

**POINTING THE WAY TO THE FUTURE OF PROJECT MANAGEMENT:**

**How the Past and Present Point Towards Project Management's Future**

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## **Abstract**

Projects were completed successfully well before the idea of project management as its own discipline existed. This paper will look at three significant construction projects from the late 1800 and early 1900's, each unique in its time due to size, scope, or technology. The lessons learned from those projects, coupled with a look at project management history in general, will be checked against a current project management theory to determine if the focus of today's project management education has project managers pointed in the right direction.

## INTRODUCTION

Picture yourself around the year 2800 B.C. You're in Egypt, in charge of constructing one of the many pyramids. You have just been informed that the stone from the quarry is arriving slower than expected. And that the slaves constructing the east face are revolting. And that the edge is just *slightly* out of alignment with true north. Oh, and by the way, Pharaoh will be by in an hour.

Problems like these would cause a lot of stress, even now, despite all the technology and management tools available. Imagine what it was like back then, with no Project Management Institute or Seven Habits of Highly Effective People to lend a hand. It must have seemed near impossible.

Yet, the pyramids were completed, and so too were the Flavian Amphitheatre (now known as the Coliseum) and the Taj-Mahal and any number of significant civil projects from history. In our own, more modern times, projects like the Brooklyn Bridge, the Empire State Building, and the Hoover Dam were all completed, and considered successful, well before anyone started using the term "project management."

This paper is going to take a quick trip through time. First, it will explore those three semi-modern construction projects in detail, exploring the specific trials faced, the challenges overcome, and the personal character and ability of the men (and in one case woman) building them. Each will be analyzed on the basis of whether it was deemed a success or failure, how specific obstacles and conflicts were handled, and what can be learned from the project. From there, the paper will jump into modern times to see just how Project Management as a discipline has grown from its origins, and what some current teaching strategies are. Finally, the new mindset will be back-checked against the

lessons learned to see if the two are consistent. As any two points create a line, these two “points” (historical lessons learned and modern project management theory) will be connected to see if the line points towards a brighter future for construction project management.

## **PROJECTS OF THE PAST**

### **Brooklyn Bridge**

Prior to 1867, there was significant clamoring by the public for a bridge connecting the cities of Brooklyn and New York City. The population had gotten a taste for how convenient such a connection would be when the East River froze over so thick that winter that people and even carriages could cross at will between the two cities.<sup>1</sup> As early as 1800, serious proposals for a bridge had been entertained, but never pursued. Location was a big factor. Spanning one of the busiest navigable salt waterways in the world, any bridge would have to “take one grand flying leap from shore to shore over the masts of the ships. There can be no piers or drawbridge. There must be only one great arch all the way across.”<sup>2</sup> Enter this scene John Augustus Roebling, “wealthy wire rope manufacturer of Trenton, New Jersey, and builder of unprecedented suspension bridges.”<sup>3</sup> Roebling, his son Washington, and his vision of a suspension bridge across the East River were about to make history.

At the time of its conception in 1867, the East River Bridge (the Brooklyn Bridge’s original name) was the largest suspension bridge ever conceived, intended to span 1616 feet between the two cities of New York City and Brooklyn. Conventional suspension bridges of the day used rope, but in the 1860’s one out of every four built was collapsing.<sup>4</sup> But Roebling, who had significant experience with both the production of wire rope and with the new technology of wire rope suspension bridges, didn’t back away from the challenge. He convinced both prominent builders of the day and local politicians that he could succeed, and construction began in 1869. The estimate was close to \$6.6 million dollars, with a construction time of over 4 years.

The elder Roebling, a bridging visionary of his time, had completed sketches and basic drawings when he died on July 21, 1869 of tetanus, leaving the actual construction to his son, Washington Roebling, also a civil engineer and a Civil War veteran. At the age of 32, Washington began to carry on his father's work.

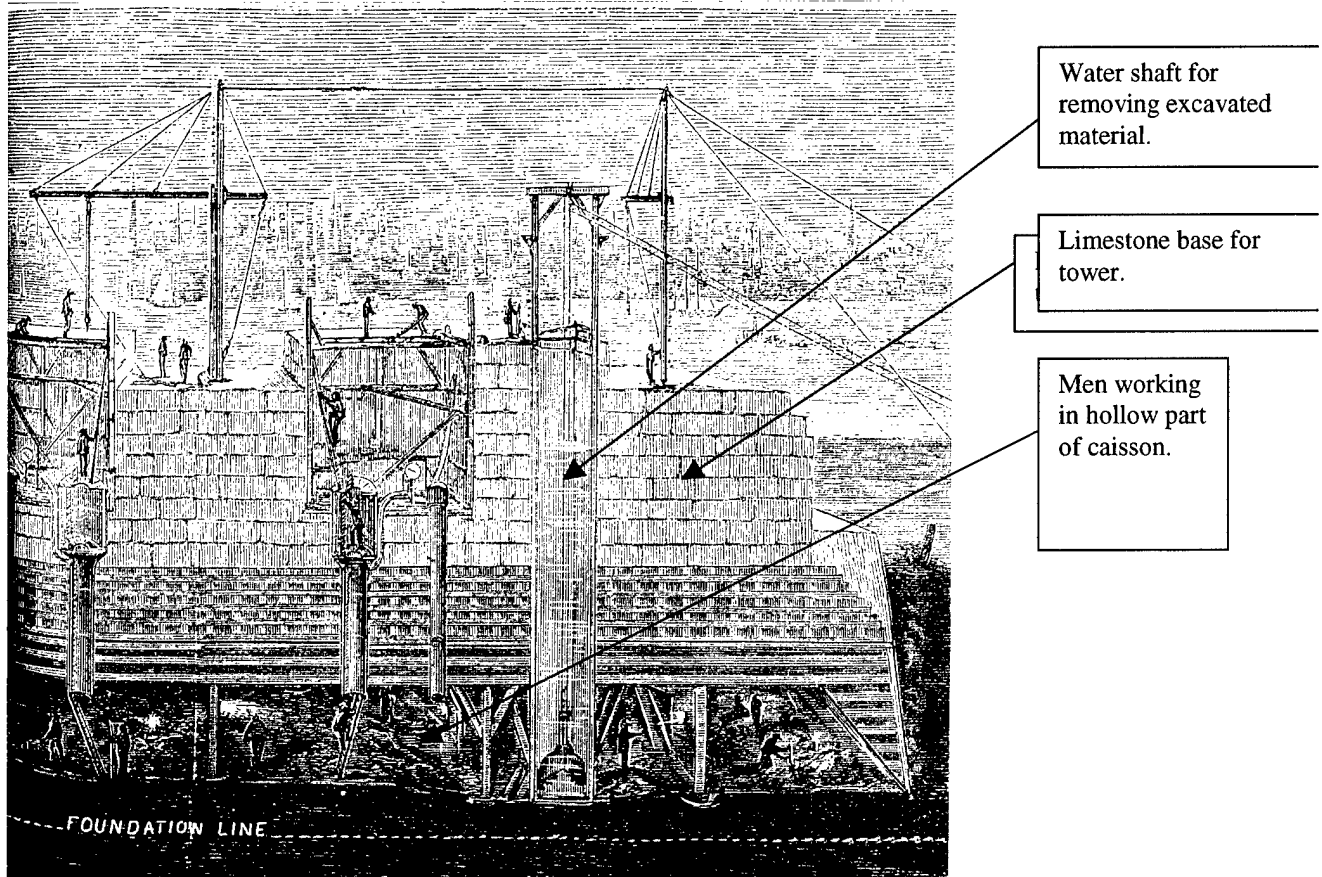
The two men were very different, though both extremely intelligent and competent. The father commanded attention and respect, the son quietly earned it. But his leadership was up to the task, and almost all of the construction was under his guidance.

