Project Management Institute

Case Studies in Project Management

Superconducting Super Collider Project

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Superconducting Super Collider Project

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This case study was adapted to make it a learning resource, and might not reflect all historical facts related to this project.

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Introduction

This case study delves into the project management techniques used on the multibillion-dollar (US$10 billion plus) Department of Energy's (DOE's) project called the Superconducting Super Collider (SSC). The SSC is a high-energy subatomic particle accelerator set to be the most powerful in the world. The intended end result was a product to be used for research and development. Thus, the project itself aimed to build the world's largest scientific instrument (Willard, 1998).

For insight into the grand scope of the project, the U.S. Department of Energy's High-Energy Physics Advisory Panel (HEPAP) reported in its Executive Summary Conclusions and Recommendations (1994):

> The goal of particle physics is to understand the nature of matter at its deepest level, to answer the questions: What are the fundamental building blocks that make up the universe? What laws of nature determine their interactions at any time and place in the universe?
>
> Twentieth century civilization has inherited a long and rich scientific tradition that began with the Greek philosophers. From the chemists of the eighteenth century who explored the behavior of atoms, to the physicists of the twentieth century who unlocked the secrets of the nucleus, scientists have probed nature in ever-finer detail in search of its basic constituents and fundamental physical laws.

Noted as being the world's largest scientific instrument of its day, the SSC project was terminated by the U.S. Congress in 1993.

The case study covers various Project Management Knowledge Areas (Project Management Institute, 2004) within four project phases: inception, development, implementation, and closeout. Within each project phase, the activities, accomplishments, and performance shortcomings in the Initiating, Planning, Executing, Monitoring and Controlling, and Closing Process Groups' processes are discussed. The case study is structured to allow an evaluation of the appropriate processes of various Project Management Knowledge Areas at the end of each phase. An overall assessment of performance is then conducted, resulting in a numeric evaluation of the management of this project, including areas of strength, opportunities for improvement, and lessons learned.

In the inception phase, the discussion focuses on the historical background of the project, its overall objectives, project definition, political climate, and the selected solution. In the development phase, the discussion addresses the overall planning, feasibility studies, funding, and conceptual design. In the implementation phase, the discussion addresses detailed design and construction. Finally, in the closeout phase, the discussion reflects on project termination, overall performance, and project evaluation.

The Inception Phase

Before discussion about the scope of the SSC can begin, it is important to understand the magnitude of the project. The SSC was a huge undertaking, from scientific, logistical, and managerial perspectives. From a scientific perspective, the goal of the SSC was to recreate the "Big Bang" safely in a laboratory setting. The SSC, once completed, would have 20 trillion volt energy beams that would allow physicists to create the particles that, according to the Big Bang Theory, were present only in the first trillionth of a second when the universe was created. Scientists would then shoot protons against other protons at the speed of light to watch them explode.

From a logistical perspective, a 54-mile (86.9 km) tunnel, ranging from 50 to 250 ft (15 m to 76 m) below ground, would have to be built for the SSC. Additionally, over 16,000 acres (6,475 hectares) of land would be needed to accommodate the necessary facilities, including nearly two million square feet (185,806 m^2) of office and laboratory space. The project was estimated to take from 10 to 12 years to complete, and cost over US$10 billion.

Despite the 1987 projections that the SSC needed US$4.4 to US$6.3 billion to construct and US$500 million annually to maintain, the President of the United States and the Secretary of the DOE convinced the U.S. Congress to appropriate preliminary funds for the SSC. As a result, in August 1988, the DOE published a request for proposal (RFP) for management of the SSC construction, as well as post-construction operation of the SSC. The DOE distributed the RFP to 121 interested contractors.

Although the DOE distributed 121 RFPs, only one response was received by the November 1988 deadline. This clearly limited the options for DOE, and may have resulted in accepting a response that was not as good as they had desired. That response was submitted by the Universities Research Association (URA), whose primary experience was with technology, specifically focused on high-energy physics, and not in construction. This was not ideal for many of the initial stages of the SSC project, which primarily required construction expertise. Toward the end of the SSC project, all major parties involved with SSC acknowledged that selecting URA as the prime contractor was a poor choice. The URA project manager, in fact, said that the SSC was 100 times larger than any other projects that he had managed, and there were too many problems that were new to him. Given the sheer size of the project, it was extremely difficult for anyone to foresee the complications of such a project. Choosing a contractor with more experience in large-scale projects, as well as having more experience with construction, may have been wiser. In hindsight, perhaps submitting separate RFPs for the different needs (technical vs. construction) of the SSC may have resulted in a more manageable and successful project.

The earliest cost estimate for the SSC project was included in the Conceptual Design Report released in 1986. This estimate, with a range from US$3.9 billion to US$4.2 billion, was said to include all design and construction costs. In the initial 1988 presentation to the U.S. Congress, projections indicated that the SSC project would cost US$4.4 billion. In the first SSC budget request in 1988, the total project cost estimate had yet again increased, this time to US$5.3 billion. By 1989, the year that the contract was awarded to URA, the cost projection had increased to US$5.9 billion, a 40% increase over the high end of the 1986 estimate. Even after all of the increases, the U.S. Congressional Budget Office released a report that indicated, based on historical costs for other high-energy particle laboratories, that the SSC costs might have been underestimated by as much as 46% (Jeffreys, 1992). Finally, after several detailed investigations of the various cost estimates were completed, the DOE concluded that the most realistic estimate of total project baseline cost was US$8.25 billion.

Although the U.S. Congress appropriated preliminary funds for the SSC project, it was obvious that there were serious discrepancies in the cost estimates. Part of the blame can be placed on the project itself. However, nothing of this magnitude had ever been attempted. This reduced the amount of data from previous projects that could be used in developing accurate estimates. There also may have been some political pressures that had an effect on the cost estimates. In any case, the rapid increase in cost estimates in the early stages was an indication of a serious problem.

The contract statement of work (SOW) required that the SSC project have a cost and schedule control system (CSCS) in place. A professor of physics was the SSC director and, therefore, was responsible for initiating all schedule planning activities.

Long-term schedule planning was a difficult task, because it was always unknown what resources would be available for the SSC project during any budget year. Because funding was approved for the project only on an annual basis, several assumptions had to be made when developing the project schedule. In addition, there were several technological issues that had to be resolved before components of the project could begin. Because much of the technology required for the SSC project had never been attempted on the scale of what was required for the SSC project, if at all, accurate planning was extremely difficult.

Despite the restrictions imposed by annual funding issues and unknowns of the technology, the project was launched successfully on several fronts, with several milestones and deliverables clearly defined. Unfortunately, there was no CSCS in place. The main reason for this shortcoming appeared to be a lack of commitment to such a system on the part of the project management staff, and ultimately, its director. This deficiency would lead to further problems down the road.

