

THE IMPORTANCE OF PROJECT MANAGEMENT SOFTWARE AND SYSTEMS ENGINEERING IN MEGA PROJECTS

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ABSTRACT

The management specialty now commonly known as “Project Management” was hardly recognized before World War II. Since then, many techniques have been added to the Project Manager’s repertoire which are necessary for successful results when undertaking very large, complex projects such as costly construction projects or complex weapons systems design. These projects are made more difficult when more than one organization is assigned to complete parts of the project. Techniques such as network scheduling using project software and systems engineering are helpful, but are not always successful in obtaining the desired results.

INTRODUCTION

Many large, complex projects were undertaken long before World War II and were somehow completed by the application of trial and error or massive amounts of labor and materials, however, we don’t have documentation of all of the methods used such as in the building of the pyramids or the Colossus of Rhodes as examples. The lessons of WWII changed much of this as the examples of the atomic bomb and long range missiles were perceived by the “superpowers” as necessary for their survival – with the requirement that they not bankrupt their governments.²

“Big Technology” came of age in the middle of the 20th century driven by military and space competition of the cold war and manned space travel to the moon.³ This technology race was accompanied by increasingly complex means of designing and fabricating the accompanying hardware in the attempt to produce usable weapons and rockets in rapid order for the military and space agencies. In the efforts to win the competition, much usable technology was spun-off for use in civilian pursuits such as new product development and construction. New software brought civilians useful devices such as PERT (Program Evaluation and Review Technique), CPM (Critical Path Method), and System Engineering. These techniques in skillful hands often resulted in improved products and less time spent plus greater reliability of products – but not always.

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² Stephen B. Johnson, Three Approaches to Big Technology: Operations Research, Systems Engineering, and Project Management,” *Insuring the Future: The Development and Diffusion of Systems Management in the American and European Space Programs.* (Ph.D. dissertation, University of Minnesota, 1997)

³ Richard Crockett, *The United States and the Soviet Union in World Politics, 1941-1991*, (New York, 1995)

Since the projects were still in human hands there were always decisions to be made that often had a poorly established base. Project Managers were still susceptible to political and faulty decisions that the best of technology could not overcome. Projects were supposed to be handled by skillful managers, but these projects were not immune from “executive meddling” or irrational budget cutting and other problems. There was even a NASA Mars Lander which had been created by two contractors: one using metric measurements, the other using “English” measurements. The Mars lander crashed into the Mars planet and was never able to fulfill its mission. This was a blatant failure of “systems engineering” which is supposed to ensure that all components on an assembly fits well with all other components.

PROJECT MANAGEMENT SOFTWARE

In the evolution of improved project management solutions many software programs were produced and made available to project managers. Recently, as many as fifty project management software packages were offered for sale to companies or individuals. And many more were developed within companies to be used only in that organization. Some of the original packages were restricted to project scheduling and budgeting, but overtime, the packages became more sophisticated and could be used for creating periodic reports and analyzing project weaknesses.

One of the most popular packages has been Microsoft Project which has evolved in recent years to Microsoft Project 98, then Microsoft Project 2000. The basic package was designed to develop a project plan, assign resources, track progress, manage budgets, and analyze work loads. The output of the package was very useful throughout the parent organization and its customers as long as all recipients of the information were using the same Microsoft version. If not, information had to be translated to the version that all could use.

A larger software package, originally developed by the Oracle Corporation for construction projects and now used on many large projects is : Primavera Enterprise Portfolio Management used to coordinate concurrent similar projects. On April 8, 2012, its Release 8.2 was designed to be used with portable iPhones and an upgrade was produced one year later, version 8.4.

One of the largest project software packages used was “Artemis.” It was used to plan and track the thousands of projects that came together in the Apollo Program to put astronauts on the moon and bring them back and to build Space Station Freedom. Both of these mega projects contained tens of thousands of activities and events that had to be coordinated. In most instances, if problems occurred, it was due to human inability to understand to software results, not software errors.

SYSTEMS ENGINEERING

The systems engineers’ primary task in most large projects is to draw up a set of specifications making the performance of each subsystem and its interactions with every other subsystem mutually compatible. While the systems engineers are not ultimately

responsible for the functioning of the final results obtained by the project, this being the responsibility of the project manager, the systems engineers are responsible for informing the project manager in no uncertain terms of the likelihood of failure or disaster if all subsystems will not function properly under operational conditions. Thus the systems managers should be involved in the test and operational environment in which the component or end item is put to work. In small or medium sized projects, the “Project Engineer” may be knowledgeable enough about all technical aspects of the project to be able to advise the project manager, but in mega project costing billions of dollars and involving many subsystems, a more knowledgeable systems engineer should be part of the project team.

A “Program” systems engineering team (A program usually has several projects contributing to its overall effort) should be recognized by all project managers interacting in the program to avoid consistent failed requirements throughout the program and¹ all component creators should have the same understanding of customer requirements

A list of attributes for Systems Engineers should include (at least) the following for a mega project: broad technical experience, effective communicator, innovative organizer, customer/user knowledge, conceptual thinker, good networking skills,² to prevent failures of programs and contributing projects.

