The lowest p-value of 0.0020 corresponded to a maturity score between 544 and 552, which are the maturity values for two projects that were used to split the data set into two subsets. This divides the projects into two groups at the most statistically significant point when comparing the two groups versus one another.

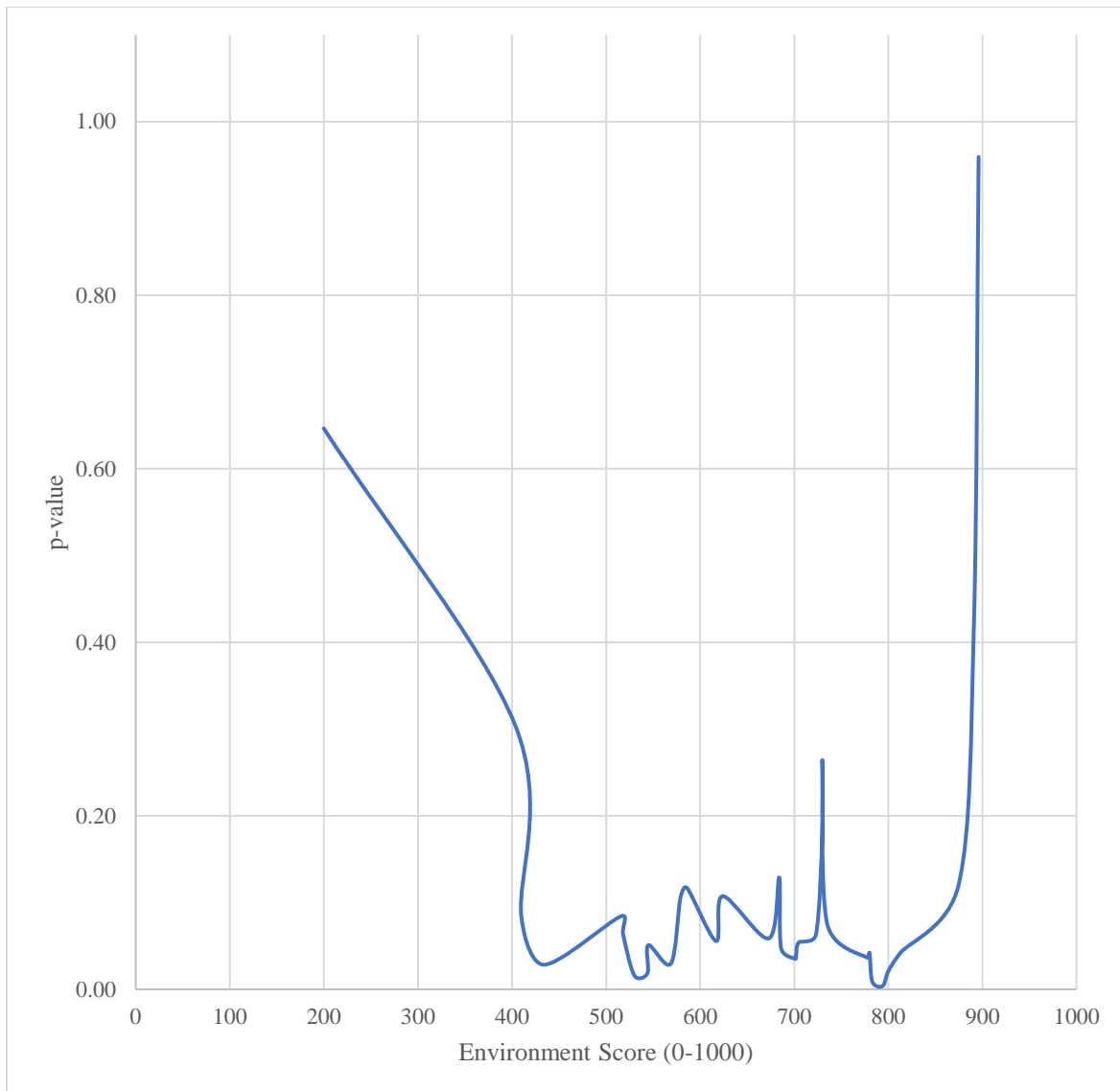
Another alternative in establishing the cut-off score was considering the median (694) of the data. However, using the median results in a p-value of 0.01, which is less statistically significant than the 0.0020 p-value corresponding to a score of 544.

The authors presented the results of these analyses to the research team. After the analysis and feedback from the research team meetings, the authors together with the research team decided to set the maturity threshold at 550 (a practical, round number score in the 544-552 range identified) to separate the projects and programs with high and low EVMS maturity. Note that the median cutoff of 694 or almost 700 will also be used later in the analysis when the data is organized into a heatmap based on performance; more on that later.

### ***Setting the Environment Cut-off Score***

The authors followed the same process of setting the maturity cut-off score to establish a cut-off environment score or a threshold value, which is in this case defined as the environment score above which the projects and programs statistically outperformed those projects and programs that have lower score than the threshold value.

The stepwise sensitivity analysis was performed by ordering the environment scores from lowest to highest and successively comparing cost growth data starting with the lowest environment score and stepping up to the very next environment score. This process generated a p-value for each successive cost comparison. The p-values were then plotted versus the environment score to establish a threshold value for the EVMS environment assessment tool. The resulting output of the stepwise sensitivity analysis is shown in Figure 21.



*Figure 21 Stepwise Sensitivity Analysis Results – Environment Scores*

The lowest p-value of 0.0038 corresponded to an environment score between 794 (corresponding to P22) and 800 (corresponding to P25), splitting the projects into two subsets resulting in the most statistically significant difference between any subsets.

Another alternative in establishing the cut-off score was considering the cut-off score to be the median (694) of the data. However, the same results hold using the median, resulting in a p-value of 0.04, which is less statistically significant than the 0.0038 p-value corresponding to a score of 794. Note that the median cutoff of 694 or almost 700 will also be used later in the analysis when the data is organized into a heatmap based on performance; more on that later.

The authors presented the results of these analyses to the research team. After the analysis and feedback from the research team meetings, the authors together with the research team decided to set the environment threshold at 800 (a practical, round number in the range identified) to separate the projects and programs with good and poor EVMS environment.

#### **4.6. Resulting Performance Plots**

After the authors and the research team determined the maturity and environment score thresholds through the project/program data analysis (i.e., 550 for maturity and 800 for environment), the authors split the projects and programs into four groups or quadrants as shown in Figure 22 based on these score thresholds.

Based on Figure 22, six projects and programs were found to be in the top right quadrant, eight projects and programs were found to be in the bottom left quadrant, and the remaining 21 projects and programs were in the top left quadrant. An important finding here is that within the sample of the 35 projects/programs, there was not a single project or program for which the environment score was high while its maturity score was low. This indicates that the cases that outperformed in their EVMS environment also seem to have had fairly mature EVMS sub-processes. Also, more than half of the projects and programs (60%) were found to be in the top left quadrant, meaning they have mature EVMS sub-processes that are applied in a poor environment (assessed at 20 percent project completion).

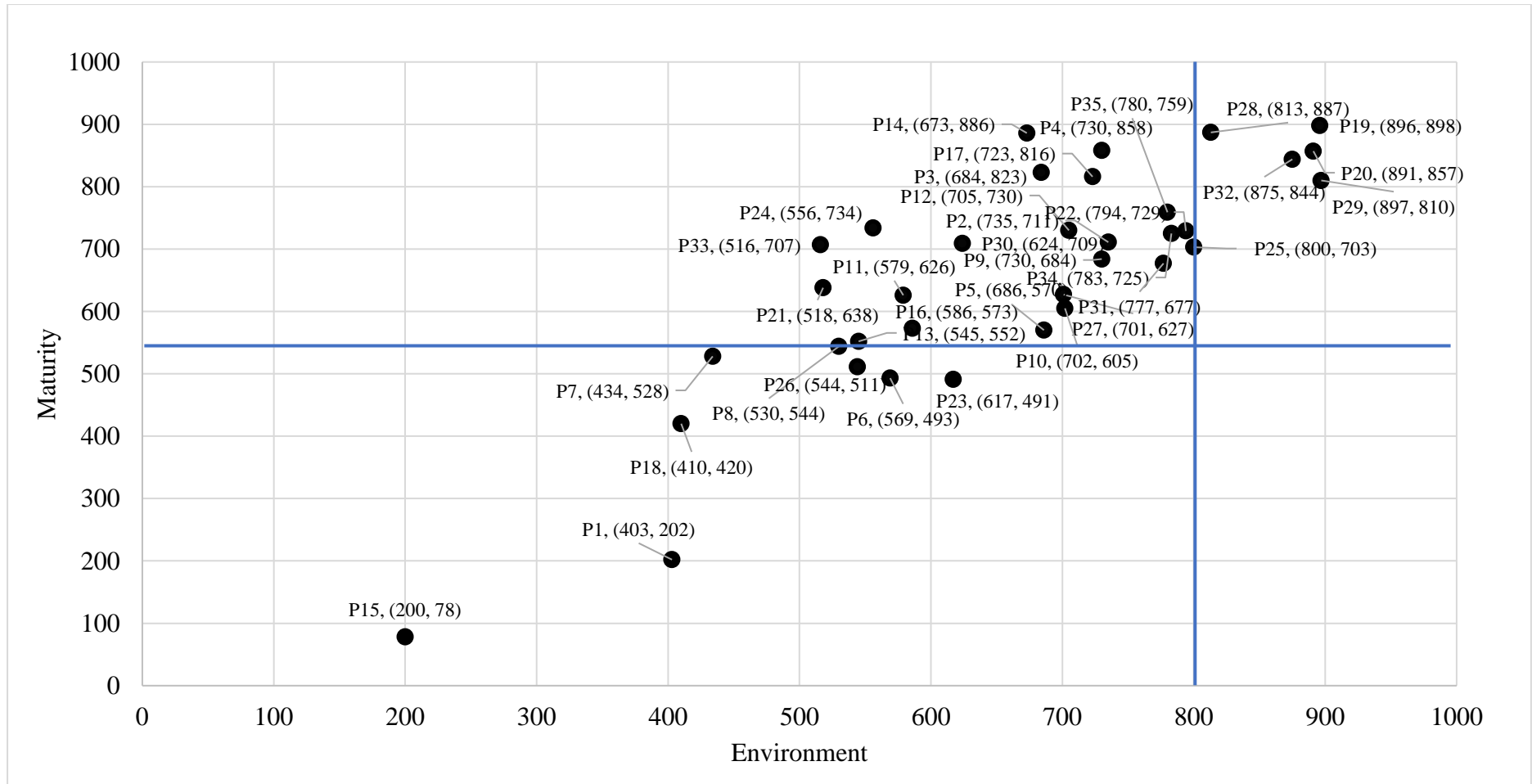


Figure 22 Four Groups of Projects and Programs separated based on Score Thresholds – N=35



Each quadrant was next assigned a specific name, as follows:

- The bottom left quadrant is referred to as “LMPE”, which stands for Low Maturity and Poor Environment.
- The top left quadrant is referred to as “HMPE”, which stands for High Maturity and Poor Environment.
- The top right quadrant is referred to as “HMGE”, which stands for High Maturity and Good Environment.
- The bottom right quadrant is referred to as “LMGE”, which stands for Low Maturity and Good Environment.

It was found that there were no projects or programs in the LMGE quadrant.

In the following sections of this report, the authors use wording such as LMPE projects or programs, to designate those projects or programs that belong to LMPE quadrant (i.e., that have low maturity and poor environment with maturity score less than 550, and environment score less than 800), and so forth.

Next, the authors studied and compared the performance of the projects and programs that are within these four quadrants.

Figure 23 shows the resulting cost and schedule performance of the different project groups, with a reduced sample of 34 projects and programs by removing one project that did not provide its performance information.

Based on Figure 23, the mean cost growth of the six HMGE projects/programs is lower than that of HMPE projects/programs. Similarly, the mean cost growth in the HMPE quadrant is lower than the mean cost growth of LMPE projects/programs. Cost growth seems strongly correlated with maturity and environment scores, but these observations still have to be tested (in the next section of this report).

Now in terms of schedule growth, the mean of the HMGE projects/programs is considerably lower than that of HMPE and LMPE projects/programs, while the mean schedule growth of HMPE projects/programs is a little bit higher than that of LMPE projects/programs, but we still need to test these observations to denote if they are indeed statistically significant or not. At first glance, schedule growth seems strongly correlated with high environment scores (rather than with traditional maturity scores).

The impact of both maturity and environment on cost growth and schedule growth is further investigated via statistical analysis in Chapter 4 of this report. The performance results corresponding to all other performance metrics are provided in Appendix E.

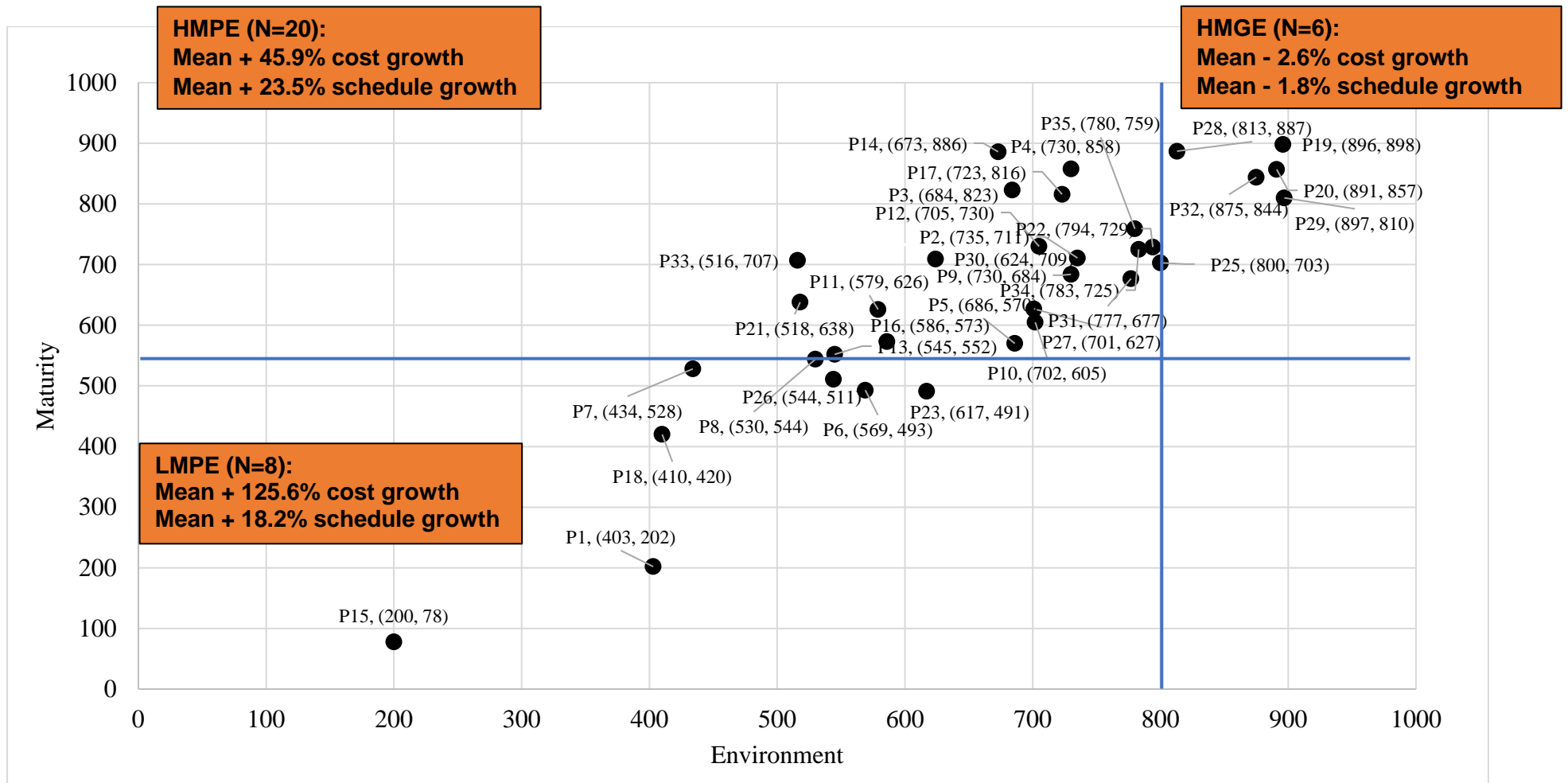


Figure 23 Cost and Schedule Matrix – N=34

After a number of meetings with the research team, presenting these results and receiving feedback, the team decided to split the same projects and programs into a performance-based “heat map” format which could provide practical guidance to practitioners, subdividing maturity and environment into four different zones (also called bands); red, orange, yellow, and green, defined as follows:

- Red zone: the common area from zero to 500; it is bounded by the x-axis, y-axis, threshold line at maturity score = 500, and threshold line at environment score = 500.
- Orange zone: the common area bounded by the threshold line at maturity score = 500, threshold line at environment score = 500, threshold line at maturity score = 700, and threshold line at environment score = 700.
- Yellow zone: the common area bounded by the threshold line at maturity score = 700, threshold line at environment score = 700, threshold line at maturity score = 800, and threshold line at environment score = 800.
- Green zone: the common area bounded by the threshold line at maturity score = 800, threshold line at environment score = 800, threshold line at maturity score = 1000, and threshold line at environment score = 1000.

These threshold lines were set based on the research team's feedback for the following reasons: First, the differences in project cost growth between these four zones were found to be statistically significant. Second, these zones contain a reasonable data distribution of projects and programs across the 0-1000 score scale, meaning no sample size is less than 5 out of the overall 35 project/program data set. Third, these thresholds, based on the research team input, allow a practical flexibility for improvement throughout a life cycle for in-progress projects and programs, when trying to move from the red zone to higher zones (by improving their EVMS maturity and environment as the project progresses).

These different zones are visually presented in Figure 24 for a sample of 33 projects and programs. In this plot, the initial sample (N=35) was reduced by removing one project with no performance information (P24) and one extreme outlier (P2).

As shown in Figure 24, five projects and programs were found to be in the green zone, seven were in the yellow zone, 15 were in the orange zone, and the remaining six projects and programs were in the red zone. In other words, within this sample, 45% of the projects and programs are in the orange zone, and the percentages in the green, yellow, and red zone are fairly similar (approximately 15% to 22% in each). This indicates that the orange zone seems to be the most prevalent in this sample, and projects and programs can strive for improvements to achieve higher scores and move into the yellow and green zones.

