

3-24-2016

Forensic Schedule Analysis of Construction Delay in Military Projects in the Middle East

James W. Forbes

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**FORENSIC SCHEDULE ANALYSIS OF CONSTRUCTION DELAY IN
MILITARY PROJECTS IN THE MIDDLE EAST**

THESIS

James W. Forbes, Captain, USAF
AFIT-ENV-MS-16-M-151

**DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY**

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AFIT-ENV-MS-16-M-151

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PROJECTS IN THE MIDDLE EAST

THESIS

Presented to the Faculty

Department of Systems Engineering and Management

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the
Degree of Master of Science in Engineering Management

James W. Forbes, BS

Captain, USAF

March 2016

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FORENSIC SCHEDULE ANALYSIS OF CONSTRUCTION DELAY IN MILITARY
PROJECTS IN THE MIDDLE EAST

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Abstract

This research performs forensic schedule analysis of delay factors that impacted recent large-scale military construction projects in the Middle East. The purpose of this study is to understand the most significant causes of project delay and how AFCEC might improve schedule management performance. The methodologies for analysis are adapted from the Professional Practice Guide to Forensic Schedule Analysis, particularly Method 3.7 Modeled/Additive/Multiple Base, or Time Impacted Analysis—Adjusted. The data is gathered from USACE and AFCEC, consisting of Primavera project schedules and project documents from the Resident Management System database. The project delays from two large-scale projects are apportioned as compensable, excusable, or non-excusable based on their liability and their impacts to the critical path. This investigation reveals that two particular delay factors are the most significant contributors to schedule overrun, accounting for 62% of the total delay. Obtaining building permits, an owner (government) responsibility, contributed to 38% of the delays. Design issues, consisting of change orders and submittal approvals, accounted for another 24% of the delays. In order to reduce schedule delay in future projects, several recommendations are provided that focus on various aspects of project management.

To those who protect and defend.

Acknowledgments

Any attempt to adequately describe how much support I received from my beautiful wife during this research effort seems almost trite. Not only did she encourage and motivate me during incessant study and writing sessions, she literally kept me alive with sustenance. Her true love was felt in every home-cooked meal and in every patient moment spent covering for me while raising our four lively children. She is an example of faith and fortitude—I cherish our future together.

Bless their little hearts, my kids tried to read this thesis. That is how much they love their dad.

To my parents, enormous gratitude for knowing the perfect balance in offering love, support, and shrewd guidance throughout my life. They are the wisest people I know.

To the lawyers and engineers in my life, thank you. Especially, Max, Josh, and Dad, I appreciate the proof-reads, suggestions, and edits.

Finally, to Major Hammond, my thesis advisor. I am forever indebted to your guidance in this effort. Your patience, expertise, and interest in this project provided the leadership I needed in order to get it done. You are an inspiration.

James W. Forbes

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FORENSIC SCHEDULE ANALYSIS OF CONSTRUCTION DELAY IN MILITARY PROJECTS IN THE MIDDLE EAST

I. Introduction

Background

Complex, large-scale construction projects frequently suffer from both schedule and cost overruns. Despite the vast resources of the Department of Defense, its Military Construction (MILCON) program—a critical support element to the United States’ national defense system—is not exempt from those challenges. In fact, executing projects in overseas or wartime environments typically amplifies construction complications, which results in wasted resources at best, or imperils missions at worst. The Department of Defense maintains a portfolio of over \$100 million per year in large-scale construction projects in the Middle East, most often utilizing the Air Force Civil Engineering Center (AFCEC) and the United States Corps of Engineers (USACE) as construction agents (Thibault, 2011). The stated mission of AFCEC includes providing support “that enables the warfighter,” which inherently includes the rapid delivery of construction requirements. Despite the withdrawal of US forces from Iraq in December, 2011, and the drawdown of forces from Afghanistan in 2014, the US continues to invest heavily in facilities and infrastructure at enduring military base locations throughout the Middle East. As the sponsor and recipient for this research, AFCEC wishes to better understand the causes of MILCON schedule overruns in order to benefit future projects, whether in that region or a different wartime location. To that end, this introduction discusses the background of the research problem, briefly considers existing research on

the subject, and then concludes with a brief overview of the scope and methodology for this thesis.

While common causes of construction delay have already been identified in academia, previous research efforts are typically limited to projects in individual countries or target specific project types. Very little research is available, at present, to shed light on the primary causes of US military construction delay in contingency environments. However, three recent studies have examined construction difficulties in the war-torn nations of Iraq and Afghanistan. The first study was sponsored by USACE and performed by Affleck et al. (2011), who determined the most frequent construction challenges by conducting surveys of construction personnel in Afghanistan. The second study was an Air Force Institute of Technology (AFIT) thesis by Jaskowiak (2012). She used quantitative data and personnel surveys in both Iraq and Afghanistan to research the relationship between project cost and schedule performance based on different contract types. The third study was an AFIT thesis by Hoff (2015) that both examined the primary factors that affect cost and schedule performance on projects completed in Afghanistan and examined the difference in outcomes based on contract types. The results of these three research projects provide important insight, but they fail to address several issues concerning the causes of MILCON delays and how to eliminate or reduce them. Consequently, this thesis seeks to build upon the three previous research efforts for a more in-depth schedule analysis of AFCEC construction projects in the Middle East.

Problem Statement

There are usually many root-causes that contribute to construction schedule overrun. However, there may also be predictive performance metrics, common delay factors, or proven management techniques that will help project managers predict, reduce, or eliminate delays. There is limited knowledge regarding these delay factors and measures for contingency construction projects. As such, the training framework and management toolbox made available to government project managers does not adequately equip them to successfully control project schedules.

Research Objectives

The objective of this thesis is to understand which factors are most significant in causing delay to recent large-scale AFCEC projects constructed in the Middle East. A literature review will reveal different types of project delay, predictive schedule performance factors, common causes of delay, and provide guidance on a variety of methods by which to analyze construction schedules. Accordingly, this thesis will seek to answer the following question:

Which factors are the most significant causes of schedule delay in large-scale AFCEC construction projects in the Middle East?

Scope and Methodology

This study will examine two large-scale construction projects at US bases in countries that make up the Gulf Cooperation Council (GCC), which are Saudi Arabia, Kuwait, Qatar, Bahrain, Oman, and the United Arab Emirates. These base locations are currently utilized as a network that provides both logistical and operational support to

full-fledged war campaigns, such as in Iraq and Afghanistan, as well as support to smaller conflicts and humanitarian missions in the Middle East region. Projects executed in these locations are federally funded and line-item approved for the exclusive use of the US government. This study will focus on projects that have been completed as of June, 2015 and look back at projects completed within the last ten years. Additionally, this study will examine projects that were managed in partnership by USACE and AFCEC, for which the primary customer is Air Force Central Command (AFCENT). The data for these projects is contained in the Resident Management System (RMS), a project management software program created and used by USACE. To aid in the data collection and analysis for this research, a memorandum of agreement for mutual support between USACE, AFCEC, AFCENT and AFIT was established.

A modern method of examining the intricacies of construction schedules was developed in 2007 in the form of a practitioner's guide titled, "Forensic Schedule Analysis" (Hoshino et al., 2007) and applied to this research. Two investigations were conducted for each project. The first step analyzed the schedule history of each project to gain a thorough understanding of the delays. The second step reviewed the daily construction reports for each project to identify all major deficiencies. The deficiency data was summarized and sorted into categories. The classification of data identified factor groups for schedule performance analysis. The primary method to categorize the causes of delay was excusability and compensability, which categorizes each delay event based on liability. After a review of literature in Chapter 2 to establish support for these techniques, an explanation of the methodology will be detailed in Chapter 3. In

Chapter 4, the appropriate analysis methods are applied to the selected construction projects. A review of the findings and a conclusion are presented in Chapter 5.

Significance

This research effort is action research in support of a current operational need. The body of knowledge within the field of construction schedule delay already contains several studies identifying the common causes of delay and the methods to accurately apportion those delays. This study is unique from previous research in two ways. First, it uses project records to identify specific causes of delay. While this method is not new, it differs from the norm of using survey instruments in academia. Second, no other study has applied forensic schedule analysis techniques to large-scale military construction projects overseas. Consequently, it provides a quantitative analysis at a deeper level than previously seen. The results provide government project managers an instrument by which to anticipate and decrease potential delays afflicting vital projects. Furthermore, this research aims to afford the government opportunities to achieve resource savings and improve delivery of support to the warfighter.

II. Literature Review

Project construction schedules are the primary instrument by which managers control and monitor progress and contract performance (Smith et al., 2009). When the Commission on Wartime Contracting published its report in 2011 about fraud, waste, and abuse in Iraq and Afghanistan, project schedule delay was faulted as a significant contributor to wasteful spending of US tax dollars (Thibault, 2011). A comprehensive investigation of existing literature identifies the most common and significant issues related to construction delay. The following literature review begins by considering construction contracts and schedules, along with the various types of delay. After defining delay, it continues with a discussion of schedule analysis methods available in industry. Next, this review looks at how academia uses models to predict schedule delay, before shifting to the key factors that scholars have determined are the most influential in delaying large-scale construction projects. It then concludes with a review of literature that focuses on the more specific subtopics of international construction projects and military construction delay.

Construction Contracts and Schedules

Large-scale construction projects are administered through contracts and schedules, whereby they legally formalize the relationship and requirements of all participants. The contract establishes responsibilities for each party, including what they agree to accomplish and when they shall begin and end. The terms of the contract are considered binding and provide for enforcement of legal protections. If a party fails to follow the agreement, it constitutes a breach of contract for which a variety of

mechanisms can be exercised to assure the right of other parties to be made whole. In construction, damages are typically direct or consequential and therefore compensatory in nature (Smith et al., 2009:462). In the event of project delay, liquidated damages are assessed to approximate a fair monetary value for the harm caused to the owner; if a contractor fails to finish a project by the agreed completion date, the owner is entitled to collect the liquidated damages. If there is sufficient reason to believe a contractor cannot complete a project on time, the owner may terminate the contract for default—typically an instrument of last resort.

While the start and end dates of a project are contractual, the rest of the details describing when each step of the project shall be completed are left to the contractor, as contained in a separate document—the project schedule. Modern project scheduling software provide users a wide range of management tools and the ability to include a variety of data, such as a list of milestones, activities, subactivities, resources, and the network of relationships between all of them. In order to expedite the construction process, many activities are performed simultaneously. Ultimately, one or more series of activities are designated as the critical path for a project and are used to determine the total duration of the project (Woolf, 2008). Construction contracts establish a period of performance, which is a number of calendar days provided for the contractor to complete the work described therein. The period of performance for a contractor is typically based on a project's total duration, determined by the sum of the durations of each activity that falls along the critical path, in addition to any extra time deliberately added to allow for flexibility and unavoidable delays. While a non-excusable delay to the final completion date is considered a breach of contract, and thereby results in post hoc damages, delays to

activities or milestones during the course of a project that are anticipated to affect the completion date might actually be mitigated later as the schedule progresses. Therefore, assessment of liquidated damages for construction delays is reserved until the end of a project, when the final count of delay days can be determined and liability can be adjudicated.

What Is Delay?