Washington Roebling faced a myriad of challenges in completing the work. The first was in establishing the proper foundations for the two large suspension towers that were to hold up the bridge. The current technology of the time, used often in Europe and on smaller bridges in the United States, was to sink a caisson (basically a large, upside down wooden reinforced box—see figure 1) into the river, and pile the masonry for the towers on top of it. As the weight on top became heavier, the caisson was pushed further into the river bed until it hit bedrock. It was then filled with concrete. Since the caisson was hollow (up until the concrete was placed inside), men could be put inside to help dig and more rapidly sink the caisson. Compressed air was also put in the hollow space to provide support, keep the water out, and keep a breathable environment for the workers. Of course, the deeper the caisson went, the more compressed air was required. This would have tragic results later on in the project.

While working on the first caisson, on the Brooklyn side, several men complained of severe discomfort, due to what became known as Caissons Disease (today we refer to it as unofficially as “the bends,” caused by expanding nitrogen in the blood stream when

moving too quickly between different pressures without proper decompression).

Roebing himself was so badly injured by Caisson's Disease that he would never fully recover.



**Figure 1** A drawing of a caisson from the Brooklyn Bridge. The limestone base sits atop the timber roof of the caisson. Pressurized air is pumped into the hollow space below, where the men can be seen working. From David McCullough, *The Great Bridge* (New York: Simon and Schuster, 1972) 221.

The experiences in the Brooklyn caisson were bad, but the experiences in the New York caisson proved to be far worse, despite an excellent start. Begun in 1871, the work on the New York caisson initially went very smoothly. Roebing had learned much from the work on the Brooklyn caisson months earlier, and made several important improvements. Systems for communicating between the men inside the caisson and

those on top were developed, and worked remarkably well (no such systems were in place for the Brooklyn caisson). The air lock system was improved, allowing a more efficient exchange of men and resulting in less lost time at shift change. An incredibly simple yet efficient method of using the compressed air in the caisson to remove excavated sand was used, and that coupled with the different soil type on the New York side greatly increased production. Once the initial level of dock muck (composed primarily of solid wastes from sewage discharges near by) was removed (to the relief of the noses of all involved) the underlying soil was relatively easy to excavate, and contained very little in the way of boulders. The New York caisson at times would sink six to eleven inches *per day*, when the Brooklyn caisson wouldn't sink that far in a week.<sup>5</sup> But as the work continued and the caisson sank deeper, higher air pressures were required inside. More and more men began to complain of intense pain within a few hours of leaving the airlock. One man died, then another. Still the work continued. The workers began to be afraid, and went on strike demanding more money for such hazardous work (they returned to work when they were threatened with the immediate loss of their jobs). With the New York caisson scheduled to go more than 60 feet deeper than its Brooklyn cousin, Roebling realized that the cost in human lives (and production) could be insurmountable. Over 110 cases of the mysterious "Caissons' Disease" had already been reported to the on-site physician, and that would surely increase as the caisson went deeper.

Roebling had noted (and found archeological proof) that the strata of the riverbed had not shifted in hundreds of years, and based on that information, he halted the New York caisson at a depth of 78.5 feet, thirty feet shy of actual bedrock, a decision which

time has proven to be correct.<sup>6</sup> And so while not without terrible cost or pain, the first major obstacle was passed.

The construction of the caissons continued to prove difficult. On December 1, 1870, there was a fire in the Brooklyn caisson (not surprising with all the compressed air) that damaged the caisson severely. Over two months of production were lost in repairing the damage, and the cost was fifty thousand dollars just for the additional payroll for the repairs.

There were other challenges as well, some technological and some completely man-made. The bridge was being built during the heyday of William "Boss" Tweed, the ruler of New York City in all but title. He and his Tammany Hall gang added their fair share of kickbacks and corruption to the process. Tweed, while acting as a member of the bridge directors, urged that Horatio Allen be appointed as consulting engineer when the elder Roebling passed away, ostensibly so that Allen, an accomplished engineer, could assist the younger Roebling. Allen would receive the same salary as Washington Roebling (\$8,000 per year).

In reality, Tweed was simply trying to boost public confidence in the bridge, so that the project would continue. Tweed's corruption in public construction was well known, starting with a county courthouse on Chambers Street. Due to Tweed's "influence", the \$250,000 project grew to well over \$3 million, including a \$41,000 line item for "brooms, etc." Of course, the excess public funds spent went right to Tweed and his associates, and he was practically drooling over the chance to be involved with a \$6 million plus project. The chances for graft and corruption were endless, and so the Allen

fiasco was perpetrated. Horatio Allen's professional contribution to the work in the next few years would add up to "just about nothing."<sup>7</sup>

The caisson challenges, the behind the scenes corruption, and several other delays associated with attempting a project that had never been done before dramatically delayed the job. Finally, after 7 years of construction (already three years late, according to John Roebling's original time table), the towers were in place, and work could begin on the suspension cables. The Roebling name was well known in the steel wire rope business, John Roebling having pioneered manufacture in America in 1841. But due to political considerations (the vice-president of the board of directors for the bridge, Abram Hewitt, threatened to resign if Roebling or any one else with a stake in the bridge was allowed to bid on the wire contract<sup>8</sup>), the steel wire rope was actually awarded to the Haigh manufacturing company. Mr. Haigh was a known scoundrel,<sup>9</sup> and his business practices were definitely unscrupulous. After a wire snapped on Thanksgiving Day in 1877, it was discovered that Haigh's company had been continuously submitting the same sample of wire for inspection by Roebling's assistants, and upon approval (which was always received, since it was always the same wire sample) would send unsuitable or previously rejected wire to the bridge for incorporation into the structure. Once caught (Roebling ordered the wire samples secretly marked), and after promising that such practices would cease, Haigh's employees were actually witnessed switching the wire en route from the factory to the bridge. Roebling responded quickly by altering the amount of wire per each suspension cable. According to the original plan, each of the four support cables required 19 strands of wire, each strand made up of 256 wires. Upon

discovery of Haigh's treachery, Roebling added an extra 150 wires to each strand (which has proven to be an adequate solution), and Haigh was never punished.

