Sample Analysis Problems

Risk Analysis

Students often select a new web site as a project because they think they understand web sites. While they may understand web sites, they usually do not have any idea about the complexities associated with a project to build them. In that case, a risk analysis is a good way to demonstrate the complexities of a project.

This section is based on the excellent article by Versa Studio called "Web Site Planning."[1] Web sites are inherently flexible, so one must reconcile the need for a clear and detailed specification (the scope) with the changeable nature of the web? The key is to define a clear process, part of which is to spend time on the creation of a clear design specification. The emphasis on clarifying what is required (the content) greatly reduces the potential for mid-project crises. It is also important to take the time to create a well-deigned product (the design process) that will support the goals of the company, both now and in the future. The scope defines both the specification and the process and is the most important document in most projects.

Since web sites change, it is essential to define a process that allows the web site to grow with time. In fact, for most web sites, it is clear that one needs to plan for expansion, allowing, for example, sections for news, social networking, users' comments, etc. This will require procedures to manage the content with the ability to swap out photos and documents; change web pages, titles, and content; and maintain growing databases. All these changes call for well-defined policies for who can make the changes.

Students frequently underestimate the importance of the specification and a risk analysis can clarify the issues. Common issues that need to be addressed in a good scope are:

- Discovering the true needs of the client halfway through the project results in backtracking, re-writing, extended schedules, cost overruns and missed deadlines.
- The developer is forced to make assumptions about what the client wants, which may or may not be correct.
- Unclear specifications results in much more back-and-forth communication about trivial matters.
- When the developer makes an incorrect assumption about the content, backtracking occurs, which causes delays and missed deadlines.
- Forgotten requirements and, even, unclear specifications result in work outside the original scope, creating cost increases.

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[1] "Web Site Project Planning, Versa Studio, versastudio.com, available at: http://versastudio.com/download/guide/wufoo/12669.

- A web site rarely stands alone, it interacts with many other departments, such as marketing, customer management, IT, etc. Their needs must be included or the web site will need to be re-designed to meet their requirements.
- Failing to identify important stakeholders results in an incomplete requirements specification.
- Different stakeholders have different priorities, which must be accounted for in the specification.
- Underestimating the complexity of the content results in costly delays and a poor web site, which reflects poorly on the organization. Photography, audio, video, YouTube, Flash, Flikr, RSS all need to be addressed.
- Poor writing reflects badly on the organization. What do the customers care about? How will the site avoid business-speak, confusing acronyms, and dry details? Which technical aspects will be assigned to multi-page PDFs available for download?
- Reading on a screen is tiring, so the design might specify short blocks of copy and bulleted or numbered lists.
- Use a uniform style that can be applied to the entire site.
- Content in one part of the site is related to content in another. Avoiding duplication helps reduce errors, but repeating information makes the scope easier to understand.
- Collecting data (e.g., web visitor data) is a good idea, but it will need to be analyzable later. For example, collecting customer names and addresses is obvious, but the ability later on to sort by last name or zip code may require some database design work early on.
- Should the site plan to optimize for Search Engine Optimization (SEO).
- Avoid committee design. While a review process is essential, allowing a committee to degrade the design will ruin the entire project. Address stakeholder comments and criticisms, but do not allow them to specify solutions—that is the designer's job.
- Think about expansion. What happens when there are 10,000 user comments?
- Is the web site to be interactive, using such things as JavaScript, jQuery, Flash? Does the organization have the technical capabilities to support these?
- Is there a defined testing process?
- Is there a process for the early users to give feedback?
- Does the site require regular backups?
- Is the website secure from hackers?

These requirements may be elicited in a class discussion. The next step is to turn these general issues into a risk assessment.

