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PEER REVIEWED PAPER

# Scheduling Practices and Project Success

Dr. Andrew F. Griffith, PE

Modern project scheduling techniques have been around for almost 50 years. The original development work on the critical path method (CPM) and the performance evaluation and review technique (PERT) began in the mid 1950s [6]&[7]. Although the basic principles behind CPM and PERT have not changed, significant advances in project scheduling have taken place in the years since these techniques were first introduced. Today, there is a comprehensive body of knowledge regarding project scheduling theory and techniques. The Association for the Advancement of Cost Engineering (AACE) and other organizations frequently publish articles describing new scheduling techniques, tools, algorithms, and applications [1]&[8]. Developmental research is ongoing, however empirical research demonstrating the value of good scheduling practices is minimal.

Industry has spent a great deal of time and money on training, software, and professional services related to project scheduling tools and techniques. In addition, many companies and consultants offer project scheduling related services, and project teams pay a lot for these services. So, after almost 50 years of development, untold investments in research, tools development, and training and continued spending on planning and scheduling services, it is important to question whether or not the investment has paid off.

The objective of this study is to empirically measure the effect that project scheduling practices have on process plant project success. This study looks at actual process industry project schedules and characterizes what scheduling practices and techniques were used early in the project at the point of full funds authorization. The study correlates these practices with actual project outcomes to measure their effect on project success or failure. The study identifies the practices that drive practice success: the drivers of success are not in the relative advantage of one scheduling algorithm versus another, but in how your project scheduling process uses the tools and resources available to the project's best advantage.

## HYPOTHESIS

There is a limited body of publicly available data that supports the investment in project scheduling tools and techniques. Using these tools and techniques on projects does require an investment of time and money. In order to justify this investment, practitioners assert that using these practices drives better project outcomes, which outweighs the cost to implement them. However, a detailed literature search of published research found little empirical evidence to support this assertion.

Most of the published work in this area is based on case studies and expert opinion. Early in the development of CPM and PERT, a number of articles were published that cite the benefits of these techniques. However, these references are over 40 years old and the conclusions are based on only a few specific projects [2] & [12]. More recent published work in this area is primarily based on expert opinion and/or survey responses from different companies. Some of these more recent studies also apply case study research techniques to identify best practices and measure the effect of those practices on project outcomes [9] & [11]. However, the author did not find any examples of empirical research with robust datasets that attempt to quantify the effect that project planning and scheduling techniques have on project outcomes.

This study is intended to fill this void by using empirical data from actual projects to measure the effect that scheduling practices have on project outcome performance. Therefore, the objective of this study is to test the following hypothesis:

There is a positive and significant relationship between scheduling practices used early in the project life-cycle and the ultimate success of the project.

The study focuses on the practices used early in the project because that is the stage when decisions can have the greatest effect on the project. Starting the execution phase with a sound and well-designed project schedule should have a measurable effect on the project outcomes. The question is, do the data support this hypothesis?

## METHODOLOGY

The unit of study for this research is individual capital projects executed in the process industries. Capital projects in the process industries involve the construction of physical plant facilities and materials processing equipment, either to produce a new product for expected profit or to maintain or develop operating capabilities [10]. The data for this study were drawn from an existing database of capital projects maintained by Independent Project Analysis, Inc. (IPA).

As part of an ongoing project management research and consulting business, IPA collects detailed data on capital projects executed in the heavy industrial manufacturing sector. For the most part, IPA works with owner organizations that are responsible for developing and executing the projects. The data collection process involves face-to-face interviews with project teams using a structured questionnaire. The questionnaire is designed to gather information related to the project objectives and scope, technology, project management practices, estimated and actual costs, planned and actual schedule, and other project information. The data are translated into a structured database, which are used in individual project evaluations and project system benchmarking [3], [4] & [5].

Typically, these interviews are conducted at two points in the project life cycle: (1) at the time of project authorization, and (2) at the end of the project after mechanical completion and startup. However, on some occasions the interviews are conducted only at the end of the project. In these cases, the teams are asked to research project files and provide data concerning the status of the project at the time of authorization. Using this approach, IPA compiles detailed information about the project characteristics, project practices, and project outcomes. This information is used to measure relative project performance, develop various statistical models, and conduct research.

The data regarding scheduling practices that are collected as part of this process provide the basis for this study. The project questionnaire includes 11 questions about the project schedule. These questions are designed to measure the level of detail and the application of specific scheduling techniques. In addition to the questionnaire, IPA collects hard copies and electronic files of the project schedule to support the analysis.

