Proceedings of the 2020 Annual General Donald R. Keith Memorial Capstone Conference
West Point, New York, USA
April 30, 2020
A Regional Conference of the Society for Industrial and Systems Engineering

A Case Study of Management: Bosnian Rail-Trail Bridge Design

Caneel Dixon and Kenneth McDonald

Department of Systems Engineering
United States Military Academy, West Point, NY

Corresponding Author: Caneel.dixon@westpoint.edu

Author Note: Author is a cadet at West Point associated with the Department of Systems Engineering. Special thanks to Dr. Jose Jimenez and Dr. Kenneth McDonald.

Abstract: Project Managers (PM) ideally keep projects running on-time and within budget. Our project team was made up of three members, one systems engineering student and two civil engineering students, with the goal to design a bridge to be used in the conversion of 12 miles of railway into a rail-trail in Bosnia and Herzegovina (BiH). There are several methods for managing a project which include Earned Value Analysis (EVA), Gantt charts, scheduling, and critical path method. These applications work for many projects of different size and length, but lack the minute detail needed to update the status of the project while outlining team dynamic feedback and the results of adjustments made by the PM. This research utilized a custom scheduling log which tracked individual progress, overall project status, and project timeline improvement strategies. The scheduling log offered a more nuanced view of the project's schedule and the improvements being made, which allowed the PM to provide a detailed report of the project status to the director overseeing the project. A major conclusion associated with this project include that having one boss with legitimate power is better than two (example: a project manager and a director giving opposing views on the project timeline) and the importance of defining clear team member roles.

Keywords: Project Management, Microsoft Project, Earned Value Analysis, Rail-Trail, Bridge Design, Interdisciplinary

1. Introduction

The full scope of this project was to plan the conversion of a 12-mile stretch of abandoned railway into a rail-trail in BiH, but the focus of this case study is the management of the rail bridge redesign portion of the project. The rail-trail would attract locals and foreigners to learn about Bosnia's past and connect with others to create a more unified future. By involving Bosnian stakeholders, the project team was able to gain insight into the specific improvements needed for the 12-mile route to be best used by the local community and up to code with European building standards.

The goal of this part of the project was to redesign the bridge on the rail-trail in four months, but a significant lack of knowledge about bridge design created project delays. The amount if background research required for the bridge was inadequately planned for in the schedule because the project team lacked experience with bridge construction and making task durations. Additionally, the project team had never worked with a PM before, so the task durations were not carefully thought out and the agreed upon schedule was not taken seriously. Once the schedule was established, the project team did not prioritize the agreed upon milestones. Instead, other side tasks were completed, and the project fell behind.

The original project management strategy included creating a schedule, meeting with the team, and allowing the team members to focus on their individual parts of the project while meeting team decided deadlines. However, the project team was unable to adhere to the schedule, so a revised strategy was created, using a custom scheduling log to analyze daily schedule updates, the group's ability to stay on-track with the originally planned timeline, and proposed changes to the group dynamic to increase performance. This case study approach analyzes the performance of the PM in the bridge design project. It outlines the PM's tools, the original scheduling strategy, the modified strategy using a scheduling log, and the results of the management techniques on the project.

2. Background

The Bosnian War was caused by severe ethnic and religious divides between the Orthodox Christian Serbians, Muslim Bosnians, and Catholic Croatians after the breakup of Yugoslavia. Over the past 25 years after the conflict's end, restoration efforts have been made to fix the broken remains of Bosnia's infrastructure and society. While shrapnel holes still mar the outside of most buildings, the country has moved past the war to focus on reconnecting its citizens and building a more stable

future for its youth. One of the methods used for involving community members and attracting tourists in the region is through outdoor activities, specifically hiking and biking through Bosnia's expansive natural terrain. Because mines were used heavily in the war, many unmarked routes are still unsafe to use. However, traveling on established trails is a popular way to bring people together and connect with others. One type of trail that has risen in popularity is the rail-trail, railroads that have been converted into trails (Taylor, 2015). The Ciro trail in southern Bosnia is a professionally developed, EU-funded rail-trail route that brings in thousands of visitors each year to bike its 100 miles of trails (Vjetrenica-Popovo polje, 2016). Organizations in Bosnia's capital, like the Sarajevo Mountain Bike Association, would like to implement a similar trail between Sarajevo and Pale, a town 12 miles away, to attract adventure tourists interested in safely traversing the area while learning about the history of BiH. The first step in creating the trail was to redesign a decrepit 400-meter-long rail bridge to be safe for the usage of hikers and bikers through the addition of new decking and railings.