Risk Identification:

Each of the above issues can result in a risk, so we might classify them into categories of risks, as follows:

- **Failing to develop all the requirements:** Discovering the true needs late in the project; The developer makes assumptions about what the client wants; Unclear specifications results in extra communication; Forgotten requirements; Including the needs of marketing, customer management, IT, etc.
- **Failing to manage stakeholders:** Failing to identify important stakeholders; Not interacting with marketing, customer management, IT, etc.; Different stakeholders have different priorities.
- **Underestimating the complexity of the content:** Web objects, such as photography, audio, video, YouTube, Flash, Flikr, RSS; Assigning technical aspects to multi-page PDFs; Collecting analyzable data; Optimize for SEO; Interactive site; Backups.
- **Poor Writing:** Understanding the customers' impressions; Avoiding business-speak, confusing acronyms, and dry details.
- **Poor Design:** Avoid committee design; Hard to read small print; Not using a uniform style; Code is vulnerable to security attacks
- **Poor Scope:** Content in multiple places.
- **Failing to allow for future maintenance:** Ability to sort & analyze data; Massive increase in data.
- **Inadequate validation and verification:** Not obtaining early user feedback about functionality, design and website usability.

The next step is to classify the risks, which is typically done by individually assessing the impact and likelihood of each one. To do this, the likelihood is typically defined with values between 1 and 5, where "1" might represent that the risk is "Rare, it occurs in exceptional circumstances," "2" represents "Unlikely," "3" represents "Possible," "4" represents "Likely—it will probably occur in the project," and "5" represents "Very Likely—it is expected to occur in the project."

The impact is similarly defined with values between 1 and 5, where "1" represents "Insignificant cost/schedule impact," "2" represents "Minor damage or loss and/or minor cost/schedule impact," "3" represents "Moderate damage and/or significant cost/schedule impact," "4" represents "Major damage or loss and/or extensive cost/schedule impact," and "5" represents "Catastrophic Damage to reputation and huge financial loss with unrecoverable cost and/or schedule impact."

Values are assigned to each of the risks in Table II-D.1.

Table II-D.1: Impact and Likelihood of Risks

Risk ID	Risk	Impact	Likelihood	Mitigation
1	Failing to uncover requirements	4	4	Conduct user & stakeholder workshops
2	Failing to manage stakeholders	3	4	Develop stakeholder Management Plan
3	Underestimating the complexity of content	3	5	Hire technical specialist to review requirements
4	Poor writing	2	4	Hire writer
5	Poor design	4	5	Contract with experienced web designer
6	Poor scope	4	3	Seek experienced PM for guidance on scope
7	No Maintenance Plan	3	2	Add maintenance requirements section to scope & PM Plan
8	Inadequate validation, verification and testing	2	3	Develop test criteria in scope Consider agile approach Do usability testing early

The final step is to create the Risk Assessment matrix, an example of which is shown in Fig. II-D.1. Risks with high values of likelihood and high values of impact should be designated for further investigation.
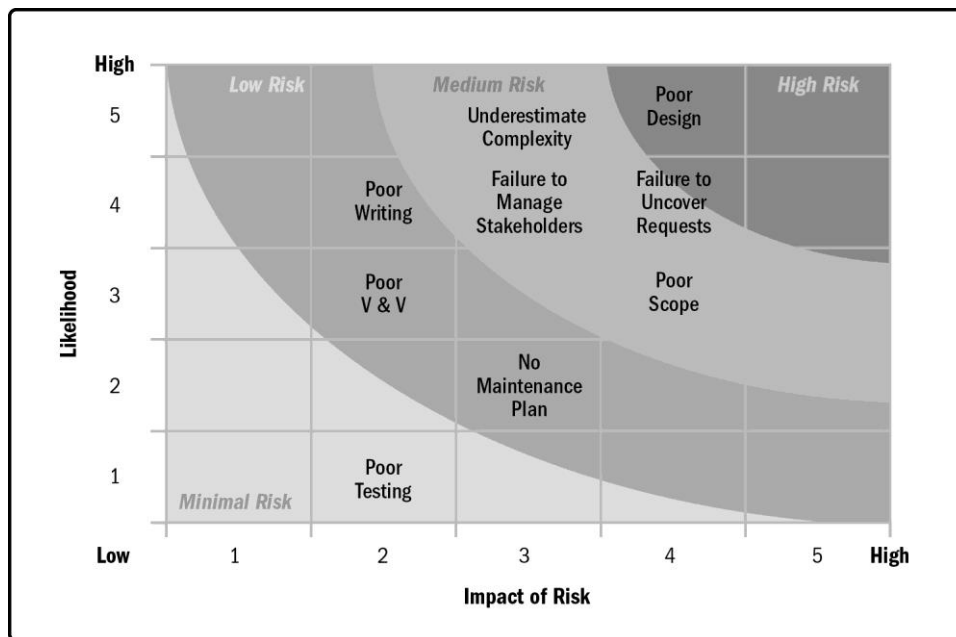