It is important to note that the responses to the questions and the schedule data-dates used in this study are all anchored at the time of authorization, or just at the start of production design. Project schedules evolve throughout the project life cycle. The level of detail in a schedule at the early conceptual engineering phase changes considerably by the time field construction begins. Limiting the study sample to the status of the schedule at authorization provides a reliable and consistent basis for measuring the effect that scheduling practices have on project success.

The data from these interviews were compiled into a single study sample database, which was used as the basis for the analysis. Statistical analysis techniques, including t-testing, ANOVA, and multivalent regressions were used to test the research hypotheses. We tested the correlation between specific project schedule characteristics and techniques and the ultimate outcome of the project. In addition, the analysis controlled for other project characteristics and practices that also demonstrate a correlation with project outcome performance. The objective was to isolate and accurately measure the effect that scheduling practices have on projects, apart from the effects of other significant drivers of project outcomes.

## SAMPLE CHARACTERISTICS

The study sample of projects provides a robust and valid basis for testing the research hypothesis. The sample contains data from 494 actual projects executed by owner organizations. The projects in the sample include a wide range of companies, industries, locations, project types, and project sizes. The sample was limited to projects for which data regarding the characteristics of the project schedule at the time of authorization were available. The sample was also limited to only projects for which actual results were available. No other restrictions were used in developing the sample. Table 1 provides a summary of the sample characteristics.

## ANALYSIS

Four different measures of project success were used as the dependent variables in this analysis. These measures of success include both the absolute performance relative to an industry benchmark and the predictability relative to the estimated targets. The four measures of project outcome performance used in this study are:

- Absolute cost performance relative to the industry benchmark for comparable projects;
- Absolute execution schedule performance relative to the industry benchmark for comparable projects;
- Cost growth relative to the estimated cost at the time of project authorization; and
- Schedule slip relative to the planned execution schedule target set at the time of authorization.

Analysis of the data identified four characteristics of project schedules that are correlated with better project outcome performance. Each of these characteristics was correlated with positive and significant project outcome metrics. The four characteristics are:

- Integration of all project phases into a single schedule;
- Application of critical path method (CPM);
- Resource-loading of the project schedule; and
- Detailed review of the schedule by the core project team.

Again, it is important to emphasize that the results of this study are based on the scheduling practices applied at the time of full-funds authorization, which is normally at the beginning of detailed engineering design.

Measured as an index (Absolute Cost Index). The index is calculated by dividing the actual project cost by the industry average cost for comparable projects. By definition, the industry average cost index is 1.0. Index values higher than 1.0 indicate that the actual cost is higher than the industry average, and values less than 1.0 indicate that the actual cost is less than the industry average. The industry average cost is based on statistical cost models developed using actual projects in IPA's proprietary database.

Measured as an index (Absolute Schedule Index). As with the cost index, the schedule index is calculated by dividing the actual execution schedule duration by the industry average duration for comparable projects. The industry average schedule index is 1.0, and values higher than 1.0 indicate that the actual schedule duration is longer than industry average, while an index less than 1.0 indicates that the actual schedule duration is shorter

## Table 1
## Study Sample Characteristics

| Characteristic | Study Sample |
|---|---|
| Number of projects | 494 completed projects |
| Project authorization date | Average project was authorized in 2nd Quarter 2000<br>• Median: 3rd Quarter 2000<br>• Range: 1993 to 2003 |
| Number of companies represented | 59 different owner organizations<br>• Max. for any single company: 7% of the sample<br>• 5 companies make up 27% of the sample |
| Project sizes | Average estimated cost: $24MM (USD)<br>• Median size: $4.3MM (USD)<br>• Range: $100K (USD) to $934MM (USD) |
| Project locations | Worldwide locations<br>• North America: 72%<br>• Europe: 16%<br>• Australia & region: 7%<br>• Asia: 2%<br>• Other regions: 3% |
| Industries | All major industrial manufacturing industries are represented<br>• Chemical: 32%<br>• Refining: 26%<br>• Mining and minerals: 13%<br>• Pharmaceutical: 10%<br>• Pipelines: 6%<br>• Consumer products: 5%<br>• Others: 8% |
| Project types | All project types are represented<br>• Revamp: 35%<br>• Colocated: 21%<br>• Expansion: 18%<br>• Add-On: 17%<br>• Greenfield: 6%<br>• Other: 3% |
| Process types | All major process categories are represented<br>• Chemical processes: 51%<br>• Mechanical processes: 23%<br>• Civil and building construction: 20%<br>• Instrumentation projects: 6% |

**Table 1 — Study Sample Characteristics**

than industry average. The industry average schedule duration is also based on statistical models developed using actual projects in IPA's proprietary database.