Due to the complex nature of construction projects, it is impossible to predict all factors that could potentially affect project schedules. There are few undertakings that require more resources, manpower, planning, and coordination than large-scale construction projects. As noted by the District of Columbia Court of Appeals, “except in the middle of a battlefield, nowhere must men coordinate the movement of other men and all materials in the midst of such chaos and with such limited certainty of present facts and future occurrences as in a huge construction project...” (Blake v. Coakley, 1981). When high costs of large projects and the reputations of organizations are added to the equation, the stakes are further raised and it is common for parties to blame each other for delays and seek recompense. It is easy to understand why the construction industry is so frequently an adversarial environment and its conflict resolution process is so often litigious (Thompson et al., 2000). Through the evolution of US construction law, three different types of construction delay have gained definitive significance in order to clearly assign fault and establish which parties shall bear the costs of the delay. The following types of delay are further explained below: 1) compensable; 2) excusable,

but not compensable; and 3) nonexcusable. Fundamentally, compensability is concerned with fiscal reparation, while excusability appertains to time extensions.

Compensable Delay

Compensable delays are caused solely by the owner, whether by negligence, omission, or purposeful acts. Any conduct by the owner which violates the strictures of the contract and forces additional costs upon the contractor or subcontractor should be borne by the owner (Dale & D’Onofrio, 2014:5). Fiscal compensation is the repayment of those costs to which the contractor is entitled. Compensable delay is inherently also excusable and thereby entitles the contractor to additional days to accomplish the work. Some examples of typical causes of compensable delay include defective drawings or specifications, improper site preparation, failure to provide access to the construction site, failure to supply materials, failure to approve submittals, failure to make timely progress payments, suspensions of work, and excessive change orders (Smith et al., 2009:284-288). When the owner is liable for delays and associated costs, the contractor is responsible for identifying and proving the claim in order to recover damages.

Excusable Delay

Excusable, but not compensable, delays are attributed to events beyond the control of either party and are thereby considered “no fault” or “shared fault” periods. These are often referred to as “force majeure” delays, as liability cannot be reasonably attributed to owners or contractors (Dale & D’Onofrio, 2014:8). The most common example of this type of delay is severe weather that prevents construction progress. In these situations, the contractor is granted additional days to accomplish the work,

equivalent to the amount of days delayed. The Federal Acquisition Regulation enumerates examples of excusable-but-noncompensable delays: acts of God or of the public enemy, acts of the Government, fires, floods, epidemics, quarantine restrictions, strikes, embargoes, and unusually severe weather (FAR 52.249-10). The common theme illustrated by those examples is that the event must be both unforeseeable and beyond the control of either party. However, the mere presence of harsh weather does not automatically guarantee the contractor will receive additional days to complete its work (Smith et al., 2009:290-291). Just as in the case of compensable delays, the burden of proof that a delay is excusable belongs to the contractor to establish when presenting its claim for additional days. Claims must therefore demonstrate how the actual weather exceeded the severity and probability of the expected weather (Finke, 1990). While creating initial construction schedules, contractors should incorporate an appropriate number of days to account for typical or average weather, at a minimum, anticipated for the region. Most other excusable-but-noncompensable delays are straightforward to establish as occurring without fault or negligence of the contractor.

Nonexcusable Delay

Nonexcusable delays are those for which the contractor bears sole responsibility, whether by faulty acts, negligence, or omission. Previous research has classified the main causes of nonexcusable delays into twelve groups: materials, labor, equipment, financial, improper planning, lack of control, subcontractor, poor coordination, inadequate supervision, improper construction methods, technical personnel shortages, and poor communication (Majid & McCaffer, 1998). For this type of delay, the

contractor is granted neither an extension of time nor additional funds. Conversely, nonexcusable delays generally trigger the owner's right to recover liquidated damages as set forth in the contract (Dale & D'Onofrio, 2014:14-15). It is the responsibility of owners to establish that a project is delayed, which is simply accomplished by showing that the contractor failed to complete the project by the contracted date. Subsequently, schedule delays are usually considered nonexcusable and the liability belongs to the contractor until proven otherwise by the contractor.

Concurrent Delay

In situations where a period of the project suffers delays that impact the critical path, which are caused simultaneously by both parties, the delay is considered concurrent. This is an analytical framework for liability apportionment used when there are overlapping time periods of both nonexcusable and compensable project delays. Concurrent delay can be difficult to assess when the periods of delay are offset or when the severity of the delay impacts the project differently (Smith et al., 2009:289). However, just as with all delay claims, modern techniques used to analyze project schedules have enabled adjudicating courts to discriminate more accurately between the portions of delay attributed to each party.

Schedule Analysis

Considering the vast number of participants and complex nature of the construction industry, it is unsurprising that a variety of schedule delay analysis methods have been developed to assist professionals in dissecting occurrences within projects. Because projects tend to differ greatly from one another, diverse techniques are used to

understand each project's schedule. Furthermore, while all users of delay analysis methodologies share a common goal to understand "what happened when" during the course of a project, their end-purposes for analysis may diverge, particularly between sides of an adversarial dispute. Unfortunately, the industry has become inundated with a surfeit of methods, with a particularly maligned naming convention. While some methodologies carry multiple names for the same technique, some names have taken on multiple meanings. In an effort to comprehensively identify, organize, describe, and compare the plethora of schedule delay analysis methods, the Association for the Advancement of Cost Engineering International (AACEI) published the Recommended Practice for Forensic Schedule Analysis (RP/FSA) in 2007 (Livengood, 2007). By instituting a new, singular, and clarifying vocabulary for the industry, experts successfully collaborated to eliminate confusion.

The RP/FSA is wholly devoted to retrospective schedule analysis, which is used to examine project schedules after delay events occur, as opposed to prospective schedule analysis, which happens real-time to estimate future events, such as in monthly updates (RP/FSA, 2007:11). Within the field of retrospective schedule analysis, the RP/FSA further utilizes four layers of hierarchical classification to establish a complete taxonomy of known schedule impact analysis methods. The authors explain that most methods are variations of two schools of analysis: observational, which examines actual events, such as the As-Planned vs. As-Built (APAB) method; and modeled, in which analysts will include or exclude events to create various simulations to compare, such as the Time Impact Analysis (TIA) method. The third taxonomy layer separates the field by specific methods. Observational methods can use static or dynamic logic, which entails either

constraining the schedule logic to the as-planned network, or incorporating the changes to the network logic made during the project life. Modeled methods can be additive or subtractive, meaning delays can be added to the baseline schedule or subtracted from a simulated as-built schedule (RP/FSA, 2007:13). The final two layers of the taxonomy address the differences in how the various methods are implemented, including analysis period lengths, contemporaneous updates, schedule recreation, and baselining. The organization is graphically depicted in Figure 1.

Taxonomy	RETROSPECTIVE												
	OBSERVATIONAL						MODELED						
	Static Logic			Dynamic Logic				Additive			Subtractive		
	3.1 Gross	3.2 Periodic		Contemporaneous Updates (3.3 As-Is or 3.4 Split)		3.5 Modified / Reconstructed Updates		3.6 Single Base		3.7 Multi Base ¹	3.8 Single Simulation		
		Fixed Periods	Variable Windows	All Periods	Grouped Periods	Fixed Periods	Variable Windows	Global Insertion	Stepped Insertion	Fixed Periods	Variable Windows or Grouped	Global Extraction	Stepped Extraction
Common Names	As-Planned vs As-Built	Window Analysis		Contemporaneous Period Analysis, Time Impact Analysis, Window Analysis	Contemporaneous Period Analysis, Time Impact Analysis, Window Analysis	Contemporaneous Period Analysis, Time Impact Analysis	Window Analysis, Time Impact Analysis	Impacted As Planned, What-If	Time Impact Analysis, Impacted As-Planned	Time Impact Analysis	Window Analysis, Impacted As-Planned	Collapsed As-Built	Time Impact Analysis, Collapsed As-Built

Figure 1 - Taxonomy of Forensic Schedule Analysis (RP/FSA, 2007)

In addition to classifying analysis methods, the RP/FSA compares and contrasts them, evaluating their associated strengths and weaknesses. Several factors are considered in the comparison, including project contractual requirements, purpose of the analysis, data availability and reliability, size or complexity of the dispute, time or budget available for evaluation, and even the level of expertise of either the analyst or audience. For example, Method 3.1 Observational/Static/Gross (APAB) might be the easiest to understand and most technically simple to perform, but it is not suitable for long or complex projects. On the other hand, Method 3.7 Modeled/Additive/Multiple Base

(TIA), which is commonly specified within government contracts, may be more accurate and intuitive for a complex project, but is perceived as a hypothetical model because it does not rely on an as-built schedule (RP/FSA, 2007:68). For projects that have reliable as-built schedules, Method 3.8 Modeled/Subtractive/Single Simulation, popularly known as Collapsed As-Built (CAB), may be preferred. In the CAB method, delay events are removed from the as-built schedule, which results in a model that shows what would have happened if it were not for the delay event. A critical advantage of this method is its executability, requiring only a moderate amount of effort while still providing significant and accurate results. Many of the other analysis methods require major efforts and thousands of hours of work; those are better suited for experts that have adequate staff to perform extensive support tasks, such as developing detailed daily as-built schedules (Livengood, 2008).

There is some disagreement within the literature concerning the benefits and drawbacks of various methods, which is at least partially caused by the mixing of methodology names. Lovejoy (2004) asserts that the Windows method, also known as the contemporaneous period analysis, is the most time consuming and costly to develop. However, her description of that method gravitates toward Method 3.7 in the RP/FSA due to its inclusion of modeling impacts after inserting delays into the nearest monthly schedule; the RP/FSA (2007:68) characterizes that method as quick and easy to implement. Several authors declare TIA as the preferred method of schedule analysis, using a definition that most closely resembles Method 3.7. Dale and D’Onofrio explain that TIA is preferred because it “chronologically and cumulatively evaluates project events utilizing the contemporaneous schedule updates and adjusts the completion date to

reflect as-built progress and any delays the same way a project is scheduled” (2014:285). However, Livengood (2006) insists that performing time impact analyses in hindsight is far less effective than performing an as-planned vs. as-built schedule delay analysis. In a separate look at Method 3.8 (CAB), Zack (1999) argues that the method is commonly used to support delay claims. Lovejoy agrees, but the RP/FSA (2007:76) explains that a disadvantage to Method 3.8 is that relatively few practitioners have significant, hands-on experience. Regardless, it is evident that the appropriate selection and application of analysis methods is highly dependent on a variety of circumstances and there is no better source that more comprehensively and procedurally guides the process than the RP/FSA.

All of these methods rely on underlying principles established in the critical path method (CPM). Traditionally, the critical path (or paths) of a project is defined as the chain of activities without any float; float is defined as the flexibility in scheduling an activity without it affecting other activities. But modern scheduling practices have found practical uses for including float even in critical paths (Van de Vonder et al., 2008). Therefore, the critical path is more accurately defined as the sequence of events that, should they be delayed, will delay the completion of the project. Thus, if an activity is delayed, and it does not impact the completion date of the project, that delay is not considered a schedule delay. The importance of CPM to the schedule analysis process was noted by the courts when the justices wrote: “The only way to accurately assess the effect of the delays alleged on the project’s progress is to contrast updated CPM schedules prepared immediately before and immediately after each purported delay” (Blinderman v. US, 1997).

It is important to note that consistent throughout the literature is an emphasis on the subjectivity of schedule analysis. “Forensic scheduling analysis, like many other technical fields, is both science and art. As such, it relies on professional judgment and expert opinion and usually requires many subjective decisions” (RP/FSA, 2007). The next section discusses the objective factors used to predict schedule performance before construction begins.