Based on the single response to the RFP that was received by the November 1988 deadline, negotiations began with the responding party for the SSC construction and maintenance contract. For this type of project, a cost-plus contract is widely used. In January of 1989, the contract was completed and awarded to URA. Although a contract was in place with URA, there was no methodology put in place to ensure that the terms of the contract were being met. Had an effective monitoring system been in place, critical problems such as the lack of a required CSCS would have been detected early.

There were many risks associated with the SSC project. Many of these risks -- including technological, financial, and even political ones -- were obvious from the start, and were identified early. Most of these were technical in nature, and were scheduled to be resolved early in the project so that they would not become roadblocks to the completion of other stages of the project. These included the critical superconducting dipole magnets and the transfer of technology to enable industrial production of components that previously had been created only in high-energy physics laboratories.

However, many risks were overlooked or ignored. Due to the scientific and technological focus of the project management team, the budgetary and political risks were not given the proper level of attention. The project management team needed to realize the importance of “selling” the SSC project to both the U.S. Congress and the public in general. Without their support, the future annual funding reviews could result in significant budget cuts for the SSC project.

The SSC project relied on several untested technologies. Therefore, much of the quality-related activity in the early phases of the project was based in the lab. Many of the project components were to be constructed for the first time as part of the SSC project. Prototypes were built in the lab to verify the design concepts. A very talented team was assembled to tackle the unique challenges posed by the SSC project. The team was more than capable of verifying the critical design concepts of the SSC project, as well as adapting to any changes that would be required as a result of testing done with the early prototypes. Additionally, due to the mathematical and physical nature of the project, many of the desired specifications for the various components could be verified during early testing.

Due to the reliance on untested technologies, the probability of having to incorporate major or even minor design changes due to problems detected during early testing and prototyping activity was high. Any design changes in a project of this size could have a significant impact on the schedule and/or cost of the SSC project.

When the contract was awarded to URA in 1989, the team appeared to have all the necessary skills required by the SSC project. URA consisted of 78 research universities, a technical services company with previous DOE experience, and an architectural and engineering firm. A professor of physics was selected as the SSC director. URA fulfilled one of the major requirements of the RFP, which was being experienced in high-energy physics research. URA acquired much valuable experience while successfully managing Fermilab, a project very similar to SSC and the largest in the world at that time.

However, the URA team was lacking in experience with projects the size of SSC. Given that the URA project manager admitted at one point later in the project that there were too many problems that were new to him, it became obvious that the team did not have the experience required to manage such an effort. URA team members also had strong experience with the technical aspects of the project, but very little experience in the area of construction, especially considering unique aspects, such as the 54-mile (86.9 km) underground tunnel. Building a strong team required experienced team members in all positions, something URA did not have.

Although communication is important in any project, the sheer size of the SSC project made good communication critical. Much of the preliminary project planning and funding activities were open to the public, as they were conducted in public forums. Later, external communications began to detail the progress and status of the project.

Initial communication required to get support for the project was successful. The U.S. Congress voted to appropriate the funds both for the initial research and planning, as well as for initial funding for the first year of the project. There was strong support from many politicians in the early stages of the project.

Due to a lack of a formal CSCS, the status of the project could not always be easily determined. This led to confusion, both internally and externally, with many outside observers questioning various aspects of the project from cost to progress reports. The communications required to continue the external support for the project in the U.S. Congress and from the public seemed to dwindle after the initial funding was secured.

The project management office was tasked with a huge undertaking. The effort required to coordinate a project of this magnitude was massive. A project management team was assembled with the task of keeping the SSC project running smoothly.

The SSC project office was established, headed by a project manager who was responsible for overseeing the technical aspects of the project, as well as ensuring that milestones were achieved and that costs were in line with expectations. The project was progressing well from a technical standpoint, and the project management office was managing a project that consisted of over 7,000 full-time workers in 48 states. The magnitude of the SSC project required comprehensive oversight and a unique management structure. The office structure required that the project manager report both to the headquarters program director and to the Secretary of Energy. This arrangement was put in place to streamline and facilitate day-to-day activities, and to ensure that the Secretary of Energy had direct oversight on the project during the critical start-up stage (O'Leary, 1993).

The unique combination of delegation of authority and the direct reporting relationship to the Secretary of Energy created a situation whereby the project was effectively shielded from the standard DOE oversight functions. As Willard (1998) noted, this situation allowed several failures by the project management office to go unnoticed. On several critical points, the project management office appears to have failed to:

- Recognize the level of project management effort that would be required
- Implement effective project management and control systems
- "Nail-down" the scope of the project at its inception
- Promote the project to Congress and to the public
- Implement effective organizational structure.

Later, the project director acknowledged that perhaps his biggest mistake was that he had "failed to get strong enough, really experienced project management staff on board, who could do these accounting and scheduling things better" and that he had underestimated the importance and magnitude of that job (Willard, 1998, p.501). These failures were instrumental in the termination of the project by the U.S. Congress in October 1993. This termination occurred despite the positive results from a government audit in the summer of 1993, which showed that the project was basically on schedule and within budget. At the point of termination, about US$2 billion had been already spent on the SSC project, and it was estimated that another US$1 billion would be needed to shut the project down.

During the selection process, the project management office had challenges in recognizing the complexity and sheer size of the project. Their lack of experience with such large projects could have led them to conclude that people with experience managing these types of projects needed to be added to the project management team. Once the project was selected, the project management office had challenges in getting the project off to a good start. The scope of the project had not been finalized, and subsequent changes resulted in both an increase in cost and in duration of the project. The project management office could have monitored the project closely at the beginning to make sure the proper project management and control systems were in place and functioning properly. If that had occurred, it would have been much easier to track the progress of the project, provide accurate status updates, and improve external communications.

There was no attempt to implement a formal project-wide configuration management system at the inception of the SSC project. Some of the activities of a configuration management system, including the Integrated Change Control process (Project Management Institute, 2004), have been previously discussed.