## INTEGRATED PROJECT SCHEDULES

An integrated project schedule provides a complete picture of the entire project life cycle, which is critical to effective project planning. Having all project phases incorporated into the same model gives the project team an opportunity to plan the critical interfaces between definition and detailed design, design and construction, and construction and startup. Limiting the project schedule to only the engineering, procurement, construction (EPC) phases limits the usefulness of the schedule and ignores the critical planning phase and the final startup phase.

For the purposes of this study, an integrated project schedule is a schedule that integrates all project phases into a single master schedule. Each project schedule was evaluated and was classed as Integrated when the schedule included all of the following phases: (1) project definition, or Front-End Loading (FEL); (2) detailed engineering; (3) procurement; (4) shutdown/turnaround (when applicable); and (5) commissioning and startup (when applicable). If a project schedule was missing one or more of these phases, it was rated as Not Integrated.

Projects with integrated schedules at the time of authorization had better absolute cost performance and less schedule slip than projects without integrated schedules. Table 2 reports the statistical results of the significant correlations, which in this case are with absolute cost and percent schedule slip. The table presents each of the outcome metrics (absolute cost performance and schedule slip), the average and standard deviation for projects that did have an integrated schedule and those that did not, and the statistical significance of the observed correlation (t value and level of significance). This table format will be used to report significant correlations throughout this paper.

Only 33 percent of the projects in the study sample had an integrated project schedule at the time of authorization. The phase that was most frequently missing was the final phase, commissioning and startup. Moreover, a number of schedules were missing the project definition phase and/or the shutdown/turnaround phase, when applicable. However, most schedules did include the core EPC phase.

## CRITICAL PATH METHOD

Projects that have schedules based on the critical path method (CPM) at the time of authorization have less cost growth, less schedule slip, and better absolute cost performance. Table 3 reports the details of this finding. The table presents each of the outcome metrics with significant correlations, average value for each outcome metric, and standard deviation for projects that applied CPM and those that did not, and the statistical significance of the observed correlation.

Applying CPM in building a project schedule is beneficial in many ways. When used properly, CPM forces the project team to break down the project into discrete activities, estimate the durations for each of the activities, and think through the possible and preferable sequencing of the activities. This process forces the team to address critical questions that might not otherwise be considered. In addition, the final project schedule with the critical path and activity float is an excellent tool for controlling the project during execution.

For the purposes of this study, project schedules were rated as CPM if they met a set of minimum criteria. The schedule's individual activities must be networked together using predecessors and/or successors. In addition, the activity start and finish dates must be based on standard network calculation algorithms. Finally, the network critical path and individual activity float must be defined and clearly documented.

Slightly less than 50 percent of the schedules in the study sample were based on CPM techniques. A small number of the schedules that were rated as not based on CPM were simple bar charts. However, many of these schedules were modeled in a scheduling software package, but activities were not networked together in a systematic way. In some cases, all the activities in the schedule were anchored using early start activity constraints. Although the criteria did not require that a scheduling software package be used, all of the schedules that were rated as CPM schedules were developed using a commercially available scheduling software program.

Although the data did show that smaller projects were less likely to have a CPM schedule at authorization, the analysis found that project size was not driving the observed correlations. The analysis tested for the possible effect of project size on project success metrics in conjunction with the use of CPM schedules. The use of CPM schedules remained significant, while project size failed to be a significant factor in regression analyses.

## RESOURCE LOADING

Resource loading involves evaluating the project, selecting the most critical resources, and defining how much of each resource a specific activity will need. Basically, you do not know if the planned approach, schedule, and cost are feasible until you evaluate a resource loaded schedule. Resource loading helps to ensure alignment between the cost estimate and schedule. It also enables you to evaluate peak labor. In addition, resource loading provides a model for resource leveling, which results in a more effective project. It also focuses the team on the critical resources. Finally, resource loading helps coordinate scarce resources when managing a portfolio of projects.

Projects with resource-loaded project schedules at the time of authorization typically had better absolute cost performance and less schedule slip. Table 4 reports the details of this finding. The table reports the average (and standard deviation) cost index and schedule slip for projects that were resource loaded and those that were not resource loaded. The table also reports the statistical significance of the observed correlation.