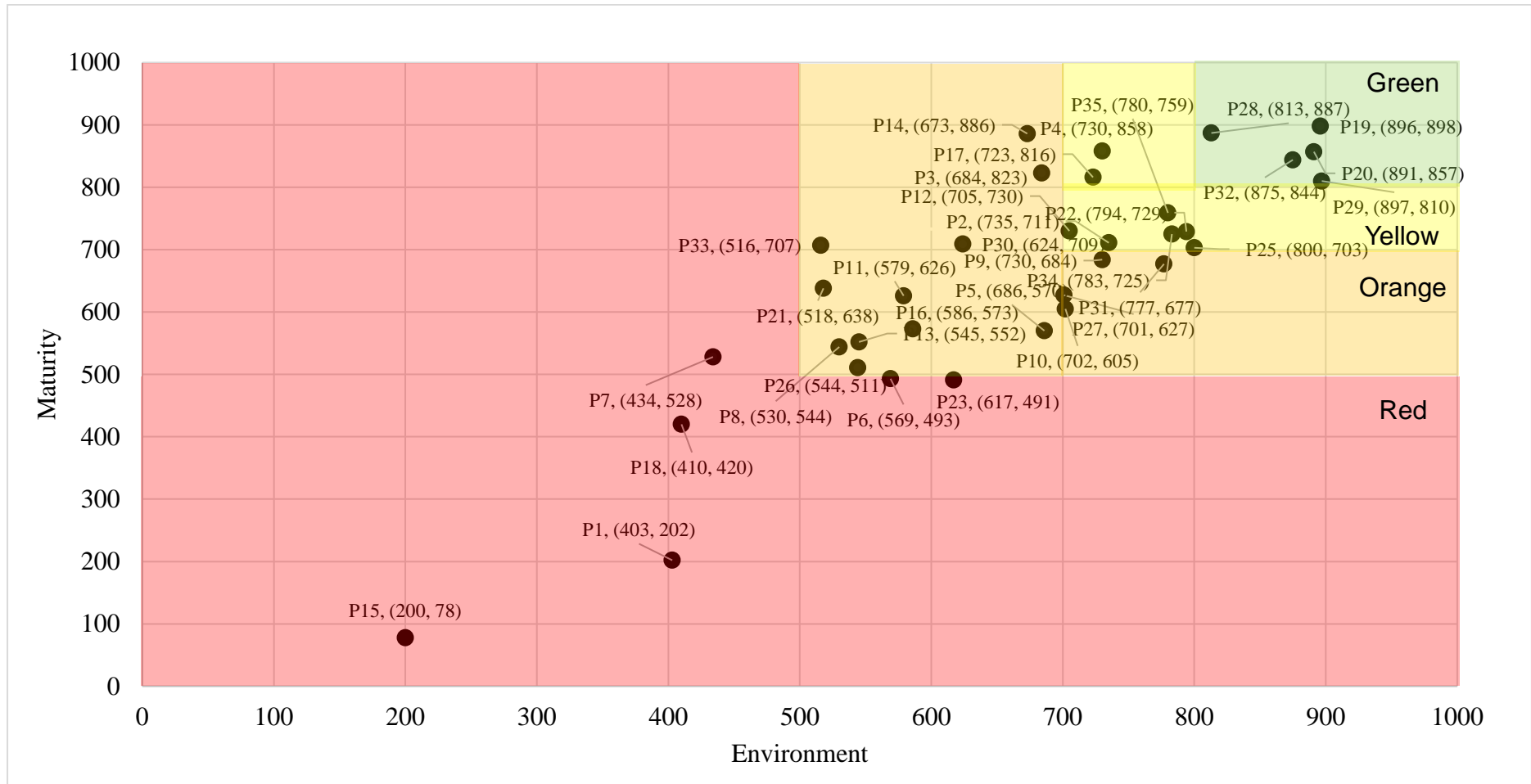


Figure 24 Cost and Schedule Performance across Four Bands – N=33

Table 7 shows the cost and schedule growth performance of the projects and programs versus the PMB set at 20% project completion across the four bands.

*Table 7 Cost and Schedule Growth – N=33*

<b>GREEN (&gt;800)</b>	
N:	5
Mean Cost Growth:	-0.3%
Mean Schedule Growth:	-5.9%
<b>YELLOW (700-799)</b>	
N:	7
Mean Cost Growth:	+13.7%
Mean Schedule Growth:	+3.7%
<b>ORANGE (500-699)</b>	
N:	15
Mean Cost Growth:	+48.1%
Mean Schedule Growth:	+26.9%
<b>RED (&lt;500)</b>	
N:	6
Mean Cost Growth:	+92.3%
Mean Schedule Growth:	+24.3%

The performance tables across the four bands for the rest of the performance metrics are provided in Tables 8 to 12. Table 8 shows the cost growth without change orders versus the PMB at 20% project completion, across the four bands.

Table 8 Cost Growth without Change Orders – N=29

<b>GREEN (&gt;800)</b>	
N:	4
Mean Cost Growth without Change Orders:	-4.3%
<b>YELLOW (700-799)</b>	
N:	8
Mean Cost Growth without Change Orders:	+0.2%
<b>ORANGE (500-699)</b>	
N:	12
Mean Cost Growth without Change Orders:	+6.3%
<b>RED (&lt;500)</b>	
N:	5
Mean Cost Growth without Change Orders:	+45.4%

Table 9 shows the change absolute value of the projects and programs versus the PMB at 20% project completion across the four bands. The sample is reduced by removing five projects with no change performance information and one outlier (N=29).

Table 9 Change Absolute Value – N=29

<b>GREEN (&gt;800)</b>	
N:	3
Mean Change Absolute Value:	7.7%
<b>YELLOW (700-799)</b>	
N:	7
Mean Change Absolute Value:	13.4%
<b>ORANGE (500-699)</b>	
N:	14
Mean Change Absolute Value:	47.2%
<b>RED (&lt;500)</b>	
N:	5
Mean Change Absolute Value:	56.7%

Table 10 shows the contingency of the projects and programs versus the PMB at 20% project completion across the four bands. The sample is reduced by removing five projects with no contingency performance information (N=30).

Table 10 Contingency – N=30

<b>GREEN (&gt;800)</b>	
N:	3
Mean Contingency:	15.4%
<b>YELLOW (700-799)</b>	
N:	7
Mean Contingency:	22.1%
<b>ORANGE (500-699)</b>	
N:	15
Mean Contingency:	51.7%
<b>RED (&lt;500)</b>	
N:	5
Mean Contingency:	13.5%

Table 11 shows the cost performance index of the projects and programs across the four bands (N=35).

Table 11 Cost Performance Index (CPI) – N=35

<b>GREEN (&gt;800)</b>	
N:	5
Mean CPI:	1.03
<b>YELLOW (700-799)</b>	
N:	8
Mean CPI:	0.95
<b>ORANGE (500-699)</b>	
N:	16
Mean CPI:	0.95
<b>RED (&lt;500)</b>	
N:	6
Mean CPI:	0.85

Table 12 shows the performance metrics of compliance with EIA-748-D (SAE 2019; NDIA 2018) if applicable, meeting business objectives, customer satisfaction, and whether EVMS helped proactively manage the project or program.

Table 12 Performance across Four Bands – N=35

<b>GREEN (&gt;800)</b>	
N:	5
Compliance with EIA-748-D:	100%
Meet Business Objectives:	5.0
Customer Satisfaction:	5.0
EVMS Helped Proactively Manage:	4.0
<b>YELLOW (700-799)</b>	
N:	8
Compliance with EIA-748-D:	100%
Meet Business Objectives:	4.4
Customer Satisfaction:	4.4
EVMS Helped Proactively Manage:	3.9
<b>ORANGE (500-699)</b>	
N:	16
Compliance with EIA-748-D:	62.5%
Meet Business Objectives:	4.3
Customer Satisfaction:	4.3
EVMS Helped Proactively Manage:	3.5
<b>RED (&lt;500)</b>	
N:	6
Compliance with EIA-748-D:	16.7%
Meet Business Objectives:	2.7
Customer Satisfaction:	2.7
EVMS Helped Proactively Manage:	2.7

In the following section, the project and program performance metrics that were presented earlier are statistically analyzed. The intent is to test whether the observed differences are indeed statistically significant.

#### 4.7. Statistical Analyses

Kruskal-Wallis tests were used to compare the groups of projects and programs across the four bands. As described earlier, Kruskal-Wallis is a nonparametric statistical test that determines statistical significance between two or more groups of independent variables and does not require normality within the groups (Creswell and Creswell 2017; Ostertagova et al. 2014). The dependent variables (e.g., cost growth, schedule growth, etc.) are continuous or discrete variables, whereas the independent variables consisted of the four independent groups or levels: green, yellow, orange, and red.



For example, a Kruskal-Wallis H test showed that there was a statistically significant difference in cost growth between the groups of projects and programs across the green, yellow, orange and red bands based on a p-value of 0.007 ( $< 0.05$ ). Another example from these results is that a statistically significant difference in compliance was found between the different groups of projects/programs. This means that not all the projects and programs were found to be compliant with NDIA EIA-748 at 20% project completion and that this depends on which group the project/program belongs to (green, yellow, orange, or red). The same statistical test was repeated for all the eight remaining performance metrics and a summary of the results is shown in Table 13.

*Table 13 Kruskal-Wallis Test Results*

Metric	N	Statistical Comparison	Sig.
Cost Growth (in %)	33	green vs. yellow vs. orange vs. red	0.007*
Schedule Growth (in %)	33	green vs. yellow vs. orange vs. red	0.102
Cost Growth without Change Orders (in %)	29	green vs. yellow vs. orange vs. red	0.093**
Change Absolute Value (in %)	29	green vs. yellow vs. orange vs. red	0.454
Contingency	30	green vs. yellow vs. orange vs. red	0.184
Cost Performance Index	35	green vs. yellow vs. orange vs. red	0.091**
Compliance	32	green vs. yellow vs. orange vs. red	0.007*
Meet Business Objectives	35	green vs. yellow vs. orange vs. red	0.003*
Customer Satisfaction	35	green vs. yellow vs. orange vs. red	0.007*
EVMS Helped Proactively Manage	35	green vs. yellow vs. orange vs. red	0.105

\*Result is significant at 0.05 level

\*\*Result is significant at 0.1 level

Notes:

1. Cost growth, schedule growth, cost growth without change orders, change absolute value, contingency, and compliance with EIA-748 are measured versus the PMB at 20% project completion.
2. “Meet Business Objectives” means that the project/program met its objectives and business drivers.
3. “Customer Satisfaction” means customers were satisfied with the results of the project/program.
4. “EVMS Helped Proactively Manage” means that the EVMS helped in proactively managing the project/program.

According to Table 13 results, the results in six out of ten performance metrics showed statistically significant differences at least between two population groups, i.e., the projects and programs belonging to a pair of bands (Vargha and Delaney 1998). In this case, in order to further analyze the origin of these differences, the different groups of projects and programs were individually tested for normality for the continuous performance metrics. When the data was normally distributed, the independent t-test was applied when comparing the two groups. Conversely, Mann-Whitney tests were used for the cases where the data was not normally distributed (Kim and Park 2019). Regarding the discrete performance metrics (i.e., meeting business objectives, customer satisfaction, EVMS helped proactively manage, and compliance), the nonparametric Mann-Whitney tests were used to compare performance between each pair of bands since these variables are based on a ranked order scale (Wilcox 2009). The results for each performance metric are given in the subsequent sub-sections.

Finally, based on Table 13, Kruskal-Wallis test results showed no statistically significant differences between the bands for four performance metrics. Consequently, in such cases, no follow-up analysis was performed for these metrics (Vargha and Delaney 1998).

The follow-up analysis, presented next, reports only on the instances where statistically significant differences were found when comparing two specific bands versus one another.

### ***Cost Growth***

Per Table 13, there was a statistically significant difference in *cost growth* between the groups of projects and programs across the green, yellow, orange and red bands (p-value = 0.007).

Next, the different groups of projects and programs were tested for normality. The data in the yellow band (N=7), orange band (N=15) and red band (N=6) are not normally distributed based on the results of the Shapiro-Wilk normality tests (p-value < 0.05). Therefore, Mann-Whitney tests were used to compare the performance between the projects and programs belonging to each combination of two bands (Kim and Park 2019).

The results showed statistically significant differences in cost growth between the following pairs of bands:

- red versus orange, p-value = 0.019 < 0.05
- red versus yellow, p-value = 0.015 < 0.05
- red versus green, p-value = 0.006 < 0.05
- orange versus green, p-value = 0.026 < 0.05

### ***Cost Growth without Change Orders***

Per Table 13, there was a statistically significant difference in *cost growth without change orders* between the groups of projects and programs across the green, yellow, orange and red bands (p-value = 0.093). Based on the results of the Shapiro-Wilk normality tests, the data in the red band (N=5) and the green band (N=4) were found to be normally distributed. Therefore, an independent t-test was applied to compare the performance of the projects and

programs between these two bands. The data in the orange (N=12) and yellow bands (N=8) showed nonnormal distributions; therefore, Mann-Whitney tests were used to compare the performance of the projects and programs between these two bands.

The significant differences in cost growth without change orders based on Kruskal-Wallis test results (Table 13) seem to appear mainly due to the following differences between the projects and programs in the following two bands:

- orange versus green, p-value = 0.052 < 0.1

### ***Cost Performance Index***

Per Table 13, there was a significant difference in the *Cost Performance Index* between the groups of projects and programs across the green, yellow, orange and red bands (p-value = 0.091). Based on the results of the Shapiro-Wilk normality tests, all of the data in the red band (N=6), orange band (N=16), yellow band (N=8), and green band (N=5) were found to be normally distributed. Therefore, independent t-tests were applied to compare the projects and programs between each pair of bands.

The results showed statistically significant differences in Cost Performance Index between the projects and programs within the following bands:

- orange versus green, p-value = 0.03 < 0.05
- red versus green, p-value = 0.051 < 0.1

### ***Compliance***

Per Table 13, there was a statistically significant difference in *Compliance* between the groups of projects and programs across the green, yellow, orange and red bands (p-value = 0.007). Based on the Mann-Whitney tests that were used to compare the projects and programs between two bands, statistically significant differences were found in Compliance between the projects and programs within the following bands:

- red versus yellow, p-value = 0.003 < 0.05
- red versus green, p-value = 0.014 < 0.05
- red versus orange, p-value = 0.052 < 0.1

Note that, based on Table 12, all the projects and programs belonging to the green and yellow bands were 100% compliant at 20% project completion. The number of compliant projects and programs is lower in the orange zone (by 37.5%), and in the red zone it is lower by another 45% or so (see Table 12). The compliance in projects and programs differed significantly mainly between the red band and each of the other bands.

### ***Meet Business Objectives***

Per Table 13, there was a statistically significant difference in *Meeting Business Objectives* between the groups of projects and programs across the green, yellow, orange and red bands (p-value = 0.003). Based on the Mann-Whitney tests that were used to compare the projects

and programs between two bands, statistically significant differences were found between the projects and programs within the following bands:

- red versus orange, p-value = 0.005 < 0.05
- red versus yellow, p-value = 0.016 < 0.05
- red versus green, p-value = 0.004 < 0.05
- orange versus green, p-value = 0.035 < 0.05

### ***Customer Satisfaction***

Per Table 13, there was a statistically significant difference in *Customer Satisfaction* between the groups of projects and programs across the green, yellow, orange and red bands (p-value = 0.007). Based on the Mann-Whitney tests that were used to compare the projects and programs between these bands, statistically significant differences were found between the projects and programs within the following bands:

- red versus orange, p-value = 0.013 < 0.05
- red versus yellow, p-value = 0.027 < 0.05
- red versus green, p-value = 0.004 < 0.05
- orange versus green, p-value = 0.035 < 0.05

### ***Other Performance Metrics***

Per Table 13, and based on Kruskal-Wallis Test results for this sample of projects, there were no statistically significant differences observed for the following performance metrics:

- Schedule growth
- Change Absolute Value
- Contingency
- EVMS Helped Proactively Manage

## **4.8. Testing of In-progress Projects**

In parallel to performing the statistical analyses to test the impact of EVMS maturity and environment on completed projects and programs, the tool was tested on in-progress projects as well (i.e., projects that had not yet ended at the time of this writing). The research team applied the maturity and environment assessments on two in-progress projects through facilitated reviews with the participation of the respective project and program stakeholders. During the facilitated reviews, positive feedback and testimonial were shared by the review participants on the usefulness of the tool. Information from two additional in-progress projects were collected from the performance workshop participants. As the research progressed, the research team also collected data from four additional in-progress projects, leading to a total sample of eight in-progress projects/programs to date (at the time of this writing).

Based on the feedback from the participants of the facilitated reviews, as well as the remaining reviews, it was found that the tool was able to effectively identify issues regarding EVMS application and integrated project management, setting the stage for corrective actions that will considerably benefit project outcomes. Overall, testing the tool on in-progress projects/programs confirmed the validity and efficacy of the IP2M METRR, and

the value added of this tool, while also determining how the tool can be applied on ongoing projects and programs.

The eight ongoing projects and programs tested are worth a combined \$6.8 billion USD, and all are located in the United States. Further information is not provided here due to confidentiality of these currently ongoing projects and programs. The maturity and environment matrix plot inclusive of the in-progress projects and programs is shown in Appendix F; where, the total sample size of the projects/programs on which the IP2M METRR was tested at the time of this writing is 43 projects and programs.

#### 4.9. Relationship between EVMS Maturity and Environment

To study the relationship between the environment score (as the independent variable) and the maturity score (as the dependent variable), correlation was tested between them using the sample of the 35 projects and programs. The authors and the research team’s hypothesis here is that maturity is related to the environment that the team is exposed to, hence the tested dependency.

The results of the correlation analysis in the sample of 35 projects and programs, shown in Figure 25, showed a Pearson R-value of 0.835 ( $R^2=0.69$ ), which indicates a strong correlation between the environment and the maturity scores, with a direct and positive relationship between them ( $p<0.05$ ). This indicates that changes in the predictor variable (environment score) were significantly correlated with the changes in the response variable (maturity score) in this sample.