In the remainder of this paper, there will be additional costly errors discussed, with guesses as to what caused the errors. Of course, the majority of projects are completed close to the desired outcomes of “on time,” “within budget,” and “desired performance/technology,” but not always. Two of the three “Mega Projects” to be discussed, did not attain these desired results.

THREE MEGA PROJECTS FOR DISCUSSION

The Boston Big Dig

The first mega project to be discussed is the “Boston Big Dig,” which was a massive undertaking to ease Boston’s auto traffic congestion that had grown from 75,000 vehicles per day in 1953 to 200,000 per day in the year 2000. Traffic jams often lasted 10 hours, causing drivers much wasted time in getting to work, delivering merchandise, taking children to school, or other normal road trips. Accidents were four times the normal average for highways of the length of the Boston Central Artery. In the 1970’s highway planners decided on a new underground central artery, replacing the old central artery and replacing it with an eight to ten lane underground central artery with five major interchanges to connect with existing highways, and new bridges..

The planners originally estimated the cost of the project to be \$2.8 billion, then upped the estimate to \$8 billion in 1992. The city allocated the work to two large construction firms: Bechtel Corporation and Parsons Brinckerhoff Corporation which acted as a

¹ James K. McCollum and Cristian S. Banacu, *Project Management: Theory and Practice*, Bucharest: Editura Universitara, 2014, p. 212.

² McCollum and Banacu, pp. 292-296.

consortium, directing subcontractors in the tasks of building needed bridges, carving the massive tunnels, pinning concrete ceilings in the tunnels, and paving the new highways. All of these tasks took more than 16 years to complete at a cost of \$22 billion. Many setbacks occurred during the construction: water leaks occurred into many tunnels, the concrete ceiling fell onto a driver and killed her, then requiring that all of the tunnels' ceilings be replaced; the contractors neglected to survey and measure an elevated roadway that had to be eliminated, and the contractors did not plan for the requirement to go around the Fleet Center (a large building that could not be demolished).

The ultimate result was accomplished allowing traffic to travel across the city at 40 miles per hour compared to the former average of 10 miles per hour on a good day (when there were no accidents). Boston is no longer choked by traffic and is praised by young drivers who never experienced the former problems, but the taxpayers are stuck with huge burdens in achieving the outcome. The big winners were the two contractors who were not well connected by systems engineers,¹ but were well compensated.

The Bucharest Basarab Overpass

After the end of communism and the onset of free market conditions in Bucharest, Romania a traffic problem developed due to the configuration of the city. In the north eastern part of the city, the bulk of the rail lines entering the city to the Gara du Nord caused drivers to take big detours in getting around these lines. Another problem was the Dambovită river that runs mostly west to east across the center of the city with few bridges to accommodate east-west traffic. These barriers that caused the later traffic jams were not a problem during the years of socialist government, but became serious by ten years of increased traffic under free market conditions. Rush hour morning and evening traffic took hours of idling vehicles and unnecessary fuel consumption as well as frazzled nerves of car, truck and bus drivers.

In early 2000, then Mayor Traian Basescu (later President of Romania) proposed a system of bridges to overcome these barriers. These bridges would close a ring of cross-city streets and greatly overcome the rush hour traffic problems. By 2006, Mayor Sorin Oprescu adopted a similar proposal and received permission to plan a solution. With an estimate of 60 million Euros, the version adopted was to have a suspension bridge over the rail lines and an arched bridge over the Dambovită. These bridges and attached roads and tram lines came to be called the Basarab Overpass: the cable suspension bridge would have two 84 meter towers and the arched bridge would have a 250 meter length steel arch. These projects took up much privately owned land and buildings and from the outset, a 100 million Euro fund was approved to buy the needed land.

Contractors for the construction were chosen. Two well known construction firms, Astaldi of Italy and FCC of Spain took the contract as a joint venture. Both firms then planned for the two bridges and connecting roadways. Construction began in 2008. A

¹ Jacobs Engineering Working Paper, "Systems Engineering Problems in Mega Projects," New York (2009).

very wise safeguard in the suspension bridge was a seismic protection of Lead-rubber bearings on the bridge anchors to prevent earthquake damage.

Work on the project took much longer than expected, but the ultimate result was an ethctically accepted project that the citizens point to as the modernization of Bucharest. The desired improvement of traffic flow is much welcomed and the illuminated bridges by night are spectacular. The down side of the project is the vastly increased cost over the original estimates. When the bridges opened for traffic in June, 2011, the cost had risen to 255 million Euros. Information about the funding of such an amount is not available on the internet, but it obviously is causing a lot of concern somewhere in the economy of Romania and the European Union. Recent investigations have determined that rich payoffs were made that were not project related. Who was responsible? The contractor consortium? The contract administrators?