Predicting Schedule Performance

Many models have been developed to help predict schedule performance in construction projects. By identifying performance factors that cause delay before projects even begin, project managers may anticipate and prevent schedule overrun. Bromilow’s time-cost model—widely considered an industry standard—utilizes three cost factors to create an exponential regression model that predicts a project’s construction time (Bromilow, 1969). Hoffman et al. (2007) used Bromilow’s instrument on 856 US Air Force projects that spanned a 16-year period, demonstrating that the model explained 37% of the variability—a remarkably significant result considering the complexity and diversity of such projects. More intricate models that include various economic factors, such as interest rates and the contractor’s working capital and assets, can successfully predict schedule failure by using multivariate regression (Russel & Zhai, 1996). Both models demonstrate a strong correlation between schedule length and project cost; nevertheless, they rely heavily on final cost estimates, consequently utilizing uncertain factors to predict unknown schedules. To predict the final costs of projects, Thal et al. (2010) developed a multivariate regression model and determined that the

primary input variable is a normalized design length ratio, which is the duration of the design period divided by the design cost. However, that model's usefulness is limited to design-bid-build projects, in which the design phase is completed before construction begins; nearly all military construction projects in the Middle East currently operate on a design-build basis, in which the design and build phases are executed concurrently. Thus, in order to predict construction delay, those three models establish the relationship between project costs and schedules, thereby revealing a list of potential delay factors: project cost, customer's average time performance for a \$1 million project, interest rates, value of the work after construction, and assets and working capital of the contractor. From the perspective of a government project management team, the only factor from that list that offers any useful opportunity for consideration is the last, namely the assets and working capital of the contractor. While the other modeled factors are predetermined and cannot be influenced by the owner for a given project, the selection criteria of contractors may reasonably incorporate increased attention to their assets and working capital.

While those predictive models only expose one relevant delay factor for improving project schedule performance, other studies consider factors that project managers can influence more easily. Chan et al. (2002) published a study concerning the critical success factors in design-build projects, organizing the results into five categories: project management actions, project procedures (procurement and tendering), external environment, human-related factors, and project-related factors (size, type, complexity). All of these success factors can impact a project schedule, and the study clearly demonstrates the effect that project owners and managers have on schedule delay.

Additionally, Russell & Jaselskis (1992) successfully created a quantitative model to predict project failure, which they define as either budget or schedule overruns, by focusing on factors central to the relationships between contractors and project owners. Their results demonstrate the importance of contractor evaluation prior to award, cost monitoring by owner, and senior management support for contractors, in order to improve schedule performance. While acknowledging the inherent correlation between every project's schedule and cost, this thesis seeks to further explore the root-causes of project delay. Although many of the key factors in the aforementioned models overlap with factors of delay, they do not provide explanations or tools for project managers that will enable them to proactively reduce schedule overruns.

Common Delay Factors

An exhaustive review of literature related to construction delay shows general consensus among academics in the identification of common causes of delay, notwithstanding dissent in their prioritization. The following discussion of previous research illuminates the key factors already established in academia. Gonzales et al. (2014) employed qualitative research methods to explore causes of construction schedule delay within three particular projects. They concluded that four factors were the most problematic: planning, subcontracts, labor, and materials. Unlike the delay factors revealed by the predictive models that were discussed in the previous section, these factors are centered on contractor responsibilities. While that in-depth research is beneficial in its unique penetration into the complex minutiae that is typical of most large-scale construction projects, other studies use much larger sample sizes to reveal the

breadth of the issue. Majid & McCaffer (1998) did so with a meta-analysis using an Ishikawa fishbone diagram, but focused only on factors that contributed to non-excusable delay. They found that late delivery of materials or slow mobilization was the most significant factor leading to poor schedule performance of contractors. Coming in at a distant second and third, the next most significant factors in their aggregate rating were damaged materials and poor planning, respectively. Thus, material and planning were the main schedule delay causes.

Recognizing the dynamic nature of the construction industry, much of the research is scoped to determine the most significant causes of delay based on specific circumstances, such as geography, contract method, or project type. Naturally, large-scale construction projects can be influenced by variations in economics, politics, technology, and climates. Over the last several decades researchers across the globe have conducted studies that systematically examine the causes of construction delay within individual countries. The results from each of the ensuing studies, which use a variety of methodologies, establish a useful, industry-standardized foundation for determining the primary factors that cause schedule delay in typical construction projects. The following table has been adapted and expanded from a regional study performed by Sweis et al. (2008).

Table 1 – Summary of previous studies of major delay factors in construction projects

Country	Author(s)	Year	Major Causes of Delay
Egypt	Abd El-Razek et al.	2008	Contractor finances, progress payments, change orders, poor project management
Ghana	Frimpong et al.	2003	Progress payments, contractor management, material procurement, poor workmanship, price escalation
Hong Kong	Chan & Kumaraswamy	1996	Identifying risks, site conditions, decision-making, change orders, work variations
Indonesia	Kaming et al.	1997	Change orders, labor productivity, poor planning, material shortages
Iran	Afshari et al.	2010	Incompetent subcontractors, poor change management, no lessons learned, material delivery
Jordan	Al-Moumani	2000	Poor design, change orders, weather, differing site conditions, late deliveries
Jordan	Odeh & Battaineh	2002	Labor productivity, contractor experience, owner interference, progress payments
Jordan	Sweis et al.	2008	Contractor finances, change orders
Kuwait	Koushki et al.	2005	Change orders, owner financial constraints, owner experience
Lebanon	Mezher et al.	1998	Financial issues (according to owners), contractual relationships (according to contractors), project management (according to consultants)
Libya	Tumi et al.	2009	Poor planning, poor communication, change orders,
Malaysia	Sambasivan & Soon	2007	Poor planning, site management, contractor experience, owner finances, progress payments, material shortages, labor shortages
Nigeria	Mansfield et al.	1994	Financing and progress payments, poor contract management, differing site conditions, material availability, and improper planning
Saudi Arabia	Al-Ghafly	1995	Financial issues, change orders, owner decision-making, obtaining permits
Saudi Arabia	Assaf et al.	1995	Preparation and approval of drawings, progress payments, change orders, labor shortages, poor workmanship
Saudi Arabia	Al-Khal & Al-Ghafly	1999	Cash flow and financial issues, obtaining permits, lowest bid system
Saudi Arabia	Assaf & Al-Hejji	2006	Change orders, progress payments, poor planning, labor shortages, contractor financing
Thailand	Ogunlana et al.	1996	Industry infrastructure shortage, material availability, owner interference, incompetent contractors
United Arab Emirates	Faridi & El-Sayegh	2006	Preparation and approval of drawings, poor planning, owner decision-making, labor shortages, poor site management and supervision, low productivity
Vietnam	Long et al.	2004	Incompetent contractors, poor schedule estimates, poor schedule management, cultural and technical issues, site related issues, improper techniques and tools

The five most frequently repeated factors from Table 1 include: 1) design errors or change orders, 2) poor planning by contractors, 3) slow decision-making by owners, 4)

progress payments or other funding issues, and 5) labor shortages or workmanship. Except for progress payments, these five factors are relevant to large-scale US military projects and can be reasonably expected to occur in projects in GCC nations. Although adequate funds for progress payments are never an issue in government projects, delayed progress payments by the government can certainly affect contractors' finances. This is even more significant in contingency environments, particularly in circumstances where the US government deliberately seeks out small, local contractors in order to strategically stimulate the local economy as part of broader reconstruction efforts.

External Factors

While the previous section includes delay factors that are commonly found in research efforts from around the globe, this section concentrates on delay factors within projects that consist of parties from different countries and cultures. Most of the literature categorizes cultural differences as an external delay factor, along with weather and security. The list of the most significant or common factors affecting construction delay inevitably fluctuates in an overseas environment, particularly when there are significant cultural differences between project managers and contractors. For example, the successful collaboration between US project managers and local national contractors often hinges on factors such as the business environment and human behavior, according to a construction management literary review conducted by Xue, Shen, and Ren (2010). There is some existing research that explores impacts to project management when engaging in construction business in foreign countries. Chan (2004) mentions the influence of cultural effects in his comprehensive list of factors, but Kremers et al. (2010)

show that those cultural effects are magnified in wartime construction projects, particularly emphasizing a predictable surge of corruption and bribery.

Even in peacetime, cultural differences usually necessitate concessions from all parties involved in construction projects. Pheng and Yuquan (2002) examined the frequent interactions between Chinese and Singaporean construction businesses, noting the need for project schedule adjustments in order to account for cultural allowances. Likewise, Baba (1996) recounts the prevalence of management procedure variation between eastern and western countries. However, not all researchers agree on the significance of cultural impacts to project management. While acknowledging minor influences of cultural differences, including geographic considerations, many scholars contest that the primary factors leading to schedule overrun in foreign countries are the same ones paralleled everywhere, which are listed in Table 1 (Al-Momani, 2000; Assaf & Al-Hejji, 2006; Ibbs, 2012; Marzouk & El-Rasas, 2014). The study in Jordan by Odeh and Battaineh (2002) ranked external factors, including cultural differences, as the least significant for schedule delay causes. However, they attribute that result to the moderate climate and well-established regulations in Jordan, where all parties are familiar with the construction environment and can anticipate and mitigate any impacts. It is reasonable to expect that neither the climate nor regulations are as accommodating to project participants in contingency environments in the GCC.

Those studies provide an ample assessment of both the similarities and differences in the causes of construction delay in international construction projects. In summary, several researchers demonstrate that common delay factors are magnified when there are cultural differences between parties involved in international construction

projects. However, other studies minimize the significance of delay factors attributed to culture and location.

Military Construction

There is little existing research regarding the specific issues that affect military construction in the Middle East. However, there are three recent studies that analyze wartime construction challenges in Afghanistan. The first was sponsored by USACE and performed by Affleck et al. (2011) who surveyed construction personnel regarding the most prevalent challenges in project execution. In addition to the industry-established factors discussed previously, a few additional causes of construction delay that are unique to wartime scenarios were emphasized. Security problems such as materiel theft or attacks against work-sites, supply convoys, and even project personnel stand out as key differences. These factors are similar to issues cited by Enshassi (2009) in a study concerning construction delay affecting the Gaza Strip. Enshassi found that strikes, border closures, military attacks, material shortages and delivery delays were the most important factors. While many projects suffer from theft and vandalism in large construction projects in the US, it is rarely considered as significant industry-factor for delay (Berg et al., 2005). Moreover, in typical US projects, many contractors do not even claim losses due to theft or vandalism because the costs are below insurance deductibles (Hoff, 2015). In addition to security problems, many issues caused by general unfamiliarity with the physical environment and weather are exacerbated in wartime situations (Affleck et al., 2011).

The second recent study regarding wartime construction challenges is an AFIT thesis by Jaskowiak (2012) that analyzed USACE and AFCEC projects in Afghanistan to find key performance differences between various contracting methods. In it, she found that the contracting method for a project can affect the behavior of contractors, and may lead to variation in schedule performance (Jaskowiak, 2012). In the third study, Hoff (2015) honed in on the primary factors that affect cost and schedule performance on projects completed in Afghanistan and examined the difference in outcomes based on contract types. He found that project management factors are predictive of schedule delay, but external factors are not. However, Hoff's thesis focused on projects that were designed for the purpose of foreign nation-building, which is merely a tangential usage of military construction. The conventional purpose of military construction is for US government use only, and streams from a different funding source altogether. The significant differences between the intended purposes of the construction projects may affect design, funding, and contracting, so they may also reveal critical differences in project management factors that affect schedule overrun, as admitted by Hoff.