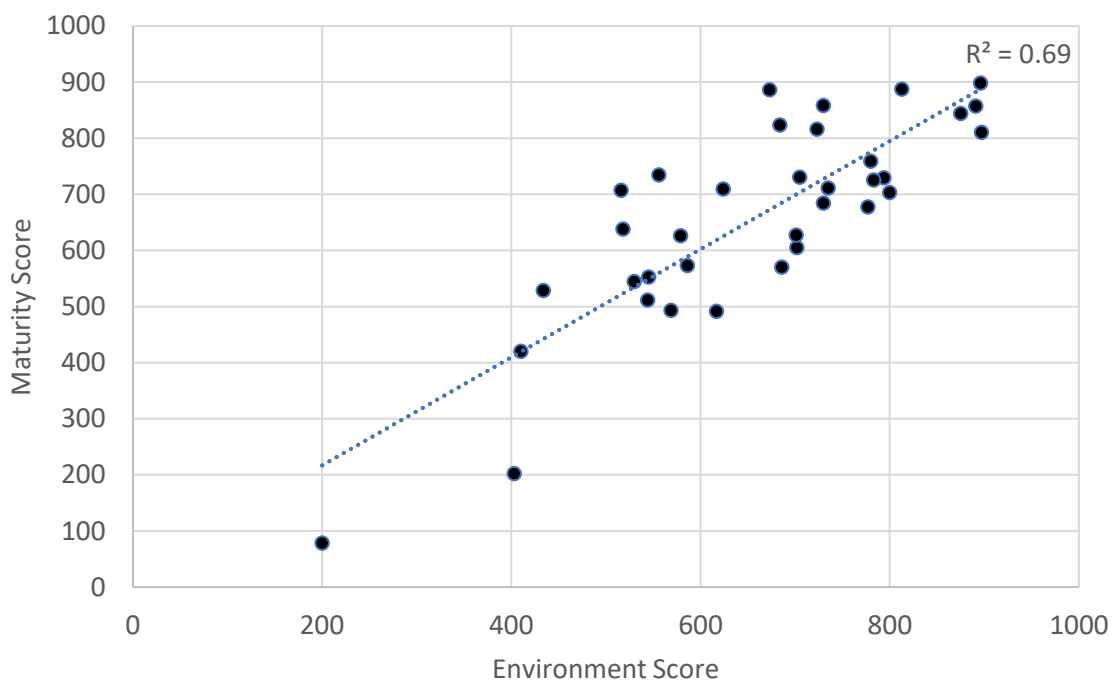


Figure 25 Correlation Results – N=35

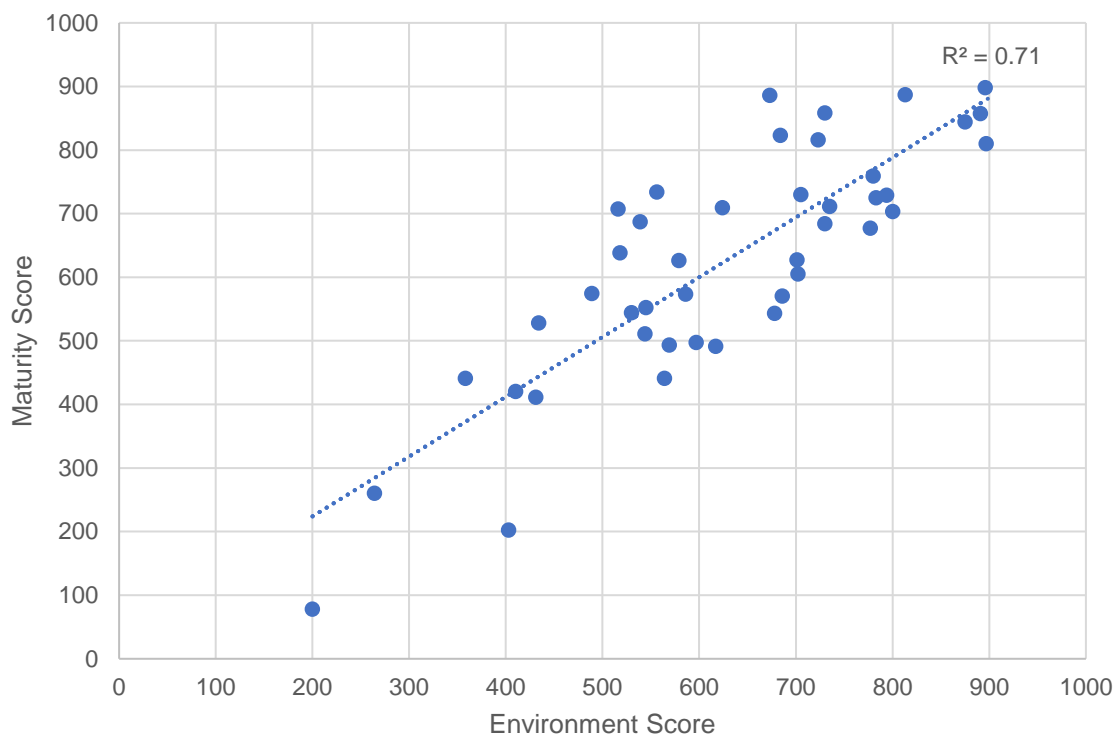
Furthermore, a linear regression was developed to predict maturity scores based on the environment score using the sample of the 35 projects and programs. The results showed the following linear regression equation ( $p < 0.05$ ):

$$\text{Maturity Score} = (\text{Environment Score} \times 0.96) + 24.27$$

This means that for each one point increase in environment score, the maturity score is predicted to increase by approximately one point (or 0.96 points to be exact). The environment score accounts for 69% of the variance in the maturity score in this sample ( $R^2=0.69$ ).

The authors also attempted a similar linear regression including data from all 43 projects in the database: the 35 completed projects in addition to the eight (8) in-progress projects discussed earlier. The results of the correlation analysis in the sample of 43 projects and programs, provided in Figure 26, showed a Pearson R-value of 0.843 ( $R^2=0.71$ ), which similarly indicates a strong correlation between the environment and the maturity scores, with a direct or positive relationship between them ( $p < 0.05$ ).

As such, the correlation considering both completed and in-progress projects was found to be even stronger than that without considering the in-progress projects. This indicates that, for this sample of projects and programs, the environment is correlated with maturity as a project progresses throughout its project lifecycle.



*Figure 26 Correlation Results – N=43*

Furthermore, a linear regression was developed to predict the maturity based on the environment in the sample of all 43 projects and programs. The results showed the following linear regression equation ( $p < 0.05$ ):

$$\text{Maturity Score} = (\text{Environment Score} \times 0.94) + 35.89$$

This means that for each one point increase in environment score, the maturity score is again predicted to increase by 0.94 point, or approximately one point. The environment score accounts for 71% of variance in the maturity score ( $R^2=0.71$ ). These results are consistent with what we observed in the sample of completed projects earlier.

#### 4.10. List of Top Well-Applied and Poorly-Applied Maturity Attributes

One additional analysis that was requested by the research team, and can help practitioners, is identifying which maturity attributes are typically applied well, and which are not. The maturity attributes rated as Levels “4” and “5” were documented in the sample, and the results are shown in Table 14. The top three attributes are:

- D.1 Direct costs
- A.5 Control Account (CA) to organizational element
- F.1 Calculating variances

*Table 14 List of Well-Applied Maturity Attributes across 35 projects/programs (frequency of attributes with level 4 or 5 rating)*

Maturity Attribute Name	Count
D.1 Direct Costs	29
A.5 Control Account (CA) to Organizational Element	28
F.1 Calculating Variances	28
C.9 Identify and Control Level of Effort (LOE) Work Scope	27
D.4 Direct Cost Breakdown Summary	27
G.5 Preventing Unauthorized Revisions to the Contract Budget Base (CBB)/Project Budget Base (PBB)	27
D.2 Actual Cost Reconciliation	26
B.2 Schedule Provides Current Status	25
C.1 Scope, Schedule and Budget Alignment	25
C.8 Appropriate Assignment of Earned Value Techniques (EVTs)	25
C.12 Reconcile to Target Cost Goal	25
D.3 Recording Direct Costs to Control Accounts (CAs) and/or Work Packages (WPs)	25
E.1 Indirect Account Organization Structure	25
E.2 Indirect Budget Management	25
F.2 Variances to Control Accounts (CAs)	25

The maturity attributes rated as Levels “1” and “2” were documented in the sample, and the results are shown in Table 15. The three attributes rated as Levels 1 and 2 the most frequently are:

- B.8 Schedule Margin
- C.6 Work package planning, distinguishability, and duration
- I.3 Subcontract oversight

*Table 15 List of Poorly-Applied Maturity Attributes across 35 projects/programs (frequency of attributes rated level 1 or 2 in the sample)*

Maturity Attribute Name	Count
B.8 Schedule Margin (SM)	8
C.6 Work Package Planning, Distinguishability, and Duration	8
I.3 Subcontract Oversight	8
B.3 Horizontal Integration	7
B.9 Progress Measures and Indicators	7
B.10 Time-Phased Performance Measurement Baseline (PMB)	7
H.5 Identification of Unit Costs and Lot Costs	7
B.6 Schedule Detail	6
B.7 Critical Path and Float	6
C.1 Scope, Schedule and Budget Alignment	6
C.5 Budgeting by Elements of Cost (EOC)	6
C.7 Measurable Units and Budget Substantiation	6
F.5 Estimates at Completion (EAC)	6
G.4 Control of Retroactive Changes	6
J.1 Identify and Analyze Risk	6
J.2 Risk Integration	6

#### **4.11. List of Top Rated and Poorly Rated Environment Factors**

The environment factors rated as “*Meets Most*” and “*High Performing*” were counted in the sample, and the results are shown in Table 16. The top 3 factors are:

- 4b. Sufficient funding is committed and available for implementing and executing the EVMS
- 4e. Data are readily available to populate EVMS tools supporting analyses for decision-making
- 2f. Team members responsible for the EVMS implementation and execution phases are co-located and/or accessible

*Table 16 List of Top Rated Environment Factors across 35 projects/programs (frequency of factors with level 4 or 5 rating)*

Environment Factor Name	Count
4b. Sufficient funding is committed and available for implementing and executing the EVMS.	28
4e. Data are readily available to populate EVMS tools supporting analyses for decision-making.	28
2f. Team members responsible for the EVMS implementation and execution phases are co-located and/or accessible.	27
1f. Effective teamwork exists and team members are working synergistically toward common project/program goals.	26
3a. The project/program promotes and follows standard practices to implement and execute an EVMS.	26
3g. Appropriate Subject Matter Expert (SME) input is adequate and timely.	26
4c. The team that implements and executes the EVMS for the project/program is adequate in size and composition.	26
4f. The project/program utilizes an appropriate periodic cycle for executing the EVMS effectively and efficiently.	26
3d. Communication is open and effective, including consistent terminology, metrics, and reports.	25



The environment factors rated as level “*Not Acceptable*” and “*Needs Improvement*” were counted in the sample, and the results are shown in Table 17. The 3 factors with most frequent low ratings are:

- 1c. The customer organization is supportive and committed to the implementation and use of EVMS
- 2b. The customer team is experienced in understanding and using EVM results to inform decision-making
- 1a. The contractor organization is supportive and committed to EVMS implementation, including making the necessary investments for regular maintenance and self-governance

*Table 17 List of Poorly Rated Environment Factors in 35 projects/programs (frequency of factors with level 1 or 2 rating)*

Environment Factor Name	Count
1c. The customer organization is supportive and committed to the implementation and use of EVMS.	12
2b. The customer team is experienced in understanding and using EVM results to inform decision-making.	11
1a. The contractor organization is supportive and committed to EVMS implementation, including making the necessary investments for regular maintenance and self-governance.	7
1d. Project/program leaders make timely and transparent decisions informed by the EVMS.	7
3e. Effective oversight is in place and used, including internal and external surveillance and independent reviews.	7
1g. Alignment and cohesion exist among key team members who implement and execute EVMS, including common objectives and priorities.	6
2d. Project/program stakeholder interests are appropriately represented in the implementation and execution of the EVMS.	6
4a. Adequate technology/software and tools are integrated and used for the EVMS.	6
4f. The project/program utilizes an appropriate periodic cycle for executing the EVMS effectively and efficiently.	6
1e. The project/program leadership effectively manages and controls change using EVMS, including corrective actions and continuous improvement.	5
3a. The project/program promotes and follows standard practices to implement and execute an EVMS.	5

## 5. Conclusions

The research results presented in this report fulfilled the objective of testing the new assessment tool, called IP2M METRR, which allows evaluating the maturity of an earned value management system (EVMS) and the environment surrounding it for effective integrated project/program management. The tool was tested on completed projects and programs, as the primary focus of this report. To address the main research hypothesis stating that projects and programs with high EVMS maturity and good EVMS environment outperform those with low EVMS maturity and poor EVMS environment, data from completed projects and programs were collected and analyzed. Data from in-progress projects and programs were also collected to reaffirm the usefulness and benefits of the IP2M METRR to support project/program success.

The authors, working closely with the research team, organized four performance workshops, allowing data collected from 35 completed projects. The participants evaluated a set of 56 EVMS maturity attributes that make up the ten EVMS sub-processes (i.e., Organizing, Planning and Scheduling, Budgeting and Work Authorization, Accounting Considerations, Indirect Budget and Cost Management, Analysis and Management Reporting, Change Control, Material Management, Subcontract Management, and Risk Management) as applied on their projects and programs at 20% project completion. They also evaluated a set of 27 EVMS environment factors grouped in four environment categories (i.e., Culture, People, Practices, Resources), as applied to their projects and programs also at 20% project completion. This data was collected from 31 industry professionals representing 23 unique organizations.

The results validated that the IP2M METRR is an effective and practical tool that has met its original purpose, being capable of measuring the maturity and environment of earned value management systems in an integrated project and program management setting. The IP2M METRR in its novel form proved its capability in allowing the projects and programs to tailor EVMS according to their specific requirements and needs in contrast to current and traditional industry practices where EVMS is implemented as a “one size fits all” format.

The findings also included statistically significant differences stemming from both maturity and environment, impacting cost growth, cost growth without change orders, cost performance index, compliance with EIA-748-D, meeting project objectives and business drivers, and customer satisfaction. These differences were found between the projects and programs that were implementing an effective EVMS with reliable data versus those that were less committed to EVMS. Moreover, EVMS environment and maturity were found to be strongly and positively correlated for this sample; in other words, Maturity is a function of Environment ( $M = f(E)$ ).

This novel model and framework represents a major paradigm shift from legacy EVMS practices. The IP2M METRR moves away from binary compliance determinations focused entirely on “guidelines”, to a new continuous framework that is on a scale of zero to 1,000 across two different dimensions, centered around management processes and environment. It provides a more useful definition of an EVMS for integrated project/program management and allows to identify gaps and paths forward, as well as associated performance implications.

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# APPENDIXES

**Appendix A. Workshop Participants' Organizations (in alphabetical order)**

Argonne National Lab
AzTech International
CACI International Inc
Central Plateau Cleanup Company
ClearPlan Consulting
Consolidated Nuclear Security, LLC (CNS)
CT Hewitt Consulting
Fermi National Accelerator Laboratory (FNAL)
General Atomics
Idaho National Laboratory (INL)
Jacobs
K2 Data Analytics
Lockheed Martin
Los Alamos National Lab (LANL)
Management System Applications Inc.
National Aeronautics and Space Administration (NASA)
National Nuclear Security Administration (NNSA)
National Scientific Foundation (NSF)
PEO Ground Combat Systems
Sandia National Laboratories (SNL)
Savannah River Nuclear Solutions (SRNS)
US Department of Energy
Washington River Protection Solutions (WRPS)



## Appendix B. List of the Maturity Attributes and the Environment Factors

### List of EVMS Maturity attributes

<p><b>A. ORGANIZING</b></p> <p>A.1. Product-Oriented Work Breakdown Structure (WBS)</p> <p>A.2. Work Breakdown Structure (WBS) Hierarchy</p> <p>A.3. Organizational Breakdown Structure (OBS)</p> <p>A.4. Integrated System with Common Structures</p> <p>A.5. Control Account (CA) to Organizational Element</p> <p><b>B. PLANNING AND SCHEDULING</b></p> <p>B.1. Authorized, Time-Phased Work Scope</p> <p>B.2. Schedule Provides Current Status</p> <p>B.3. Horizontal Integration</p> <p>B.4. Vertical Integration</p> <p>B.5. Integrated Master Schedule (IMS) Resources</p> <p>B.6. Schedule Detail</p> <p>B.7. Critical Path and Float</p> <p>B.8. Schedule Margin (SM)</p> <p>B.9. Progress Measures and Indicators</p> <p>B.10. Time-Phased Performance Measurement Baseline (PMB)</p> <p><b>C. BUDGETING AND WORK AUTHORIZATION</b></p> <p>C.1. Scope, Schedule and Budget Alignment</p> <p>C.2. Summary Level Planning Packages (SLPPs)</p> <p>C.3. Work Authorization Documents (WADs)</p> <p>C.4. Work Authorization Prior to Performance</p> <p>C.5. Budgeting by Elements of Cost (EOC)</p> <p>C.6. Work Package Planning, Distinguishability, and Duration</p> <p>C.7. Measurable Units and Budget Substantiation</p> <p>C.8. Appropriate Assignment of Earned Value Techniques (EVTs)</p> <p>C.9. Identify and Control Level of Effort (LOE) Work Scope</p> <p>C.10. Identify Management Reserve (MR) Budget</p> <p>C.11. Undistributed Budget (UB)</p> <p>C.12. Reconcile to Target Cost Goal</p> <p><b>D. ACCOUNTING CONSIDERATIONS</b></p> <p>D.1. Direct Costs</p> <p>D.2. Actual Cost Reconciliation</p> <p>D.3. Recording Direct Costs to Control Accounts (CAs) and/or Work Packages (WPs)</p> <p>D.4. Direct Cost Breakdown Summary</p>	<p><b>E. INDIRECT BUDGET AND COST MANAGEMENT</b></p> <p>E.1. Indirect Account Organization Structure</p> <p>E.2. Indirect Budget Management</p> <p>E.3. Record/Allocate Indirect Costs</p> <p>E.4. Indirect Variance Analysis</p> <p><b>F. ANALYSIS AND MANAGEMENT REPORTING</b></p> <p>F.1. Calculating Variances</p> <p>F.2. Variances to Control Accounts (CAs)</p> <p>F.3. Performance Measurement Information</p> <p>F.4. Management Analysis and Corrective Actions</p> <p>F.5. Estimates at Completion (EAC)</p> <p><b>G. CHANGE CONTROL</b></p> <p>G.1. Controlling Management Reserve (MR) and Undistributed Budget (UB)</p> <p>G.2. Incorporate Customer Directed Changes in a Timely Manner</p> <p>G.3. Baseline Changes Reconciliation</p> <p>G.4. Control of Retroactive Changes</p> <p>G.5. Preventing Unauthorized Revisions to the Contract Budget Base (CBB)/Project Budget Base (PBB)</p> <p>G.6. Over Target Baseline (OTB)/Over Target Schedule (OTS) Authorization</p> <p><b>H. MATERIAL MANAGEMENT</b></p> <p>H.1. Recording Actual Material Costs</p> <p>H.2. Material Performance</p> <p>H.3. Residual Material</p> <p>H.4. Material Price/Usage Variance</p> <p>H.5. Identification of Unit Costs and Lot Costs</p> <p><b>I. SUBCONTRACT MANAGEMENT</b></p> <p>I.1. Subcontract Identification and Requirements Flow Down</p> <p>I.2. Subcontractor Integration and Analysis</p> <p>I.3. Subcontract Oversight</p> <p><b>J. RISK MANAGEMENT</b></p> <p>J.1. Identify, Analyze and Manage Risk</p> <p>J.2. Risk Integration</p>
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List of EVMS Environment Factors