Only 24 percent of the schedules in the sample were resource loaded. For this study, a project schedule was rated as resource loaded if the schedule had any number of resource categories loaded into the schedule. However, when the schedule simply had only one generic man-hour resource, it was not rated as resource loaded. Categories of construction labor (welders, laborer, electricians, etc.) were the most common resource type used. Table 5 reports the percent of schedules that were loaded with different types of resources. This table includes only project schedules that were classed as resource loaded.

Projects with estimated capital costs equal to or less than US $5MM.

| Outcome Metric | Projects With Integrated Schedules | Projects Without Integrated Schedules | Correlation Significance |
|---|---|---|---|
| Absolute Cost (Cost Index) | Avg. 0.96<br>SD: 0.19 | Avg: 1.02<br>SD: 0.20 | t = 2.4<br>P>\|t\| = 0.02 |
| Percent Schedule Slip | Avg. 8%<br>SD: 31% | Avg. 26%<br>SD: 60% | t = 3.3<br>P>\|t\| = 0.01 |

Table 2—Outcome Metrics that Correlate With Use of Integrated Schedules

| Outcome Metric | Projects That Applied CPM | Projects That Did Not Apply CPM | Correlation Significance |
|---|---|---|---|
| Percent Cost Growth | Avg. 0%<br>SD: 16% | Avg: 6%<br>SD: 25% | t = 3.1<br>P>\|t\| = 0.01 |
| Percent Schedule Slip | Avg: 14%<br>SD: 48% | Avg. 26%<br>SD: 54% | t = 2.2<br>P>\|t\| = 0.03 |
| Absolute Cost Performance (Cost Index) | Avg. 0.97<br>SD: 0.21 | Avg. 1.02<br>SD: 0.21 | t = 2.2<br>P>\|t\| = 0.03 |

Table 3 — outcome metrics That Correlate With Use of CPM

| Outcome Metric | Resource-Loaded Schedules | Not Resource Loaded | Correlation Significance |
|---|---|---|---|
| Absolute Cost Performance (Cost Index) | Avg. 0.95<br>SD: 0.21 | Avg. 1.02<br>SD: .19 | t = 2.5<br>P>\|t\| = 0.01 |
| Percent Schedule Slip | Avg. 9%<br>SD: 33% | Avg. 19%<br>SD: 41% | t = 2.2<br>P>\|t\| = 0.03 |

Table 4 — Outcome Metrics That Correlate With Resource Loading

| Resource Category | Percent of Projects |
|---|---|
| Construction Labor | 73% |
| Engineering Labor | 58% |
| Construction Equipment | 24% |
| Estimated Cost | 21% |
| Other (Material, Management, etc.) | 10% |

Table 5 — Mix of Resource Categories for Projects With Resource Loading

| Outcome Metric | cts That Did Reviews | Projects That Did Not Do Reviews | Correlation Significance |
|---|---|---|---|
| Percent Cost Growth | Avg 0%<br>SD: 0.20 | Avg 11%<br>SD: 0.30 | t = 4.1<br>P>\|t\| = 0.01 |

**Table 6 — Cost Growth Correlation With Schedule Reveiws**

## PROJECT TEAM REVIEW

Finally, the study found that projects on which the core project team conducted a formal review of the project schedule demonstrated less cost growth than projects that did not conduct a formal schedule review. Table 6 provides the basic statistics around this finding.

The data found that 76 percent of the projects in the sample did conduct formal reviews of the project schedule at the time of project authorization. However, this also shows that 26 percent of projects do not take the time to review and challenge the schedule.

Review of the project schedule provides a number of benefits. First, a formal review by the core project team provides a check to ensure accuracy. The review also allows the functional leaders the opportunity to verify that their plans and expectations are properly reflected in the final authorization schedule. Finally, the review also supports buy-in to the plan by the team members, who are ultimately responsible for delivering the project.

Data from almost 500 actual industry projects show that the application of project scheduling techniques early in the project is correlated with better project outcomes. The study identified four specific scheduling practices that demonstrated significant and positive relationships with outcome performance metrics: (1) integrating all project phases into a single project schedule; (2) application of CPM techniques; (3) resource loading critical project resources into the project schedule; and (4) core project team reviews of the project schedule.

In order to validate the results of this analysis, a single measure of schedule definition was developed and evaluated using the sample database. The four specific practices identified are all measured using a simple yes/no construct. However, the single measure uses four levels of schedule definition and is designed to combine all four of the specific practices into one variable. Using this new measure, each project in the dataset was assigned a level of definition, which was used for additional statistical analysis.