The results of those three recent research efforts on military projects provide important insight by identifying schedule delay factors common to the contingency environment, but they fail to address several issues concerning the causes of military construction delays or how to reduce them. Moreover, while previous studies have developed several useful, predictive models for project performance, and other research efforts have established comprehensive lists of delay factors through survey instruments, no studies have used project records to identify causes of delay, and then applied forensic schedule analysis techniques to quantify construction delay impacts to US military

projects overseas. Consequently, this thesis seeks to build upon the previous research efforts for a more in-depth analysis of AFCEC construction projects in the Middle East. Based on the literature review, several delay factors are expected to impact the projects selected for this research effort: design errors or change orders, poor planning by contractors, slow decision-making by owners, progress payments or other funding issues, labor shortages or workmanship, project management issues, and external environmental factors.

III. Methodology

Because schedule overrun is often associated with—if not the direct cause of—project cost overruns, several different delay analysis methods have been established in the construction industry. While each technique can be characterized by various strengths and weaknesses, they all attempt to identify and quantify delays by isolating problems that occurred during the life of a project. Many approaches are available, the most common of which rely heavily on meticulous investigations of project schedules, whether in their original, planned state before construction (as-planned) or in their actual, final state after construction (as-built).

As discussed in Chapter 2, a widely accepted, comprehensive taxonomy of all the different methodologies for forensic schedule analysis was established by a committee of recognized experts in the field of claims and dispute resolution (RP/FSA, 2007).

Subsequently, Lowe & Nagata (2008) affirmed that all of the approaches that might be considered appropriate for the analysis of schedules and delays are presented in the RP/FSA. They wrote: “given the thoroughness and objectivity of the process employed by the AACE International to develop the RP/FSA, this is believed to be a valid and easily defensible assumption” (Lowe & Nagata, 2008). After thorough review, the committee agreed that each available method was a variation of either one of two primary methods: 1) Time Impact Analysis (TIA), or 2) As-Planned vs. As-Built (APAB) (Livengood, 2007). In addition to defining the eight analysis methods, the RP/FSA provides significant discussion concerning the processes for reviewing project documentation and validating sources. Utilizing those principles and procedures, this thesis develops a supplemental method, Project Documentation Analysis, for analyzing

delay in projects that are lacking project schedules, but that still have other documents that sufficiently account for delay events. Essentially, this new method relies on the retrospective analysis of bilateral contract documents that explain delay apportionment, without the independent verification of project schedule review.

The data made available for this research precludes all analysis of any ongoing construction projects. However, because the accessible data consists of recently completed projects, it allows for retrospective analysis. Lovejoy (2004) asserts that “only after a project is substantially complete can a more detailed analysis of overall delays be effectively performed.” Considering the advantages and disadvantages of various methods presented in the RP/FSA, as well as the purpose of analysis and the nature of accessible data for this research effort, one particular method stands out: Method 3.7 Modeled/Additive/Multiple Base, popularly referred to as Time Impacted Analysis—Adjusted (TIA). The projects selected for analysis will be matched to the appropriate method after an initial review of documentation.

Method 3.7 Modeled/Additive/Multiple Base

For projects that have reliable monthly schedule updates, this research will utilize Method 3.7 Modeled/Additive/Multiple Base, or TIA. TIA does not require an as-built schedule. Instead, it relies on the work progress information provided in monthly or regular schedule updates. TIA is most often accepted as accurate for large, complex projects because of its consideration of the dynamic nature of the critical path.

Additionally, most government projects specifically require the TIA method for any contractor claims submitted to the government for consideration. Therefore, using the

same methodology for this research simplifies any potential comparisons to delay analyses performed by the contractor.

To begin the analysis, the project documentation is reviewed to understand the history and background of the scheduling issues. Understanding the original purpose and scope of the project creates the requisite paradigm for analysis. The next step is to identify project activities that impacted the final project completion date. These activities are considered to be parts of the critical path, and the complete sequence of these activities makeup the entirety of the critical path. They can be found within daily construction reports, material submittals, contractor invoices, government payment statements, contract modifications, and all other communication exchanges. The significant milestone dates are readily available in the RMS project file, while the critical path is made evident by examination of the project schedule within the Primavera scheduling software.

After reviewing the project documentation, the next step is to review the as-planned schedule in order to establish the baseline schedule against which delay impacts are measured. The original schedule logic and the activity durations require validation; therefore they are checked for reasonableness. Next, the delay events that were previously identified through examination of project documentation are listed, described, and then sequenced chronologically. At this point, the presumed liability for each event is noted in the description for the purpose of apportionment. As discussed in Chapter 2, if the delay event does not affect the completion date, it is not apportioned.

After defining the delay events, the next step in the TIA method is to create analysis periods or windows. Then, within those windows, the impact to the project's

forecasted completion date is measured in days. Each delay event is compared to its contemporaneous schedule update, which also contains the as-built progress of the project. Contemporaneous schedule updates are defined as the update that was completed just prior to the delay event. The end date of each analysis period is determined by identifying the beginning of each delay event and matching it to its contemporaneous schedule update. The beginning of each analysis period is determined by using the end date of the previous period, or in the case of the first analysis period, the beginning of the project.

After the windows of analysis are determined for each of the delay events, the first delay event is inserted into its analysis window to create a fragnet, or a sub-network, which is a new baseline for each window of analysis. Next, the delay event is modeled by establishing logical links to predecessor and successor activities. If the projected completion date is affected, the delay event is assessed for that window. Then, the type of delay is apportioned based on the liability for the event. Lastly, the number of days is determined by comparing the newly modeled completion date with the completion date from the contemporaneous schedule update.

For the second window of analysis, the steps are repeated for creating the new fragnet. If a contemporaneous schedule update is not available, a copy of the impacted schedule from the previous window is created, and then updated with work progress up to the end date of the analysis window. These steps are repeated until the last delay event is analyzed. A summary of the analysis of apportioned delay days is created in tabular format to easily synthesize the results.

Project Documentation Analysis

For some projects, the as-planned and as-built schedules may not be available to the researcher for review. Delay analysis may proceed if other project documentation sufficiently accounts for the entirety of the total delay period, which is determined from the difference between the planned, original contract completion date and the actual, final completion date. However, this method is not preferred because it limits the opportunities to independently validate and verify the accuracy of each delay impact on the critical path by utilizing methods established in the RP/FSA.

The first step of this method is a thorough review of project documentation. A review of the documents available in RMS provides the history and background of the schedule issues. Understanding the original purpose and scope of the project creates the requisite paradigm for analysis. The next step is to identify key sources of information that discuss project activities that impact the critical path and final completion date. The significant milestone dates are available in the RMS project file, along with comments regarding schedule changes entered into the system fields by the Project Manager.

Once the amount of delay is determined, accompanied by any notes input by government representatives, the project documentation review continues by examination of claims submitted by the contractor to the government for compensable delay. As previously discussed, the burden of proof for compensation in delay claims belongs to the contractor, after the government establishes the occurrence of delay.

Next, the validity of each claim by the contractor is analyzed using a review of project documentation within RMS to identify corroborating responses from the government. Communications and payment statements, which respond to contractor

claims and invoices, usually include details of government responses to the contractor claims.

Finally, the various sources of delay are listed, tabulated, and classified according to liability to complete the apportionment of delay for the project. The number of delay days that impact the final completion date and can be reasonably attributed to the government are subtotaled as compensable delay. The number of delay days that impact the final completion date and can be reasonably attributed to the contractor are subtotaled as non-excusable delay. Any number of delay days that impact the final completion date for which the contractor and the government are concurrently liable are subtotaled as excusable delay. Furthermore, any number of delay days that impact the final completion date but cannot be reasonably attributed to either party, are considered force majeure, and counted as excusable delay. The grand total of the apportioned delay days should be equivalent to the total delay period established in the first step. Any difference indicates unaccountable delay for the project.

The methods selected and crafted for this research effort are based on the RP/FSA, a comprehensive practitioner guide developed by industry experts. The preferred method for this research is Method 3.7 (TIA), which is widely accepted as the most accurate analysis instrument for large, complex construction projects due to its ability to handle float and the dynamic nature of the critical path. For projects that do not have sufficient project schedules, a Project Documentation Analysis is conducted, which relies on review of contract documents that bilaterally apportion delay.

IV. Analysis and Results

In this chapter, the methodologies described in the previous chapter were applied to two construction projects in order to determine the primary causes of schedule delay in large-scale US military projects in the GCC.

PROJECT 1 – Blatchford-Preston Complex, Phase 2

The first project selected for analysis was the construction of the Blatchford-Preston Complex (BPC), Phase 2, at Al Udeid Air Base, Qatar. Its identifiers included a Contract ID of N0001918, a Contract Number of W912ER-11-C-0001, and a Project Number of 320779. The project provided housing billets, or dormitory facilities, for US personnel assigned to Al Udeid Air Base. BPC Phase 2 cost \$60 million and was awarded on December 16, 2010 to the contractor Rizzani De Eccher (RdE). The Notice to Proceed was issued on January 24, 2011 with a 741 day Period of Performance and a contract completion date of February 3, 2013. However, execution of this project faced many difficulties throughout the duration, and substantial completion was not reached until December 30, 2014. The project suffered 695 days of delay, or 93.8% schedule growth. In addition to a nearly two-year delay, the project suffered significant cost growth of nearly \$10 million, or 20%. Due to those extreme results, the project was specifically requested for analysis by AFCEC at the onset of this research effort.

The first step of analysis was a thorough review of project documentation. A review of the documents available in RMS provided the history and background of the schedule issues. Understanding the original purpose and scope of the project created the requisite paradigm for analysis and aided in selection of the appropriate schedule analysis

method. As discussed in Chapters 2 and 3, proper method selection relies, in part, on what kind of project documentation is available. Additionally, the document review step enabled identification of key sources of project activities that impacted the final project completion date. The significant milestone dates were readily available in the RMS project file, while the critical path was made evident by examination of the project schedule in Primavera.

Based on several criteria, Method 3.7 Modeled/Additive/Multiple Base (TIA) was selected to use for analysis on the BPC project. First, Method 3.7 does not require an as-built schedule, which was not available for this project. Instead, it relies on the work progress information provided in monthly or regular schedule updates, of which this project had many. Next, the sponsor was interested in thorough, accurate analysis in order to better understand the root-cause of project delay. Method 3.7 is most often accepted as accurate for large, complex projects because of its consideration of the dynamic nature of the critical path. Additionally, the project's original contract specifically required the use of a "Windows Analysis" for any contractor claims submitted to the government for consideration. While many different delay analysis methods are referred to as "Windows," it was clear from the language within the various contractor claims that RdE assumed a methodology that conformed most closely to Method 3.7, and therefore presented much of its own schedule analysis in that format.

The next step was to review the as-planned schedule in order to establish the baseline against which to measure delay impacts. For this project, the original schedule logic was validated and the durations of activities found to be reasonable. Next, the delay events were identified through examination of project documentation. Below, Table 2

lists the delay events specifically described in the schedule updates, claims submitted by the contractor, and notes that the government entered into RMS.