<b>1. Culture (7 factors)</b>	
1a.	The <b>contractor organization is supportive and committed</b> to EVMS implementation, including making the necessary investments for regular maintenance and self-governance.
1b.	The project/program <b>culture fosters trust, honesty, transparency, communication, and shared values</b> across functions.
1c.	The <b>customer organization is supportive and committed</b> to the implementation and use of EVMS.
1d.	Project/program leaders make <b>timely and transparent decisions</b> informed by the EVMS.
1e.	The project/program <b>leadership effectively manages and controls change</b> using EVMS, including corrective actions and continuous improvement.
1f.	<b>Effective teamwork exists</b> and team members are working synergistically toward common project/program goals.
1g.	<b>Alignment and cohesion exist among key team members</b> who implement and execute EVMS, including common objectives and priorities.
<b>2. People (6 factors)</b>	
2a.	The <b>contractor team is experienced/qualified</b> in implementing and executing the EVMS.
2b.	The <b>customer team is experienced</b> in understanding and using EVM results to inform decision-making.
2c.	Project/program <b>leadership is defined, effective, and accountable.</b>
2d.	<b>Project/program stakeholder interests are appropriately represented</b> in the implementation and execution of the EVMS.
2e.	<b>Professional learning and education</b> of key individuals responsible for EVMS implementation and execution, <b>is appropriate</b> to meet project/program requirements.
2f.	<b>Team members</b> responsible for the EVMS implementation and execution phases <b>are co-located and/or accessible.</b>
<b>3. Practices (8 factors)</b>	
3a.	The project/program <b>follows standard practices</b> to implement and execute an EVMS.
3b.	<b>EVMS requirements definition is in place, and agreement exists</b> among key stakeholders and customer.
3c.	<b>Roles and responsibilities are defined, documented and well-understood</b> for implementing and executing EVMS.
3d.	<b>Communication is open and effective,</b> including consistent terminology, metrics, and reports.
3e.	<b>Effective oversight is in place and used,</b> including internal and external surveillance and independent reviews.
3f.	<b>Contractual terms and conditions</b> that impact the effectiveness of EVMS <b>are known and have been addressed.</b>
3g.	Appropriate <b>Subject Matter Expert (SME) input is adequate</b> and timely.
3h.	<b>Coordination exists</b> between the key disciplines involved in implementing and executing the EVMS.
<b>4. Resources (6 factors)</b>	
4a.	<b>Adequate technology/software and tools are integrated and used</b> for the EVMS.
4b.	<b>Sufficient funding is committed</b> and available <b>for implementing and executing EVMS.</b>
4c.	The team that implements and executes the EVMS is adequate in <b>size and composition.</b>
4d.	<b>Sufficient calendar time and work-hours are committed and available</b> for implementing and executing the EVMS.
4e.	<b>Data are readily available</b> to populate EVMS tools supporting analyses for decision-making.
4f.	The <b>project/program utilizes an appropriate periodic cycle</b> for executing the EVMS effectively and efficiently.

## Appendix C. Performance Workshop Qualtrics Questionnaire

### Maturity and Environment Assessment Workshop

Overview The Integrated Project/Program Management (IP2M) Maturity and Environment Total Risk Rating (METRR) using EVMS is an assessment mechanism being developed as part of a DOE-sponsored Joint Research Study led by Arizona State University (ASU) and representing 15+ government and industry organizations. The envisioned tool will assess a spectrum of EVMS maturity and environment issues centered around the 32 EIA-748 EVMS Guidelines, while also referencing the ANSI Standard for EVM (2019) and ISO 21508 (2018) guidance.

The purpose of this workshop is to assess your recently completed project/program using the EVMS METR tool.

#### **Confidentiality Statement:**

All data provided to ASU in support of this research activity will be considered confidential information. Individual organization data will not be communicated in any form to any party other than the ASU authorized academic researchers. Any data or analyses that are shared with others or published will represent summaries of data from multiple participating organizations that have been aggregated in a way that will preclude identification of proprietary data. If you have any questions, please contact Dr. G. Edward Gibson, Jr. ([egibson4@asu.edu](mailto:egibson4@asu.edu)) or Dr. Mounir El Asmar ([asmar@asu.edu](mailto:asmar@asu.edu)).

Please note that when you answer questions, you must also click on the **NEXT button (Right Arrow)** to move to the following screen.

- Name: \_\_\_\_\_
- Phone: \_\_\_\_\_
- Email: \_\_\_\_\_
- Organization Name: \_\_\_\_\_

Q1 Please indicate your employer type.

- Government contractor
- Government
- Consultant
- Manufacturer/Constructor
- Other (Software Developer, World Bank, Non-Profit, etc.). Please specify.  
\_\_\_\_\_

Q2 Please provide your typical employment role.

- Project controls management
- Project/program management
- Compliance management
- Executive or senior management
- Consulting
- Other (contracting, control accounts management, finance, engineering & systems engineering or other). Please specify. \_\_\_\_\_

Q3 How many years of Earned Value Management (EVM) experience do you have in total?

- < 5 years
- 5 to 10 years
- 11 to 15 years
- 16 to 20 years
- 21 to 25 years
- > 25 years

Q4 Think of an EVMS application on a recently completed project/program that you were involved with. You will use this project/program as your anchor while assessing its EVMS maturity and environment.

Note: if any values cannot be shared, please write N/A.

- Please provide the name of the project/program (e.g., USS Enterprise):  
\_\_\_\_\_
- Briefly describe the scope of the project/program (e.g., this project was a major cleanup facility to process high-level nuclear waste, or this program was to deliver a new fighter aircraft):  
\_\_\_\_\_
- Please provide the primary location of the project/program (i.e., Nevada, Alabama, India):  
\_\_\_\_\_

**Initial** Performance Measurement Baseline (PMB) Budget (\$M):

\_\_\_\_\_

**Final** Project/Program Cost (\$M) (if you provided N/A for PMB, please provide % of cost underrun (-X%) or overrun (+Y%) versus baseline):

\_\_\_\_\_

**Initial** Baseline Project/Program Duration (Months):

\_\_\_\_\_

**Final** Project/Program Duration (Months) (if you provided N/A for baseline duration, please provide % of schedule underrun (-X%) or overrun (+Y%) versus baseline):

\_\_\_\_\_

Please explain any changes that impacted the initial baseline cost or schedule by more than 5%. If not, please write N/A. \_\_\_\_\_

Budgeted owner contingency above the PMB (\$M or a % of PMB):

\_\_\_\_\_

Final Cost Performance Index (CPI):

\_\_\_\_\_

Absolute value of change orders (\$M or a % of PMB):

\_\_\_\_\_

Feel free to use this box to explain anything unusual in this project/program.

\_\_\_\_\_

Q5 Was the anchor project/program used in your evaluation compliant with NDIA EIA-748 at the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC, where BCWP is Budgeted Cost for Work Performed, PMB is Performance Measurement Baseline, and BAC is Budget at Completion)?

Yes

No

N/A. Please explain. \_\_\_\_\_

Q6 Was the information provided in the last questions a Project or a Program?

Project

Program

Q7 What is the perspective that you are bringing to this anchor project/program evaluation? (i.e., are you representing the owner organization, contractor, consultant, or other?)

- Owner/sponsor organization
- Contractor organization
- Consultant organization
- Other. Please specify. \_\_\_\_\_

Q8 Reflecting on your perspective, rate the anchor project/program using a scale of 1 to 5, as shown below.

	1 very unsuccessful	2 unsuccessful	3 somewhat successful	4 successful	5 very successful
The project/program met its objectives and business drivers.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Customers were satisfied with the results of the project/program.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
The EVMS helped to proactively manage the project/program.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Next Moving forward to the questions assessing the Maturity component for your anchor project/program.

### Maturity

Q9 This question is focused on the attributes that make up the **Organizing Sub-Process** (Sub-Process A). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each attribute's maturity at that point in time, where BCWP is Budgeted Cost for Work Performed, PMB is Performance Measurement Baseline, and BAC is Budget at Completion.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
A.1 Product-Oriented Work Breakdown Structure (WBS)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A.2 Work Breakdown Structure (WBS) Hierarchy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

A.3 Organizational Breakdown Structure (OBS)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A.4 Integrated System with Common Structures	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
A.5 Control Account (CA) to Organizational Element	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q10 This question is focused on the attributes that make up the **Planning and Scheduling Sub-Process** (Sub-Process B). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each attribute's maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
B.1 Authorized, Time-Phased Work Scope	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
B.2 Schedule Provides Current Status	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
B.3 Horizontal Integration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
B.4 Vertical Integration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
B.5 Integrated Master Schedule (IMS) Resources	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
B.6 Schedule Detail	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
B.7 Critical Path and Float	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
B.8 Schedule Margin (SM)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
B.9 Progress Measures and Indicators	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
B.10 Time- Phased Performance Measurement Baseline (PMB)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q11 This question is focused on the attributes that make up the **Budgeting and Work Authorization Sub-Process** (Sub-Process C). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each attribute's maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
C.1 Scope, Schedule and Budget Alignment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.2 Summary Level Planning Packages (SLPPs)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.3 Work Authorization Documents (WADs)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.4 Work Authorization Prior to Performance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.5 Budgeting by Elements of Cost (EOC)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.6 Work Package Planning, Distinguishability, and Duration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.7 Measurable Units and Budget Substantiation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.8 Appropriate Assignment of Earned Value Techniques (EVTs)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.9 Identify and Control Level of Effort (LOE) Work Scope	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.10 Identify Management Reserve (MR) Budget	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.11 Undistributed Budget (UB)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.12 Reconcile to Target Cost Goal	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q12 This question is focused on the attributes that make up the **Accounting Considerations Sub-Process** (Sub-Process D). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each attribute's maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
D.1 Direct Costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
D.2 Actual Cost Reconciliation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
D.3 Recording Direct Costs to Control Accounts	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



(CAs) and/or  
Work Packages  
(WPs)  
D.4 Direct Cost  
Breakdown  
Summary

Q13 This question is focused on the attributes that make up the **Indirect Budget and Cost Management Sub-Process** (Sub-Process E). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each attribute’s maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
E.1 Indirect Account Organization Structure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
E.2 Indirect Budget Management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
E.3 Record/Allocate Indirect Costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
E.4 Indirect Variance Analysis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q14 This question is focused on the attributes that make up the **Analysis and Management Reporting Sub-Process** (Sub-Process F). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each attribute’s maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
F.1 Calculating Variances	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
F.2 Variances to Control Accounts (CAs)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
F.3 Performance Measurement Information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
F.4 Management Analysis and Corrective Actions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
F.5 Estimates at Completion (EAC)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q15 This question is focused on the attributes that make up the **Change Control Sub-Process** (Sub-Process G). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each attribute’s maturity at that point in time.

N/A      Level 1      Level 2      Level 3      Level 4      Level 5

G.1 Controlling Management Reserve (MR) and Undistributed Budget (UB)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
G.2 Incorporate Customer Directed Changes in a Timely Manner	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
G.3 Baseline Changes Reconciliation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
G.4 Control of Retroactive Changes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
G.5 Preventing Unauthorized Revisions to the Contract Budget Base (CBB)/Project Budget Base (PBB)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
G.6 Over Target Baseline (OTB)/Over Target Schedule (OTS) Authorization	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q16 This question is focused on the attributes that make up the **Material Management Sub-Process** (Sub-Process H). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each attribute's maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
H.1 Recording Actual Material Costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
H.2 Material Performance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
H.3 Residual Material	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
H.4 Material Price/Usage Variance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
H.5 Identification of Unit Costs and Lot Costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q17 This question is focused on the attributes that make up the **Subcontract Management Sub-Process** (Sub-Process I). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each attribute’s maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
I.1 Subcontract Identification and Requirements Flow Down	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I.2 Subcontractor Integration and Analysis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I.3 Subcontract Oversight	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q18 This question is focused on the attributes that make up the **Risk Management Sub-Process** (Sub-Process J). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each attribute’s maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
J.1 Identify, Analyze and Manage Risk	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
J.2 Risk Integration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Q19 General Comments on the Maturity component.**

Please feel free to skip this question or share briefly any general thoughts about the Maturity component (such as a typo error you found or other).

Also, if you have assessed some attributes as not applicable to your project/program, please provide a clear justification to explain why each particular attribute is considered as not applicable.

**If you would like to modify any previous answers on maturity, you can click the left arrow to go back to the previous pages.**

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Next Moving forward to the questions assessing the Environment component for your anchor project/program.

**Environment**



Q20 This question is focused on the factors that make up the **Culture Category** (Category 1). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each environment factor at that point in time, where BCWP is Budgeted Cost for Work Performed, PMB is Performance Measurement Baseline, and BAC is Budget at Completion.

	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
1a. The <b>contractor organization is supportive and committed</b> to EVMS implementation, including making the necessary investments for regular maintenance and self-governance.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1b. The project/program <b>culture fosters trust, honesty, transparency, communication, and shared values</b> across functions.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1c. The <b>customer organization is supportive and committed</b> to the implementation and use of EVMS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1d. Project/program leaders make <b>timely and transparent decisions</b> informed by the EVMS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1e. The project/program <b>leadership effectively manages and controls change</b> using EVMS, including corrective actions and continuous improvement.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1f. <b>Effective teamwork exists</b> and team members are working synergistically toward common project/program goals.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1g. <b>Alignment and cohesion exist among key team members</b> who implement and execute EVMS, including common objectives and priorities.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q21 This question is focused on the factors that make up the **People Category** (Category 2). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each environment factor at that point in time.

	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
2a. The <b>contractor team is experienced and qualified</b> in implementing and executing EVMS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2b. The <b>customer team is experienced</b> in understanding and using EVM results to inform decision-making.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2c. Project/program <b>leadership is defined, effective, and accountable.</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2d. <b>Project/program stakeholder interests are appropriately represented</b> in the implementation and execution of the EVMS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

- 2e. **Professional learning and education** of key individuals responsible for EVMS implementation and execution, **is appropriate** to meet project/program requirements.
- 2f. **Team members** responsible for the EVMS implementation and execution phases **are co-located and/or accessible**.

Q22 This question is focused on the factors that make up the **Practices Category** (Category 3). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each environment factor at that point in time.

	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
3a. The project/program <b>promotes and follows standard practices</b> to implement and execute an EVMS. <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3b. <b>EVMS requirements definition is in place, and agreement exists</b> among key stakeholders and customer. <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3c. <b>Roles and responsibilities are defined, documented and well-understood</b> for implementing and executing EVMS. <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3d. <b>Communication is open and effective</b> , including consistent terminology, metrics, and reports. <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3e. <b>Effective oversight is in place and used</b> , including internal and external surveillance and independent reviews. <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3f. <b>Contractual terms and conditions</b> that impact the effectiveness of EVMS <b>are known and have been addressed</b> . <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3g. Appropriate <b>Subject Matter Expert (SME) input is adequate</b> and timely. <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3h. <b>Coordination exists</b> between the key disciplines involved in implementing and executing the EVMS. <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Q23 This question is focused on the factors that make up the **Resources Category** (Category 4). Think back to the point in time at 20% project completion (CUMULATIVE BCWP/PMB BAC), and assess each environment factor at that point in time.

	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
4a. Adequate technology/software and tools are integrated and used for the EVMS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4b. Sufficient funding is committed and available for implementing and executing the EVMS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4c. The team that implements and executes the EVMS for the project/program is adequate in size and composition.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4d. Sufficient calendar time and work-hours are committed and available for implementing and executing the EVMS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4e. Data are readily available to populate EVMS tools supporting analyses for decision-making.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4f. The project/program utilizes an appropriate periodic cycle for executing the EVMS effectively and efficiently.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

**Q24 General Comments on the Environment component.**

Please feel free to skip this question or share briefly any general thoughts about the Environment component (such as a typo error you found or other).

**If you would like to modify any previous answers on environment, you can click the left arrow to go back to the previous pages.**

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**Final Questions**

Result The following is the assessment results of your project/program:

Total Raw Score for Maturity Component: ...

Total Score for Environment Component: ...

Q25 Do you want us to provide benchmarking data of your project/program after we have completed all the workshops?

Yes

No

**Q26 General Comments.**

Please feel free to share any other thoughts about the Maturity and/or Environment Component assessments, as well as feedback on the workshop itself in the space below.

Also, feel free to use this box to explain anything unusual in this project/program, or to provide the general context and reasoning behind your assessment. This is an optional question and you may skip it if you do not feel the need to explain or provide more information.

**If you would like to modify any previous answers, you can click the left arrow to go back to the previous pages.**

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Q27 Would you like to receive **Continuing Education Unit (CEU)** credit for this workshop?





Yes

No

Q28 **Are you ready to exit?** If yes, please click the yes button and the NEXT button (Right Arrow) to complete this workshop and record all your responses. Once you click next, you cannot go back to modify any previous answers. Thank you.