3. Project Management Practices

The project used several tools to keep the schedule on track. These tools included Microsoft Project (MS Project), which covers all the tasks in the project's schedule and the critical path recommended to complete the tasks, earned value analysis (EVA), which compares the project's actual progress with the planned schedule, and a scheduling log that tracked the work done by each of the team members and specified what tasks needed to be crashed to remain on pace with the schedule.

The project itinerary was created in MS Project, which allows a detailed schedule to be planned with tasks, durations, predecessors, and theoretical expenses outlined on a Gantt chart. This tool provides the means to add additional tasks to the schedule, update the project status, and evaluate performance with EVA (Vargas, 2003). EVA was noted through the daily collection of earned value (budgeted cost for work performed: BCWP), planned value (budgeted cost of work scheduled: BCWS), and actual cost (Lipke, 2003). The EVA provided realistic updates of where the project was and how it needed to be improved upon (Anbari, 2003).

The main metric used to evaluate the execution of the project was schedule performance index (SPI), which dictates how close the project was kept to the planned schedule. To calculate the SPI, the earned value is divided by the planned value (Lipke, 2012). A value equal or above one means that the project is on or ahead of schedule, while a value less than one means that the project is behind schedule (the closer to zero, the further behind). Since the schedule had several milestones throughout the year, SPI was the easiest metric to monitor progress and compare actual work with planned work.

The critical path in MS Project presented the order that the tasks needed to be completed for maximum efficiency, but it was not sufficient for this project because of the project's changing task durations and requirements. To identify specifically which tasks needed to be crashed or reevaluated, the scheduling log became the primary tool. The log provided a detailed analysis of each work session so that the order of tasks being completed could be changed or to understand what, if anything, was impeding progress. Specific information included the events corresponding with each working day, how those events correspond with the schedule, what needs to be adjusted to stay on-track with the timeline, how previous adjustments have worked, and overall team updates. By monitoring the events of each meeting, the group kept its members accountable for work that was proposed to have been done and motivated to finish. However, when members deviated from the schedule in favor for sick days or days off, the log also denoted these periods of inactivity and explained why the schedule had fallen behind. The log allowed the project director to be quickly updated on the status of the project.

4. Project Goal

The goal of the project was to design a rail-trail bridge with decking and railing and then model that bridge to check for structural integrity and feasibility. To create the bridge designs, the project team relied on brief introductions to the material in previous training and planned to conduct additional independent research on topics outside of the scope of their instruction. This proved to be problematic for the creation of the scheduled tasks and their durations because the team members were not aware of how long their external research would take. Thus, the PM's estimates were based on the improper assumptions about research requirements, which de-railed the entire schedule. By not consulting subject matter experts, the task durations were wildly unrealistic because the project team members did not know how long the research would take. Thus, the schedule began with multiple tasks overdue, even though the work being done was still in the introductory phases of being completed. These poor estimations are discussed in the excerpt of the scheduling log, shown in Table 1, which outlines two non-consecutive days of work for the project team. The four group members include the project manager (PM), the civil engineer (CE), the designer, and the director. These logs show the two extremes of first being behind and then having a design breakthrough that allowed several overdue tasks to be completed. The bolded text outlines lessons learned alongside group member successes and problems. Log 21, for example, outlines a difficult meeting when the project team was waiting on the Designer to complete the

digital bridge model, which was required to advance to the next stage of the project. Instead of being productive, the Designer was complaining about the amount of work he/she had to do, despite not having worked the previous week. Only after meeting with the Director was the Designer ready to work on the project again. Although the Designer was unhappy with being rushed to crash the project, the Designer knew the schedule required the bridge model to be complete for the rest of the project team to continue working. Overall, the scheduling log was a tool that kept all group members accountable for the work associated with each role and allowed the team's director to monitor progress.