Haigh's time would come. While not punished specifically for his switching of the wire, the impact of the contract would eventually catch up with him. The contract for the wrapping wire (surrounding the main wire) originally awarded to him was cancelled, and quietly awarded to John A. Roebling Sons. No mention of "conflict of interest" was ever made.<sup>10</sup> Haigh eventually went bankrupt, partially due to his having to bear the expense of providing the extra suspension wire required without compensation, partially due to losing the wrapping wire contract. He eventually went to jail for passing bad checks.

Other incidents surrounding the wire also plagued the project. On June 14<sup>th</sup>, 1878, one of the wires used in the mechanism that pulled the actual suspension wires across the bridge parted, killing two people, seriously injuring a third, and narrowly missing countless others. Critics were quick to point out that the wire was made by the John A. Roebling Sons company, and using the Bessemer steel process, which immediately brought Washington Roebling's reputation, that of the wire rope made by his brothers, Bessemer steel, and the bridge in general under sharp scrutiny. Work continued, and a few days later (with much less press and fanfare) the cause was found (the wire was misaligned in a pulley, which cut into it and caused the parting), and the wire rope and John A. Roebling Sons wire company absolved.<sup>11</sup>

With the completion of the cabling of the bridge, Roebling still had one more challenge. The construction almost came to a halt in 1881 due to the late delivery of the steel floor beams. (This was the first major use of steel in a suspension bridge, and from

the start, steel delivery caused a problem. “Edge Moor Iron Company was maddeningly slow on delivery.”<sup>12</sup> Modern project managers can relate).

With such a difficult project underway, one would think the chief engineer practically slept on site, but it is interesting to note that Roebling was almost never seen on the job. He managed most of the work from a bedroom window overlooking the construction site, for he was still in intense pain from Caisson’s disease, and his mobility was seriously reduced. Since telephones were not yet common (they were actually invented while the bridge was under construction) Roebling communicated with his assistants through his loyal wife Emily. This remarkable woman at first only communicated exactly what was spoken by her husband, but as she became more and more involved, her engineering and problem solving skills grew, and she became an important part of the team (which is amazing, considering that professional women were a non-entity in the professional world of the late 1800’s!).



**Figure 2 Colonel Washington Roebling (right) and his wife Emily. From David McCullough, The Great Bridge (New York: Simon and Schuster, 1972) 216-217.**

As tribute to her incredible impact to the bridge, she was the very first person to cross it upon its completion.

“Then in early May, when the last of the superstructure was in place, the roadway at last completed, and the time had come to send a carriage across—to test the effect of a trotting horse—Roebing had asked that she be the first person to ride over. The others on the staff and in the bridge offices agreed wholeheartedly. So one fine morning, she and a coachman had crossed over from Brooklyn in a new victoria, its varnish gleaming in the sunshine.”<sup>13</sup>

Though completed late and over budget, the bridge was still seen as a success (despite almost killing the engineer in charge), as evidenced by the fifty thousand people, including President Chester A. Arthur, in attendance on opening day.

“It’s practicality, no less than its grandeur, was unmistakable. There below was the sparkling river and there beyond was New York, stretched out before the eye like an enormous scale model. The bridge was the way to get there. It was the great highway to New York, just as had been intended from the start.”<sup>14</sup>

Roebing’s intelligence, competence, problem solving ability, strong decision making, and ability to work through others (most notably his wife) were the key factors in the success of one of the greatest civil engineering works of the last two centuries.

### **Empire State Building**

One of the most recognizable buildings in the United States, and probably the world, is New York’s Empire State Building. 1,252 feet tall with 2.1 *million* square feet of office space, this monstrosity was the tallest building in the world when it was completed in 1931, and still ranks among the tallest in the world today. While notable, its size is not what makes the building so remarkable, but rather the speed with which it was planned and constructed. From planning to complete and ready for tenants, the entire 102 story structure took only twenty months. The 86 stories of steel structure took only six months to erect, and the entire construction phase, foundations to completion, took 11 months. At peak activity, 3,500 workers worked the site every day, and the

frame went up faster than one story *per day*. No comparable structure has since reached that rate of ascent.<sup>15</sup>

The driving force behind this achievement was Paul Starrett, of the construction firm Starrett Bros. & Eken, formed with his brother William in the early 1920's. The marriage of the two brother's experience formed the basis for the success to come. William Starrett, despite only finishing two years of engineering education before striking out in the construction world (he later did finish his bachelor's degree), served as timekeeper on the large Flatiron Building job in New York City, and then moved on to be the superintendent in charge of building Washington D.C.'s Union Station. World War I saw William become the head of the Emergency Construction Section of the War Industries Board, where he oversaw the construction of troop housing at a total contract value of \$150 million (in currency of that day!).

Paul Starrett's résumé was equally impressive. He worked as a construction superintendent at the 1893 World's Fair, and then joined his brother on the Flatiron project. Though a smaller building, the Flatiron building's steel frame went up one floor per day, a hint of things to come under the Starrett's guidance. During World War I, Paul took a hiatus from construction to build steamships for the government, and by the time he joined with William for their joint construction endeavors, Paul had already built Macy's department stores, Pennsylvania Station, and the Biltmore hotel.<sup>16</sup>



**Figure 3. Paul (left) and William Starrett. From Carol Willis, ed. Building the Empire State (New York: Norton, 1998) 25.**

The Starrett brothers' skills at business management and development were seen from the very beginning. They maneuvered themselves so that they would give the last presentation (of the five competing bidders) to the developers, and won the job with a combination of skillful negotiation and brutal honesty. It is interesting to note that the directors did not award the building on price alone, although that was clearly a consideration. "Their primary concern was the ability of the contractor to finish the job in as short a time as possible."<sup>17</sup> It was generally recognized that that the Starrett brothers could do just that. The General Motors giant John J. Raskob, who originally came up with the idea for the building, likened construction to industrial production, and said that there were three main factors: capital, labor, and management. "He stressed, however, that the three parts were not equal. The integral part was management, the brains necessary to direct production, and the only way to measure managerial ability was by performance. At that, Starrett had no equal."<sup>18</sup>

Further, the developers knew this was no ordinary undertaking, and were willing to pay a little more if it meant ensuring good results. They were keenly aware of some of the other projects which were going on or had recently been completed in the area, must

notably Roebling's Brooklyn Bridge discussed earlier, and (for all the successes the bridge did achieve) "nobody wanted to be faced with the problems that John Roebling had encountered"<sup>19</sup> (specifically referring to his material problems with Haigh in wire manufacture and delivery, and also steel delivery.) Also, this project would have to be designed from the bottom up, in such a way that the lower floors were designed first, then built while the design for the upper floors was being completed (today we call this "fast-tracking" and it is relatively routine, but it was a new concept then, especially on a project the scope of which had never been attempted).