Yes

# Appendix D. Sample Performance Workshop Presentation

<div style="text-align: center;"> <h2>Project/Program Performance Workshop #3</h2> <p>06/03/2021</p> <p>EVMS Maturity and Environment Total Rating (EVMS METR)</p>   </div>	<h3>Workshop Agenda</h3> <ul style="list-style-type: none"> <li>■ 8:00 – 8:30 am Introductions and Workshop Objectives</li> <li>■ 8:30 – 8:45 am Project/program Characteristics and Performance</li> <li>■ 8:45 – 9:30 am Maturity Component Assessment</li> <li>■ 9:30 – 9:45 am 15-Minute Break</li> <li>■ 9:45 – 11:00 am Maturity Component Assessment</li> <li>■ 11:00 – 11:25 am 25-Minute Break</li> <li>■ 11:25 – 12:45 pm Environment Component Assessment</li> <li>■ 12:45 – 1:00 pm Conclusions &amp; Wrap-Up</li> </ul> <p>Note: All times are in Pacific Daylight Time (PDT)</p> 																																																																								
<h3>Welcome</h3> <p><b>Melvin Frank</b>, Project Controls Division (PM-30), Office of Project Management (PM), U.S. Department of Energy</p> <ul style="list-style-type: none"> <li>- Effective and Efficient EVMS: attributes, enablers, barriers</li> <li>- Office of Management and Budget: Reciprocity</li> <li>- EIA-748 Update</li> <li>- Better Governance: Plan → Do → Check → Act → (Rinse and Repeat)</li> </ul> 	<h3>The tool name is changing...</h3> <ul style="list-style-type: none"> <li>■ Our tool is currently called EVMS Maturity and Environment Total Rating (EVMS METR), pronounced 'EVMS meter'</li> <li>■ Our plan is to change the tool name to 'Integrated Project/Program Management (IP2M) Maturity and Environment Total Risk Rating (METRR) using EVMS' prior to publication, pronounced 'IPM meter'</li> <li>■ Reasoning:             <ul style="list-style-type: none"> <li>- After development, we recognized the need for a title that is more representative of the already existing integrated management framework of EVMS for projects and programs (e.g., integration of systems and processes, risk management, subcontract management, etc.</li> <li>- We want a tool more broadly acceptable to project/program managers that simplifies and democratizes EVMS</li> </ul> </li> </ul> 																																																																								
<h3>Introductions (15 seconds/person)</h3> <ul style="list-style-type: none"> <li>■ Name</li> <li>■ Organization</li> </ul>  	<h3>Workshop Objectives</h3>  <ul style="list-style-type: none"> <li>■ Provide background of Research Team efforts</li> <li>■ Introduce participants to this new tool</li> <li>■ Use the maturity and environment components to assess your anchor project/program:             <ul style="list-style-type: none"> <li>- Background</li> <li>- Maturity</li> <li>- Environment</li> </ul> </li> <li>■ Provide a copy of the draft maturity and environment tools for participants' reference/use</li> </ul> 																																																																								
<h3>Research Aims and Objectives</h3> <ul style="list-style-type: none"> <li>■ Elevate the worth and utility of the EVMS through <b>unbiased scientific research</b></li> <li>■ Develop a <b>scalable EVMS Maturity and Environment Model</b> inclusive of EIA-748 requirements that can accommodate the unique missions, program and project types of the DOE, DoD, NRO, NASA, and other agencies, as well as commercial ventures requiring disciplined scope, schedule, and cost management</li> <li>■ Develop a <b>weighted EVMS Maturity and Environment Scoring Method</b> that provides insights into implementation risks and opportunities</li> <li>■ The <b>target audience</b> includes individuals with the <b>necessary EVM experience</b>, technical <b>background</b>, and training in the relevant subject matter to provide an informed opinion and contribute to the decision-making process based on acceptable best practices, recognizable standards, and methods</li> </ul> 	<h3>Research Team Members</h3> <table border="1"> <thead> <tr> <th>Team Member</th> <th>Organization</th> <th>Team Member</th> <th>Organization</th> </tr> </thead> <tbody> <tr> <td>Varianita Arzamal</td> <td>Arizona State University</td> <td>Jeffrey King</td> <td>Hortrup Grumman</td> </tr> <tr> <td>Elizabeth Baley Ballard</td> <td>Tacolote Research</td> <td>Derek D. Lehman</td> <td>Washington River Protection Solutions</td> </tr> <tr> <td>Amy Basche</td> <td>Mission Support Alliance</td> <td>Doug Marlbough</td> <td>Los Alamos National Laboratory</td> </tr> <tr> <td>Ivan Bembers</td> <td>National Reconnaissance Office</td> <td>Ben Pina</td> <td>U.S. Department of Energy - NNSA</td> </tr> <tr> <td>Danielle A. Benita</td> <td>U.S. Department of Defense - DCMA</td> <td>John C. Post</td> <td>Jacobs</td> </tr> <tr> <td>Callitt O'Grady</td> <td>U.S. Department of Defense</td> <td>Garrett Richardson</td> <td>U.S. Department of Energy</td> </tr> <tr> <td>Thomas P. Carney</td> <td>Lockheed Martin</td> <td>Russell W. Rodewald</td> <td>Raytheon Corp</td> </tr> <tr> <td>Mouatt El Azzam, PI</td> <td>Arizona State University</td> <td>Nata Sarabewant</td> <td>Arizona State University</td> </tr> <tr> <td>Jon Fleming</td> <td>National Aeronautics and Space Administration</td> <td>Paul J. Sample</td> <td>CACI International Inc.</td> </tr> <tr> <td>Mark Frampton</td> <td>National Reconnaissance Office</td> <td>Vaughn M. Schlegel</td> <td>Lockheed Martin</td> </tr> <tr> <td>Melvin Frank</td> <td>U.S. Department of Energy</td> <td>Anthony W. Spillman</td> <td>Washington River Protection Solutions</td> </tr> <tr> <td>G. Edward Gibson, PI</td> <td>Arizona State University</td> <td>Robert Sudermann</td> <td>FLUOR</td> </tr> <tr> <td>Jonathan de Guzman</td> <td>Booz Allen Hamilton</td> <td>David Tervonen</td> <td>U.S. Department of Defense</td> </tr> <tr> <td>Wayne A. Harris</td> <td>Tech Source</td> <td>Tristan Walters</td> <td>Sandia National Laboratories</td> </tr> <tr> <td>Craig T. Hewitt</td> <td>Washington River Protection Solutions</td> <td>William G. Weisler</td> <td>U.S. Department of Defense - DCMA</td> </tr> <tr> <td>David Kester</td> <td>U.S. Department of Energy</td> <td>Matthew Z. (Zac) West</td> <td>U.S. Department of Energy</td> </tr> <tr> <td>Kristen Kester</td> <td>National Aeronautics and Space Administration</td> <td></td> <td></td> </tr> </tbody> </table> <p>DCMA: Defense Contract Management Agency NNSA: National Nuclear Security Administration</p> 	Team Member	Organization	Team Member	Organization	Varianita Arzamal	Arizona State University	Jeffrey King	Hortrup Grumman	Elizabeth Baley Ballard	Tacolote Research	Derek D. Lehman	Washington River Protection Solutions	Amy Basche	Mission Support Alliance	Doug Marlbough	Los Alamos National Laboratory	Ivan Bembers	National Reconnaissance Office	Ben Pina	U.S. Department of Energy - NNSA	Danielle A. Benita	U.S. Department of Defense - DCMA	John C. Post	Jacobs	Callitt O'Grady	U.S. Department of Defense	Garrett Richardson	U.S. Department of Energy	Thomas P. Carney	Lockheed Martin	Russell W. Rodewald	Raytheon Corp	Mouatt El Azzam, PI	Arizona State University	Nata Sarabewant	Arizona State University	Jon Fleming	National Aeronautics and Space Administration	Paul J. Sample	CACI International Inc.	Mark Frampton	National Reconnaissance Office	Vaughn M. Schlegel	Lockheed Martin	Melvin Frank	U.S. Department of Energy	Anthony W. Spillman	Washington River Protection Solutions	G. Edward Gibson, PI	Arizona State University	Robert Sudermann	FLUOR	Jonathan de Guzman	Booz Allen Hamilton	David Tervonen	U.S. Department of Defense	Wayne A. Harris	Tech Source	Tristan Walters	Sandia National Laboratories	Craig T. Hewitt	Washington River Protection Solutions	William G. Weisler	U.S. Department of Defense - DCMA	David Kester	U.S. Department of Energy	Matthew Z. (Zac) West	U.S. Department of Energy	Kristen Kester	National Aeronautics and Space Administration		
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## Confidentiality

- Responses coded.
- Only ASU team members will know who provided project information.
- Data is not attributable to any individual and/or organization.
- If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Office of Research Integrity and Assurance, at (480) 965-6788.



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## Progress to Date

05/08/19	Team kick-off
12/31/19	Completed literature review; conducted and analyzed survey of 294 experts
06/30/20	Developed Maturity and Environment draft assessments
Jul-Sep 2020	EVMS Environment Workshops #1,2,3,4
Jul-Nov 2020	EVMS Maturity Workshops #1,2,3,4
Aug-Nov 2020	Addressed Environment comments and developed factor weights
12/08/20	Finalized the EVMS Environment Assessment
01/21/21	Software taskforce kickoff
Dec-Feb	Addressed Maturity comments and developed attribute weights
Apr-Jun 2021	Conduct additional workshops to collect performance data
07/15/21	Finalize performance analysis
08/31/21	Finalize publications
09/01/21	Start training
11/30/21	Software testing completion
12/31/21	Project completion



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## Typical Large and Complex Projects/Programs

- Industrial
- Energy
- Defense
- Aerospace
- Manufacturing
- Infrastructure
- etc.



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## Definitions

**Earned Value Management (EVM):** The use of performance management information, produced from the EVMS, to plan, direct, control, and forecast the execution and accomplishment of contract/project cost, schedule, and technical performance objectives versus the plan.

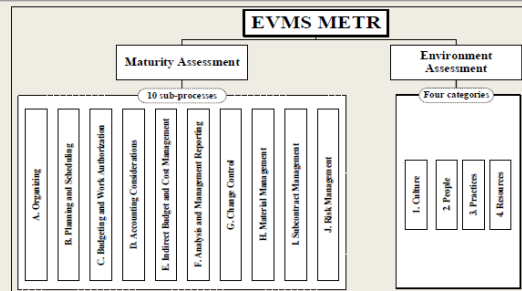
**Earned Value Management System (EVMS):** An organization's management system for project/program management that integrates a defined set of associated work scopes, schedules and budgets for effective planning, performance, and management control. It integrates these functions with other business systems such as accounting and human resources, among others.

**Maturity:** The degree to which an implemented system, associated processes, and deliverables serve as the basis for an effective and compliant EVMS.

**Environment:** The conditions (i.e., people, culture, practices, and resources) that enable or limit the ability to manage the project/program using the EVMS, serving as a basis for timely and effective decision-making.



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## Maturity Component

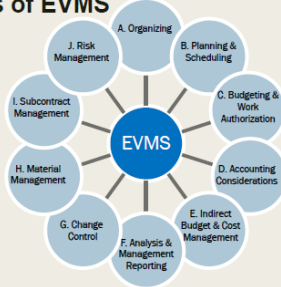


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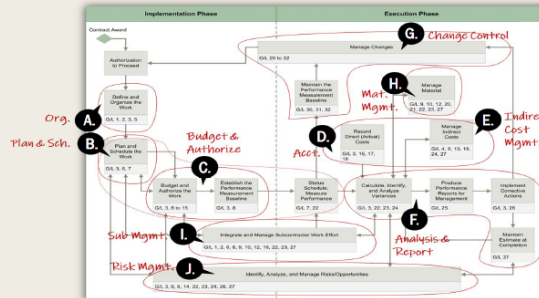
## Ten Sub-Processes of EVMS

- Maturity Attributes can have a significant impact on the efficacy of the EVMS.
- The team identified 56 attributes making up the 10 sub-processes of EVMS.
- Each attribute can be assessed a maturity level from 1 to 5, with 5 being highest maturity.

**Sub-Process:** A series of interrelated tasks that, together, transform inputs into a system to achieve Earned Value Management (EVM).



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Source: NDIA EVMS Scalability Guide and NDIA EIA 748-D Intent Guide

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# List of 56 Maturity Attributes

<b>A. ORGANIZING</b>	<b>E. INDIRECT BUDGET AND COST MANAGEMENT</b>
A.1 Product-Oriented Work Breakdown Structure (WBS) (Work Breakdown Structure (WBS) Hierarchy)	E.1 Indirect Account Organization Structure
A.2 Organizational Breakdown Structure (OBS)	E.2 Reconcilable Indirect Costs
A.3 Integrated System with Common Structures	E.3 Indirect Variance Analysis
A.4 Control Account (CA) to Organizational Element	<b>F. ANALYSIS AND MANAGEMENT REPORTING</b>
<b>B. PLANNING AND SCHEDULING</b>	F.1 Estimates to Control Accounts (CA)
B.1 Approved, Time-Phased Work Scope	F.2 Performance Measurement Information
B.2 Schedule Provides Current Status	F.3 Management Analysis and Corrective Actions
B.3 Horizontal Integration	F.4 Estimates at Completion (EAC)
B.4 Integrated Master Schedule (IMS) Resources	<b>G. CHANGE CONTROL</b>
B.5 Schedule Float and Float	G.1 Controlling Management Reserve (MR) and Undistributed Budget
B.6 Schedule Margin (SM)	G.2 (U) Incorporate Customer Directed Changes in a Timely Manner
B.7 Progress Measures and Indicators	G.3 Baseline Changes Recognition
<b>10. Time-Phased Performance Measurement Baseline (PMB)</b>	G.4 Control of Retrospective Changes to the Contract Budget Base
C.1 Approved, Time-Phased Work Scope	G.5 Preventing Unapproved Changes to the Contract Budget Base
C.2 Scope, Schedule and Budget Alignment	G.6 (P) Project Budget Base (PBB)
C.3 Progress Management Review (PMR) (C) Work Authorization Documents (WADs)	G.7 (O) Authorize (OTB) Authorization Over Target Schedule
C.4 Work Authorization Prior to Performance	<b>H. MATERIAL MANAGEMENT</b>
C.5 Budgeting by Elements of Cost (EOC)	H.1 Recording Actual Material Costs
C.6 Work Package Planning, Distinctibility, and Duration	H.2 Recurring Material
C.7 Measurable Units and Budget Substantiation	H.3 Material Performance
C.8 Appropriate Assignment of Earned Value Techniques (EVTs)	H.4 Recurring Material
C.9 Identify and Control Level of Effort (LOE) Work Scope	H.5 Material Price/Volage Variance
C.10 Identify Management Reserve (MR) Budget	H.6 Identification of Unit Costs and Lot Costs
C.11 Identified Budget (IB)	<b>I. SUBCONTRACT MANAGEMENT</b>
C.12 Reconcile to Target Cost Goal	I.1 Subcontract Identification and Requirements Flow Down
<b>D. ACCOUNTING SUBCONTRACTORS</b>	I.2 Subcontractor Integration and Analysis
D.1 Direct Costs	I.3 Subcontract Oversight
D.2 Actual Cost Recognition	<b>J. RISK MANAGEMENT</b>
D.3 Accounting Direct Costs to Control Accounts (CA) and/or Work Packages (WPs)	J.1 Identify, Analyze and Manage Risk
D.4 Direct Cost Breakdown Summary	J.2 Risk Integration

# Maturity Attribute Example

Subprocess / Organized	Maturity Level	Indicator	Notes
A.1 Product-Oriented Work Breakdown Structure (WBS)	1	1	1
A.2 Organizational Breakdown Structure (OBS)	2	2	2
A.3 Integrated System with Common Structures	3	3	3
A.4 Control Account (CA) to Organizational Element	4	4	4
A.5 Control Account (CA) to Organizational Element	5	5	5
A.6 Control Account (CA) to Organizational Element	6	6	6


# Environment Component

- Environment Factors can have a significant impact on the efficacy of the EVMS.
- The team identified 27 Factors divided into 4 Environment Categories.

# Environment Component

- Environment Factors can have a significant impact on the efficacy of the EVMS.
- The team identified 27 Factors divided into 4 Environment Categories.

**Environment Category**  
A class or division of factors regarded as having particular shared characteristics, arranged in a topological fashion.



# List of 27 Environment Factors (1 of 2)

- 1. Culture (7 factors)**
  - The contractor organization is supportive and committed to EVMS implementation, including making the necessary investments for regular maintenance and self-governance.
  - The project/program culture fosters trust, honesty, transparency, communication, and shared values across functions.
  - The customer organization is supportive and committed to the implementation and use of EVMS.
  - Project/program leaders make timely and transparent decisions informed by the EVMS.
  - The project/program leadership effectively manages and controls change using EVMS, including corrective actions and continuous improvement.
  - Effective teamwork exists and team members are working synergistically toward common project/program goals.
  - Alignment and cohesion exist among key team members who implement and execute EVMS, including common objectives and priorities.
- 2. People (6 factors)**
  - The contractor team is experienced and qualified in implementing and executing the EVMS.
  - The customer team is experienced in understanding and using EVMS results to inform decision-making.
  - Project/program leadership is defined, effective, and accountable.
  - Project/program stakeholder interests are appropriately represented in the implementation and execution of the EVMS.
  - Professional learning and education of key individuals responsible for EVMS implementation and execution, is appropriate to meet project/program requirements.
  - Team members responsible for the EVMS implementation and execution phases are co-located and/or accessible.

# List of 27 Environment Factors (2 of 2)

- 3. Practices (8 factors)**
  - The project/program promotes and follows standard practices to implement and execute an EVMS.
  - EVMS requirements definition is in place, and agreement exists among key stakeholders and customer.
  - Roles and responsibilities are defined, documented and well-understood for implementing and executing EVMS.
  - Communication is open and effective, including consistent terminology, metrics, and reports.
  - Effective oversight is in place and used, including internal and external surveillance and independent reviews.
  - Contractual terms and conditions that impact the effectiveness of EVMS are known and have been addressed.
  - Appropriate Subject Matter Expert (SME) input is adequate and timely.
  - Coordination exists between the key disciplines involved in implementing and executing the EVMS.
- 4. Resources (6 factors)**
  - Adequate technology/software and tools are integrated and used for the EVMS.
  - Sufficient funding is committed and available for implementing and executing the EVMS.
  - The team that implements and executes the EVMS for the project/program is adequate in size and composition.
  - Sufficient calendar time and work-hours are committed and available for implementing and executing the EVMS.
  - Data are readily available to populate EVMS tools supporting analyses for decision-making.
  - The project/program utilizes an appropriate periodic cycle for executing the EVMS effectively and efficiently.

# Environment Factor Example

Category	Factor Title	Description
1. Culture	1a. The contractor organization is supportive and committed to EVMS implementation, including making the necessary investments for regular maintenance and self-governance.	The contractor's integrated project/program team (IPT) is in place (i.e., corporate leadership, execution/operations, oversight, and support staff), and has a demonstrated belief in the value and disciplined use of the EVMS. The project/program follows an integrated project management strategy to identify and manage risks using the EVMS that avoids excessive negatively impact a well-formed baseline plan. It has committed resources, including funding, to ensure that effective implementation of the EVMS is a priority, assuring continuous improvement and accountability at every level of the contractor organization. This commitment ensures the availability and protected time of key individuals who contribute to implementing and executing EVMS in a substantive and measurable way. Typically, this also includes the availability/commitment of other personnel with specialized skills/knowledge, who may or may not be "dedicated" to the project/program.  Leadership and team members' attitude and discipline, both at the corporate office level and the project/program level, leads to the correct use, application, and acceptance of EVMS as an integrated project/program management tool (ranging from the definition of work scope to planning and scheduling to budgeting and work authorization, to analysis and reporting to forecasting and risk management). Leadership actively revisits the most effective ways to evaluate EVMS metrics that support decision-making. The organization's policies provide incentives and education to foster support and commitment. The contractor team does not choose convenience over following the EVMS regulations and procedures applicable to the project/program. Project/program decision-making, which ultimately drives project results, is collaborative, and effectively uses EVMS generated data and metrics. Governance is enforced and effective at dealing with the challenges of the project/program.  Comments: Self-governance refers to the capacity of a contractor to govern autonomously and, as such, is an important approach to overseeing the effective implementation of the EVMS. When a contractor initiates integrated project/program management principles using the EVMS in a way that benefits all levels of the organization, the results can guide management decisions, lead to improved project/program execution, and optimize performance of the project/program team.