Assessment and Analysis

1. Please complete your evaluation of project management during this phase, using the following grid:

   Rating Scale: 5–Excellent, 4–Very Good, 3–Good, 2–Poor, 1–Very Poor

Project Management Area	**Inception Phase**
Scope Management	
Time Management	
Cost Management	
Quality Management	
Human Resource Management	
Communications Management	
Risk Management	
Procurement Management	
Integration Management	

2. Please highlight the major areas of strength in the management of this phase of the project:

3. Please highlight the major opportunities for improvement in the management of this phase of the project:

The Development Phase

Developing a scope statement for the SSC project was a truly gargantuan and iterative task, requiring the input from many sources. The U.S. Department of Energy conducted extensive reviews and spent US$60 million on research on the SSC from 1984 through 1986. The President of the United States made a decision to proceed with the SSC in January 1987, and a site selection process was initiated (Jeffreys, 1992; SSCINFO, 1995). The Ellis County, Texas site was finalized in November 1988, and the SSC laboratory was created under the management of URA in January 1989. One of the early actions was to form a series of international advisory bodies. A substantial number of scientists and engineers had relocated to Texas to construct this new facility. A total laboratory staff of over 2,000 employees, including more than 250 foreign scientists and engineers from 38 countries, was assembled (U.S. Department of Energy, 1994, Appendix A). This project operated in a highly charged political context, with scientists and academicians serving as project managers. The technical aspects of scope definition seem to have been done as well as could be expected.

The SSC project management team had challenges in documenting, communicating, and gaining approval of the project's scope to the extent that this project required. Because the project operated outside of the normal organizational controls during the planning phase, the project managers did not document or implement a scope management plan. A work breakdown structure (WBS) was developed and used effectively. There were no technical showstoppers for both the accelerator and experimental systems, when the project was ultimately terminated (U.S. Department of Energy, 1994).

Resource planning, cost estimating, and cost budgeting were among the fundamental failure areas of the SSC project management team. The team did not control the project's scope, schedule, or cost, and the project's resource requirements changed continually. The estimated costs of the SSC project continued to vary wildly throughout its life, and no CSCS was ever established. A cost baseline, a spending plan, and cash-flow forecasts were not effectively developed. This may have been a strategy to keep the actual cost of the SSC project from becoming known, and thus endangering congressional funding in an era of federal budget deficits. The funding requested from Congress may have been less than the cost estimated for the project. It may have been thought that once the project achieved a critical mass of broad-based special interest support, the required funds could be secured at a later date.

The description of the project states that shortly before the project was terminated, a thorough DOE review of the SSC project revealed that the project was basically on schedule and within budget (Willard, 1998). Therefore, it appears that the project schedule development was adequately addressed. The trouble was not the schedule development itself. The trouble was a lack of schedule control. The project manager could neither demonstrate nor document that the project was "on schedule" because the management team had not implemented any formal schedule control mechanisms. A combination of a schedule management plan, milestone charts, and routine status reporting of schedule performance within a structured CSCS could have solved this problem.

There was no apparent oversight of contracts in this project. Project management made no attempts to bring project procurement within the guidelines or controls of the performing organization. This was a huge failure in the SSC project.

The project successfully overcame some of the technical and scientific hurdles before it was terminated. However, the SSC project managers did not fully address risk management. They did not effectively use risk planning and communication planning to integrate the project by looking across all other Knowledge Areas to plan for situations and events that may impact the project positively or negatively. As Willard (1998) stated:

> The SSC project represented the marriage of world-class science and world-class construction. Missing was "world-class" management! Thousands of scientists around the world had devoted many years of their lives to the conceptual development of the SSC and the results of their efforts were proving successful! No impassable technical barriers had been encountered that threatened the feasibility of the SSC performing successfully after its completion from a scientific standpoint (p. 501).

It can be inferred from the ignominious failure of the SSC project that the project team did not properly consider the project's organizational, political, and funding risks. Apparently these risks were not identified, analyzed, and planned for during project planning. The project operated in a highly charged, high-stakes political environment with many communities of interests, as well as many project supporters and detractors, all with opinions about the merits of the SSC project. The project management team simply failed to adequately anticipate and respond to what may have been predictable project risks in these areas.

The project team produced excellent quality results of both a scientific and technological nature. However, there was no hint that the project management team developed a quality control plan or established a system for systematically reporting on project quality.

As previously stated, the people who managed and staffed the SSC project had sterling credentials in the areas of high-energy physics and cutting-edge construction and tunneling. Thousands of highly skilled scientists from around the globe and dozens of prestigious research universities participated in the program. However, the project's organizational planning and integration of the project into the operating environment of the DOE organization appears to have been totally neglected by the project manager. As a result and over time, effective interfaces and reporting relationships became more challenging, and the project manager became increasingly ignored and remote from top-level management and decision-makers within the DOE. The project management team became organizationally dysfunctional.

Project communication for the SSC project was big and important enough to almost warrant a separate project of its own. The stakeholders of this project extended all the way from the President of the United States to individual taxpayers. The global scientific and business communities were also interested parties in the outcome of this project. The stakes were very high and the informational needs of many communities were neither planned for during the development phase, nor adequately addressed during the implementation phase of the SSC project. The SSC project managers had little or no project management experience and were more focused on producing good science rather than practicing world-class project management. The SSC project managers could have better promoted and defended the SSC project had they done a more thorough job of anticipating, planning, and implementing a communications plan to meet the myriad of communication needs of the project. Project status information and project performance reporting required an effective CSCS to be implemented, as is routinely done with other DOE projects, but this was not done. Failing to plan for the project's communication needs was a recipe for disaster.

The DOE selected the project manager based on expertise in high-energy physics research. Thus, the URA team was selected to manage the project. This management team was given total control of all aspects of the project. The reporting relationship allowed the SSC director to report directly to the Secretary of the DOE, bypassing the organizational and informational processes of the DOE. The director set up a project management office at the Texas site to support the SSC project, and to manage the project as an integrated program.

However, the project management function was not established in a way to gain control of the project. The SSC project managers shunned the excellent project support structures and competencies within the DOE. The focus was placed on the science of the project rather than its management. Project management reviews and audits were ignored. Information distribution and performance reporting were not coordinated in a manner that would enhance the project's image outside of the scientific community. No attempt was made to manage stakeholder expectations.

The SSC project was taking shape as envisioned, and the dimensions of the project were in conformance with the theoretical model. The technical and construction challenges were being overcome. The configuration of the SSC project appeared to be on course. However, ineffective project management made configuration management ultimately moot.

Assessment and Analysis

1. Please complete your evaluation of project management during this phase, using the following grid:

   Rating Scale: 5–Excellent, 4–Very Good, 3–Good, 2–Poor, 1–Very Poor

Project Management Area	Development Phase
Scope Management	
Time Management	
Cost Management	
Quality Management	
Human Resource Management	
Communications Management	
Risk Management	
Procurement Management	
Integration Management	

2. Please highlight the major areas of strength in the management of this phase of the project:

3. Please highlight the major opportunities for improvement in the management of this phase of the project:

The Implementation Phase
During the implementation phase, scope management was critical and extremely complex. The major difficulty was that the expected outputs were not clearly defined in the inception and development phases, so comparing results based to the original RFP was difficult to do. The fact that only one of the 121 companies requesting copies of the RFP actually presented a proposal could be considered a good indicator that this RFP was not clearly prepared. This was one of the major deficiencies that hampered the SSC project from the very beginning.