Table 1. Scheduling Log (# 21 & 23)

Log #	SPI / EVA	Events	Detailed Schedule Status	Status Discussion	Action Taken / Adjustments	Results from Previous Actions	General Comments (Frustrations & Successes)/ Team Input
21	0.743	Designer & Civil Engineer (CE) meet with Director, Project Manager (PM) makes website post on Designer's SolidWorks design progress	CE's railroad **research is requiring much more time than originally anticipated** (over a week overdue and that is all that the group member has been working on).	Designer is finally **meeting with the Director after at least a few weeks of no contact/ updates** to guide the team member's way forward and spur progress.	CE and PM discuss other tasks needed to finish the bridge design by the scheduled date. Team is waiting on Designer to complete the digital bridge model, which is required to advance the project, so the **due out date will have to be pushed back**.	PM added additional website updates showing project progress.	Designer was **upset with needing to do more work**, but the CE and PM reminded that the Designer's role is to design the bridge parts. CE has modeled both bridges on Visual Analysis (VA), so that member just needs to add the Designer's work to complete the analysis.
23	0.821	PM finished Annual Equivalent Cost (AEC) comparison of the decking materials, Designer finishes the bridge decking model on SolidWorks, CE completes VA.	Designer expanded the original pieces of the digital bridge model by combining it into one long bridge. The product simulation provides a great visual tool for the final project. CE added the finalized decking loads, which **completed the VA project portion**.	CE wrote to Bosnian student contacts to get specific construction pricing, but has been unable to get a response. CE has also reached out to train specialists, both in the US and Bosnia, to get the proper dimensions of the century-old train to model.	After getting great work done, the PM **must keep the team motivated** as the meeting location changes for the week. Next tasks are to compile a final written report and presentation to document the team's work for the project.	PM completes the engineering economy report used to compare the four different decking materials for the bridge.	This working tone period was **extremely productive**. All the group members were actually working on the project and everyone **completed a task that had been worked on for a few meetings**.

The bolded delays and breakthroughs shown in Table 1 are also depicted in the overall progress of the project in the graph illustrating SPI in Figure 1. The biggest progress slowdown seen in the SPI was in mid-November (shown at point A in Figure 1). This slowdown resulted from the team preparing for and conducting work unrelated to the project during the allotted task completion time due to an upcoming national holiday. Since the project had a four-month timeline, it became second priority as the group members diverted their attention to other assignments that required more immediate attention. The timeline was seen as a recommendation instead of essential to finish on-time. As a result, the group was unable to stay on-schedule and the SPI declined sharply. Attempts were made to get the team on track by meeting with the project director and emphasizing the list of requirements due, but there were no changes to the behavior of the group. Instead of focusing on crashing the project to finish the outstanding tasks before the group stopped work for a week, the group members concentrated on their individual responsibilities outside of the project.

ISBN: 97819384961-8-9

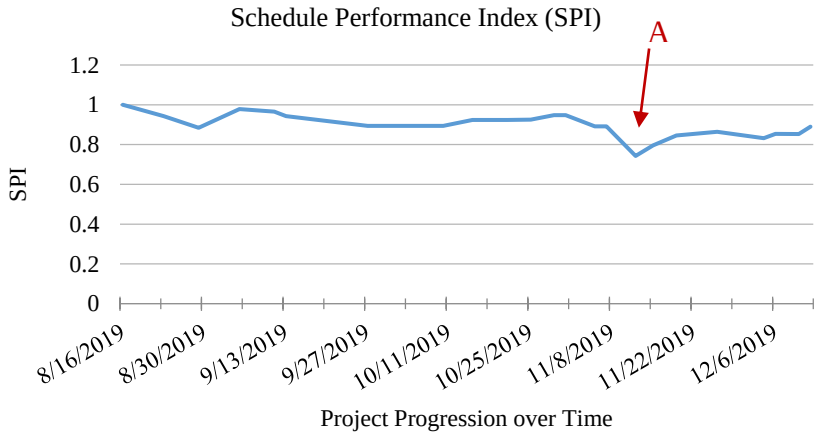

Figure 1. Project Schedule Performance Index

The EVA graph, presented in Figure 2, allowed the PM to see where the project was in relation to the planned schedule versus the actual schedule with earned value used as the metric to measure the difference (the planned cost for the actual work performed). The graph reveals that the majority of the four-month project was behind schedule and over budget as the earned value is less than both the planned cost and the actual cost. Point B in Figure 2 illustrates the only time when earned value was greater than actual cost and planned cost. This meant that the project was ahead of schedule and under budget. This resulted from the PM pushing the project team members to embrace their roles and get started on the project. Before this point, the project team was creating tasks and completing them each day, making the schedule as part of the day's work instead of planning ahead. By mid-September, at point B, the PM was able to create the first draft of the scheduling log that could accurately track the work being done and projected future work.