# Environment Rating Scheme

Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
Rating a factor Not Acceptable indicates that the factor's criteria are consistently below expectations and current performance is unacceptable. The ability to effectively manage the project/program cannot be achieved in this current state and actions are required to improve.	Rating a factor Needs Improvement indicates that the factor's criteria are not consistent in meeting project/program expectations and without improvement, the ability to effectively manage the project/program is at risk. Substantial action is required to meet expectations.	Rating a factor Meets Some indicates that the factor's criteria are partially met and without improvement, the ability to effectively manage the project/program could be in jeopardy.	Rating a factor Meets Most indicates that the factor's criteria are consistently met and understood, with minor gaps, leading to effective management of project/program.	Rating a factor High Performing indicates that the factor's criteria are fully met within the context of their respective category (e.g., culture, people, practices, or resources).

## We need your help in:

- Assessing your recently completed project/program using the new EVMS METR tool.

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## Background Information

Q1. Please indicate your employer type.

- Government contractor
- Government
- Consultant
- Manufacturer/Contractor
- Other (Software Developer, World Bank, Non-profit, etc.) Please specify: **Academia**

If you choose other, please specify.

When you finish, please click next!

Q2. Please provide your typical employment role.

- Project contracts management
- Project/program management
- Compliance management
- Executive or senior management
- Consulting
- Other (contracting, control accounts management, finance, engineering & systems engineering, or other). Please specify.

Q3. How many years of Earned Value Management (EVM) experience do you have in total?

- 0-5 years
- 6-10 years
- 11-15 years
- 16-20 years
- 21-25 years
- 26 years or more

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## Background Information

Q4. Think of an EVMS application on a recently completed project/program that you were involved with. You will use the project/program as your anchor while assessing its EVMS maturity and environment.

Note: If any values cannot be shared please write N/A.

Please provide the name of the project/program (e.g. Use an acronym): **CAVC**

Briefly describe the scope of the project/program (e.g. the project was a major campus building to process high-level nuclear waste at the program was to allow cross-finger access): **Research Building**

Please provide the primary location of the project/program (i.e. Nevada, Arizona, India): **Tempe, Arizona**

Initial Performance Measurement Baseline (PMB) Budget (\$M): **60 \$M**

Please input any amount in dollar value (e.g. \$60 M, \$0 M, \$50,000,000, or \$50 Million)

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## Anchor Project/Program

Final Project/Program Cost (\$M) (if you provided N/A for this, please provide a cost estimate (+/-) or overrun (+/%) value baseline): **54.5 \$M**

Initial Baseline Program Duration (Months): **21 months**

Final Project/Program Duration (Months) (if you provided N/A for baseline duration, please provide a duration estimate (+/-) or overrun (+/%) value baseline): **21 months**

Please indicate any changes that impacted the initial baseline cost or schedule by more than 25%. If not, please write N/A. **User change on AV equipment**

Budgeted owner contingency above the PMB (\$M or a % of PMB): **3%**

(continued on next page) 40

## Q4 (continued)

Final Cost Performance Index (CPI): **1.0**

Absolute value of change orders (\$M or a % of PMB): **1 \$M**

Feel free to use this box to explain anything unusual in this project/program: **Late user change**

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## Anchor Project/Program

Q5. Was the anchor project/program used in your evaluation compliant with NEMA 404-748 at the point in time at 20% project completion (CIMA/ATVE/ACM/ATVE/ABC, where ECVR is Budgeted Cost for Work Performed, PMB is Performance Measurement Baseline, and BAC is Budget at Completion)?

Yes

No

N/A. Please explain: **Not necessarily sponsor**

Think back at a time around 20% project completion: was your project/program compliant at that point?

In this case, EVMS compliance was not contractually required by the sponsor

Q6. Was the information provided in the last questions a Project or a Program?

Project

Program

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## Anchor Project/Program

Q7. What is the perspective that you are bringing to the anchor project/program evaluation? (i.e. are you representing the owner, organization, contractor, consultant, or other?)

- Owner/sponsor organization
- Contractor organization
- Consultant organization
- Other. Please specify.

Q8. Reflecting on your perspective, rate the anchor project/program using a scale of 1 to 5 as shown below.

	1 very unsuccessful	2 unsuccessful	3 somewhat successful	4 successful	5 very successful
The project/program met its objectives and business intent.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
Customers were satisfied with the results of the project/program.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>
The team helped to proactively manage the project/program.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

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## Any questions so far?

Next. Moving forward to the questions assessing the Maturity component for your anchor project/program.

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### Sub-process C

Q17. This question is focused on the attributes that make up the **Budgeting and Work Authorization Sub-Process** (Sub-Process C). Think back to the point in time of 20% project completion (CUMULATIVE BOWF/PMB SAC), and assess each attribute's maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
C.1 Basic Organizational Budget Alignment	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.2 Summary Accounting Packages (SAPs)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.3 Work Authorization Documents (WADs)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.4 Work Authorization Plan	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.5 Budgeting Performance Data	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.6 Work Package Planning, Organization, and Execution	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.7 Measurable Work and Budget Suballocation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.8 Appropriate Assignment of Earned Value Metrics (EVM)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.9 Identify and Control Level of Work (L2) Work Item	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.10 Identify Management Reserve (MR) Budget	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.11 Suballocated Budget (SAB)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
C.12 Accurate to Begin Cost Base	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Sub-process D

Q18. This question is focused on the attributes that make up the **Accounting Considerations Sub-Process** (Sub-Process D). Think back to the point in time of 20% project completion (CUMULATIVE BOWF/PMB SAC), and assess each attribute's maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
D.1 Direct Costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
D.2 Actual Cost Reconciliation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
D.3 Recording Direct Costs to Control Accounts (CA) and/or Work Packages (WPs)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
D.4 Direct Cost Breakdown Summary	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Sub-process E

Q19. This question is focused on the attributes that make up the **Indirect Budget and Cost Management Sub-Process** (Sub-Process E). Think back to the point in time of 20% project completion (CUMULATIVE BOWF/PMB SAC), and assess each attribute's maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
E.1 Indirect Account Organization Structure	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
E.2 Indirect Budget Management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
E.3 Indirect/Allocate Indirect Costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
E.4 Indirect Variance Analysis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Sub-process F

Q20. This question is focused on the attributes that make up the **Analysis and Management Reporting Sub-Process** (Sub-Process F). Think back to the point in time of 20% project completion (CUMULATIVE BOWF/PMB SAC), and assess each attribute's maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
F.1 Calculating Variances	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
F.2 Variances to Control Accounts (CA)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
F.3 Performance Measurement Information	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
F.4 Management Analysis and Corrective Action	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
F.5 Estimate of Completion (EAC)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Sub-process G

Q21. This question is focused on the attributes that make up the **Change Control Sub-Process** (Sub-Process G). Think back to the point in time of 20% project completion (CUMULATIVE BOWF/PMB SAC), and assess each attribute's maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
G.1 Controlling Management Reserve (MR) and Suballocated Budget (SAB)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
G.2 Mitigating Customer Contract Changes and Work Item	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
G.3 Baseline Change Management	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
G.4 Control of Indirect Changes	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
G.5 Preventing Unapproved Reserve in the Current Budget Base (CBB) Project Budget Base (PBB)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
G.6 Over Target Baseline (OTB) Cost Target Allocation (CTA) Allocation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Sub-process H

Q22. This question is focused on the attributes that make up the **Material Management Sub-Process** (Sub-Process H). Think back to the point in time of 20% project completion (CUMULATIVE BOWF/PMB SAC), and assess each attribute's maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
H.1 Recording Actual Material Costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
H.2 Material Reconciliation	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
H.3 Material Material	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
H.4 Material Price/Variance Variance	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
H.5 Identification of L20 Costs and Job Costs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Sub-process I

Q23. This question is focused on the attributes that make up the **Subcontract Management Sub-Process** (Sub-Process I). Think back to the point in time of 20% project completion (CUMULATIVE BOWF/PMB SAC), and assess each attribute's maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
I.1 Subcontract Identification and Requirements Flow Down	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I.2 Subcontract Integration and Analysis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I.3 Subcontract Oversight	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Sub-process J

Q24. This question is focused on the attributes that make up the **Risk Management Sub-Process** (Sub-Process J). Think back to the point in time of 20% project completion (CUMULATIVE BOWF/PMB SAC), and assess each attribute's maturity at that point in time.

	N/A	Level 1	Level 2	Level 3	Level 4	Level 5
J.1 Identify Analyze and Manage Risk	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
J.2 Risk Integration	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

### Comments/Feedback on Maturity

Q19. General Comments on the Maturity component. Please feel free to skip this question or share briefly any general thoughts about the Maturity component (such as a typo error you found or other). Also, if you have assessed some attributes as not applicable to your project/program, please provide a clear justification to explain why each particular attribute is considered as not applicable. If you would like to modify any previous answers on maturity, you can click the left arrow to go back to the previous pages.

Attribute H.5 (Identification of unit and lot costs) is not applicable since our project is not a production project.

Overall, the assessment was useful in highlighting the gaps that could be fixed at that time.

### Workshop Agenda

- 8:00 – 8:30 am Introductions and Workshop Objectives
- 8:30 – 8:45 am Project/program Characteristics and Performance
- 8:45 – 9:30 am Maturity Component Assessment
- 9:30 – 9:45 am 15-Minute Break
- 9:45 – 11:00 am Maturity Component Assessment
- 11:00 – 11:25 am 25-Minute Break
- 11:25 – 12:45 pm Environment Component Assessment
- 12:45 – 1:00 pm Conclusions & Wrap-Up

Note: All times are in Pacific Daylight Time (PDT)

## Moving forward

Next, Moving forward to the questions assessing the Environment component for your anchor project/program.



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## Stop here.

Category 1 (Category 1). This question is focused on the factors that make up the **Culture** Component (Cumulative BCWP/FMB/BAC), and assess each environment factor at that point in time, where BCWP is Budgeted Cost for Work Performed, FMB is Performance Measurement Baseline, and BAC is Budget at Completion.

	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
1a. The contractor organization is supportive and committed to EVMS implementation, including making the necessary investments for regular maintenance and self-governance.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1b. The project/program leadership effectively manages and controls change using EVMS, including corrective actions and continuous improvement.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1c. The project/program members are working synergistically toward common project/program goals.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1d. Alignment and cohesion exist among key team members who implement and execute EVMS, including capturing objectives and priorities.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



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## Example: Environment Factor 1a

Q20. This question is focused on the factors that make up the **Culture** Category (Category 1). Think back to the point in time at 20% project completion (Cumulative BCWP/FMB/BAC), and assess each environment factor at that point in time, where BCWP is Budgeted Cost for Work Performed, FMB is Performance Measurement Baseline, and BAC is Budget at Completion.

Think back to a time around 20% project completion

	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
1a. The contractor organization is supportive and committed to EVMS implementation, including making the necessary investments for regular maintenance and self-governance.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



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## Environment Factor Example

Category	Title	Description
1a.	The contractor organization is supportive and committed to EVMS implementation, including making the necessary investments for regular maintenance and self-governance.	The contractor's integrated project/program team (IPT) is in place (i.e., corporate leadership, execution/operations, oversight, and support staff), and has a demonstrated ability and discipline to use the EVMS. The project/program follows an integrated project management strategy to identify and manage risk using the EVMS that would otherwise negatively impact a well-formed baseline plan. It has committed resources, including funding, to ensure that effective implementation of the EVMS is a priority, assuring continuous improvement and accountability at every level of the contractor organization. This commitment ensures the availability and protected time of key individuals who continue to implement and executing EVMS in a substantive and measurable way. Typically, this also includes the availability/commitment of other personnel with specialized skill/knowledge, who may or may not be "dedicated" to the project/program.  Leadership and team member attitude and discipline, both at the corporate office level and the project/program level, leads to the correct use, application, and acceptance of EVMS as an integrated project/program management tool (ranging from the definition of work scope to planning and scheduling to budgeting and work authorization, to analysis and reporting to forecasting and risk management). Leadership actively revises the most effective ways to evaluate EVMS metrics that support decision-making. The organization's policies provide incentives and education to foster support and commitment. The contractor team does not choose convenience over following the EVMS equations and processes applicable to the project/program. Project/program decision-making, which ultimately drives project results, is collaborative, and effective relies on EVMS generated data and metrics. Governance is enforced and effective at dealing with the changes of the project/program.  Comments: Self-governance refers to the capacity of a contractor to govern autonomously and, as such, is an important approach in overseeing the effective implementation of the EVMS. When a contractor initiates integrated project/program management principles using the EVMS in a way that benefits all levels of the organization, the results can guide management decisions, lead to improved project/program execution, and optimize performance of the project/program team.



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## Example: Environment Factor 1a

Q20. This question is focused on the factors that make up the **Culture** Category (Category 1). Think back to the point in time at 20% project completion (Cumulative BCWP/FMB/BAC), and assess each environment factor at that point in time, where BCWP is Budgeted Cost for Work Performed, FMB is Performance Measurement Baseline, and BAC is Budget at Completion.

	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
1a. The contractor organization is supportive and committed to EVMS implementation, including making the necessary investments for regular maintenance and self-governance.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
1b. The project/program leadership effectively manages and controls change using EVMS, including corrective actions and continuous improvement.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1c. The project/program members are working synergistically toward common project/program goals.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1d. Alignment and cohesion exist among key team members who implement and execute EVMS, including capturing objectives and priorities.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



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## Example: Environment Factor 1a

Q20. This question is focused on the factors that make up the **Culture** Category (Category 1). Think back to the point in time at 20% project completion (Cumulative BCWP/FMB/BAC), and assess each environment factor at that point in time, where BCWP is Budgeted Cost for Work Performed, FMB is Performance Measurement Baseline, and BAC is Budget at Completion.

	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
1a. The contractor organization is supportive and committed to EVMS implementation, including making the necessary investments for regular maintenance and self-governance.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1b. The project/program leadership effectively manages and controls change using EVMS, including corrective actions and continuous improvement.	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
1c. The project/program members are working synergistically toward common project/program goals.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1d. Alignment and cohesion exist among key team members who implement and execute EVMS, including capturing objectives and priorities.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>



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## Category 1

Q20. This question is focused on the factors that make up the **Culture** Category (Category 1). Think back to the point in time at 20% project completion (Cumulative BCWP/FMB/BAC), and assess each environment factor at that point in time, where BCWP is Budgeted Cost for Work Performed, FMB is Performance Measurement Baseline, and BAC is Budget at Completion.

	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
1a. The contractor organization is supportive and committed to EVMS implementation, including making the necessary investments for regular maintenance and self-governance.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1b. The project/program leadership effectively manages and controls change using EVMS, including corrective actions and continuous improvement.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1c. The project/program members are working synergistically toward common project/program goals.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
1d. Alignment and cohesion exist among key team members who implement and execute EVMS, including capturing objectives and priorities.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



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## Category 2

Q21. This question is focused on the factors that make up the **People** Category (Category 2). Think back to the point in time at 20% project completion (Cumulative BCWP/FMB/BAC), and assess each environment factor at that point in time.

	Not Acceptable	Needs Improvement	Meets Some	Meets Most	High Performing
20. Project/program stakeholders interested in EVMS are appropriately represented in the implementation and execution of the EVMS.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21. Professional training and education in key individuals responsible for EVMS implementation and execution is appropriate to meet project/program requirements.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
22. Team members responsible for the EVMS implementation and execution process are well-located and/or accessible.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



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### Category 3

Q22. This question is focused on the factors that make up the **Precise** Category (Category 3). Think back to the point in time at 20% project completion (COMPLETING THE BCP/PA&B ETC.) and assess each seven-point factor of that point in time.

	Not Applicable	Needs Improvement	Meets Some	Meets Most	High Performing
3a. The project/program <b>governance and follow-through</b> practices in place and executed:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3b. EVMS requirements <b>adherence to be</b> plans, and <b>agreements</b> with among key stakeholders and customer:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3c. Roles and responsibilities are defined, <b>understood</b> and <b>accountability</b> is established for implementing and executing the EVMS:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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### Category 4

Q23. This question is focused on the factors that make up the **Resources** Category (Category 4). Think back to the point in time at 20% project completion (COMPLETING THE BCP/PA&B ETC.) and assess each seven-point factor of that point in time.

	Not Applicable	Needs Improvement	Meets Some	Meets Most	High Performing
4a. <b>Adequate technology/software and tools are integrated and used</b> for the EVMS:	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4b. <b>Sufficient funding is committed and provided for implementing and executing the EVMS.</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4c. The team that implements and executes the EVMS for the project/program is <b>appropriate in size and composition.</b>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

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### Comments/Feedback on Environment

Q24. **General Comments on the Environment component.** Please feel free to skip this question or share briefly any general thoughts about the Environment component (such as a typo error you found or other).

If you would like to modify any previous answers on environment, you can click the left arrow to go back to the previous pages.

In factor 1e (leadership effectively manages and controls change), there is a missing comma after the verb "manages".

ASU Arizona State University

### Total Raw Score Results (example)

Result: The following is the assessment results of your project/program:

Total Raw Score for Maturity Component: 751

Total Score for Environment Component: 502

Out of 1,000 points, not too bad

Out of 1,000 points, needed some work

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Would you be willing to provide further data after the workshop...?

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### Benchmarking (optional)

Q25. Do you want us to provide benchmarking data of your project/program after we have completed all the workshops?

Note: This will be available in summer 2021.

Yes

No

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### General Comments/Feedback

Q26. **General Comments.** Please feel free to share any other thoughts about the Maturity and/or Environment Component assessments, as well as feedback on the workshop itself in the space below.

Also, feel free to use this box to explain anything unusual in this project/program, or to provide the general context and reasoning behind your assessment. This is an optional question and you may skip it if you do not feel the need to explain or provide more information.

If you would like to modify any previous answers, you can click the left arrow to go back to the previous pages.

Good value for our organization! Especially to self-rate. Looking forward to the software version of this tool.

Tasty bacon.

Amnesty

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### Continuing Education Unit (CEU) Credit

Q27. Would you like to receive Continuing Education Unit (CEU) credit for this workshop?

Yes

No

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## Exit Confirmation

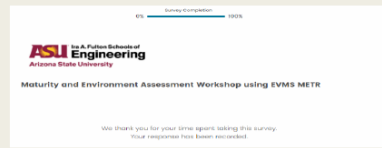
Q28.  
Are you ready to exit? If yes, please click the yes button and the NEXT button (Right Arrow) to complete this workshop and record all your responses. Once you click next, you cannot go back to modify any previous answers. Thank you.