The challenges were as varied as any construction project of the day. The site was already occupied by the Waldorf-Astoria hotel, and that would have to be torn down and removed. Then the location would have to be prepared and the foundations put in. Considering the scope of the project, this would be hard enough in an open field or readily accessible site. It was certainly no small matter in bustling Manhattan, and additionally, the integrity of the surrounding buildings would have to be maintained. "You couldn't help but wonder whether the buildings that had been shored up to ward off collapse might not fall into the pit, or whether one of the trucks hauling away refuse might not actually tip over the side of the precariously angled ramp."<sup>20</sup> It was also discovered that there was an underground stream running through the site which had not been anticipated or accounted for in the design. (It happened even back then.)

Further, the building would require 50,000 tons of steel, the largest order ever placed for a single building.<sup>21</sup> In addition to the steel, all the other trades would have to be scheduled and monitored so that they all had access to where they needed to be, but

did not impinge upon the other trades' ability to do work. To illustrate the scheduling nightmare that the project was, consider that:

“An example of the speed required was that the fifty thousand tons of steel had to be fabricated, shipped, hoisted into place, and secured by October 4, 1930, so that the floors and fireproofing could be finished by October 10, to allow the cladding to be installed by December 1, so that the interior work could be finished by April 1, so that everything could be in readiness for opening day, May 1, 1931. The controlling dates for sixty trades were tied to this schedule.”<sup>22</sup>

As an added challenge, it was decided that this grand building would have a feature that no other building every constructed would have. Dirigibles (large, passenger carrying blimps) would be able to dock at a mooring mast to be installed at the top of the building. (Interestingly enough, no one did research on how many people would be willing to descend the 135 feet or so *by ladder or steep stair* from the ship to the roof of a 1250 foot building before the feature was incorporated.) This required that the entire steel frame be altered and strengthened, so as to be able to transfer the load of a fifty ton airship 1250 feet down to the foundations below. The steel changes were made and incorporated into the building, but unpredictable winds caused by the effects of the surrounding buildings proved too difficult to overcome, despite several tests of the idea. Critics stated that the mooring mast feature was only added to ensure that the building would be the tallest in the world when built, and that fact is still debated.<sup>23</sup>

Material challenges were also evident, and in abundance. The quantities of steel, marble, limestone, and a host of other materials were far in excess of anything that had been demanded before. Paul Starrett attacked this problem with his typical aggressiveness.

“If a supplier could not perform on time, Starrett found another that could. The choice of facing marble for the entrance hall and public areas was originally to have been dark Hauteville marble, but the decision was revised when the quarry

informed Starrett that it could not keep up with the pace of construction. The solution was to buy an entire quarry in Germany for the Rose Famosa marble.”<sup>24</sup>

The limestone for the outside of the structure came from Indiana, the steel from Pittsburgh, the cement and mortar from upper New York State, the marble from Italy, France, England, and Germany, the wood from the northern forests and Pacific Coast, and the hardware from New England.<sup>25</sup> Many project managers can attest that coordinating all these materials is difficult enough today, with FedEx and UPS and computer inventory and online ordering and email and telephones. But Starrett was able to manage this material circus in 1930, when none of these things (except the telephone) were available to help!

One solution Starrett developed to cut down on his material warehousing costs involved the limestone. Mined in Indiana, it was rough cut and shipped to the site. Starrett, seeking to eliminate transportation and storage costs, hired local milling shops to do the finish work, saving many thousands of dollars..

The managerial effort involved in the actual construction process almost boggles the mind.

“Erecting the building required a synchronization of infinitely varied activities that had scarcely ever been attempted before. The supervision entailed was enormous. The overseers, from job foreman to architect and engineer, were on the site constantly, watching, seeing that everything was proceeding according to both plan and schedule.”<sup>26</sup>

But despite these challenges, through the guidance and prowess of Paul Starrett, the building was getting built, and quickly. The record at this period in construction history for a steel building of the scale being constructed was 3.5 stories per five-day work week. Starrett’s goal was five stories per work week, an ambitious one per day. At times that was achieved, and the overall rate was 4.5 stories per week, a full story ahead

of the record. The steel contract finished 23 days ahead of schedule, and it was said that the builders of the Empire State building “threw steel into the sky not just higher but faster than anybody had ever dreamed possible”.<sup>27</sup>

Once the steel was complete, both the exterior skin and the interior finishing were attacked in the same aggressive fashion, saving time wherever possible. One innovation was the use of an interior railway system, using both bucket and flat cars. Tracks were laid all around the floors, and on all the hoists. While there were no locomotives (everything was “people-powered”) this system, coupled with innovations like a brick delivery hopper, drastically reduced the amount of time necessary to get materials where they were needed within the structure.<sup>28</sup>

Another innovation aimed at increasing productivity centered on the delay in work due to lunch breaks. As the building climbed ever higher, it took longer and longer for the men to get down out of the building, find something to eat, and get back to their work area. Starrett realized that this could greatly impact production, and his solution was the installation of cafeterias on five different floors throughout the building. Starrett offered to prominent restaurateurs in the local area the opportunity, for a nominal fee to cover power and water, to install and operate cafeterias for the men. The stipulations were that Starrett’s company would do any construction work required, that the owner would install and remove the equipment when necessary, that the cafeteria would serve the same food as in the local restaurant, and that they would serve that food at slightly reduced prices. James P. Sullivan jumped on the opportunity, and

“the result of the arrangement as worked out, was that the restaurant man made a fair profit, the men bought food at cheaper prices than same could be purchased outside the building, and the very vexing problem of getting 3500 men in and out of the building during the lunch hour with limited elevator service was

satisfactorily solved...During the life of the entire job not one complaint was received concerning the quality or price of the food served. This is a remarkable record, in view of the fact that the commissary department on every construction operation is generally the source of prolific complaints.”<sup>29</sup>

Through Starrett’s superb managerial skills, the building was completed in the ridiculously short time period of eleven months. “Not a single contractor lagged behind the assigned period, and the average contract was completed ahead of schedule. Each of the four pacemakers [steel, floor, metal, stone]—the trades that had to take the lead and set the pace for the trades that followed—was ahead of schedule.”<sup>30</sup> The least amount of time saved by one of the pacemakers was 4 days (floor arches) and the exterior metal was completed 35 days ahead of schedule. With all of the research, education, and theory that have since gone into developing project management as a discipline, few if any projects (with the exception of Boulder Dam, discussed below) have yet achieved that level of construction efficiency.