In spite of all the difficulties, URA did a fairly good job in implementing the SSC project as far as its objectives were concerned. When the project was terminated in 1993, URA was managing the project with more than 7,000 full-time employees in 48 states involved in project construction, in addition to more than 1,000 scientists in the United States and another 1,000 scientists around the world who were developing experiments for the SSC project. Furthermore, more than 12,000 acres (4,856 hectares) of land had been acquired, more than 14 miles (22.5 km) of underground tunnel had been dug, and more than 7 million cubic yards (5.4 million cubic meters) of earth had been excavated (Willard, 1998).

Because of the unclear scope specification in the inception and development phases, changes in scope throughout the project were inevitable. This turned out to be very costly and ineffective. For instance, in the beginning, the SSC project was to have only one detector; this soon changed to two detectors. Because of high costs, the first detector was built and the decision to build the second was postponed. These decisions on scope changes without proper planning made the project more expensive and ineffective.

The original cost of the SSC project was estimated at US$4.4 billion, which later increased to US$5.9 billion, then to US$8.25 billion. As mentioned before, most of this escalation was due to scope changes. Furthermore, project cost was supposed to be sponsored by several international partners and not only the United States. The problem was that this international support never really occurred and the funding for the SSC project was basically drawn from U.S. taxpayers. This support had to be approved annually by the U.S. Congress, and SSC management could not really rely on long-term resources because budget approval was not certain.

Although international financial support never materialized, the SSC management was successful in obtaining necessary resources approved by the U.S. Congress. Due to strong political intervention, the resources were not properly allocated to the project throughout the first years and comparisons to the baseline were not properly made because of the lack of effective cost control methods. Therefore, this made it hard for opponents of the SSC project to determine whether the project was within budget or not. The SSC project managers did not really consider the potential international partners when making strategic decisions. They expected to receive international resources, but from the beginning all the choices were made unilaterally. From the selection of the site, to the benefits of the outputs, and finally to the cancellation of the project altogether, the international partners were never heard. In other words, the international partners never had a say in the why, where, and when of the project (O'Leary, 1993), and it is no wonder that the resources expected to arise from them never really materialized.

As stated before, the contractual SOW required that the SSC project have a CSCS in place. Had this been done, the project team would have been able to better control the implementation of the project and defend the continuity of the SSC project. During the summer of 1993, a government audit was performed and highly publicized. Although numerous issues were found, the conclusion was that the SSC project was basically "on schedule and within budget" (Willard, 1998, p. 493). Apparently, the project was not as far behind schedule as some in the U.S. Congress insisted on saying. However, when no clear objective is stated, and there is a general lack of a proper control system, any conclusion can be drawn from the analyzed data. As stated by the popular saying, "When you don't know where you want to go, any road can lead you to your destination!"

Because of the lack of a proper CSCS, it was very difficult to define whether the project was fulfilling its objectives. This would have been important for the communication of the project's status and outputs, and would have helped the project management team take corrective and preventive actions when necessary. It was hard for URA to defend its position as the project manager, and to explain why this system was not in place. One could only imagine that this was either because of lack of project management competency, or a desire for not wanting to be controlled by the project's stakeholders. In that same investigation performed by DOE, the auditors harshly criticized URA for its lack of full commitment to openness and accountability.

When DOE solicited proposals, it received only one response, which came from URA. Throughout the implementation of the project URA was kept as the only prime contractor for the project and no attempt was made to change that situation until too late in the project. When the situation started to deteriorate, the associate director of energy research for DOE recommended that action should be taken and that DOE should take time to look for a new contractor in the project management area. As the sole contractor for managing the SSC project, URA did not appear to be fully suited for managing the project because they had very little experience in this type of construction business. DOE overlooked the problems that were constantly showing and did not worry about finding more specialized people to support the management of the project. It was only in August 1993 that the U.S. Secretary of Energy stated that DOE would restructure the entire SSC project and that URA would no longer be considered the prime contractor. DOE was to have two major contractors with complementary strengths—a "design/operate" contractor and a separate "execute/integrate" contractor. URA would be the "design/operate" contractor and would still be responsible for the scientific design and research, but the execution would then be transferred to another contractor. Unfortunately, these actions were taken way too late, and before DOE had a chance to implement any of these changes, the U.S. Congress voted for the termination of the project. DOE took corrective actions regarding its main contractor too late in the project. This was a crucial mistake because most of the problems regarding this project were related to its ineffective management. DOE learned the hard way that it is not sufficient to have good project content, but that this project had to be well managed to produce the expected results.

After identifying the risks in the beginning of the project, DOE could have developed mitigation plans to deal with those risks and the risk could be constantly checked to verify if the necessary corrective actions were in fact being taken. Because of the uncertainty of the project and the concentration on developing a completely new technology for the construction of the particle accelerator, the risks that would arise from such a project would be numerous and difficult to identify. This alone would have been enough reason for URA to develop a strong risk mitigation plan. It would have been fully expected several problems would arise throughout the implementation of the project and that URA would be prepared to deal with such problems. However, it seemed that the risks were identified and dealt with in a non-organized manner. In other words, when a problem happened, URA decided what to do to solve that problem in a reactive way. Some of the identified risks were properly dealt with and URA was able to continue the project, especially when the emerging problems were related to the scientific aspects of the project. Because URA did not implement a clear risk mitigation plan, several risks were ignored or overlooked until it was too late to take any corrective measure.

The SSC project was to be a landmark in the history of physics. It was supposed to provide answers to questions such as: How did matter form? How did matter acquire mass? Is there a force more fundamental than presently known? What will eventually happen to the universe? What is the most elementary element? (Willard, 1998). These alone were important questions to be answered by the project, had it been successfully completed. However, the impact on science was expected to be greater than finding answers to these questions, and would have produced important results for scientific research and for practical applications.

Although the SSC project was terminated before it could answer these questions, the accompanying scientific research led to various potential benefits in the fields of medicine, computing, electronics, and environmental science (SSCINFO, 1995). One notable benefit was the generation of accelerated-generated proton beams, which could be used in the treatment of certain types of cancer and other diseases. A plan to utilize the SSC project's assets after its termination called for the implementation of various projects, including the Texas Regional Medical Technology Center (RMTC). The RMTC was intended to be a state-of-the-art medical facility for providing proton cancer therapy. A conceptual design, cost estimate, summary schedule, and management plan were completed, and an environmental assessment was conducted (Sah, Cain, Cleveland, Saadatmand, Schulze, & Winje, 1995). However, the Texas Legislature decided in May 1995 not to support the RMTC or other prospective derivative projects (SSCINFO, 1995).