Yes

Please click on NEXT button (Right Arrow) to record your responses. If you click here, you will not be able to modify any previous answers.

## Completion Screen

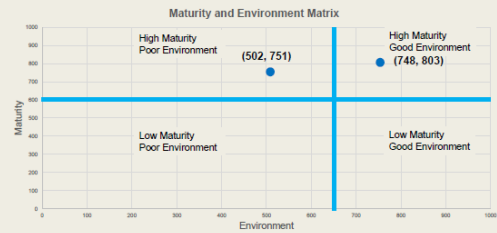
If you see this screen, your response is successfully saved in our database.



## Conclusions and Wrap-up

- What we did today
  - You assessed your project/program using the new EVMS METR
  - You got a score at 20 percent project completion
- Thank you for your input!
- CEUs will be emailed to you
- We will send you published documents when they become available

## Envisioned Rating Plot



## Questions/Comments/Discussion

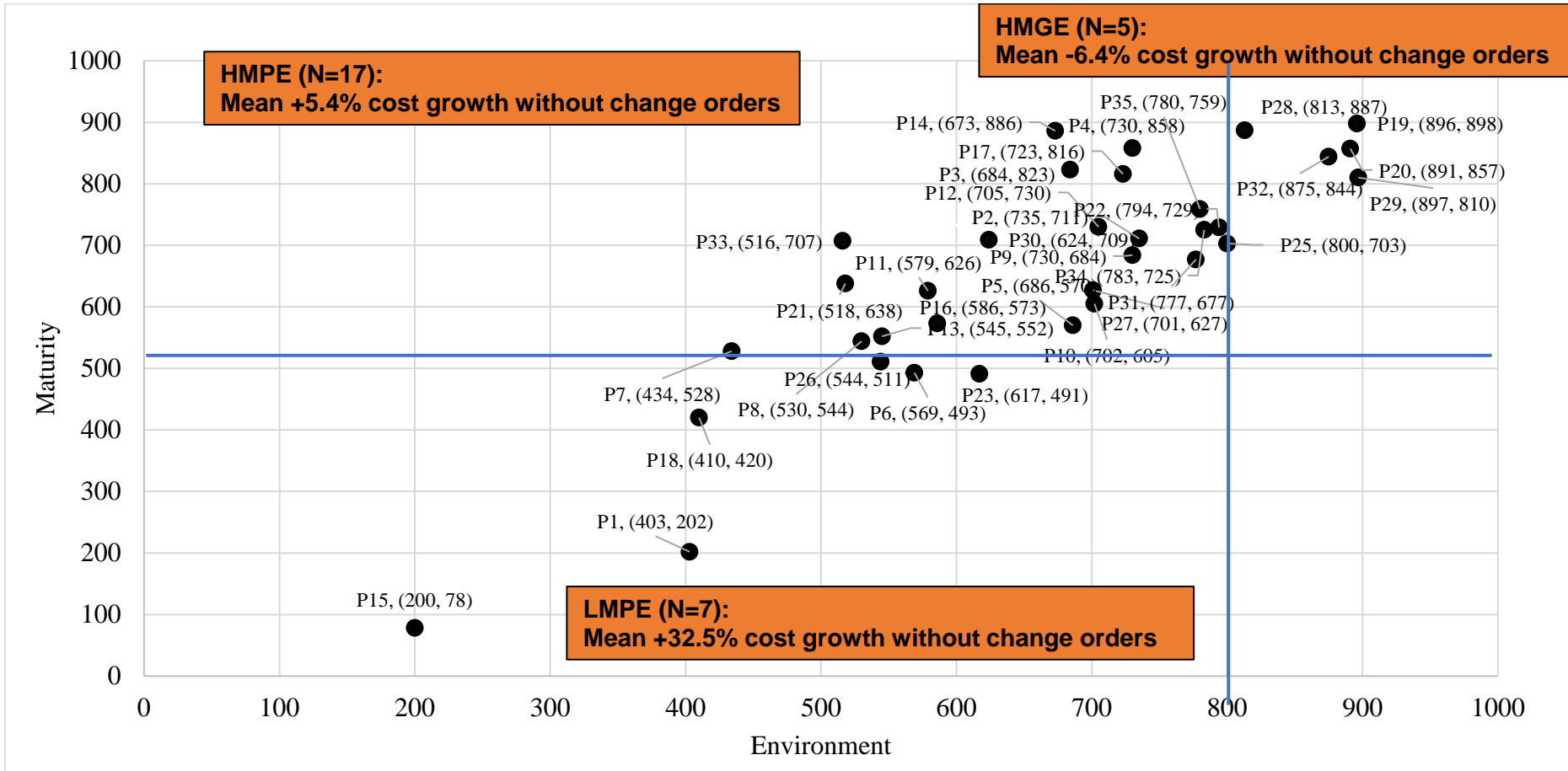


THANK YOU!

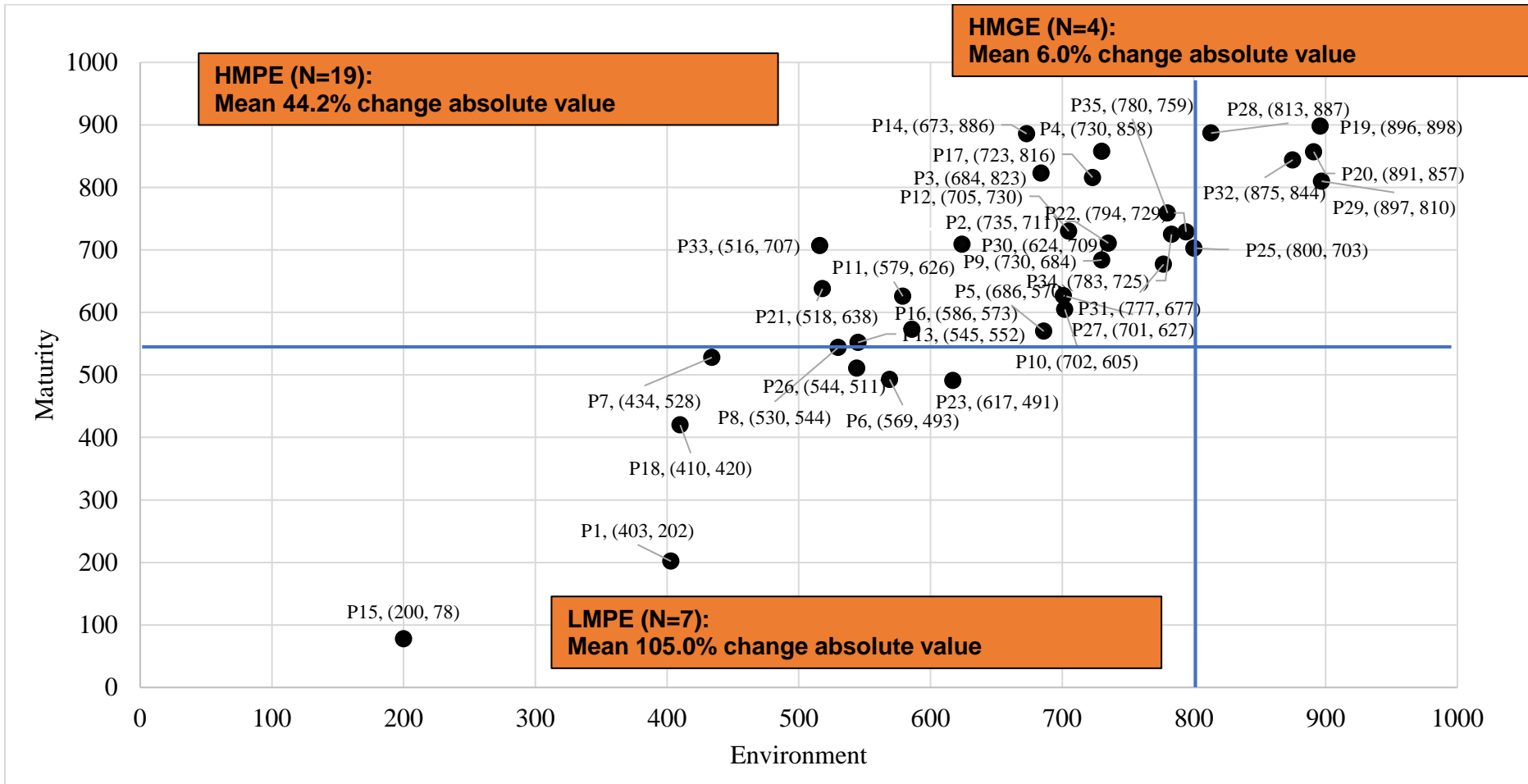


## Appendix E Performance Matrixes

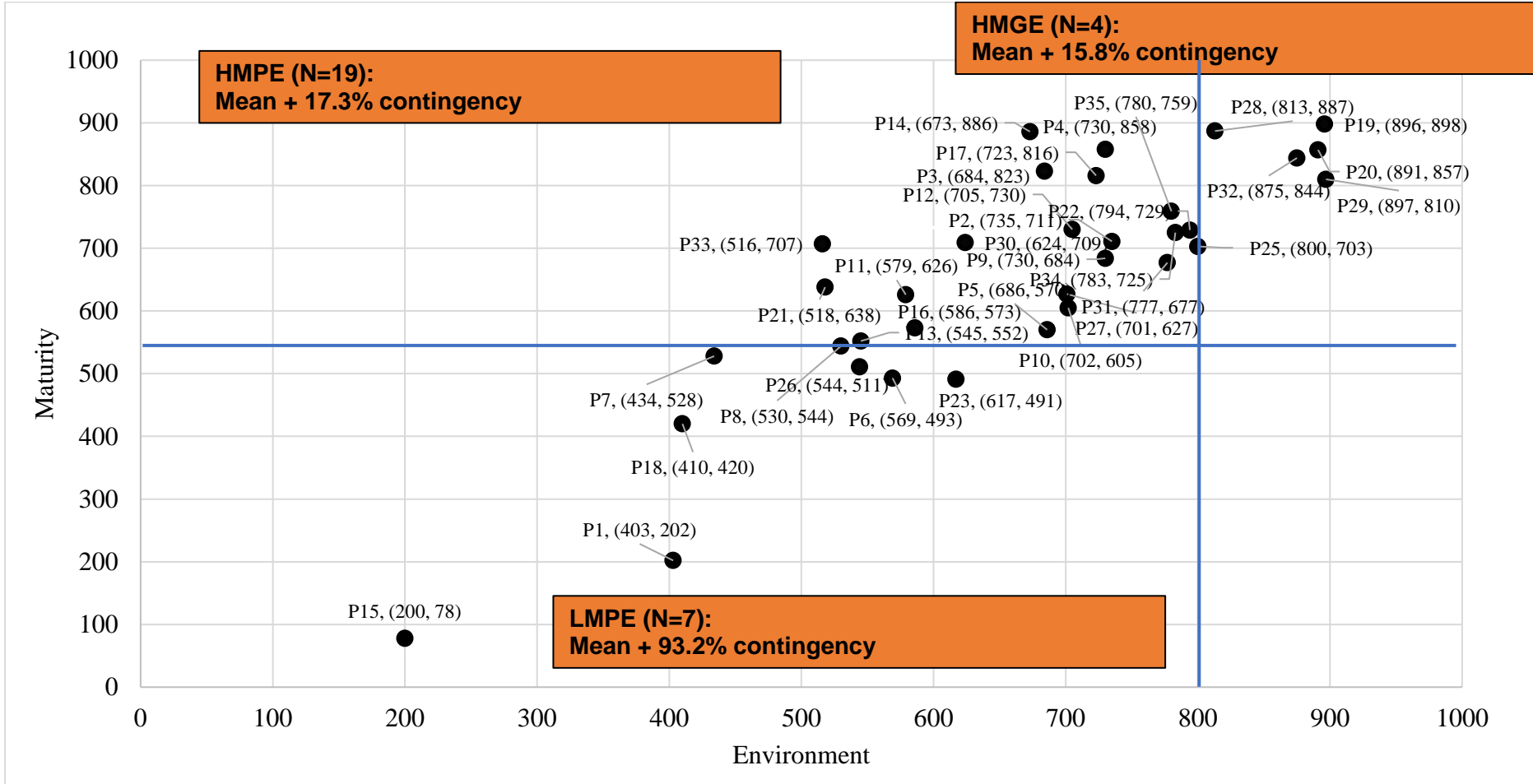
### Cost Growth without Change Orders (N=29)



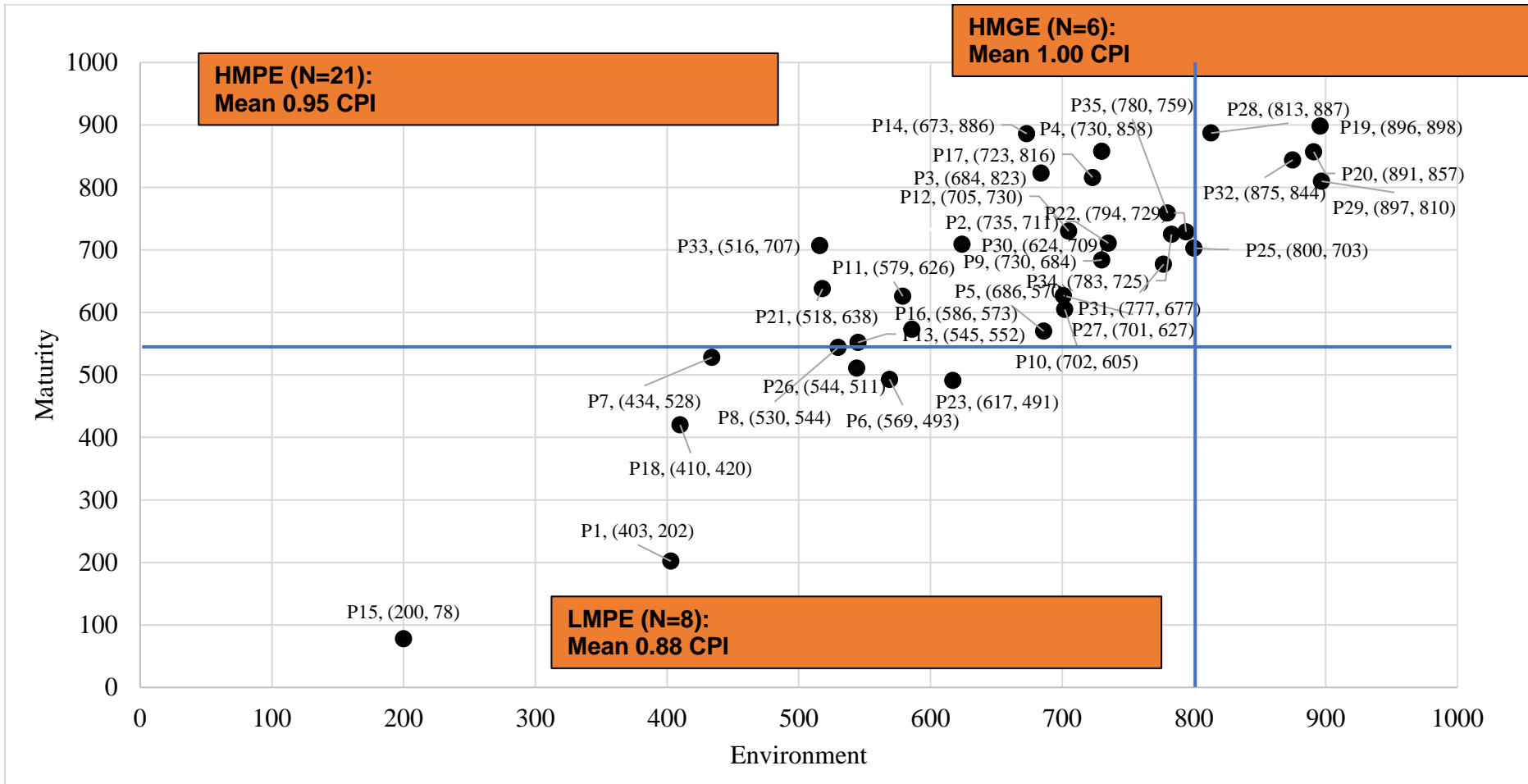
Change Absolute Value (N=30)



Contingency (N=30)

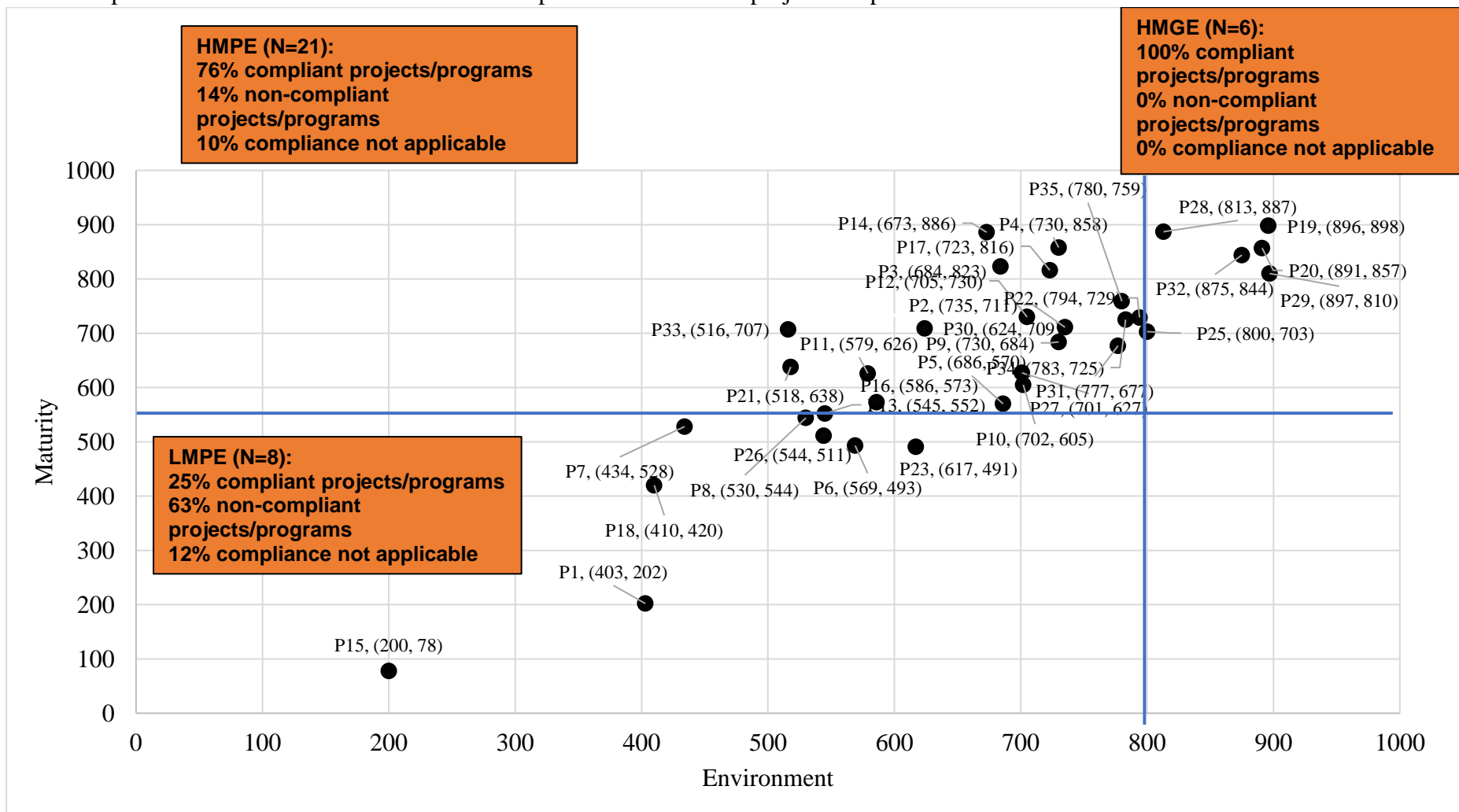


Cost Performance Index (N=35)