### **Hoover Dam**

Boulder Dam (or Hoover Dam, as it is more commonly known) stands 726 feet high and is 650 feet wide at the base.<sup>31</sup> Through its production of electrical power and control of the Colorado River, it is largely responsible for the growth of Las Vegas and southern California into the modern areas known today. It is an engineering marvel, containing 3.22 million tons of concrete, and when completed in 1936, was the largest dam in the world, and the largest government contract award to that time.

Construction of the Boulder Dam began on May 16, 1931. The contract had been awarded on March 11, 1931 for a contract price of \$48,890,955, with the bid being won over four other firms by the joint venture called Six Companies.<sup>32</sup> Construction was

supposed to take seven years, but Six Companies completed construction two years early (something any modern day project manager would be proud of).

To manage the construction of this project, Six Companies hired the services of Frank Crowe, a tall, quiet man originally born in Quebec. He had received an engineering degree from the University of Maine in 1904, and worked a variety of jobs in the private sector and for the United States Reclamation Service. He gained experience and reputation while working on canal and dam projects throughout the country. He gained particular fame on the Jackson Lake dam in northwestern Wyoming, which was completed in record time. This success got Crowe noticed, and moved into the “big leagues” of dam building, starting with the Arrowrock Dam on the Boise River in Idaho. This was a critical step for Crowe. It proved to be the most productive experience of his early career, exposing him to a vast range of challenging new problems. This would set him up well for the challenges of constructing Boulder Dam.<sup>33</sup> When Six Companies formed with the intention of winning the dam work, they knew they had to have Crowe to be successful, and hired him away from the Reclamation Service to be the superintendent.

Crowe had many of the skills that modern day project management theory preaches as absolute requirements. He had an excellent technical background, plus significant experience in the job at hand. But he also had important “people” skills, which were often lacking in technical giants of the day. “Crowe was a gifted technician, whose ability to interact effectively with the special breed of men who worked on the dams supplemented his talent for designing and putting in place the systems that

harnessed their labor.”<sup>34</sup> It was also said that “he was a superb manager of men and systems, part military commander and part production manager.”<sup>35</sup>

A project of that size in any environment could tax even the best project manager, no matter what his experience. But Boulder Dam had circumstances which made the difficult project seem almost impossible. The first was its location. It was a desolate canyon, with temperatures routinely above 100 degrees.<sup>36</sup> Further, the site of the dam was thirty miles from the nearest town, the fledgling city of Las Vegas. Therefore, Six Companies planned to build an entire city near the site, capable of housing and feeding the 5000 workers required, and their families, and providing all the necessary functions (law enforcement, shopping, schools, etc.). The company planned to have much of this infrastructure in place before construction actually began, but President Hoover ordered that hiring and construction were to begin “right away,” as the project was seen as a significant step in relieving the great depression.<sup>37</sup> In order to abide by the President’s decree, Six Companies had to build the camp and the dam at the same time, resulting in shantytowns springing up all around the site until the city of Boulder was substantially complete around 1932. In addition, miles of roads and even a railroad had to be built in order to easily transport the massive amounts of men and material required by the project.

A further complication was the contract itself. It was the largest government award in history, and because of the importance of the project to the government, had a then-unheard of liquidated damages clause of a shocking \$3000 per day (\$25,000 in modern currency!).<sup>38</sup>

Finally, before the work on the massive dam could even begin, the mighty Colorado River would have to be diverted, and that was no small task. Four large

tunnels, each as wide as a modern four-lane highway, would have to be drilled through a mile of solid rock, and then lined with concrete.<sup>39</sup> In addition, high levees were needed to keep out any water that got past the mouths of the tunnels or tried to back up along the bed at the exits. These tunnels were extremely important, critical in every sense of the word, and any delay there would seriously impact the project as a whole. One main reason that the dam was completed two years ahead of schedule is that the tunnels were completed nearly a year ahead of schedule.

Further engineering concerns surrounded the curing of the concrete. With such a large structure (3.22 million cubic yards of concrete), if the mix of cement used was allowed to cool naturally, almost 150 years would elapse.<sup>40</sup> Serious consideration was given to a solution, and in the end several miles of five inch pipe, fed from a refrigeration plant, were used to ensure proper cooling without the development of undue thermal stresses.

Despite these and numerous other challenges, the dam was completed two years earlier than the government estimate, due primarily to Frank Crowe's efficiency and skill as a manager. With only on the job training in project management, he nevertheless was able to construct one of the greatest civil works in history.

## **PROJECT MANAGEMENT AS A DISCIPLINE**

### **History of Project Management--The Beginning**

As discussed earlier, projects were undertaken and completed long before the term “project management” was ever used. But in the early 1950’s, in an ever-so-subtle way, formal project management began to emerge as a stand-alone discipline. No one person is credited with the invention of project management, and its roots are instead traced to the Department of Defense and the defense industry as a whole.<sup>41</sup> Emphasis in the early years was placed on managing projects, organizational concepts, and the matrix approach to organizing projects.<sup>42</sup>

Though the theories have evolved much since its introduction, some of the basic tenants can be traced back to this time period. In a 1959 issue of *The Harvard Business Review* appeared an article titled “The Project Manager.” In it, author Paul Gaddis “described the role of an individual in an advanced technology industry who works as a focal point for the management of the resources being applied to a project.”<sup>43</sup> This is also possibly the first codification of the three most important aspects of managing a project (discussed further in the next section): get it done on time, finish within budget, and meet the technical specifications of the person paying the bills.

A difficult issue for early project managers was the level of authority they were allowed to wield. In order to truly impact the schedule, the budget, or the performance of the project, they needed actual legal authority to manage the project and the project team. But all too often in the 1950’s authority was regarded as “more or less a gravitational force that flowed from the top down.”<sup>44</sup> Since the project managers were seldom at the

top, the amount of authority they could exercise was limited to what they had earned in the eyes of their peers and subordinates. On a new project with unfamiliar people, this authority could be severely limited.

High-level executives recognized that this system was stifling to project managers, as it did not give them the tools they needed to complete the job (yet it still often held them responsible). A shift in thinking began to emerge, and it became one of the greater benefits of the development of project management as a discipline. Authority was seen to be both a vertical *and* horizontal force, and the basis for that authority must come from both the merits of the person (their experience, education, and working relationships) and have some legal backing from senior management.<sup>45</sup>

Another important idea that grew as project management developed concerned that of recognizing stakeholders. This concept began to appear in the 1970's, as enterprises began to realize exactly who was at risk in each particular endeavor. This myriad group needed to be recognized, and project management theory began to embrace that idea. Stakeholders were identified and the nature of their interests specified. Those particular interests were built into the project plan, so that success for the project meant success for all involved.