The schedule motivated the project team, with each meeting being highly productive. The peak of the earned value at the end of September was the result of finishing the first major portion of the project, the literature review. Despite the designer being sick for a week and being unable to contribute, the CE and PM pushed to finish the report, conducting research into bridge design and how to manage a trail construction project. However, after the completion of the literature review, progress slowed. The project team became overconfident in how fast they could work, creating task durations that were too short to be realistic. Considering the Designer and CE had no experience with bridge design modeling or structural analysis, it became apparent that the original proposed schedule would be impossible to adhere to. The PM adjusted the scheduling log by adding project team input and realistic discussion of the project's status. These additions helped the project improve because now the PM had a more realistic assessment of the work required for each task and a forecast of what issues the project team might have with the next stage of the project.

However, Point C, which shows the flattening of the earned value curved, illustrates that there were more issues in the project that were still unresolved by the new scheduling log. These problems were not a result of the schedule, but a lack of work by a member of the project team. The CE was working hard on learning the engineering and technology behind modeling structural analysis, but the task was taking three times as long to complete as it was planned for. The PM had assumed that the Designer would be working to assist the CE to complete the structural analysis, but the Designer saw his/her role as extremely limited, only dealing with the design of bridge decking. Once the Designer's work was completed each day, the Designer left. When the PM's influence tactics did not work to encourage the Designer to help the team, the Director got involved. The Director was the only supervisor that the Designer would listen to, which was problematic because the Director would change project milestones due dates to fit the Designer and CE's personal schedules instead of abiding by the project schedule. This eroded the PM's power and caused productivity to rapidly decline when deadlines were pushed back. The cycle of moving project milestones and extending the project timeline caused the earned value to remain stagnant for over a month, which was 25% of the project.

The only other time the earned value got close to catching up with the planned and actual costs occurred when the project team reached a breakthrough in their design work as described in the second log (#23) in Table 1 (shown at point D in Figure 2). This breakthrough occurred using project crashing to complete the work planned for the end of November on-time as a final push to the end of the project. The project team had finally finished the bridge design and the structural analysis, which were the major projects for the Designer and CE respectively. The completion of these events allowed the project to move to the final stage, a written report summarizing the work done on the project and a final presentation.

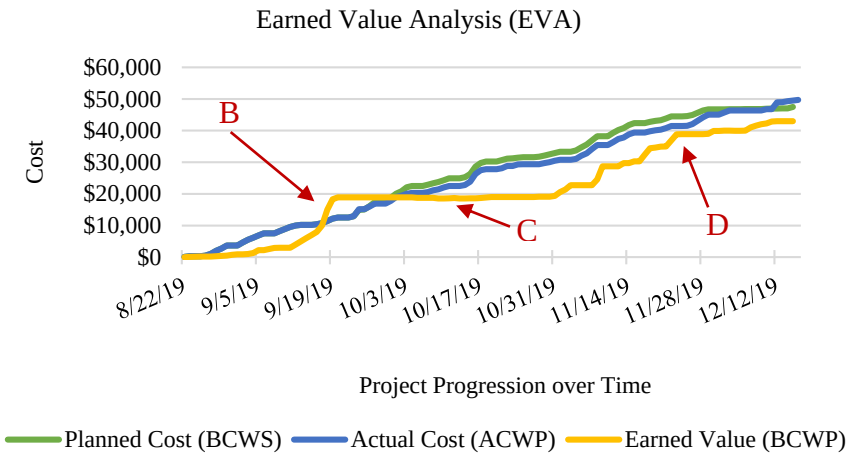

Figure 2. Project Earned Value Analysis

5. Results

The largest learning curve, as expressed in Figure 1, was the lack of understanding about the amount of research and planning required to re-design a century old railway bridge. Almost the entirety of the first five months work on the project was spent conducting research into the safety and structural requirements of the bridge. Since none of the group members had any experience with bridge construction, design, or the technologies that assist with these tasks (Virtual Analysis, SolidWorks, Google Maps route design), every task took three times as long as what was planned. What finally fixed the duration estimates was an in-person meeting with experts at the Rail-to-Trail Conservancy who oversee similar projects across the US.