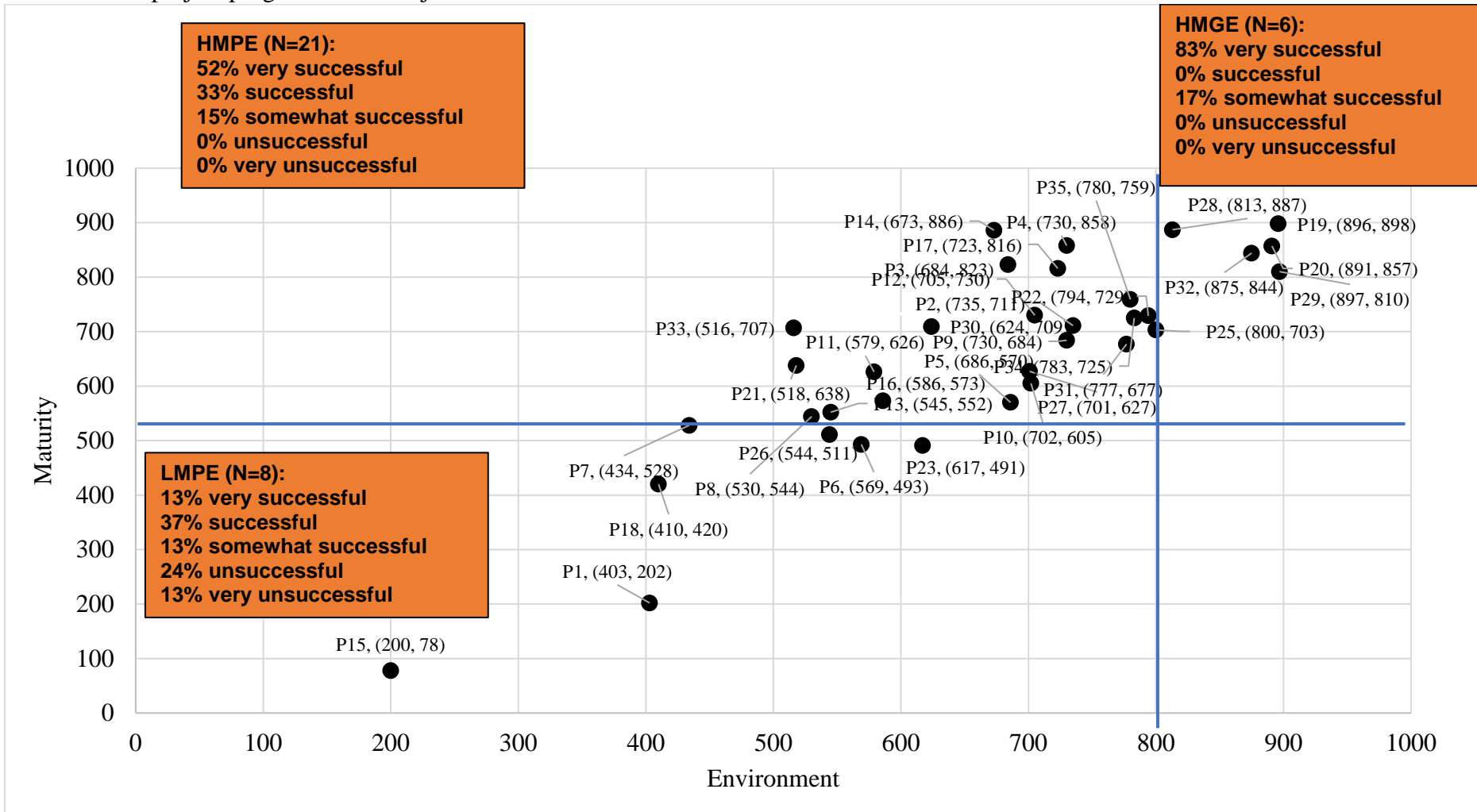
Compliance (N=35)

Note: Compliance with EIA-748-D is assessed at the point in time at 20% project completion.



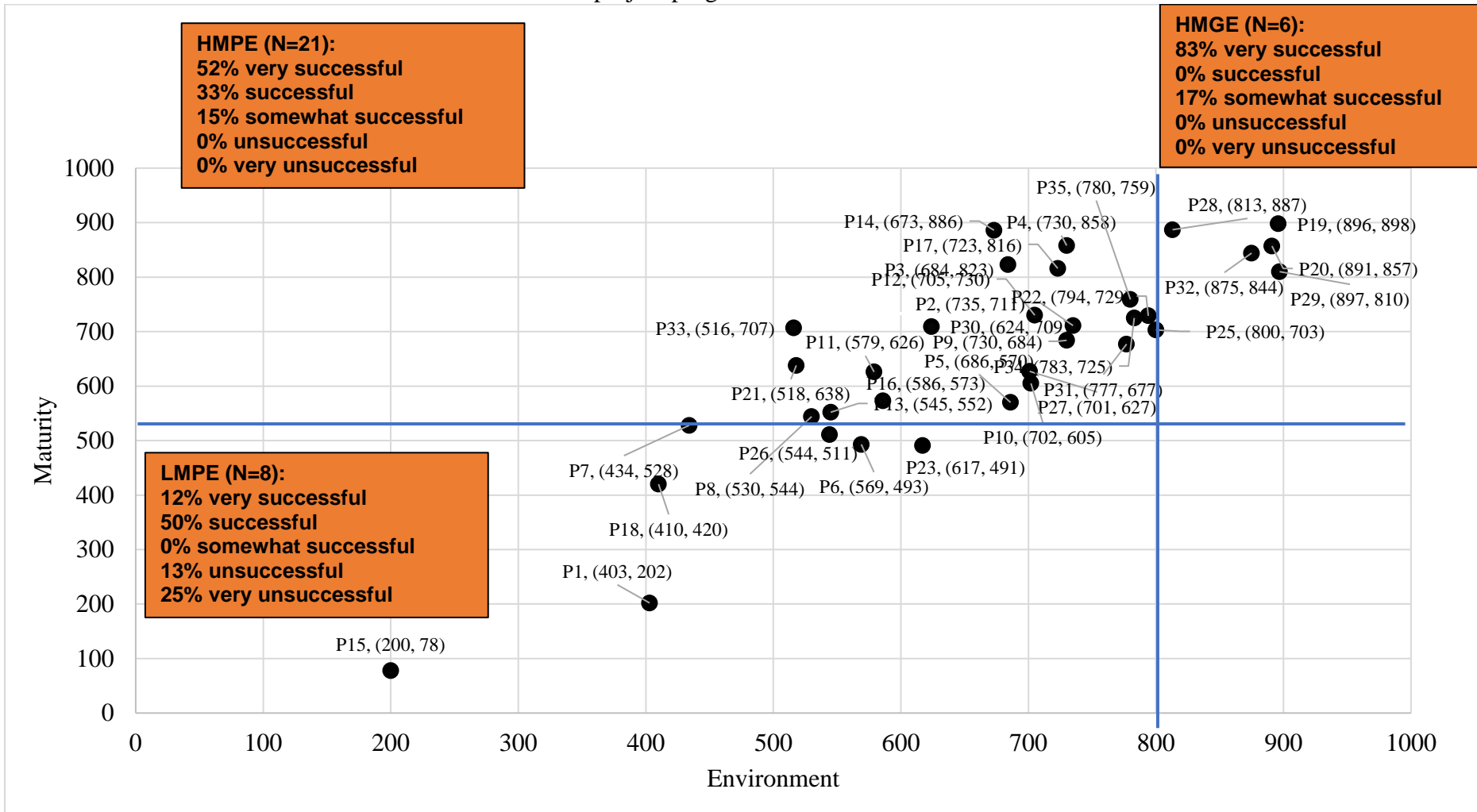
Business Objectives (N=35)

Note: The project/program met its objectives and business drivers.



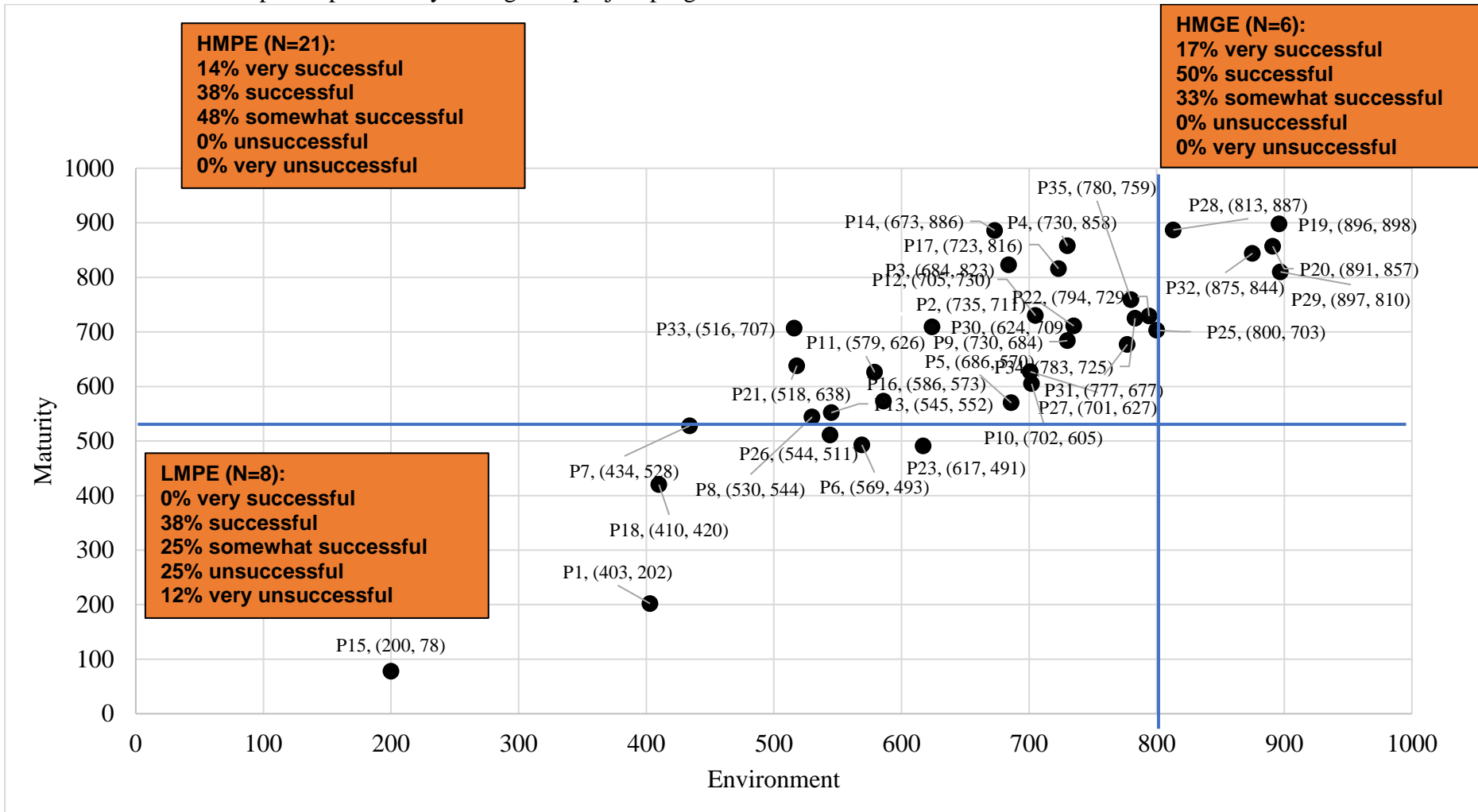
Customer Satisfaction (N=35)

Note: Customers were satisfied with the results of the project/program.



EVMS Helped Proactively Manage the Project/Program (N=35)

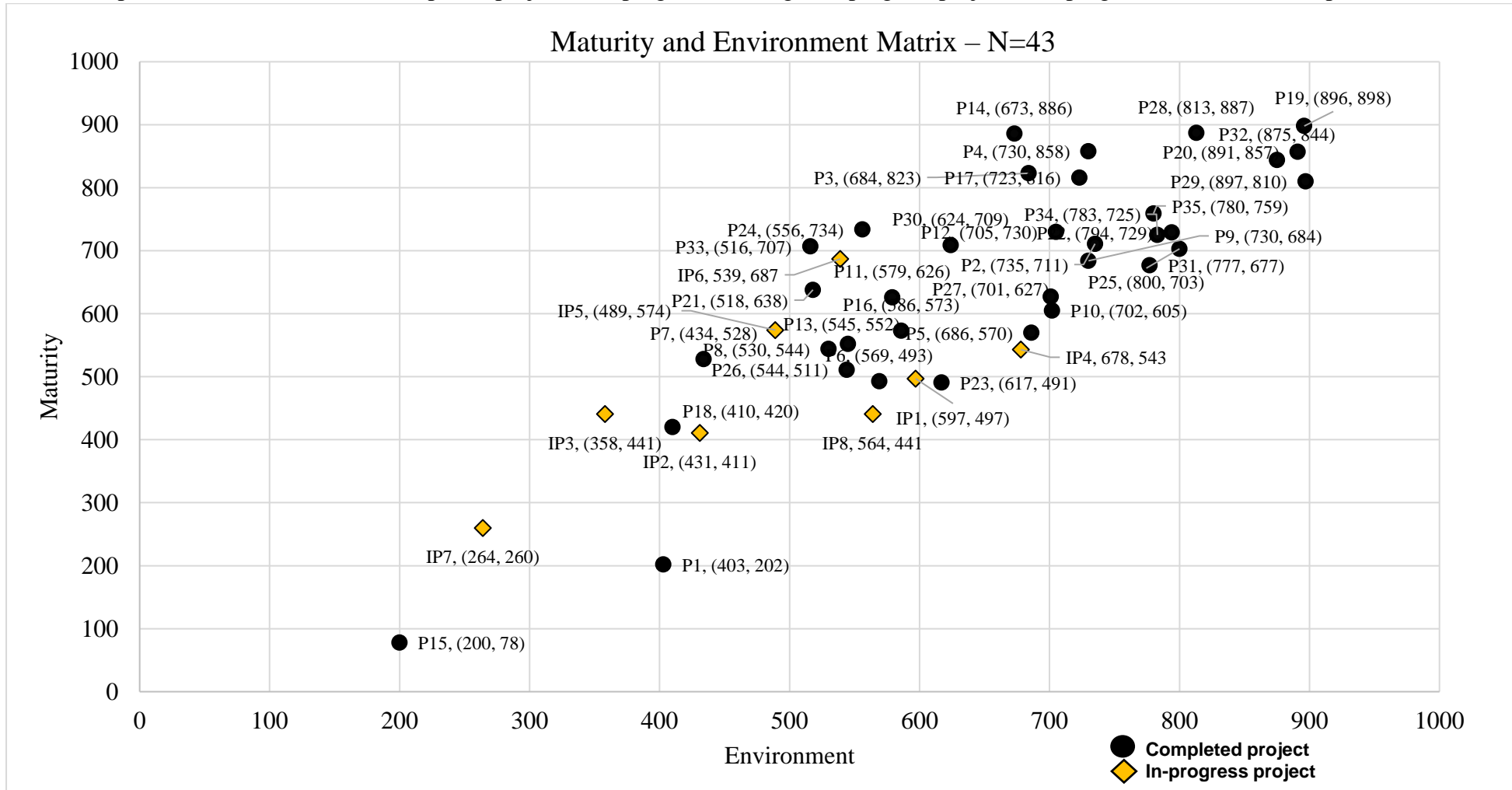
Note: The EVMS helped to proactively manage the project/program.





## Appendix F. Maturity and Environment Matrix

The below plot contains data from 35 completed projects and programs and eight in-progress projects and programs, therefore a sample size of 43.



**Appendix G. IP2M METRR Research Team**  
(2019-2022)

\*Vartenie Aramali, California State University, Northridge  
Elizabeth Betsy Ballard, Tecolote Research, Inc. (previously U.S. Department of Energy)  
Amy Basche, Hanford Mission Integration Solutions (previously Mission Support Alliance)  
Ivan Bembers, National Reconnaissance Office  
Danielle A. Bemis, U.S. Department of Defense  
Thomas P. Carney, Lockheed Martin  
\*Mounir El Asmar, Arizona State University  
Jon Fleming, National Aeronautics and Space Administration  
Mark Frampton, National Reconnaissance Office/Contract support  
Melvin Frank, U.S. Department of Energy  
\*G. Edward Gibson, Jr., Arizona State University  
Wayne A. Harris, U.S. Department of Energy/Contract support  
Craig T. Hewitt, Washington River Protection Solutions  
Kristen Kehrer, National Aeronautics and Space Administration  
David Kester, U.S. Department of Energy  
Jeffrey King, Northrup Grumman (previously BAE Systems)  
Derek D. Lehman, Washington River Protection Solutions  
Doug Marbourg, Los Alamos National Lab  
John C. Post, Jacobs (previously Lawrence Livermore National Lab)  
Garrett Richardson, U.S. Department of Energy  
Russel W. Rodewald, Raytheon Corp  
Paul J. Sample, CACI International Inc  
\*Hala Sanboskani, Arizona State University  
Anthony W. Spillman, Washington River Protection Solutions  
Tristan Walters, Sandia National Lab  
William G. Weisler, U.S. Department of Defense  
Matthew Z. West, U.S. Department of Energy

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