Another problem was that, although several potential benefits were realized from the applied research associated with the SSC project, those benefits were not effectively communicated to society, taxpayers and the U.S. Congress. It appeared that the project had no clear benefit and that nobody knew for what all that money was spent. Of course, the realized benefits were only side benefits and the main objective of the project was never achieved. Still, the realized benefits could have been better addressed and communicated to various stakeholders.

The management of the complete team of the SSC project turned out to be an extremely complex task. As previously stated, there were more than 7,000 full-time employees in 48 states involved in construction, more than 1,000 scientists in the United States and another 1,000 scientists around the world developing experiments for the SSC project. In a project of this magnitude, a complete human resource management system could have been introduced. Proper communications channels could have been developed to integrate team members and to facilitate their job performance. Aside from integration and communication, team members could follow clear management procedures to properly report the outcome of their work.

The people involved in the research for the SSC project were highly qualified scientists and URA itself was very qualified in high-energy physics research. Because of its previous experience in this type of research and its qualified scientists and staff, URA was able to produce results that continued to be implemented in several other applied research technologies. However, because several SSC managers, despite being excellent experimental scientists, had limited or no knowledge or experience in management, especially in the management of projects this size, teamwork and the relationship between SSC project managers and DOE quickly deteriorated. DOE was not receiving the expected reports and could not understand what was really happening in the labs where the project was being implemented. This relationship became so unbearable that URA project managers and DOE talked to each other only through written documents. This problem also affected the rest of the team bringing the morale to a very low point and the confidence in the existing management almost disappeared.

The communication process in a project of this magnitude is of extreme importance, especially given the strong political influences. There were too many parties interested in this project, which required that communications issues must be addressed, properly planned, and very carefully executed. Such a project must develop a communication process to address at least key stakeholders concerns including those of team members, upper management, government agencies, U.S. Congress, and the general public. Very little was accomplished in terms of communication process in the SSC project. This was probably one of the greater problems that URA faced, compromising the entire project and bringing it to an abrupt end. URA completely failed to communicate to society the benefits of the project and apparently was worried with only the implementation of the project as they felt it should be done. Further, the fact that the project was located in Texas brought challenges in the U.S. Congress. URA had to be prepared to defend the location choice to keep the support from Congress that they had received in the beginning. According to the *Congressional Quarterly*: “Support for the super collider was nearly unanimous in 1987 and 1988 before the Energy Department selected its location in Waxahachie, Texas. But now that construction is about to begin, it is increasingly seen as a costly project that largely benefits Texas” (Jeffreys, 1992).

The project management office implemented at URA would be responsible for the SSC project and would be responsible for providing the required information for the proper management of the project. Among other activities, the office could have implement a proper CSCS, provided proper management tools, standard forms and reporting procedures, supported and facilitated project meetings, and prepared project status reports. As previously mentioned, the SSC project had a unique management structure that gave its top managers direct access to DOE top management. With this privileged structure, URA was able to accomplish important activities, with full access to proper funds and flexibility in the management of the vast amounts of resources. That special management structure that gave the SSC management such a flexible environment with full access and authority over resources was also one of the major causes for its failure. Due to this extreme flexibility, the management of the SSC project did not feel required to follow standard DOE procedures or to implement a formal configuration change management system, thus bypassing critical project management requirements.

Assessment and Analysis

1. Please complete your evaluation of project management during this phase, using the following grid:

   Rating Scale: 5–Excellent, 4–Very Good, 3–Good, 2–Poor, 1–Very Poor

Project Management Area	Implementation Phase
Scope Management	
Time Management	
Cost Management	
Quality Management	
Human Resource Management	
Communications Management	
Risk Management	
Procurement Management	
Integration Management	

2. Please highlight the major areas of strength in the management of this phase of the project:

3. Please highlight the major opportunities for improvement in the management of this phase of the project:

The Closeout Phase

The closeout phase of the SSC project was not exactly a textbook process. Because the U.S. Congress ultimately cancelled the project with the Superconducting Super Collider Termination Act of 1993, the project was never completed. However, shutting down a project of the size of SSC was no small effort.

Because the project was being cancelled, scope management activities in the closeout phase focused on how to shut down the project in a way that would best salvage some positive results while minimizing additional cost. Congress provided US$640 million to remain available until expended for the orderly termination of the SSC project. The U.S. Congress stated the terms and conditions of the termination as follows (SSCNEWS, 1993):

(1) To the extent provided by guidelines of the Secretary of Energy, full-time employees of contractors and designated subcontractors whose employment is terminated by reason of the termination of the SSC may receive (A) up to 90 days termination pay dating from the date of termination notice, and (B) reasonable relocation expenses and assistance;

(2) The Secretary of Energy shall prepare and submit a report with the recommendations to the President and the Congress containing:

   (a) A plan to maximize the value of the investment that has been made in the project and minimizing the loss to the United States and involved states and persons, including recommendations as to the feasibility of utilizing SSC assets in whole or in part in pursuit of an international high energy physics endeavor;

   (b) The Secretary is authorized to consult with and use Universities Research Association and/or contractors and/or recognized experts in preparing this report and recommendations, and is authorized to contract with such parties as may be appropriate in carrying out such duties; and

   (c) The Secretary shall release any recommendations from time to time as available, but the final report shall be submitted by July 1, 1994.

The project team had a new focus, with tasks such as providing outplacement assistance, selling the project's assets, and ensuring that knowledge gained during the project was not lost. Obviously, the major shortcoming was the termination of the SSC project. This occurred despite the fact that a government audit done prior to the project's termination showed that the project was on schedule and within budget. In addition, at the time the project was terminated, there were no known technical roadblocks that would prevent the successful completion of the SSC project. From this information, a conclusion could be drawn that the termination of the SSC project resulted from project management failure, not from scientific or technological failures.

During closeout, several activities that are done in the closeout phase of a successful project also should have been done in the case of the terminated SSC project. Some of the information gathered at this stage may be useful in planning future projects. Cost performance and analysis, as well as contract reconciliation, were all necessary activities. One of the main reasons cited for the termination of the project was constantly rising cost estimates. As such, much cost analysis had been performed by internal and external organizations prior to the termination of the SSC project. It became apparent that several earlier cost projections for the SSC project were severely underestimated. There were several cost estimates published when the project was being considered for further funding in 1993. The DOE's office of SSC projected the cost of the SSC project to be US$8.25 billion. The DOE's Energy Research Review Committee projected the cost of the project to be US$8.4 billion. The DOE's HEPAP projected the cost of the project to be US$8.9 billion. The DOE's Independent Cost Estimate Group projected the cost of the project to be US$11.8 billion, including US$1.2 billion for detectors that were not included in the other estimates.