Table 2 - Delay events in Project 1

	Delay Event
1	Additional Qatar Public Holidays (2012 & 2013 only)
2	Design Change – Fire Protection Strobe Lighting; New Requirement – Illuminated Notification Sign
3	Design Delay – Blast Resistance Windows, Doors & Louvers
4	New Requirement – Contractor to Provide Masonry Inspector
5	Site Access – Al Udeid Air Base Closure
6	Utility Delay – Power Upgrade Project (separate contractor)
7	Permit Delay (Part 1) – Issuance of Building Permit
8	Design Delay – Fire Sprinkler Systems Approval
9	Permit Delay (Part 2) – Issuance of Building Permit
10	Design Change – Fan Coil Unit

Delay Event Descriptions

The following descriptions of the delay events were found within the claim submissions provided by the contractor to the government on February 28, 2013. The events were then validated by reviewing comments by the government within RMS and the contracting officer’s response and payment certification.

1) Additional Qatar Public Holidays: Official authorities of Qatar declared in late 2011 that the 2nd Tuesday of every February would become a public holiday. Accordingly, 2 non-working days were added to the project schedule: February 14, 2012 and February 12, 2013. This event was beyond the control of either party, and therefore considered an excusable, non-compensable delay.

2) Design Change – Fire Protection Strobe Lighting; New Requirement – Illuminated Notification Sign: In March, 2012, the government made changes to the

design requirements of the fire protection strobe lighting, and added a requirement for illuminated notification signs. This event was caused by the government and classified as a compensable delay.

3) Design Delay – Blast Resistance Windows, Doors & Louvers: During April, 2012, the government failed to provide the specifications on-time required for the contractor design of blast resistant windows, doors, and louvres. This delay was caused by the government and classified as a compensable delay.

4) New Requirement – Contractor to Provide Masonry Inspector: In June, 2012, the government added a requirement for the contractor to provide a masonry inspector. This delay was caused by the government and classified as a compensable delay.

5) Site Access – Al Udeid Air Base Closure: In August, 2012, the contractor's access to the site was denied during a base closure event for 1 day. This delay was caused by the government and classified as a compensable delay.

6) Utility Delay – Power Upgrade Project: In October, 2012, progress on the project was halted due to its reliance on a separate project for upgraded incoming permanent power supply. The power project was contracted between the government and a separate contractor (QIT). RdE bore no responsibility for this delay, and the liability belonged to either the government or QIT, so it was therefore classified as a compensable delay.

7) Permit Delay (Part 1) – Issue of Building Permit: The government was obligated to obtain a building permit from Qatar authorities and provide to the contractor at the notice to proceed date of December 16, 2010. However, the contractor was able to continue work activities (at their own legal risk) without the permit, until it prevented

them from procuring electrical equipment. This delay event began to significantly impact project progress on October 1, 2012, and was partitioned into 2 analysis periods. This delay was caused by the government and classified as a compensable delay.

8) Design Delay – Fire Sprinkler Systems Approval: In January, 2013, the government issued a change order for the design of the fire sprinkler systems in the billets. This delay was caused by the government and classified as a compensable delay.

9) Permit Delay (Part 2) – Issue of Building Permit: The last schedule update included in the records made available to the researcher was dated December 31, 2012. However, it was clear from the contractor’s claim and government’s response that the permit delay continued at least until March 31, 2013. There were no further indications of delay during that period. Therefore the second part of the permit delay was also classified as compensable delay.

10) Design Change – Fan Coil Unit: Through examination of contractor claim submittals and modifications to the contract approved by the government, a design change made to the project in July, 2013 was discovered. Based on the acknowledgement from the government, this delay was classified as compensable delay.

Delay Analysis Periods

For the next step in the TIA method, each delay event was inserted into an analysis window. Then, within each window, the impact to the project’s forecasted completion date was measured in days. To create a fragnet (a sub-network, or new baseline for each period of analysis), each delay event was compared to its contemporaneous schedule update, which also contained the as-built progress of the

project. Below, Table 3 lists the delay events and their windows of analysis. The end date of each analysis period was determined by identifying the beginning of each delay event and matching it to the contemporaneous schedule update. The beginning of each analysis period was determined by using the end date of the previous period, or in the case of the first analysis period, the beginning of the project. This data was collected from the contractor’s project schedules, claim submissions, and government inputs to RMS.

Table 3 - Windows of analysis for delay events in Project 1

	Delay Event	Analysis Period
1	Additional Qatar Public Holidays (2012 & 2013 only)	16-Dec-10 to 31-Jan-12
2	Design Change – Fire Protection Strobe Lighting; New Requirement – Illuminated Notification Sign	31-Jan-12 to 29-Feb-12
3	Design Delay – Blast Resistance Windows, Doors & Louvers	29-Feb-12 to 31-Mar-12
4	New Requirement – Contractor to Provide Masonry Inspector	31-Mar-12 to 31-May-12
5	Site Access – Al Udeid Air Base Closure	31-May-12 to 31-Jul-12
6	Utility Delay – Power Upgrade Project (separate contractor)	31-Jul-12 to 30-Sep-12
7	Permit Delay (Part 1) – Issuance of Building Permit	31-Jul-12 to 31-Dec-12
8	Design Delay – Fire Sprinkler Systems Approval	30-Sep-12 to 31-Dec-12
9	Permit Delay (Part 2) – Issuance of Building Permit	31-Dec-12 to 31-Mar-13
10	Design Change – Fan Coil Unit	31-Mar-13 to 30-Dec-14

Window 1: New Qatar National Holidays

The closest schedule update to the first delay event was the monthly progress update developed by the contractor, dated January 31, 2012. This update was copied over as “BPC Window 1” and used to create a fragnet to demonstrate delay. In order to assess the effect of this delay event, the fragnet in Figure 2 was introduced into the schedule by inserting both new holidays as activities.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date
Blatchford Preston Complex Project - Window 1_Additional Qatar Public		1092		14-Feb-12	12-Feb-13
Rizzani De Eccher USA		1092		14-Feb-12	12-Feb-13
Project Milestones		1092		14-Feb-12	12-Feb-13
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ		1092		14-Feb-12	12-Feb-13
General Area		1092		14-Feb-12	12-Feb-13
CLIN0001-Mobilization and Demobilization		1092		14-Feb-12	12-Feb-13
Project Activity Summary		1092		14-Feb-12	12-Feb-13
No FOW		1092		14-Feb-12	12-Feb-13
Qatat Public Holidays		1092		14-Feb-12	12-Feb-13
BPC0071	Qatar National Sports Day (2012) on 14-Feb-12	0	0%	14-Feb-12*	
BPC0081	Qatar National Sports Day (2013) on 12-Feb-13	0	0%	12-Feb-13†	

Figure 2 - Window 1 fragnet for Project 1 shows the holidays on the bottom three rows

To measure the impact of the schedule changes in Window 1, before and after images of the final completion date were captured. The project completion date before impacts can be seen in Figure 3. The project expected completion date was February 3, 2013, which was the planned, original project completion date.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - January 2012 Update		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Rizzani De Eccher USA		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Milestones		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
General Area		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
CLIN0001-Mobilization and Demobilization		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Activity Summary		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
No FOW		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Key Dates		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Perm/SDCA	0	0%	31-Jan-12		16-Dec-10		42
BPC0050	Project Final Inspection	1	0%	29-Jan-13	29-Jan-13	13-Jan-13	13-Jan-13	2
BPC0060	Project Substantially Complete	1	0%	29-Jan-13	30-Jan-13	13-Jan-13	14-Jan-13	2
BPC0061	End Project Complete	0	0%		03-Feb-13*		03-Feb-13	0

Figure 3 – Project completion date before impact, based on the January, 2012 update

The next image displays the project completion date after computing the impacts of Window 1 delay events. As seen Figure 4, the impacted project completion date

remained the same due to previously existing, unnecessary float associated with the critical path activities. Therefore, the delay assessed to the project completion date in Window 1 was zero days.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - Window 1_Additional Qatar Public Holidays								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Rizzani De Eccher USA								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Milestones								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
General Area								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
CLIN0001-Mobilization and Demobilization								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Activity Summary								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
No FOW								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Key Dates								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Permit/SDCA	0	0%	31-Jan-12		16-Dec-10		42
BPC0050	Project Final Inspection	1	0%	29-Jan-13	29-Jan-13	13-Jan-13	13-Jan-13	2
BPC0060	Project Substantialy Complete	1	0%	29-Jan-13	30-Jan-13	13-Jan-13	14-Jan-13	2
BPC0061	End Project Complete	0	0%		03-Feb-13*		03-Feb-13	0
Qatad Public Holidays								
		0		14-Feb-12	14-Feb-12			0

Figure 4 – Project completion date after impacted by delay events in Window 1

Window 2: Design Change–Fire Protection Strobe Lighting, and New Requirement–Illuminated Notification Sign

To analyze delay in Window 2, the impacted schedule from Window 1 was copied over as “BPC Window 2” and used to create a fragnet to demonstrate delay. Next, Window 2 was updated according to the progress in the closest schedule update developed by the contractor, dated February 29, 2012. In order to assess the effect of this delay event, the fragnet in Figure 5 was introduced into the schedule by inserting the missing activity named “Strobe Lighting & Notification Signs” and establishing logical links.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Rizzani De Eccher USA		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Milestones		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
RDE USA - BLATCHFORD PRESTON COMPLEX (BPC) PROJ		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
General Area		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
CLIN0001-Mobilization and Demobilization		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Activity Summary		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
No FOW		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Key Dates		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Stat Public Holidays		0		14-Feb-12 A	14-Feb-12 A			
Strobe Lighting & Notification Signs		125		12-Mar-12	14-Aug-12	17-Mar-12	07-Jun-12	62
BPC0071	RdE sent an RFI no. 52 for the locations of Fire Alarm Strobes Lighting for the Mass Notification Strobes	0	0%	12-Mar-12*				0
BPC0121	RdE sent an RFI no. 57 for the Fire Alarm Strobe Lighting Spacing in the Warehouse	0	0%	12-Mar-12*				0
BPC0151	RdE sent an RFI no. 89 for RdE's DWGs & Specs dont require illuminated Signs to be provided	0	0%	07-Apr-12*				0
BPC0081	COE replied for RdE's RFI no. 52	0	0%	15-Apr-12*				0
BPC0131	COE replied for RdE's RFI no. 57	0	0%	15-Apr-12*				0
BPC0161	COE replied for RdE's RFI no. 89	0	0%	21-Apr-12*				0
BPC0211	RdE replied by letter ref. no. S-0095 for COE's reply of RFI no. 89	0	0%	25-Apr-12*				0
BPC0141	RdE replied by letter ref. no. S-0096 for COE's reply of RFI no. 57	0	0%	26-Apr-12*				0
BPC0091	RdE replied by letter ref. no. S-0100 for COE's reply of RFI no. 52	0	0%	29-Apr-12*				0
BPC12M1927	SUBM 28 31 76 P.Data Fire Alarm System Strobe Lighting	1	0%	16-May-12	16-May-12	17-Mar-12	18-Mar-12	62
BPC0201	COE's reply letter ref. no. CETAM-CD-D-0062 for all RdE's letters S-95, S-96, S-100	0	0%	16-May-12*				0
BPC12M1937	SUBM 28 31 76 P.Data Illuminated Notification Signs	1	0%	16-May-12	17-May-12	18-Mar-12	19-Mar-12	62
BPC9380	SHOP Draw 28 31 76 Fire Alarm System Strobe Lighting	12	0%	16-May-12	30-May-12	18-Mar-12	01-Apr-12	63
BPC9580	SHOP Draw 28 31 76 Illuminated Notifications Signs	12	0%	17-May-12	31-May-12	19-Mar-12	02-Apr-12	62
BPC12M3927	ACE Review Subm 28 31 76 P.Data Fire Alarm System Strobe Lighting	24	0%	30-May-12	27-Jun-12	01-Apr-12	01-May-12	63
BPC12M3937	ACE Review Subm 28 31 76 P.Data Illuminated Notification Signs	24	0%	31-May-12	28-Jun-12	02-Apr-12	01-May-12	62
BPC01390	PRC 28 31 76 Fire Alarm System Strobe Lighting	30	0%	27-Jun-12	09-Aug-12	01-May-12	05-Jun-12	63
BPC01400	PRC 28 31 76 Illuminated Notifications Signs	30	0%	28-Jun-12	12-Aug-12	02-May-12	05-Jun-12	62
BPC12210	DEL Fire Alarm System Strobe Lighting	2	0%	11-Aug-12	13-Aug-12	05-Jun-12	06-Jun-12	63
BPC12400	DEL Illuminated Notifications Signs	2	0%	12-Aug-12	14-Aug-12	06-Jun-12	07-Jun-12	62