Figure II-D.1: Risk Assessment Matrix.

Students should also consider "good risks," which provide an opportunity to reduce costs and optimize the schedule. For example, one could research the availability

of new tools or methods that could help with building the website. Tools may also provide automatic generation of quality code, which reduces errors. One could also consider subcontracting some work to a high-quality vendor to exploit their knowledge in reducing risks and improving the design.

Earned Value Road Problem

The following problem is designed to test the understanding of the students' appreciation of earned value (EV) concepts.

Problem Statement for Students

Route I93 is planned to be re-paved. The entire route from the I90-I93 interchange to the Route 128/I93 interchange is 7.7 miles. The plan is for 0.77 miles to be complete each month for 10 months. The estimated cost of the entire project is $1,470,000.

Table II-D.2 represents the status of the project at the end of month 4:

Table II-D.2: Sample Earned Value Analysis Problem

Month	Miles Completed		Cost		
	Planned	Earned	Planned	Actual	Earned
1	0.77	0.77	$147,000	$173,531	$147,000
2	0.77	0.62	$147,000	$161,711	$118,364
3	0.77	0.64	$147,000	$154,089	$122,182
4	0.77	0.72	$147,000	$199,213	$137,455
5	0.77				
6	0.77				
7	0.77				
8	0.77				
9	0.77				
10	0.77				

1. Calculate the cumulative planned and earned value, as well as the cumulative actual costs. Calculate the CPI and SPI.
2. Plot the quantities.
3. Estimate the final cost.
4. Write a letter to the mayor, explaining the status of the project.

Rationale and Explanation of the Assignment

This is a relatively simple earned value problem, but it features many of the essential features that the students should understand.

Assignment #4 is an excellent example of the goal of encouraging, not just analysis skills (calculation of the overrun), but of also showing students why analysis skills are important. The assignment also shows the importance of communication skills. Further, both analysis and communications are complementary and important to a PM.

Route I93 goes right through the middle of Boston and, so, everyone knows the route. It is immediately and practically relevant. Faculty members can easily substitute their local highway for I93.

The "Miles Completed" data can actually be seen and measured as you drive down the highway. That is, as the improvements proceed, it is quite possible for a driver to measure the progress with little effort. Actually, it is not even necessary to get out of the car to track miles completed over time. This reinforces the idea that earned value is a measurable quantity.

The "Actual Cost" data is made up to make an interesting case.

The key assignment is #4, "Write a letter to the mayor." This emphasizes that the problem is not about the earned value analysis, but the communications skills. The topics to be discussed upon completion of this assignment are discussed in some detail.

Standard Answer

1.   Calculate the cumulative planned and earned value, as well as the cumulative actual costs. Calculate the CPI and SPI.

The first thing the student is expected to do is to complete a table with the cumulative values for Planned Value (PV), Earned Value (EV), and Actual Cost (AC). A sample is given in Table II-D.3. It is important to emphasize that EV calculations are all performed using on cumulative data.

These calculations are best performed in a spreadsheet.

Table II-D.3: Cumulative Values for PV, EV, and AC.