### **Alphabet Soup**

Several mathematical systems for managing projects began to emerge during this period, starting in the 1950's. Prior to this, the Gantt chart, developed by Henry Gantt in 1919, was the main tool for scheduling projects. One of the earliest new systems was the Program Evaluation Procedure, or PEP, developed in 1954 by Lieutenant General Bernard Schriever of the United States Air Force. Then a Colonel, Schriever developed

the system to assist in the management of the Air Force's missile program. PEP led to PERT, which was developed in 1958 for the Navy's Polaris missile project. This system is credited by Vice Admiral Raborn with saving at least a full year in the development of the Polaris missile system.<sup>46</sup>

In 1959, Critical Path Planning and Scheduling (CPPS) was developed, which had two major advantages over anything previously used. First, the calculations involved were easier, and could be repeated more often (an important factor in the those days, when computers were severely limited in what they could process). Second, using these multiple iterations, a least-cost schedule could be developed. Still, with computers not very capable, and in short supply besides, the true value of this method was not realized at the time. But from this apparent failure, the now popular Critical Path Method (CPM) was born. James Kelley Jr. and Morgan Walker took the CPPS system and simplified it by eliminating the time-cost trade off aspects, and CPM was the result.<sup>47</sup>

The use of PERT and CPM as the management tools of choice for the time sparked a flurry of articles, many which sang the praises of one system over the other, some blasting both systems, and some offering modifications and extensions. One particularly important extension was the Monte Carlo approach to PERT, developed in 1964, which makes allowances for uncertainties and is widely used today to assess time risks.<sup>48</sup>

Another variation was PERT/COST, introduced by the Department of Defense in 1962. Though highly touted by both the Department of Defense and NASA, it produced less than dramatic results and was succeeded by the newer and flashier Cost/Schedule Control Systems Criteria (C/SCSC).<sup>49</sup>

One of the biggest changes in project management theory, at least with regards to scheduling, occurred in 1968. John Fondahl led the charge to replace the widely used (and confusing) activity-on-arrow (AOA) graphical representation common in PERT and CPM. His efforts lead to the wide acceptance of the easier activity-on-node (AON) method, which is the primary method taught today<sup>50</sup> (though many programs still try and confuse students with AOA from time to time).

DCPM and GERTS, follow-ons to PERT, were also developed in the 1960's, primarily with research and development applications. The late sixties also saw the publication of Project Management with CPM, PERT, and Precedence Diagramming, by Moder, Phillips, and Davis. It is still very relevant to scheduling, and was continually updated and reprinted, most recently in 1983.<sup>51</sup>

### **Time for Certification**

As authority was redefined, stakeholders better recognized and understood, and PERT and CPM more expertly used, project management was no longer seen as an “extra” skill set or a spin-off from the more technical fields, but as it’s own discipline. It required mastery of a unique brand of knowledge and skills. It required a thorough understanding of the new “matrix” concept of delegating authority, responsibility, and accountability. There was research into what worked in the field, and development of more modern strategies and new, alternative teams to get things accomplished. Project management was growing up, and was looking for a right of passage.

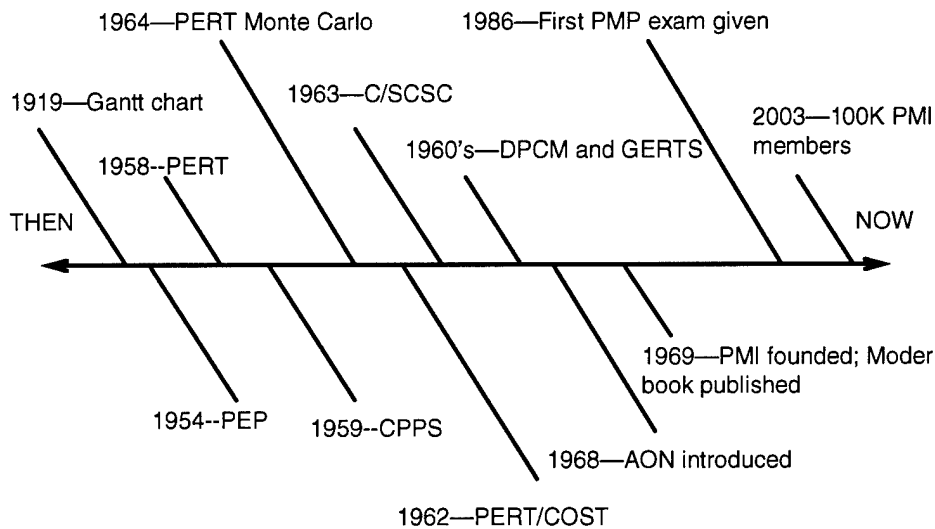
As with any established discipline, there was a need to develop and test against a known knowledge base, in order to provide a certification for members so that common professional standing was established. No one recognized this need more than the

members themselves. In 1983, it was reported that 86 percent of all PMI members surveyed “favored some type of certification program.”<sup>52</sup> In 1984 the article “The Project Management Professional (PMP) Program: Certifying Project Managers” appeared in the March 1984 Project Management Journal. That article detailed the process for obtaining certification, and listed the three areas in which points could be earned towards certification: education, experience, and service. The first exam was given in 1986 in Philadelphia, and of the fifty-six candidates, forty-three passed and became the first Project Management Professionals. In 1994, more than ten times that number sat for the exam, a testament to the growth and recognized importance of project management as a discipline.<sup>53</sup>

### **Some Current Project Management Theory**

Project management education has taken off rapidly in the past years. The Project Management Institute (PMI) currently lists 28 U.S. universities and 29 international universities which offer degree programs (though some unaccredited) in Project Management.<sup>54</sup> In addition to the growth of the education program, the amount of people identifying themselves with professional project management has also grown. From its humble beginnings in 1969, PMI grew to 7,500 members by 1990.<sup>55</sup> Six years later membership was just shy of 25,000. In 2001, it was over 75,000, and on January 8, 2003 at 7:15 PM, the 100,000<sup>th</sup> member joined.<sup>56</sup>

## Project Management Significant Events



**Figure 4 Significant Events in Project Management History**

With all the education programs and professional seminars on project management, there are of course several different methodologies being offered. But there are definitely some common threads. First would be the definition of project management: *the application of knowledge, skills, tools, and techniques to project activities to meet project requirements.*<sup>57</sup> Second would be the importance of the three aspects of a project every project manager should have tattooed on his or her professional forehead: *time (how fast?), cost (how much?), and performance (how well were specifications met?).*<sup>58</sup> Of these, performance is usually seen as the most important, followed by time and cost. (The Brooklyn Bridge is a perfect illustration of that fact. Ten years late at twice the budget, it was still considered a success when the dust settled, because it linked up Brooklyn and New York in exactly the manner hoped for.)