Figure 5 - Window 2 fragnet shows the delay event inserted, along with its subactivities

To measure the impact of the schedule changes in Window 2, before and after images of the final completion date were captured. The project completion date before the new delay impacts can be seen in Figure 6. The project expected completion date was February 3, 2013, consistent with the completion date from the previous analysis window.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - February 2012 Update		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Rizzani De Eccher USA		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Milestones		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
RDE USA - BLATCHFORD PRESTON COMPLEX (BPC) PROJ		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
General Area		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
CLIN0001-Mobilization and Demobilization		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Activity Summary		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
No FOW		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Key Dates		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Permb/SDCA	0	0%	29-Feb-12				70
BPC0050	Project Final Inspection	1	0%	27-Jan-13	27-Jan-13	31-Jan-13	31-Jan-13	4
BPC0060	Project Substantiality Complete	1	0%	27-Jan-13	28-Jan-13	02-Feb-13	02-Feb-13	4
BPC0061	End Project Complete	0	0%		03-Feb-13*		03-Feb-13	0
Strobe Lighting & Notification Signs		125		12-Mar-12	14-Aug-12	17-Mar-12	07-Jun-12	62

Figure 6 - Project completion date before impact, based on the February, 2012 update

The next image, Figure 7, displays the project completion date after computing the impacts of Window 2 delay events. Although the subactivities such as submission of shop drawings, procurement, and delivery were delayed for two months, there was sufficient float in that path and the assessed delay for Window 2 was zero days.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - Window 2_ Strobe Lighting & Notification Signs								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Rizzani De Eccher USA								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Milestones								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
RFE USA - BLATCHFORD PRESTON COMPLEX (BPC) PROJ								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
General Area								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
CLIN0904-Mobilization and Demobilization								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Activity Summary								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
No FOW								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
Project Key Dates								
		756		16-Dec-10 A	03-Feb-13	16-Dec-10	03-Feb-13	0
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Permit/SDCA	0	0%	29-Feb-12		16-Dec-10		70
BPC0050	Project Final Inspection	1	0%	27-Jan-13	27-Jan-13	31-Jan-13	31-Jan-13	4
BPC0060	Project Substantially Complete	1	0%	27-Jan-13	28-Jan-13	02-Feb-13	02-Feb-13	4
BPC0061	End Project Complete	0	0%		03-Feb-13*		03-Feb-13	0
(Window 1)	Qatari Public Holidays	0		14-Feb-12 A	14-Feb-12 A			
(Window 2)	Strobe Lighting & Notification Signs	125		12-Mar-12	14-Aug-12	17-Mar-12	07-Jun-12	62

Figure 7 - Project completion date after impacted by delay events in Window 2

Window 3: Design Delay – Blast Resistance Windows, Doors & Louvers

To analyze delay in Window 3, the impacted schedule from Window 2 was copied over as “BPC Window 3” and used to create a fragnet to demonstrate delay. Next, Window 3 was updated according to the progress in the closest schedule update developed by the contractor, dated Mar 31, 2012. In order to assess the effect of this delay event, the fragnet in Figure 8 was introduced into the schedule by inserting the missing activity named “Blast Resistance Design for Windows, Doors and Louvers” (in black) and establishing logical links.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Project Activity Summary		147		01-Apr-12	04-Oct-12			-76
No FOW		147		01-Apr-12	04-Oct-12			-76
Blast Resistance Design for Windows, Doors and Louvers		147		01-Apr-12	04-Oct-12			-76
BPC0071	RdE raised RFI no. 83 for the Louver type 2	0	0%	01-Apr-12*				0
BPC0081	COE replied back to RdE's RFI no.83 "to comply with DoD requirements	0	0%	15-Apr-12*				0
BPC0091	RdE raised RFI no. 105 for the steel doors and frames	0	0%	22-Apr-12*				0
BPC0131	RdE requested the COE for standoff distance for design calculations_WPM 47	0	0%	24-Apr-12*				0
BPC0141	RdE requested the COE for standoff distance for design calculations_WPM 48	0	0%	01-May-12*				0
BPC0121	COE replied back to RdE's RFI no. 105 "Frames shall meet the UFC-4-010 req."	0	0%	02-May-12*				0
BPC0151	COE sent an e-mail to RdE asking to propose a solution for the product	0	0%	06-May-12*				0
BPC0161	RdE sent an RFI no.161 for reminding the COE of not allowing KTR to proceed with Calc.	0	0%	26-Sep-12*				-69
BPC0171	COE replied back to RdE RFI no. 161 "appl. explosive weights to be used with UFC 4-010-01"	0	0%	04-Oct-12*				-76

Activity ID	Activity Name	Driving	Relations	Lag	Remaining Duration	Early Start	Early Finish	Activity Status	ation % Complete	Total Float	Star
BPC0240	SUBM 08 11 13 P.Data Hollow Metal Doors - Rev 0	<input checked="" type="checkbox"/>	FS	0	0	04-Oct-12	04-Oct-12	Not Started	0%	-76	04-
BPC0250	SUBM 08 11 16 M.Instr. Aluminum Doors and Frames	<input type="checkbox"/>	FS	0	1	08-Oct-12	08-Oct-12	Not Started	0%	4	08-
BPC0260	SUBM 08 51 13 P.Data Aluminum Windows	<input type="checkbox"/>	FS	0	1	22-Oct-12	22-Oct-12	Not Started	0%	-49	22-
BPC0290	SUBM 08 91 00 P.Data Metal Wall Louvers	<input type="checkbox"/>	FS	0	0	23-Oct-12	23-Oct-12	Not Started	0%	-35	23-
BPC12M1750	SUBM 08 91 00 P.Sample Wall Louvers	<input type="checkbox"/>	FS	0	1	23-Oct-12	23-Oct-12	Not Started	0%	-10	23-
BPC12M1824	SUBM 08 11 13 P.Data Door Frames - Rev 0	<input checked="" type="checkbox"/>	FS	0	0	04-Oct-12	04-Oct-12	Not Started	0%	-76	04-
BPC12M1825	SUBM 08 11 13 P.Data Door Accessories - Rev 0	<input checked="" type="checkbox"/>	FS	0	0	04-Oct-12	04-Oct-12	Not Started	0%	-76	04-
BPC12M1854	SUBM 08 51 13 P.Sample Window Sample	<input type="checkbox"/>	FS	0	1	03-Nov-12	03-Nov-12	Not Started	0%	-49	03-

Figure 8 - Window 3 fragnet shows the delay event inserted with successor activities

To measure the impact of the schedule changes in Window 3, before and after images of the final completion date were captured. The project completion date before the new delay impacts can be seen in Figure 9. The project expected completion date was February 11, 2013, indicating 8 days of unexplained or otherwise non-excusable contractor delay when compared to the date from the previous window, February 3, 2013.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - March 2012 Update		765		16-Dec-10 A	11-Feb-13	16-Dec-10	03-Feb-13	-9
Rizzani De Eccher USA		765		16-Dec-10 A	11-Feb-13	16-Dec-10	03-Feb-13	-9
Project Milestones		765		16-Dec-10 A	11-Feb-13	16-Dec-10	03-Feb-13	-9
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ		765		16-Dec-10 A	11-Feb-13	16-Dec-10	03-Feb-13	-9
General Area		765		16-Dec-10 A	11-Feb-13	16-Dec-10	03-Feb-13	-9
CLIN0001-Mobilization and Demobilization		765		16-Dec-10 A	11-Feb-13	16-Dec-10	03-Feb-13	-9
Project Activity Summary		765		16-Dec-10 A	11-Feb-13	16-Dec-10	03-Feb-13	-9
No FOW		765		16-Dec-10 A	11-Feb-13	16-Dec-10	03-Feb-13	-9
Project Key Dates		765		16-Dec-10 A	11-Feb-13	16-Dec-10	03-Feb-13	-9
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Permit/SDCA	0	0%	31-Mar-12		16-Dec-10		-8
BPC0050	Project Final Inspection	1	0%	10-Feb-13	10-Feb-13	31-Jan-13	31-Jan-13	-8
BPC0060	Project Substantially Complete	1	0%	10-Feb-13	10-Feb-13	02-Feb-13	02-Feb-13	-8
BPC0061	End Project Complete	0	0%		11-Feb-13*		03-Feb-13	-8
Strobe Lighting & Notification Signs		137		12-Mar-12 A	16-Aug-12	17-Mar-12	07-Jun-12	78

Figure 9 - Project completion date before impact, based on the March, 2012 update

The next image displays the project completion date after computing the impacts of Window 3 delay events. As seen in Figure 10, the impacted project completion date was changed to May 2, 2013, demonstrating a total delay of 88 days, including the 8 days of unexplained or otherwise non-excusable delay found in Figure 9. This indicated 80 days of compensable delay in Window 3 due to the design delay caused by the government for the requirement to install blast resistant windows, doors, and louvers.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - Window 3_Blast Resistance Design for Win, [843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
Rizzani De Eccher USA		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
Project Milestones		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
General Area		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
CLIN0001-Mobilization and Demobilization		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
Project Activity Summary		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
No FOW		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
Project Key Dates		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Permit/SDCA	0	0%	31-Mar-12		16-Dec-10		-8
BPC0050	Project Final Inspection	1	0%	01-May-13	02-May-13	31-Jan-13	31-Jan-13	-76
BPC0060	Project Substantially Complete	1	0%	02-May-13	02-May-13	02-Feb-13	02-Feb-13	-76
BPC0061	End Project Complete	0	0%		02-May-13*		03-Feb-13	-76
Qatari Public Holidays		0		14-Feb-12 A	14-Feb-12 A			
Strobe Lighting & Notification Signs		137		12-Mar-12 A	16-Aug-12	17-Mar-12	07-Jun-12	78
Blast Resistance Design for Windows, Doors and Louvers		147		01-Apr-12	04-Oct-12			-76