### Single Measure of Schedule Definition

The single measure of schedule definition is based on four levels of schedule development and application of scheduling techniques. The four ratings from least well defined to most well defined are:

1. No Schedule: A project is assigned this rating if, at the time of authorization, the project team has not developed a documented project schedule. If the team only has a target completion date, this does not qualify as having a schedule. The team must have some type of activity and milestone list with planned durations for each activity.
2. Milestone Schedule: A milestone schedule shows the timing required for most of the major phases. At minimum, this is a one or two page bar chart with perhaps 5 to 20 activities, depending on the complexity of the project. The activities are normally high level, and are not tied into a critical path network. Often, some project phases (e.g., engineering and design, or construction) have only one bar to represent the phase. This level of schedule definition only gives an overview of the planned durations but offers little detail.
3. Integrated CPM Network Schedule: In order to qualify for this category, the project schedule must cover all of the core project phases and be based on CPM techniques. The schedule network should have a discernable critical path and should avoid excessive activity float. All activities in the schedule should be tied into the network, and the use of activity constraints should be limited. The level of detail can vary depending on the size and complexity of the project; but the entire project needs to be broken down into specific activities and a critical path analysis done.
4. Integrated CPM Network Schedule with Resource Loading: The underlying level of detail for this classification is the same as for the previous one. However, this classification also requires that the schedule be resource loaded. Resource loading involves evaluating the project, selecting the most critical resources, and defining how much of each resource a specific activity will need. The project team needs to define the quantity of each selected critical resource it will need to complete each activity in the schedule. Once all critical resources are "loaded," the team can generate resource histograms to evaluate the peak resource use, total resource use, and the distribution of the resource demand.

The sample of 494 projects was then subdivided based on the schedule definition measure outlined above. Table 7 shows the distribution in terms of the percent of projects that fell into each category of schedule definition. The category with the most projects is "Milestone Schedule," with 55 percent of the sample.

An analysis of the data found that this single measure of schedule definition is significantly correlated with all four outcome performance measures: absolute cost performance, cost growth, absolute schedule performance, and schedule slip. Table 8 provides the data supporting this finding. The table presents the average and standard deviation for each of the four outcome metrics segregated by level of schedule definition. In the last column, the table also presents the significance of the correlation. There were not enough observations in the "No Schedules" category to include in the analysis. As a result, Table 8 reports results for three levels of schedule definition: resource loaded CPM, CPM, and Milestone.

The application of modern scheduling techniques appears to pay off in better project performance. The analysis found that the application of four specific project scheduling practices early in the project life cycle have a positive and significant relationship with the ultimate success of the project. The study also presented a single measure of schedule definition, which is significantly correlated with all four measures of project success. The results from this study clearly support the assertion that using project scheduling techniques early in the project life cycle improves the chances of project success.

In terms of the potential value added, the data show a significant improvement in outcome performance to justify the additional investment. Projects that reached the highest level of schedule definition at the time of authorization had, on average, 8 percent lower cost and 13 percent faster schedules than the projects with only milestone schedules at authorization. In addition, the projects with well defined schedules also were more predictable than the projects with only milestone schedules. They averaged 6 percent less cost growth and 23 percent less schedule slip. These benefits easily outweigh the cost of competent scheduling support, which should amount to less than one percent of the project cost.

Like all research studies, this study has limitations that must be addressed. The sample of projects used in this study is limited to capital projects in the heavy industrial sector. Therefore, transferability of the findings to projects in other industries needs to be questioned. Second, the study was also limited in terms of project life cycle. The schedules used in this study were all anchored at the time of project authorization; the specific practices and measure of schedule definition, therefore, are limited to this stage of a project. The efficacy of scheduling practices and measures of schedule definition would likely be different at another stage in the project. For example, the characteristics of project schedules at the start of field construction should be more advanced than the schedules used in this study.

However, the basic relationship between scheduling practices and project outcome success is transferable to other categories of projects and other stages in the project life. The sample of projects used in this study covers a wide range of project types and a number of different industries within the heavy industrial manufacturing sector. The general finding that better project schedule definition is correlated with better outcomes was not limited to any type of project or industry. Therefore, it is reasonable to conclude that this basic relationship is also valid for projects in completely different sectors, and applicable at different stages in the project life cycle.

**Recommendations-** Based on the results of this study, the author puts forward two recommendations for project professionals.