Month	Planned Miles	Actual Miles	Monthly			Cumulative		
			Planned	Earned	Actual	Planned	Earned	Actual
1	0.77	0.77	$147,000	$147,000	$173,531	$147,000	$147,000	$173,531
2	0.77	0.62	$147,000	$118,364	$161,711	$294,000	$265,364	$335,242
3	0.77	0.64	$147,000	$122,182	$154,089	$441,000	$387,545	$489,331
4	0.77	0.72	$147,000	$137,455	$199,213	$588,000	$525,000	$688,544

We use capital letters for the cumulative values and lower case for the monthly values. The cumulative PV is computed as follows:

$$PV(1) = pv(1) = 147,000$$

$$PV(2) = PV(1) + pv(1) = 147{,}000 + 147{,}000 = 294{,}000$$

$$EV(3) = EV(2) + ev(3) = 265{,}364 + 122{,}182 = 387{,}545$$

and so on.

The next thing the student is expected to do is to compute the EV, which is the percentage of planned value that has been completed. In month #1, 0.77 miles were complete, which is 100% of the plan that was assigned to month #1. Therefore, the earned value is 100% of the plan = 147,000.

In month #2, they only completed 0.62 miles, which is $0.62/0.77 = 0.805$ of the work. Therefore, they only earn 80.5% of the planned value, which is $0.805 \times \$147{,}000 = \$118{,}364$.

The cumulative EV is then computed in the same way as the cumulative PV:

$$EV(1) = ev(1) = 147{,}000$$

$$EV(2) = EV(1) + ev(2) = 147{,}000 + 118{,}364 = 265{,}364$$

$$EV(3) = EV(2) + ev(3) = 265{,}364 + 154{,}089 = 387{,}545$$

and so on. The cumulative AC is calculated in the same way.

The next thing the student is expected to do is to compute the cost and schedule performance indices (CPI and SPI). The formulas are:

$$CPI = EV/AC \qquad SPI = EV/PV$$

For example:

$$CPI(2) = 265{,}364/335{,}242 = 0.79$$

$$SPI(2) = 265{,}364/294{,}000 = 0.90$$

These calculations are completed in Table II-D.4.

Table II-D.4: CPI and SPI.

Month	Planned Miles	Actual Miles	Monthly Planned	Monthly Earned	Monthly Actual	Cumulative Planned	Cumulative Earned	Cumulative Actual	CPI	SPI
1	0.77	0.77	$147,000	$147,000	$173,531	$147,000	$147,000	$173,531	0.85	1.00
2	0.77	0.62	$147,000	$118,364	$161,711	$294,000	$265,364	$335,242	0.79	0.90
3	0.77	0.64	$147,000	$122,182	$154,089	$441,000	$387,545	$489,331	0.79	0.88
4	0.77	0.72	$147,000	$137,455	$199,213	$588,000	$525,000	$688,544	0.76	0.88

Students should not provide more decimal places than necessary. Two places for CPI and SPI are sufficient.

This completes the calculation portion of this assignment, which is #1.

2.   Plot the quantities

The next part of the assignment is to plot the quantities. The students should be encouraged to plot as many quantities as they can. Plotting the data shows the status much better than just viewing the data in a table. The following plots can be drawn (again, most easily in a spreadsheet).
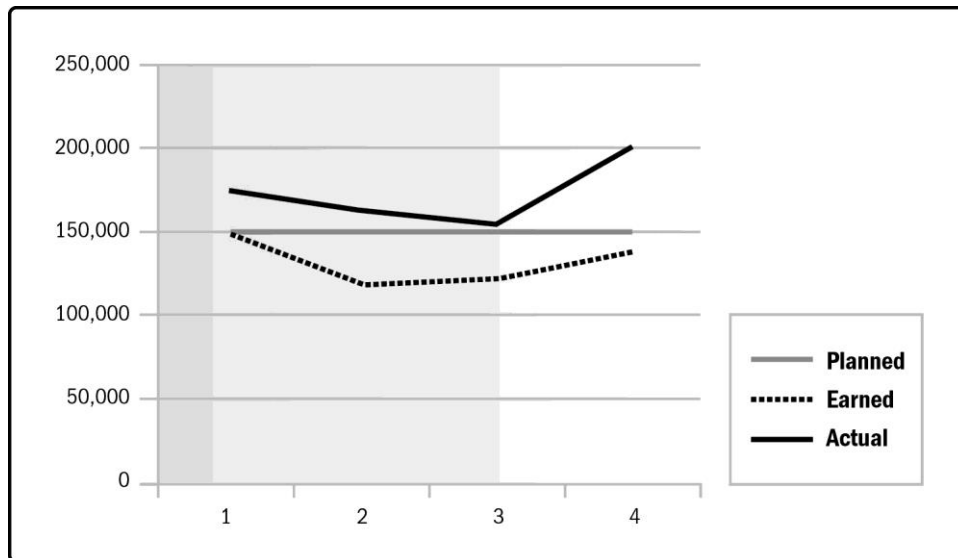
Figure II-D.2: Monthly Data.