Figure 10 - Project completion date after impacted by delay events in Window 3

Window 4: New Requirement – Contractor to Provide Masonry Inspector

To analyze delay in Window 4, the impacted schedule from Window 3 was copied over as “BPC Window 4” and used to create a fragnet to demonstrate delay. Next, Window 4 was updated according to the progress in the closest schedule update developed by the contractor, dated May 31, 2012. In order to assess the effect of this delay event, the fragnet shown in Figure 11 was introduced into the schedule by inserting the missing activity named “Masonry Inspector” (in black) and establishing logical links.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Project Milestones		32		19-Jun-12	31-Jul-12			-30
RDE USA - BLATCHFORD PRESTON COMPLEX (BPC) PROJ		32		19-Jun-12	31-Jul-12			-30
General Area		32		19-Jun-12	31-Jul-12			-30
CLIN0001-Mobilization and Demobilization		32		19-Jun-12	31-Jul-12			-30
Project Activity Summary		32		19-Jun-12	31-Jul-12			-30
No FOW		32		19-Jun-12	31-Jul-12			-30
Masonry Inspector		32		19-Jun-12	31-Jul-12			-30
BPC0091	COE instructed RdE to provide Masonry Inspector	0	0%	19-Jun-12*				0
BPC0081	RdE intended to proceed with the masonry mock up	0	0%	21-Jun-12*				0
BPC0121	RdE asked the COE to proceed with the mock up without hiring Masonry Inspector	0	0%	26-Jun-12*				-3
BPC0071	RdE intended to proceed with the masonry works Prep. meeting on	0	0%	27-Jun-12*				-4
BPC0141	RdE hired Masonry Inspector and approved by the COE	0	0%	01-Jul-12*				-7
BPC0131	COE informed RdE not to proceed with the masonry Prep. meeting without Inspector	0	0%	24-Jul-12*				-26
BPC0151	RdE's Masonry Inspector arrived to Site	0	0%	26-Jul-12*				-27
BPC0161	Masonry Works Prep. meeting took place	0	0%	31-Jul-12*				-30

Activity ID	Activity Name	Driving	Relations	Lag	Remaining Duration	Early Start	Early Finish	Activity Status	ation % Complete	Total Float	Star
BPC01R260	CS - STR Install Slip Dowels CMU Shear Walls 1st FL Qtr. B	<input checked="" type="checkbox"/>	FS	0	0	07-Jul-12	31-Jul-12	Not Started	0%	-5	07-Jul-12
BPC01R265	CS - STR Install Slip Dowels CMU Shear Walls 1st FL Qtr. C	<input type="checkbox"/>	FS	0	5	07-Aug-12	16-Aug-12	Not Started	0%	7	07-Aug-12
BPC01R270	CS - STR Install Slip Dowels CMU Shear Walls 1st FL Qtr. D	<input type="checkbox"/>	FS	0	5	07-Aug-12	16-Aug-12	Not Started	0%	7	07-Aug-12
BPC16182	PREP Preparatory CMU Openings	<input type="checkbox"/>	FS	0	1	29-Aug-12	29-Aug-12	Not Started	0%	-23	29-Aug-12
BPC16194	PREP Preparatory Exterior CMU Walls for Billets	<input type="checkbox"/>	FS	0	0	31-Jul-12	31-Jul-12	Not Started	0%	-30	31-Jul-12
BPC53224	CS - STR Install Slip Dowels CMU Shear Walls 1st FL Qtr. A	<input checked="" type="checkbox"/>	FS	0	0	31-Jul-12	31-Jul-12	Not Started	0%	-1	31-Jul-12
BPC53662	WB - PREP Preparatory CMU Walls / Damp proofing	<input type="checkbox"/>	FS	0	1	24-Nov-12	25-Nov-12	Not Started	0%	-42	24-Nov-12

Figure 11 - Window 4 fragnet shows the delay event inserted, with its successor activities

To measure the impact of the schedule changes in Window 4, before and after images of the final completion date were captured. The project completion date before the new delay impacts can be seen in Figure 12. The project expected completion date was April 15, 2013, indicating 17 days of acceleration when compared to the date from the previous window, May 2, 2013.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - May 2012 Update		826		16-Dec-10 A	15-Apr-13	16-Dec-10	03-Feb-13	-70
Rizzani De Eccher USA		826		16-Dec-10 A	15-Apr-13	16-Dec-10	03-Feb-13	-70
Project Milestones		826		16-Dec-10 A	15-Apr-13	16-Dec-10	03-Feb-13	-70
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ		826		16-Dec-10 A	15-Apr-13	16-Dec-10	03-Feb-13	-70
General Area		826		16-Dec-10 A	15-Apr-13	16-Dec-10	03-Feb-13	-70
CLIN0001-Mobilization and Demobilization		826		16-Dec-10 A	15-Apr-13	16-Dec-10	03-Feb-13	-70
Project Activity Summary		826		16-Dec-10 A	15-Apr-13	16-Dec-10	03-Feb-13	-70
No FOW		826		16-Dec-10 A	15-Apr-13	16-Dec-10	03-Feb-13	-70
Project Key Dates		826		16-Dec-10 A	15-Apr-13	16-Dec-10	03-Feb-13	-70
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Permit/SDCA	0	0%	31-May-12		16-Dec-10		-61
BPC0050	Project Final Inspection	1	0%	14-Apr-13	14-Apr-13	31-Jan-13	31-Jan-13	-61
BPC0060	Project Substantially Complete	1	0%	14-Apr-13	15-Apr-13	02-Feb-13	02-Feb-13	-61
BPC0061	End Project Complete	0	0%		15-Apr-13*		03-Feb-13	-61
Strobe Lighting & Notification Signs		186		12-Mar-12 A	17-Sep-12	17-Mar-12	07-Jun-12	47

Figure 12 - Project completion date before impact, based on the May, 2012 update

The next image, Figure 13 displays the project completion date after computing the impacts of Window 4 delay events. As seen below, the impacted project completion date was changed back to May 2, 2013. This signified that the government-caused delay in Window 4 only impacted the contractor's opportunity to accelerate progress, resulting in a compensable delay of 17 days.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - Window 4_Masonry Inspector		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
Rizzani De Eccher USA		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
Project Milestones		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
General Area		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
CLIN0001-Mobilization and Demobilization		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
Project Activity Summary		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
No FOW		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
Project Key Dates		843		16-Dec-10 A	02-May-13	16-Dec-10	03-Feb-13	-87
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Permit/SDCA	0	0%	31-May-12		16-Dec-10		-61
BPC0050	Project Final Inspection	1	0%	01-May-13	02-May-13	31-Jan-13	31-Jan-13	-76
BPC0060	Project Substantially Complete	1	0%	02-May-13	02-May-13	02-Feb-13	02-Feb-13	-76
BPC0061	End Project Complete	0	0%		02-May-13*		03-Feb-13	-76
Qatari Public Holidays		0		14-Feb-12 A	14-Feb-12 A			
Strobe Lighting & Notification Signs		287		12-Mar-12 A	30-Dec-12	17-Mar-12	07-Jun-12	-54
Blast Resistance Design for Windows, Doors and Louvers		95		01-Apr-12 A	04-Oct-12			-76
Masonry Inspector		32		19-Jun-12	31-Jul-12			-30

Figure 13 - Project completion date after impacted by delay events in Window 4

Window 5: Site Access – Al Udeid Air Base Closure

To analyze delay in Window 5, the impacted schedule from Window 4 was copied over as “BPC Window 5” and used to create a fragnet to demonstrate delay. Next, Window 5 was updated according to the progress in the closest schedule update developed by the contractor, dated July 31, 2012. In order to assess the effect of this delay event, the fragnet in Figure 14 was introduced into the schedule by inserting the missing activity named “Closure of Air Base” (in black).

Activity D	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
	Blatchford Preston Complex Project - Window 5_One Day Closure for the Air-Base	0		12-Aug-12	12-Aug-12			0
	Rizzani De Eccher USA	0		12-Aug-12	12-Aug-12			0
	Project Milestones	0		12-Aug-12	12-Aug-12			0
	RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ	0		12-Aug-12	12-Aug-12			0
	General Area	0		12-Aug-12	12-Aug-12			0
	CLIN0001-Mobilization and Demobilization	0		12-Aug-12	12-Aug-12			0
	Project Activity Summary	0		12-Aug-12	12-Aug-12			0
	No FOW	0		12-Aug-12	12-Aug-12			0
	Closure of the Air-Base	0		12-Aug-12	12-Aug-12			0
BPC0091	Closure of the Air-Base for one day (12-Aug-12)	0	0%	12-Aug-12*				0

Figure 14 - Window 5 fragnet shows the base closure event on the bottom two rows

To measure the impact of the schedule changes in Window 5, before and after images of the final completion date were captured. The project completion date before the new delay impacts can be seen in Figure 15. The project expected completion date was June 10, 2013, indicating 39 days of unexplained or otherwise non-excusable contractor delay when compared to the date from the previous window, May 2, 2013.

Activity D	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - July 2012 Update								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
Rizzani De Eccher USA								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
Project Milestones								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
General Area								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
CLIN0001-Mobilization and Demobilization								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
Project Activity Summary								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
No FOW								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
Project Key Dates								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Permit/SDCA	0	0%	31-Jul-12		16-Dec-10		-93
BPC0050	Project Final Inspection	1	0%	08-Jun-13	09-Jun-13	31-Jan-13	31-Jan-13	-108
BPC0060	Project Substantially Complete	1	0%	09-Jun-13	10-Jun-13	02-Feb-13	02-Feb-13	-108
BPC0061	End Project Complete	0	0%		10-Jun-13*		03-Feb-13	-108
122	Strobe Lighting & Notification Signs			12-Mar-12 A	04-Dec-12	17-Mar-12	07-Jun-12	-29

Figure 15 - Project completion date before impact, based on the July, 2012 update

The next image displays the project completion date after computing the impacts of Window 5 delay events. As seen in Figure 16, the impacted project completion date remained at June 10, 2013, the same date shown in the July 31, 2012 update (Figure 15). Therefore, the delay assessed to the project completion date in Window 5 remains as 39 days of non-excusable contractor delay.

Activity D	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - Window 5_One Day Closure for the Air-Base								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
Rizzani De Eccher USA								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
Project Milestones								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
General Area								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
CLIN0001-Mobilization and Demobilization								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
Project Activity Summary								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
No FOW								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
Project Key Dates								
881				16-Dec-10 A	10-Jun-13	16-Dec-10	03-Feb-13	-125
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Permit/SDCA	0	0%	31-Jul-12		16-Dec-10		-93
BPC0050	Project Final Inspection	1	0%	08-Jun-13	09-Jun-13	31-Jan-13	31-Jan-13	-108
BPC0060	Project Substantially Complete	1	0%	09-Jun-13	10-Jun-13	02-Feb-13	02-Feb-13	-108
BPC0061	End Project Complete	0	0%		10-Jun-13*		03-Feb-13	-108
189	Qatari Public Holidays			14-Feb-12 A	12-Feb-13			-9
122	Strobe Lighting & Notification Signs			12-Mar-12 A	04-Dec-12	17-Mar-12	07-Jun-12	-29
47	Blast Resistance Design for Windows, Doors and Louvers			01-Apr-12 A	04-Oct-12			-76
0	Masonry Inspector			19-Jun-12 A	31-Jul-12			-27
0	Closure of the Air-Base			12-Aug-12	12-Aug-12			0

Figure 16 - Project completion date after impacted by delay events in Window 5

Extension of Time Awarded

Due to the delay caused by the associated (but separately contracted) utility project to upgrade incoming power supply, the government awarded an extension of time for this project completion date. The period of performance was extended by 22 days, pushing the expected completion date back to July 2, 2013 (from June 10, 2013).

However, the duration of this extension was disputed by the contractor, RdE, who argued that the delay further impacted the schedule, beyond the granted extension. That claim is analyzed in Window 6. Based on the extension awarded by the government, 22 days of compensable delay were assessed in between Windows 5 and 6.