There are some possible explanations for the cost increases. One explanation could attribute these increases to issues and problems in the management of the SSC project (O'Leary, 1993). Another could be that the U.S. Congress consistently appropriated an amount less than that necessary for the efficient completion of the SSC project. Each time this was done, components of the project scheduled for the upcoming fiscal year had to be delayed, resulting in delays in the overall project schedule. This increase in the overall duration of the project increased the cost significantly. Prior to the termination of the project, more than US$1.7 billion had been spent during the four-year lifespan of the project. The work completed at the time of termination was estimated to represent approximately 20% of the total work of the SSC project.

Even the lowest cost estimate from those previously listed, US$8.25 billion, is more than 87% higher than the original cost estimate of US$4.4 billion for the project that was presented to the U.S. Congress in 1988. It is obvious that the cost of the project was severely underestimated. Though there are some explanations as to why this occurred, there are still many questions, and certainly no assurances that this situation will not occur again in future large-scale government projects.

Among the most useful activities during the closeout of the SSC project with respect to future projects were schedule analysis, and handover of technology and assets associated with the project. Analysis of the project schedule showed a correlation between the consistently lower funding levels and the overall project duration and cost. Because Congress consistently appropriated an amount less than necessary for the most efficient completion of the SSC project, several components of the project had to be delayed, resulting in delays to the overall project schedule, which generated significant cost increases, because even the day-to-day overhead of this project was massive. Unfortunately, although required by the original contract, there was no CSCS in place. At no time during the life of the project was there a way to fully measure whether cost and schedule objectives were being met.

Below are some of the recommendations by the Inspector General based on an investigation into the project (O'Leary, 1993). These recommendations may help future projects avoid the same pitfalls as the SSC project.

1. Require that the project director:
   a. Expedite the appointment of a permanent head of the procurement department;
   b. Emphasize continuity in assignments of procurement personnel so that the same buyer or subcontract administrator retains continuing responsibility for procurement actions throughout the life cycle of the subcontract;
   c. Establish a central point for control and oversight of contract audits;
   d. Implement controls to ensure that items to be purchased are needed and justified, and that items will not be purchased before they are needed;
   e. Provide budget distributions on a timely basis; and

f. Expedite full implementation of a cost and schedule control system.

2. Initiate a departmental rulemaking on the issue of what constitutes reasonable cost under contractual terms, including discretionary expenditures under any management allowance.
3. Establish policy and procedures for procurement actions that provide for:
   a. Cost/price reasonableness determinations;
   b. Limiting such actions to items not obtainable from private commercial cost;
   c. Fully justified actions appropriately documented;
   d. Standardized agreements outlining requirements such as SOWs, work breakdown structures and baseline accounting, invoicing, progress reporting disposition of equipment and materials, and overall responsibilities;
   e. Adequate equipment accountability controls;
   f. Adequate fund control, to include detailed invoices, cost performance reports, and uniform accounting procedures that provide an adequate audit trail for tracking purposes; and,
   g. Modifications to agreements that are fully described, justified, and documented.

The failure of the SSC project was at least partially responsible for the effort to reform U.S. scientific policy that occurred late in 1993. The President of the United States issued Executive Orders 12881 and 12882. Order 12881 created the National Science and Technology Council (NSTC). The NSTC was given Cabinet status and it overtook the function of the National Space Council, the National Critical Materials Council, and the Federal Coordinating Council. Order 12882 created the President's Committee of Advisors on Science and Technology. The purpose of the committee was to help the NSTC coordinate its relations with the private sector.

Many risks identified with the SSC project were considered to be technical in nature, which is logical, given the background of the project team. The technical risks that were identified were handled well by the project team. As noted, there were no known technical roadblocks that would have prevented the completion of the SSC project. However, there were other risks that were not recognized by the project team. Specifically, risks related to the overall cost of the project, as well as risks associated with the political nature and public image of the project, were not given proper consideration. Due to the lack of a CSCS, it is difficult to assess the impact of any problems that may have occurred during the project, and whether other significant risks were overlooked or ignored by the project team.

Since the SSC project did not reach a successful completion, the typical step of obtaining project acceptance during the closeout phase was not necessary. Some lessons-learned activities and project evaluations were possible. However, most of these activities took place in the months leading up to the termination of the project. The work completed prior to project termination was generally perceived to be of high quality. However, not much was done in the way of verifying the quality of the work completed, other than to evaluate project progress with respect to the schedule.

Teamwork in the closeout phase can be difficult in an unsuccessful project. Team members may be ready to transition to a new project, or may already be working on a new project. In the case of the SSC project, some team members were to stay behind to close down the project at termination. When the contract was awarded to URA in 1989, the team appeared to have all the necessary skills required by the SSC project. However, given the sudden end to the project, there were many disappointed and bitter project team members to deal with. Some members of the organization were designated to manage the termination process. The focus of the remaining organization was on new tasks such as outplacement assistance, selling projects assets, and ensuring that knowledge gained during the project was not lost. In general, the termination went about as smoothly as could be expected, given the circumstances.

Unfortunately, termination of the project led to a breakdown in communication. Although some avenues remained open, the trauma of the event itself made it difficult for the remaining organization to communicate effectively. Despite the obvious problems imposed by terminating a project before its successful completion, the remaining organization was able to communicate well enough to successfully perform the tasks of assisting employees with relocation and job search activities, dealing with the project's physical assets, and ensuring that knowledge gained during the project was preserved for others. It is disappointing that much of the information about the life of the project was not communicated because few formal records were kept. Communication of lessons learned and project evaluation information took place mostly prior to the termination event itself. There is no doubt that much was lost as project employees scattered to try to find new jobs and assignments.

The project was terminated. Therefore, project management had failed in its primary responsibility of implementing and executing the SSC project plan successfully. There was little left to do other than to try to assist in the management of the orderly termination of the project. Some of the assets of the SSC project did not go to waste. Some of the machinery left over from the SSC project was sold to interested companies. The Texas Land Office was successful in selling 2,044 acres (827 hectares) of SSC land for US$3.3 million. The remaining land was designated for residential use and released at the rate of 2,000 acres (809 hectares) per year to protect the local real estate market. Office supplies were donated to local schools, and the State of Texas bought 500 computers, albeit for about 25 cents on the dollar. Much of the furniture went to refugees, and the remaining equipment ended up at various universities or was purchased by salvage companies. Obviously, there was no way to recover anything more than a small percentage of the US$1.7 billion spent on the SSC project. Furthermore, the impact of the failure went beyond the SSC project itself, because it is likely that funding for future projects will be more difficult to obtain due to this highly visible failure.