Monthly data gives a good view of what is happening—see Fig. II-D.2. The planned number of miles to be completed is constant. The earned value is the percentage of the planned value that was actually completed and in month #1 is equal to the planned value. However, in month #2, the earned value is less, which is shown in the figure by the EV falling below the PV.

The EV rises a little in months 3 and 4 showing that the monthly work is completed is increasing.

The AC is above the plan, showing that the project is over budget. Also, the monthly costs seem to be increasing and could be a sign of trouble.

Next, the student should plot the cumulative data, which is shown in Fig. II-D.3.
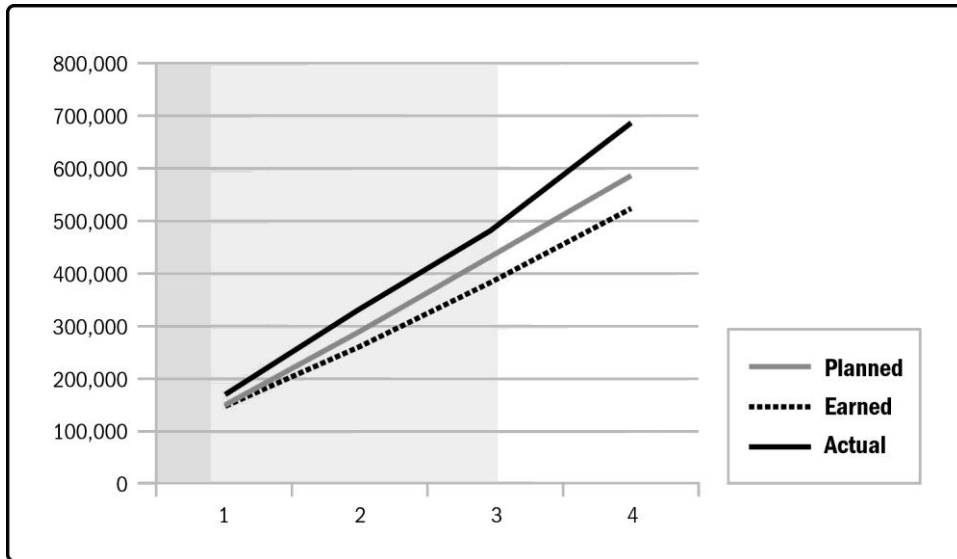
Figure II-D.3: Cumulative Monthly Data.

The cumulative data is much less informative as to what is happening on the project. A student might observe a slight increase in the cost trend, but the cumulative figure is not as informative as the monthly figure.

It is clear, however, that the EV is below the PV and that the AC is above the PV.