1. Use the results of this study to help justify the investment in sound scheduling practices. The findings of this study help to support the assertion that proper planning and scheduling contribute to the ultimate success of projects, and are worth the investment. Project professionals should use these findings to help explain the benefits of sound planning and scheduling to project sponsors and team members. The results should also be used to help acquire the resources needed to develop and use a comprehensive project schedule.
2. Benchmark schedule development and application on projects. In order to improve the application of scheduling techniques, project organizations need to initiate a benchmarking program. Project organizations should design an applicable metric for schedule definition. As noted in the conclusions, the proposed measure outlined in this article is limited by the sample of projects used in the study. However, regardless of project type, a reasonable measure of schedule definition can be developed. The project organization should then systematically measure schedule definition on all of its projects. The objective is to measure trends and raise the level of schedule definition used on all projects. However, schedule definition should be evaluated early in the project life cycle when the ability to influence the outcome is greatest.

## REFERENCES


1. AACI. **Professional Practice Guide #4: Planning and Scheduling.** AACE, Morgantown, WV, USA. (1999)
2. Berman, H. *The Critical Path Method for Project Planning and Control*. **The Constructor**, (September. 1961).
3. IPA (2004). Independent Project Analysis, Inc. web site. Retrieved 2004, August 6 from http://www.ipaglobal.com.
4. Merrow, E.W., & Yarossi, M.E. Managing capital projects: *Where have we been - where are we going*? Chemical Engineering, October.1994
5. Needham, D.E., & Merrow, E.W. (2003). *Benchmarking petroleum asset developments requires individual and system focus*. **Offshore**, January.
6. Moder, J., Phillips, C., & Davis, E. . **Project Management with CPM and PERT**. Van Nostrand Reinhold Company, New York, NY, USA. ISBN: 0-442-25415-6. (1983)
7. O'Brian, J. **CPM in Construction Management**. McGraw-Hill, New York, NY, USA. ISBN 0-07-047921-6. (1993)
8. PMI (2004). Proceedings of the 1st Annual International Conference: PMI College of Scheduling. Montreal, Quebec, Canada. April 25 to 28. Project Management Institute, Newtown Square, PA, USA.
9. Riggs *Cost and Schedule Control in Industrial Construction. Source Document 24*, Construction Industry Institute, Austin, TX, USA. (1986)
10. Scott-Young, C., & Samson, *D. Project Success and Project Team Human Resource Management: Evidence from Capital Projects in the Process industries*. Proceedings of PMI Research Conference. London, England, July 11 2004

14. Project Management Institute, Newtown Square, PA, USA.
11. Songer . *Re-Engineering the EPC Process*, Research Report 124-11. Construction Industry Institute, Austin, TX, USA. (2000)
12. Steinfeld, R. C. (1960). *Critical Path Saves Time and Money*. **Chemical Engineering,** November 28.

Dr. Andrew F. Griffith, PE
Independent Project Analysis, Inc
Koningin Julianaplein 30, 4B Babylon
2595 AA The Hague
The Netherlands

| Definition Rating | Percent of Sample |
|---|---|
| No Schedule | 3% |
| Milestone Schedule | 55% |
| CPM Network Schedule | 29% |
| CPM Network with Resource Loading | 13% |

**Table 7 — Sample Distribution by Schedule Definition Rating**

| Outcome Metric | Resource-Loaded CPM | CPM | Milestone | Correlation Significance |
|---|---|---|---|---|
| Absolute Cost Performance (Cost Index) | Avg: 0.95<br>SD: 0.14 | Avg: 0.98<br>SD: 0.17 | Avg: 1.03<br>SD: 0.22 | t = 3.5<br>P>\|t\| = 0.01 |
| Percent Cost Growth | Avg: -1%<br>SD: 17% | Avg: 2%<br>SD: 17% | Avg: 5%<br>SD: 25% | t = 2.1<br>P>\|t\| = 0.04 |
| Absolute Schedule Performance (Schedule Index) | Avg: 0.91<br>SD: 0.25 | Avg: 0.97<br>SD: 0.36 | Avg: 1.04<br>SD: 0.45 | t = 2.3<br>P>\|t\|=0.02 |
| Percent Schedule Growth | Avg: 2%<br>SD: 22% | Avg: 19%<br>SD: 59% | Avg: 25%<br>SD: 50% | t = 2.7<br>P>\|t\| = 0.01 |

**Table 8 — Coorelations Between Outcome Metrics and Schedule Definition Rating**