Finally, most people and materials seem to agree on the importance of the project manager being well rounded. Gone are the days when a gifted engineer with no leadership style or skills could still muddle through a project successfully. True, experience and professional credibility are still important attributes of a project manager. But most education programs have embraced the idea that the successful project manager displays more than just keen technical knowledge, that it is simultaneously a human and technical challenge.<sup>59</sup> He or she, in addition to being a technical expert, must be a facilitator, a communicator, a negotiator, and a “fire-fighter”. Further, he or she must be creative, in order to remain flexible to handle the myriad of problems that arise. In short, people skills are now as important as technical qualifications, and both are needed to succeed.

The University of Maryland’s Project Management program, taught by the Civil Engineer Department, is an example of a modern, well-rounded approach to project management curriculum. In addition to technical skills such as estimating, scheduling, and linear programming, students are also instructed in vital leadership and people skills. Time is given to discussing different personalities and personality traits, negotiation skills, and communications tools. Leadership by example is stressed, and motivating teams and fostering teamwork also receive significant attention. Finally, the element of risk (identification, management, and mitigation strategies) is included, leaving the students with a full toolbox of both technical and non-technical skills. Through the entire education process, the idea of using technical and people skills equally to not only meet but EXCEED the customer’s expectations is emphasized.

The skill sets taught in such a curriculum are well used in the following example of current project management theory, as practiced by CH2MHill, a project delivery company. This 12,000 person company (as of 2002) delivers 13,000 projects annually. To accomplish this, the company has taken the goals of time, cost, and performance and coupled them with the ideals of proper authority, personal interaction and communication, recognition of stakeholders, and the latest computer methods to develop a six step process for managing projects. The process steps are **develop, charter, plan, endorse, manage change, and close**,<sup>60</sup> and each will be discussed in more detail in the following paragraphs.

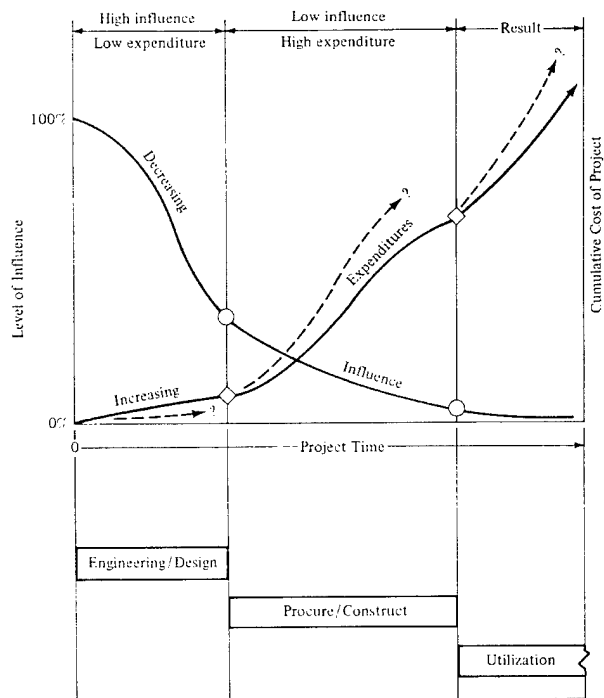
Step 1 in the CH2MHill process is to **develop** the project. In this step, the project vision is created, detailing the purpose, objectives, requirements, and measures of success.<sup>61</sup> Following the development, **chartering** of the project team takes place, where members are named to the team, general responsibilities are assigned, and operating guidelines are established.<sup>62</sup> The final part of the charter process is to gain agreement from all team members about the direction the project should go.

**Planning** comes next. Since inadequate planning is the most significant factor contributing to project cost escalation<sup>63</sup>, this step could be seen as the lynchpin of the entire process. Within this step, the work breakdown structure is created, roles and responsibilities are further defined, the all-important schedule is developed (using PERT, CPM, or a similar method), estimates are transformed into a budget, and instructions on how to carry out the plan are given.<sup>64</sup> The more time and effort that are spent in this phase, the less likely the occurrence of unforeseen incidents which will extend or delay

the project. As shown in figure 3 below, the time to best influence the project with the least expenditure is in this stage.

Upon completion of the plan, the next step is the **endorse** step, where the customer, entire project team, management, and the stakeholders (their importance now recognized) are briefed and given the opportunity to improve the plan.<sup>65</sup> CH2MHill defines “endorsement” as 100% commitment to doing whatever it takes to move the project forward. Grudging compliance or simple approval are not enough to fulfill this step, and all efforts toward full harmony must be made.<sup>66</sup>

Following endorsement, the next step is to **manage change**. This is much more than simply processing change orders and amending the contract. Managing change includes monitoring the work and observing elements of performance in order to make positive, corrective changes, with the goal of constant project improvement.<sup>67</sup>

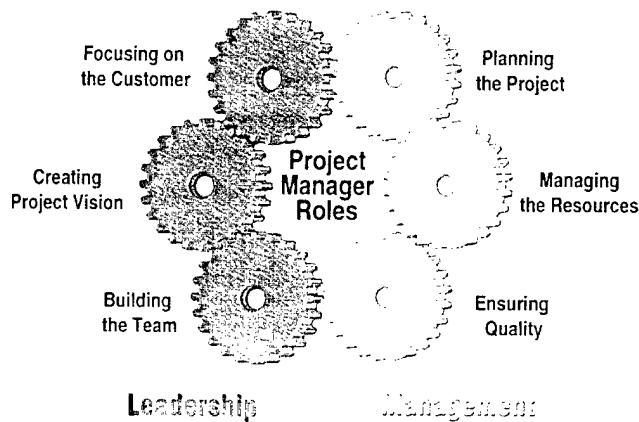


**Figure 5 Level of Influence On Project Costs. From Donald Barrie and Boyd Paulson Jr. Professional Construction Management Including CM, Design-Construct, and General Contracting, 3<sup>rd</sup> ed. (New York: McGraw-Hill, 1992) 178.**

The final step in CH2MHill's process is **closing the project**. This can be likened to "running the race all the way to the end." The same level of effort applied in the previous five steps must now be put forth here to ensure successful completion. Efficient demobilization, archiving of important documents, and the creating and filing of lessons learned (for EASY location in the future) are all important elements of this step.<sup>68</sup>

It is important to note that CH2MHill does not simply discuss its process as a faceless, human-less system of procedures. It recognizes the intangible element of leadership as well. As shown in the figure below, CH2MHill teaches that the relationship between leadership and management is made up of six interlocking gears, three on the management side and three on the leadership side. Further, the company goes on to define the difference between the two. *Leadership* is about doing the right thing,<sup>69</sup> while *management* is about doing it right.<sup>70</sup>

### Project Management Has Six Primary Leadership/Management Areas



**Figure 6** CH2MHill shows the relationship between leadership and management in their project management system. From Steve Romanow, "Project Delivery System: Achieving Excellence with Project -Centered Enterprises," ENCE 662 Guest Lecture, University of Maryland, 25 November, 2002.