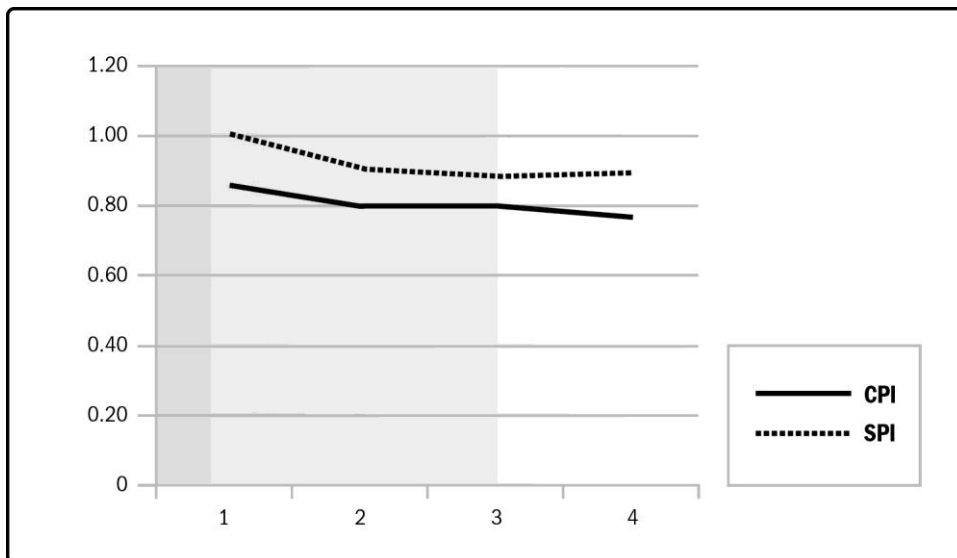Next, the student should plot the CPI and SPI, which are shown in Fig. II-D.4.

Figure II-D.4: CPI and SPI.

The CPI seems to be hovering around 0.8 and is declining. The SPI may have leveled off. Therefore, the schedule performance of the project is much better than the cost performance.

3   Estimate the final cost.

To determine the seriousness of the cost overrun, one computes the estimate at completion, EAC, which is the budget divided by the average CPI:

$$EAC = Budget/<CPI>$$

For example, for month #2:

$$EAC(2) = 1,470,000/CPI(2) = 1,470,000/0.79 = 1,860,759.$$

The final budget is predicted to be $1,860,759, which is $390,759 over budget. This is 26.5% overrun.

Note that from standard EV theory, one cannot use the SPI to compute the final schedule, one has to use a concept called "Earned Schedule." This presents a challenge to the students who might be tempted to compute the new final duration as

Schedule at Completion, $SAC(2) = Planned Schedule/SPI = 10/0.9 = 11.1$ months.

It must be emphasized that this calculation is not valid. While the SPI *indicates* that the project is behind schedule, it cannot be used to compute the final duration.

Finally, the student should plot the monthly value of the computed EAC, which is shown in Fig. II-D.5.
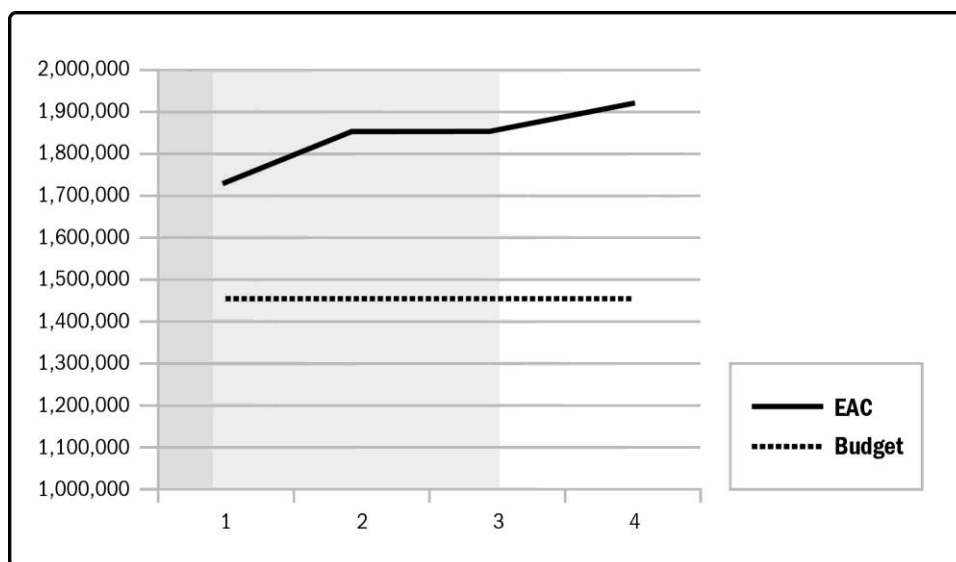

Figure II-D.5: The value of the Estimate at Completion, EAC.