Some of the valuable lessons learned from the SSC project go beyond the normal realm of project management. The U.S. government may have learned the importance of incorporating international funding and participation into "large-scale science and technology projects from the very beginning, when prospective partners still have a say in the why, where, when, and how such projects will be pursued." Another lesson deals with how to maintain national support for "a decision that has scientific and technical merit before and after the potential economic benefits for individual regions of the country are determined." Another lesson may address how to obtain public support for fundamental science projects. "The super collider never captured broad support from the American public, in no small part because its scientific promise was difficult to understand even by those who are scientifically literate" (O'Leary & Brown, 1993).

Obviously, the termination of the project meant that the project was not completed and, therefore, the project could not be completed to the customer's satisfaction. There has been much written on the failure of the SSC project since its termination in 1993. These writings and this case study should provide valuable insights into what went wrong during the SSC project, and should be useful in helping others to avoid similar problems in the future.

Assessment and Analysis

1. Please complete your evaluation of project management during this phase, using the following grid:

   Rating Scale: 5–Excellent, 4–Very Good, 3–Good, 2–Poor, 1–Very Poor

Project Management Area	**Closeout Phase**
Scope Management	
Time Management	
Cost Management	
Quality Management	
Human Resource Management	
Communications Management	
Risk Management	
Procurement Management	
Integration Management	

2. Please highlight the major areas of strength in the management of this phase of the project:

3. Please highlight the major opportunities for improvement in the management of this phase of the project:

Summary of Project Assessment and Analysis

1. Please complete your evaluation of project management for this project and calculate the average rating using the following grid:

   Rating Scale: 5–Excellent, 4–Very Good, 3–Good, 2–Poor, 1–Very Poor

Project Management Area	**Inception Phase**	**Development Phase**	**Implementation Phase**	**Closeout Phase**	**Average**
Scope Management					
Time Management					
Cost Management					
Quality Management					
Human Resource Management					
Communications Management					
Risk Management					
Procurement Management					
Integration Management					
Average					

2. Please highlight the major areas of strength in the management of this project:

3. Please highlight the major opportunities for improvement in the management of this project:

4. Please highlight the major project management lessons learned from this project:

References

Jeffreys, K. (1992). Super boondoggle: Time to pull the plug on the superconducting super collider. CATO Institute Briefing Papers. Retrieved on March 8, 2005 from http://www.cato.org/pubs/briefs/bp-016.html

O'Leary, H. R. (1993). Statement of Secretary of Energy Hazel R. O'Leary before the Subcommittee on Oversight and Investigations of the Committee on Energy and Commerce U.S. House of Representatives June 30, 1993. Retrieved on March 8, 2005 from http://www.hep.net/ssc/new/history/hepssc/oleary_06_30_93.html

O'Leary, H., & Brown Jr., G. E. (1993, December 10). The future of the Superconducting Super Collider. Retrieved on March 8, 2005 from http://www.lbl.gov/Science-Articles/Archive/ssc-and-future.html

Project Management Institute. (2004). *A guide to the project management body of knowledge* (3rd ed.). Newtown Square, PA: Author.

Sah, R., Cain, T. D., Cleveland, E. K., Saadatmand, K., Schulze, M. E., & Winje, R.A. (1995). Texas Regional Medical Technology Center. Retrieved on April 13, 2005 from http://epaper.kek.jp/p95/ARTICLES/FAG/FAG05.PDF

SSCINFO. (1995). The Superconducting Super Collider Project. Retrieved on March 8, 2005 from http://www.hep.net/ssc/

SSCNEWS. (1993, November). October on the hill: Beginning of the end. *SSC News: An electronic mail newsletter about the Superconducting Super Collider, 4*(11). Retrieved on March 8, 2005 from http://www.hep.net/ssc/new/history/sscnews/nov93

U.S. Department of Energy. (1994). HEPAP'S Subpanel on Vision for the Future of High-Energy Physics. Office of Energy Research, Division of High Energy Physics, Washington, DC. Retrieved on March 8, 2005 from http://www.hep.net/ssc/new/history/fullreport.html

Willard, P. E. (1998). The Demise of the Superconducting Supercollider: Strong politics or weak management? In D. I. Cleland, K. M. Bursic, R. Puerzer, & Y. A. Vlasak (Eds.), *Project Management Casebook* (pp. 493–503). Newtown Square, PA: Project Management Institute.

The following works, although not cited, were also consulted while preparing this document:

Roberts, M. J. (2001). *Developing a teaching case (Abridged).* Boston: Harvard Business School Publishing.

Swiercz, P. M. (2003). *SWIF learning: A guide to student written- instructor facilitated case writing,* unpublished manuscript, Washington, DC: The George Washington University.

Superconducting Super Collider Project

Teaching Note

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Superconducting Super Collider Project

Teaching Note

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This case study was adapted to make it a learning resource and might not reflect all historical facts related to this project.

Case Study

Superconducting Super Collider Project

Teaching Note

This case study is structured to allow the reader to evaluate the project management methods and processes used in this project. It covers a wide range of project management areas within four project phases: inception, development, implementation, and closeout. Discussion is provided within each project phase of specific activities, accomplishments, and performance shortcomings in applicable processes of the five Project Management Process Groups (Initiating, Planning, Executing, Monitoring and Controlling, and Closing). The reader is asked to perform an assessment of performance in terms of the appropriate processes of various Project Management Knowledge Areas at the end of each phase. At the end of the case, the reader is asked to summarize his or her assessments and to provide a list of lessons learned from the case study.

In this teaching note, the following is provided:

1. Assessment of appropriate project management processes in terms of the Project Management Knowledge Areas. Suggested assessments are provided for each phase, and an average is calculated for each Knowledge Area.
2. A discussion of major areas of strength, opportunities for improvement, and lessons learned from the evaluation of the case study.
3. A brief description of project life-cycle phases, Project Management Process Groups, and Project Management Knowledge Areas, based on *A Guide to the Project Management Body of Knowledge* (Project Management Institute, 2004).

It is expected that the reader will reach somewhat similar conclusions to those provided in this teaching note. However, it is very possible that readers may conduct additional research, develop further insights, and reach other conclusions.