The Apollo Program

In the aftermath of World War II a new conflict occurred that became known as the “Cold War.” The Soviet Union under Stalin and his successors took over many countries that had been monarchies or constitutional republics and these territorial gains were not obtained with the acceptance of the citizens of those countries. In alarm, countries of the west began rearming their military forces to stop any further gains by the soviets. A line between the opposing forces became known as the “Iron Curtain” and both sides began to modernize their military capabilities. This entailed developing improved rockets and guided missiles. Both sides invited rocket scientists and designer from the former Nazi Germany.

The United States obtained a large group of rocket scientists from the German group that had developed the German V-2 rocket and kept them under their wartime director, Dr. Wehner von Braun. Their first operational location was at Fort Bliss, Texas, where many U.S. military rockets had been developed. The West Texas terrain was not to the liking of the German scientists and they readily accepted a move to Redstone Arsenal, Huntsville, Alabama which was more like their previous German homes with small, green mountains and the Tennessee river nearby .

The German scientists, augmented by American rocket scientists then developed many new weapon systems that kept America’s military on a similar pace with the Soviets in their development of intercontinental rockets. At the same time, a competition arose between the antagonists to put satellites in orbit around the earth. The Soviets won that competition in 1955 by putting two satellites in orbit before the American military could do so. At that time, Dr. von Braun convinced the American government that he could put a satellite into orbit using the Jupiter C rocket his team at Redstone Arsenal had developed. Within a short time, his team had succeeded in putting a satellite into orbit that outperformed those that the Soviets had launched.

At that point, the new challenge was to put men on the moon. President John F. Kennedy announced the challenge in his State of the Union speech in 1961, “We will put a man on

the moon and bring him back safely within this decade.” This was a dramatic increase in outcome over simply orbiting the earth

By that time, a new organization named National Aeronautical and Space Administration (NASA) had been formed and Dr. von Braun’s team at Redstone Arsenal was taken into NASA with the understanding that the NASA organization at Redstone Arsenal would be the oversight organization for the “Moon” project, to develop and test the rockets that would make the journey to the moon with three astronauts. Additionally, telemetry stations were established all over the globe to track the moon rockets named “Saturn” within the overall program named “Apollo.” The NASA team had many challenges to overcome within that nine year time frame.

The NASA organization at Redstone Arsenal contracted projects with civilian companies to perform most of the building of the hardware for the program while the NASA organization monitored their projects and performed the testing of the rocket motors and training for astronauts. Money for the program was allocated by the, but only ten percent was spent by NASA & ninety percent was spent by the civilian contractors

The first safe landing on the moon and return to earth took place in July, 1969. In 1972, after six successful Apollo missions, Dr. von Braun’s deputy program manager, Dr. Eberhard Rees gave a complete description of the painstaking work that occurred in getting the 12 men to the moon and back. He wrote, “For the guarantee of success of the Apollo Program, it became the first order of business to minimize technological risks or actual mission risks as much as possible.”¹ Due to the time constraints, it was necessary to engage in parallel rather than sequential developments. This necessitated sophisticated “System Engineering” to insure that all aspects of the program worked together properly.

Thus many projects were ongoing simultaneously, but were integrated to insure mission success. Not all were completely successful. Three astronauts died in a fire while training on the ground in the control module before any flights occurred. Apollo 13, the third mission to the moon, was not a success due to a leak of its oxygen supply and it could only go around the moon and return to earth. Even the Apollo 11, the first moon landing was very tenuous since the landing on the “Sea of Tranquility” was not exactly where the landing was planned. A short period occurred when the control base in Houston didn’t know where the Moon Lander was until they heard the voice of Command Pilot Neil Armstrong say, “Houston, the Eagle has landed!” In total, six Apollo missions landed men on the moon and Apollo 13’s crew also safely to Mother Earth.

The follow on to the Apollo program was the NASA Shuttle program to furnish the materials for Space Station Freedom. Much had been learned from the Apollo Program, but two of the shuttles were lost with all of the astronauts aboard, one on takeoff and one on landing. Despite the systems engineering efforts, the risks in space flight were still very great. NASA has launched many successful un-manned space probes in search of

¹ Eberhard Rees, “Project and Systems Management,” CIOS World Management Congress XVI, Section 6, Topic 4.3, Munich, (1972).

more information about the universe, and the next big project will be a manned landing on Mars using what is called the largest rocket ever built, the “SLS rocket.”

CONCLUSIONS

The evolution of project management was become much more technical since World War II. Many “Mega Projects” were attempted by the adversaries in the Cold War era and many innovations have been made in the attempt to improve the project techniques in use to attain acceptable results within the desired time, cost, and results. The mega projects have made improvements by using increasingly sophisticated project software and systems engineering. The use of these techniques has often been successful in, but not always, especially with regard to project costs.

In the examples of the “Boston Big Dig,” the “Basarab Overpass,” and the “Apollo” programs, improvements could have been made. This probably can be said about many more programs and projects. Therein lies the challenge for all future program and project manager. The technology will be developed, but will the execution be well understood and applied without political constraints?