## Analyzing the Past in Light of the Present

Now that the history of project management has been discussed, and some popular current project management theory reviewed, what can be learned from the three historical projects visited earlier?

As the historical projects are reviewed, the intent is not to disparage Roebling or Starrett or Crowe. The Brooklyn Bridge still stands, the Hoover Dam still holds water, and the Empire State Building is majestic as ever. Rather, the point is to look at what these three construction managers did well, and to make sure those successes are adequately reflected in the modern theory. In addition, it is important to note any problem areas, to make sure that current management education is attempting to arm fledgling project managers with the tools to avoid the same pitfalls.

In the case of Washington Roebling, it was demonstrated that he was a competent engineer, and that his abilities to make positive changes (communication systems in the New York caisson) and important decisions (reducing the required depth of the New York caisson, and increasing the wire rope per cable due to Haigh's poor quality wire) were up to the task. A hint of the authority issue discussed in an earlier section is evident, as Roebling had some authority over work practices, but was completely helpless to prevent Haigh being awarded the wire rope contract, despite knowledge of Haigh's reputation. Finally, there is evidence that meeting the customer's expectations can go along way in earning forgiveness for cost and budget overages (which is still *usually* the case today).

Looking at Roebling's performance in light of the CH2MHill guidance, it's obvious that while a little shaky in the development of the entire project (he was

involved, but it was his father's brainchild), he did an excellent job of planning and managing change. Finally, he must have done an excellent job closing the project (since fifty thousand people plus the President of the United States were on hand for the opening ceremonies!).

So using expertise, communication, and personal supervision (albeit through his wife) a competent, experienced engineer did a good job meeting the expectations of the customers, but with more authority could have done a great job and probably saved time and money. This appears to be fairly consistent with modern thought when it comes to project management.

In the case of Paul Starrett and the Empire State Building, there are two key points to recognize. The first is that Starrett embraced new, innovative solutions to old problems, as evidenced by the construction of the rail system throughout the building and by the cafeteria contract. The second was Starrett's constant monitoring, adapting, and improving of the material procurement for the job (for example, buying the quarry to ensure that sufficient stone was available in a timely fashion).

Starrett also gets high marks when his performance is looked at in light of CH2MHill's guidance. He and his brother did an exceptional job of developing the project, and of getting everyone on board and focused in the right direction. Starrett especially managed change well, whether it was the mooring mast change order, the changing work environment as the structure climbed higher, or the material supply situation.

So, in the case of that historic project, we have an experienced, motivated individual who embraced new ideas, thought outside the box, and managed several

different material streams at one time. Again, these concepts are very much in line with what is being taught today.

It's already been stated that Frank Crowe was both a recognized expert in his field and an able manager. But it is also important to note that even then the importance of being able to connect with *people*, on the non-technical side of the project equation, was recognized (note the quotes to that effect in the Hoover Dam section). Further, his quiet efficiency is worth mentioning. There are no stories similar to Roebling's monumental caisson decision, or Starrett's buying the marble quarry, because Crowe's solid management and ability to get the most out of his team prevented such situations from ever arising.

That quiet efficiency and solid base of people skills led to the dam being completed two *years* ahead of schedule. It took Crowe five years (instead of seven) to build the largest dam of its time. Referring again to the CH2MHill model, obviously such an accomplishment could not have been done without a significant amount of effort in the planning stage, a tremendous ability to manage change, and a significant effort in closing the project. (Experienced project managers know that the last few months of effort are always the hardest, as the job winds down. It's even harder when everyone knows you are ahead of schedule, and there is time to give.)

## **CONNECTING THE DOTS (conclusion)**

Project management has evolved into a blending of solid technical skills and comprehensive people skills, coupled with sound business judgment. In the late fifties and early sixties, more emphasis was placed on “systems” of project management, like PERT and CPM, and some of the people element was lost. Thankfully, current theories, as evidenced by the education program at University of Maryland and the CH2MHill model discussed, have brought that element back into focus.

Washington Roebling, Paul Starrett, and Frank Crowe placed a solid point in history for current project management to anchor upon. Roebling took risks and made important decisions. Starrett showed the importance of dynamically managing change and grasping innovation. Crowe showed the importance of the people side of the equation. All three softly spoke volumes about the importance of being a technical expert in your field. From that point, it is possible to draw a line through the fifties and sixties to the present day, where new project managers are trained in technical competence, project management systems and tools, team dynamics and how to deal with people. The line connecting the historical point with the modern day, if extended, points to a bright project management future.

## NOTES

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- <sup>8</sup> McCullough 374.
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- <sup>10</sup> McCullough 451.
- <sup>11</sup> McCullough 440.
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- <sup>13</sup> McCullough 517.
- <sup>14</sup> McCullough 513.
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- <sup>16</sup> Willis 172-173.
- <sup>17</sup> John Tauranac, The Empire State Building (New York: Scribner, 1995) 177.
- <sup>18</sup> Tauranac 177.
- <sup>19</sup> Tauranac 171.
- <sup>20</sup> Tauranac 203.
- <sup>21</sup> Tauranac 181.
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- <sup>23</sup> Tauranac 187.
- <sup>24</sup> Tauranac 205.
- <sup>25</sup> Tauranac 204.
- <sup>26</sup> Tauranac 205.
- <sup>27</sup> Tauranac 212-213.
- <sup>28</sup> Tauranac 215.
- <sup>29</sup> Willis 9 (quoted construction notes).
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- <sup>31</sup> Donald Wolf, Big Dams and Other Dreams: The Six Companies Story (Norman: University of Oklahoma Press, 1996) ix.
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- <sup>34</sup> Wolf 35.
- <sup>35</sup> Wolf xiv.
- <sup>36</sup> Wolf 5.
- <sup>37</sup> Wolf 36.
- <sup>38</sup> Wolf 37.
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- <sup>41</sup> David Cleland, "Project Management: Profile of Changes," Proceedings of the 29<sup>th</sup> Annual Project Management Institute, October 9-15, 1998: (Long Beach: Project Management Institute, 1998) 1.
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- <sup>43</sup> Cleeland 1.
- <sup>44</sup> Cleeland 2.
- <sup>45</sup> Cleeland 3.
- <sup>46</sup> Webster, "They Wrote" 61.
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<sup>62</sup> Romanow lecture

<sup>63</sup> Romanow lecture

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<sup>68</sup> Romanow lecture

<sup>69</sup> Romanow lecture

<sup>70</sup> Romanow lecture