Fig. II-D.5 shows that the EAC is rising. This means that the current value of the EAC should probably be considered an optimistic value and that the project is likely to cost more than the current EAC is predicting.

4   Write a letter to the mayor, explaining the status of the project.

Fig. II-D.6 is an example of an excellent letter to the mayor, in this case, the recently deceased mayor of Boston, Mayor Menino. This letter highlights many of the sorts of issues that students should be encouraged to explore:

- What is the best way to present detailed technical data, such as CPI and SPI?
- Are charts or data better for CPI and SPI?
- Does the letter to the mayor need to include this technical data? Is it enough to say the project is over budget? An interesting class discussion can be encouraged on whether the inclusion of CPI and SPI provides credibility to the PM and therefore enhances the impact of the budget overrun.
- Should charts go in the letter? The class will often split on this issue. Adding charts as appendices is a reasonable compromise.
- The reasons for the overrun can be hinted at in the case so that students have something on which to hang their explanation of the problem. Typical extra information that can be added include information about weather condition, contract negotiation problems, etc.

ML Construction

October 23, 2014

The Honorable Thomas M. Menino
Mayor of Boston
1 City Hall Square, Suite 500
Boston, MA 02201

Re: Route 93 Road Project update

Dear Mayor Menino,

I was sorry to hear about your health issues and wish you a speedy recovery.

I am writing to you in response to your request that I present a detailed, updated, and honest assessment of where we stand on the Rt. I93 Re-paving Project.

We have recently completed the fourth month of the planned 10 month project and, unfortunately, our company's performance is less than stellar on both the schedule progress and the cost of the project to date. As you know, we planned completing 0.77 miles of re-pavement per month and should by now have completed 3.08 miles; however the team only completed 2.75 miles.

On the cost side we had planned to spend $147,000 per month, so we should have spent no more than $588,000 in four months of work. However our Cumulative Actual Cost (AC) amounts to $688,544. If we consider that the value of the work actually delivered, our Cumulative Earned Value (EV), is $525,001, we emerge with a negative Cost Variance (CV): We are therefore $163,543 over budget after four months.

The indices confirm that we have poor efficiency. The SPI, which measures the schedule performance, is SPI = 0.89, which indicates that we are advancing at 89% efficiency in the schedule. The CPI, which measures the cost performance, CPI = 0.76, a less than desirable 76% cost efficiency.

I made some projections in order to discover how much the project is going to really cost and my current Estimate at Completion (EAC) is a very concerning $1,931,964.

I 'd like to be able to tell you that an improvement in our efficiency would help get us back on track, but I know that the people on your team will remind me that if our CPI is 0.76, then the improvement in efficiency we need is substantial.

So this is the sad state of this affair. I hope you do not find it in poor timing when I remind you of my earlier disapproval in our choice of contractor. The methods used by the city to award contracts for important projects such as this one need to be revised. More emphasis on verifying the ability of the petitioners to honor their commitments should be encouraged during the bidding process. Choosing the most reliable team over the lowest bidder would surely result in better overall performance.

My calculations point to the fact that we were in trouble after the second month and I could have alerted you earlier. I apologize for that. I suggest that we meet with contractors and engineers as soon as possible to review how we will correct the course of this project.

Best regards,
ML, Inc.

Figure II-D.6: A student's letter to the Mayor.

Fig. II-D.6 is an excellent example of the required combination of analysis skills (calculation of the EAC) and communication skills. Both types of skills are important to a PM as the PM must both determine the true project status and also effectively communicate that status to stakeholders.