The group dynamic changed throughout the project. Most noticeably between the PM and the rest of the team. The PM was an implant from an organization separate from the CE, designer, and director's, so the PM did not have access to the same resources or information that the other teammates had. The PM also faced a learning curve finding the best use of his/her personal skills and place on the team. The team workers originally did not see the need for the role of a PM since there was a 2:1 ratio of team members to managers. However, the PM played a dual role as manager and team member so that the project could avoid scope creep and stay on-schedule. The team also had a director who served as an advisor to the team. The director held the real power over the team by controlling final evaluations and being the subject matter experts in engineering and design. Since the team members did not view the PM as a legitimate source of authority, the group did not adhere to the PM's schedule. The schedule was viewed as a recommendation, not as the strict plan that needed to be followed to complete the project on time. This created tension between the PM and the director. Whenever the group was behind, the director would give an extension and change the deadline, thus undercutting the influence of the PM to motivate the group members to finish his/her work. This caused the schedule to receive further delays because the group did not understand that the schedule built on itself. Certain tasks had to be completed on time in order to move on to other aspects of the project. If the deadline was changed, the schedule was forced to change as well.

Another challenge was having group members with differing views of the team's roles and responsibilities. The designer viewed the role solely as designing and building of the bridge model. The CE, however, provided structural analysis and external research on BiH while also acting as the outreach coordinator with external stakeholders in Bosnia and the US, and the director's liaison with the team. The PM worked to utilize the connections outside the team to create an efficient project schedule, design evaluative criteria to pick the bridge design using engineering economy, maintain the project's website, and create a schedule for the rail-trail to be built in Bosnia. Allowing the designer to define a narrow role created significant friction within the group as other team members were obligated to take on additional responsibilities to keep the schedule from slipping behind. Despite having many challenges due to inaccurate task durations, changing deadlines, and poor information on Bosnian construction materials, the team came together to complete all due outs and created a product that all group members are proud to give to the project's Bosnian stakeholders.

6. Conclusion

By using a scheduling log, the group members were able to identify areas that needed to be worked on and prioritize the most important tasks. While the project timeline was more fluid than originally planned, the group adapted and learned that understanding the end goal would speed up the path to get there. While side projects and unclear roles detracted from the project and caused tasks to take an average of three times longer than originally planned, the group was able to unify efforts to complete the work required. In the future, by encouraging more realistic task lengths, the project timeline can be improved and made more efficient. Project management is a science in the sense that leaders have a plethora of tools to use to plan, orchestrate, and monitor the group's schedule and project status, but it is also an art requiring the knowledge of the team members personalities, work ethics, and end goals to achieve project completion.

7. Acknowledgment

Special thanks goes to Dr. Jose Jimenez and Dr. Kenneth McDonald. Dr. Jimenez provided guidance and expert instruction on MS Project and Earned Value Analysis. Dr. McDonald offered invaluable help in framing the scheduling log.

8. References

Anbari, F. T. (2003). Earned value project management method and extensions. *Project management journal*, *34*(4), 12-23.
Lipke, W. (2012). Earned schedule contribution to project management. *PM World Journal*, *1*(2), 6-13.
Lipke, W. (2003). Schedule is different. *The Measurable News*, *31*(4), 31-34.
Taylor, P. (2015). What factors make rail trails successful as tourism attractions? Developing a conceptual framework from relevant literature. *Journal of Outdoor Recreation and Tourism*, 12, 89-98
Vargas, R. V. (2003). Earned value analysis in the control of projects: Success or failure. *AACE International Transactions*, *21*(4), 211-214.
Allen, T. (1974). *Vanishing wildlife of North America.* Washington, D.C.: National Geographic Society.
Boorstin, D. (1992). *The creators: A history of the heroes of the imagination.* New York: Random House.
Devitt, T. (2001, August 2). *Lightning injures four at music festival*. Retrieved January 23, 2002, from The Why? Files: http://whyfiles.org/137lightning/index.html
GVU Center. (n.d.). Retrieved August 8, 2000, from 8th WWW user survy: http://www.cc.gatech.edu/gvu/usersurveys/survey1997-10/
Harlow, H. (1983). Fundamentals for preparing psychology journal articles. *Journal of Comparative and Physiological Psychology*, *55*, 893-896.
Henry, W. I. (1990, April 21). Making the grade in today's schools. *Time*, *135*, pp. 28-31.
Kalette, D. (1986, July 21). California town counts town to big quake. *USA Today*, *9*, p. A1.
Nicol, A., & Pexman, P. M. (1999). *Presenting your findings: A practical guide for creating tables.* Washington, D.C.: American Psychological Association.
Searles, B., & Last, M. (1979). *A reader's guide to science fiction.* New York: Facts on File, Inc.
The safety of genetically modified food crops. (2002, February). Retrieved March 22, 2005, from Health Canada: http://www.hc-sc.gc.ca/english/protection/biologics_genetics/gen_mod_foods/genmodebk.html