Assessment of Project Management
The following table summarizes the assessment of appropriate project management processes, in terms of the nine Project Management Knowledge Areas, by phase:

Rating Scale: 5–Excellent, 4–Very Good, 3–Good, 2–Poor, 1–Very Poor

Project Management Area	**Inception Phase**	**Development Phase**	**Implementation Phase**	**Closeout Phase**	**Average**
Scope Management	2.00	2.00	3.00	2.00	2.25
Time Management	1.00	2.00	1.00	1.00	1.25
Cost Management	2.00	1.00	2.00	3.00	2.00
Quality Management	3.00	4.00	3.00	3.00	3.25
Human Resource Management	2.00	1.00	1.00	3.00	1.75
Communications Management	2.00	1.00	1.00	1.00	1.25
Risk Management	2.00	2.00	2.00	2.00	2.00
Procurement Management	3.00	1.00	1.00	3.00	2.00
Integration Management	2.00	2.00	2.00	1.00	1.75
Average	2.11	1.78	1.78	2.11	**1.94**

Major Areas of Strength, Opportunities for Improvement, and Lessons Learned
As noted in the table, several things went well with the SSC project, yet far more things went wrong. This case study illustrates many of the shortcomings of project management endeavors in the SSC project. From the early phases of the project, it was apparent that an effective project management methodology was not in place.

During the inception phase, the issuance of an RFP by the DOE may give the impression that the scope of the project was clearly defined. During the development phase, the case study indicated that little project management was effected. However, some areas such as quality management were performed better than other areas such as time management, human resource management, communications management, and procurement management. During the implementation phase, performance appeared to focus on scope management and quality management to satisfy the expectations of the research community, compared to less emphasis on time management, human resource management, and communications management. During the closeout phase, it becomes evident that project management practices were implemented too late in the project and as a result, proper project management methods were used to terminate the project.

There were some fluctuations in performance in project management areas; some going up while others going down during the four-year life of the SSC project. As the information provided in the case study is carefully analyzed, it becomes apparent that the SSC project performed comparatively well in quality management, but performance was seriously impaired in time management, communications management, human resource management, and integration management of various project management areas.

This project could be considered as an example of the benefits of effective project management and the perils of ignoring it. Of course, we cannot be sure that using proper project management methods would have kept the project running. However, more information would have been made available at earlier stages to assist in the congressional hearings that followed and in maintaining the health of the SSC project. Actions that could have been beneficial to the SSC project may have included developing and maintaining meaningful schedules, using a CSCS, implementing proper risk management, using effective project communications tools and a project management information system, careful configuration and change management, and comprehensive project integration management.

Further, the SSC project demonstrates that politics can play an enormous role in ventures of this scope, size, and cost. When the end result of the project is difficult-to-understand scientific research, public support could erode and politics could prevent the project from being completed. When economic benefits of such projects are concentrated in an individual region of the country, support in other regions may disappear. Failing to work internationally to obtain participation and additional funding resulted in fewer funds than anticipated. "This shortfall eroded congressional support, which made foreign involvement even less likely, accelerating the project's downward spiral" (O'Leary & Brown, 1993). Making unilateral decisions without discussions with the international science community provided telltale signs of doom for the SSC project.

Project Life-Cycle Phases, Project Management Process Groups, and Knowledge Areas

Project Life-Cycle Phases

Project managers or the organization can divide projects into phases to provide better management control with appropriate links to the ongoing operations of the performing organization. Collectively, these phases are known as the project life cycle. The project life cycle defines the phases that connect the beginning of a project to its end. Phases are generally sequential and are usually defined by some form of technical information transfer or technical component handoff. Although many project life cycles have similar phase names with similar deliverables, few life cycles are identical. Some can have four or five phases, but others may have nine or more (Project Management Institute, 2004, pp. 19–22). In this case study, the following phase descriptions are used:

Inception

This phase may also be called initiation, conception, or preparation. It deals with project proposal, selection, and initiation. It considers alignment of the project within the organization's overall strategy, architecture, and priorities. It explores linkages of the project to other projects, initiatives, and operations. It addresses methods of identification of the opportunity or definition of the problem leading to the need for the project, and clarification of the project's general premises and basic assumptions. It considers the project concept, feasibility issues, and possible alternative solutions.

Development

This phase may also be called detailed planning, definition and design, formulation, the formal approach, preliminary engineering, and preliminary design. It covers project organizing, planning, scheduling, estimating, and budgeting. It addresses development of plans for various project parameters, such as risk, quality, resources, and so forth, as well as plan audits (possibly pre-execution). It considers development of a project baseline and establishment of the detailed project work breakdown structure (WBS) and master plan. It discusses finalizing the project charter and obtaining approval to proceed with the project.

Execution

This phase may also be called implementation, implementing and controlling, adaptive implementation, and deployment. It examines directing, monitoring, forecasting, reporting, and controlling various project parameters, such as scope, time, cost, quality, risk, and resources. It considers appropriate methods for change management and configuration control in evolving conditions. It addresses resource assignment, problem solving, communications, leadership, and conflict resolution. It also looks at documentation, training, and planning for operations.

Closeout

This phase may also be called closing, termination, finish, conversion, cutover, conclusion, results, and final documentation. This last phase advises on finalizing and accepting the project, product, system, or facility. It addresses transferring the responsibility for operations, maintenance, and support to the appropriate organizational unit or individual. With reassignment or release of project resources, this phase considers closing and settling any open project items. It addresses post-project evaluation (audit), and preparation of lessons learned. It covers documentation of areas of strength and opportunities for improvement. It frames the development of recommendations to support success in future projects.

Project Management Process Groups

Project management is accomplished through processes, using project management knowledge, skills, and tools and techniques that receive inputs and generate outputs. These processes are divided into five groups, defined as the Project Management Process Groups: Initiating Process Group, Planning Process Group, Executing Process Group, Monitoring and Controlling Process Group, and Closing Process Group. Process Groups are seldom either discrete or one-time events; they are overlapping activities that occur at varying levels of intensity throughout the project. The Process Groups are not project phases. Where large or complex projects may be separated into distinct phases or subprojects, all of the Process Group processes would normally be repeated for each phase or subproject. The project manager and the project team are responsible for determining what processes from the Process Groups will be employed, by whom, and the degree of rigor that will be applied to the execution of those processes to achieve the desired project objective (Project Management Institute, 2004, pp. 37–67). In this case study, the Project Management Process Group processes are imbedded within each phase, as appropriate.

Project Management Knowledge Areas

The Project Management Knowledge Areas organize the project management processes from the Project Management Process Groups into nine Knowledge Areas. These areas are: Project Integration Management, Project Scope Management, Project Time Management, Project Cost Management, Project Quality Management, Project Human Resource Management, Project Communications Management, Project Risk Management, and Project Procurement Management (Project Management Institute, 2004, pp. 9–10). In this case study, the Project

Management Knowledge Areas are considered within each phase and are used for performance assessment, as appropriate.