Window 6: Utility Delay – Power Upgrade Project

To analyze delay in Window 6, the impacted schedule from Window 5 was copied over as “BPC Window 6” and used to create a fragnet to demonstrate delay. Next, Window 6 was updated according to the progress in the closest schedule update developed by the contractor, dated September 30, 2012. In order to assess the effect of this delay event, the fragnet in Figure 17 was introduced into the schedule by inserting the missing activity named “QIT Additional Work” (in black) and establishing logical links.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - Window 6_QIT Add. Work								
		257		17-Oct-12	21-Aug-13			-171
Rizzani De Eccher USA								
		257		17-Oct-12	21-Aug-13			-171
Project Milestones								
		257		17-Oct-12	21-Aug-13			-171
RDE USA - BLATCHFORD PRESTON COMPLEX (BPC) PROJ								
		257		17-Oct-12	21-Aug-13			-171
General Area								
		257		17-Oct-12	21-Aug-13			-171
CLIN0001-Mobilization and Demobilization								
		257		17-Oct-12	21-Aug-13			-171
Project Activity Summary								
		257		17-Oct-12	21-Aug-13			-171
No FOW								
		257		17-Oct-12	21-Aug-13			-171
QIT Additional Work Delay Event								
		257		17-Oct-12	21-Aug-13			-171
BPC0071	Issuance of Change Order No.01 (QIT Add. Work)	0	0%	17-Oct-12*				-165
BPC0081	RdE received Change Order no.01 on	0	0%	22-Oct-12*				-169
BPC0171	Preparation of Sub-contract Agreement by RdE to QIT	13	0%	22-Oct-12	10-Nov-12			-169
BPC0201	Allowing Time for preparation of Agreement and negotiations bet. RdE & QIT	50	0%	22-Oct-12	24-Dec-12			-171
BPC0091	Sub-contract agreement sent by RdE to QIT on	0	0%	11-Nov-12*				-170
BPC0181	Preparation of Revised Sub-contract Agreement by RdE to QIT	11	0%	11-Nov-12	24-Nov-12			-170
BPC0121	Revised Sub-contract sent by RdE to QIT on	0	0%	25-Nov-12*				-171
BPC0191	Negotiations bet. RdE & QIT before signing the agreement	24	0%	25-Nov-12	24-Dec-12			-171
BPC0131	Sub-contract agreement signed by QIT on	0	0%	24-Dec-12*				-171
BPC0141	Installation of 11kV permanent power substation at the Subs. Warehouse	203	0%	24-Dec-12	21-Aug-13			-171
BPC0151	Repl. of transformers with new 1600 KV transformer incl. sec. cables_C09	203	0%	24-Dec-12	21-Aug-13			-171
BPC0161	Repl. of transformers with new 1600 KV transformer incl. sec. cables_C10	203	0%	24-Dec-12	21-Aug-13			-171

General	Status	Predecessors	Successors	Resources	Codes	Relationships	Notebook	Steps	Feedback	WPs & Docs	Expenses	Summary	
Activity	BPC0141	Installation of 11kV permanent power substation at the Subs. Warehouse										Project	BPC_Window 6
Activity ID	Activity Name	Driving	Relations	Lag	Remaining Duration	Early Start	Early Finish	Activity Status	ation % Complete	Total Float	St		
BPC12982	WB - Final inspection	<input checked="" type="checkbox"/>	FF	0	1	20-Aug-13	21-Aug-13	In Progress	0%	-171	01		

Figure 17 - Window 6 fragnet shows the delay event inserted, with its successor activities

To measure the impact of the schedule changes in Window 6, before and after images of the final completion date were captured. The project completion date before the new delay impacts can be seen in Figure 18. The project expected completion date was July 31, 2013, indicating 29 days of unexplained or otherwise non-excusable contractor delay when compared to the date from the previous window, July 2, 2013.

Activity D	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - September 2012 Update								
Rizzani De Eccher USA								
Project Milestones								
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ								
General Area								
CLIN0001-Mobilization and Demobilization								
Project Activity Summary								
No FOW								
Project Key Dates								
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Permit/SDCA	0	0%	01-Oct-12		16-Dec-10		-138
BPC0050	Project Final Inspection	1	0%	30-Jul-13	31-Jul-13	13-Jan-13	13-Jan-13	-153
BPC0060	Project Substantially Complete	1	0%	31-Jul-13	31-Jul-13	13-Jan-13	14-Jan-13	-153
BPC0061	End Project Complete	0	0%		31-Jul-13*		03-Feb-13	-153
Strobe Lighting & Notification Signs								
		103		12-Mar-12 A	15-Jan-13	17-Mar-12	07-Jun-12	-69

Figure 18 - Project completion date before impact, based on the September, 2012 update

The next image displays the project completion date after computing the impacts of Window 6 delay events. As seen in Figure 19, the impacted project completion date was changed to August 22, 2013, indicating 51 days of delay in Window 6, including the 29 days of unexplained or otherwise non-excusable delay, along with 22 days of compensable delay. These 22 days of delay should not be confused with the 22 days already granted as an extension by the government for the same delay event. Therefore, the 22 days granted should have been 44 days and the contractor was responsible for another 29 days of non-excusable delay.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - Window 6_QITAdd. Work								
		954		16-Dec-10 A	22-Aug-13	16-Dec-10	03-Feb-13	-198
Rizzani De Eccher USA								
		954		16-Dec-10 A	22-Aug-13	16-Dec-10	03-Feb-13	-198
Project Milestones								
		954		16-Dec-10 A	22-Aug-13	16-Dec-10	03-Feb-13	-198
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ								
General Area								
		954		16-Dec-10 A	22-Aug-13	16-Dec-10	03-Feb-13	-198
CLIN0001-Mobilization and Demobilization								
		954		16-Dec-10 A	22-Aug-13	16-Dec-10	03-Feb-13	-198
Project Activity Summary								
		954		16-Dec-10 A	22-Aug-13	16-Dec-10	03-Feb-13	-198
No FOW								
		954		16-Dec-10 A	22-Aug-13	16-Dec-10	03-Feb-13	-198
Project Key Dates								
		954		16-Dec-10 A	22-Aug-13	16-Dec-10	03-Feb-13	-198
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Permit/SDCA	0	0%	01-Oct-12		16-Dec-10		-138
BPC0050	Project Final Inspection	1	0%	20-Aug-13	21-Aug-13	13-Jan-13	13-Jan-13	-171
BPC0060	Project Substantially Complete	1	0%	21-Aug-13	22-Aug-13	13-Jan-13	14-Jan-13	-171
BPC0061	End Project Complete	0	0%		22-Aug-13*		03-Feb-13	-171
Qatar Public Holidays								
		405		14-Feb-12 A	12-Feb-13			-29
Strobe Lighting & Notification Signs								
		103		12-Mar-12 A	15-Jan-13	17-Mar-12	07-Jun-12	-69
Blast Resistance Design for Windows, Doors and Louvers								
		4		01-Apr-12 A	04-Oct-12			-76
Masonry Inspector								
		0		19-Jun-12 A	31-Jul-12 A			
Closure of the Air-Base								
		0		12-Aug-12 A	12-Aug-12 A			
QIT Additional Work Delay Event								
		257		17-Oct-12	21-Aug-13			-171

Figure 19 - Project completion date after impacted by delay events in Window 6

Window 7: Permit Delay (Part 1) – Issuance of Building Permit

The delay event in Window 7 overlapped with the delay event in Window 6. Therefore, the same schedule update developed by the contractor, dated September 30, 2012, was used to create a fragnet to demonstrate delay. In order to assess the effect of this delay event, the fragnet in Figure 20 was introduced into the schedule by inserting the missing activity named “Building Permit” (in black) and establishing logical links.

Activity ID	Activity Name	Original Duration	Activity % Complete	Early Start	Early Finish	Total Float
Blatchford Preston Complex Project - Window 7						
	Rizzani De Eccher USA	238		31-Dec-12	19-Oct-13	-268
	Project Milestones	238		31-Dec-12	19-Oct-13	-268
	RDE USA, BLATCHFORD PRESTON COMPLEX (BPC) PROJ	238		31-Dec-12	19-Oct-13	-268
	General Area	238		31-Dec-12	19-Oct-13	-268
	CLIN0004-Mobilization and Demobilization	238		31-Dec-12	19-Oct-13	-268
	Project Activity Summary	238		31-Dec-12	19-Oct-13	-268
	No FOW	238		31-Dec-12	19-Oct-13	-268
	(Window 7) Building Permit/SDCA Delay Event	238		31-Dec-12	19-Oct-13	-268
BPC0070	Delay in issuance of the Building Permit/SDCA	26	0%	31-Dec-12	30-Jan-13	-293
BPC0090	RdE is waiting for the Building Permit/SDCA	0	0%	31-Dec-12		-293
A1000	Submission of KAHRAMAA Electrical Design Drawings (Billets Buildings)	26	0%	31-Jan-13	03-Mar-13	-293
A1010	Submission of KAHRAMAA Electrical Design Drawings (Warehouse Building)	26	0%	31-Jan-13	03-Mar-13	-293
BPC0030	Issuance of Building Permit/SDCA (assumed)	0	0%	31-Jan-13		-293
A1020	Approval of Electrical Design Drawings by USACE/KAHRAMAA (Billets Buildings)	52	0%	04-Mar-13	02-May-13	-293
A1030	Approval of Electrical Design Drawings by USACE/KAHRAMAA (Warehouse Building)	52	0%	04-Mar-13	02-May-13	-293
A1040	Procurement of Major Electrical Long Lead Items approved by KAHRAMAA (Billets Buildings)	28	0%	04-May-13	04-Jun-13	-293
A1050	Procurement of Major Electrical Long Lead Items approved by KAHRAMAA (Warehouse Building)	28	0%	04-May-13	04-Jun-13	-293
BPC1410	Delivery of MV Panels for Billets Buildings approved by KAHRAMAA	96	0%	18-May-13	18-Sep-13	-293
BPC1490	Delivery of MV Panels for Warehouse Building approved by KAHRAMAA	96	0%	18-May-13	18-Sep-13	-268
BPC1500	Delivery of FDB for Warehouse Building approved by KAHRAMAA	96	0%	18-May-13	18-Sep-13	-268
BPC1530	Delivery of SMDB, DB for Billets Buildings approved by KAHRAMAA	96	0%	18-May-13	18-Sep-13	-293
BPC1540	Delivery of Generators approved by KAHRAMAA	84	0%	18-May-13	04-Sep-13	-281
BPC1560	Delivery of Interior & Exterior Lighting approved by KAHRAMAA	96	0%	18-May-13	18-Sep-13	-293
BPC1600	Delivery of Ceiling Fans approved by KAHRAMAA	84	0%	18-May-13	04-Sep-13	-281
BPC1610	Increase in construction activities duration due to change in sequence of work_Warehouse Building	26	0%	18-Sep-13	19-Oct-13	-268
BPC1620	Increase in construction activities duration due to change in sequence of work_C 9 Building	26	0%	18-Sep-13	19-Oct-13	-282
BPC1640	Increase in construction activities duration due to change in sequence of work_C 10 Building	26	0%	18-Sep-13	19-Oct-13	-293

Figure 20 - Window 7 fragnet shows the delay event inserted, along with its sub-activities

To measure the impact of the schedule changes in Window 7, before and after images of the final completion date were captured. The project completion date before the new delay impacts can be seen in Figure 21. The project expected completion date was July 31, 2013, indicating the same 29 days of unexplained or otherwise non-excusable contractor delay that were found in Window 6.

Activity D	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - September 2012 Update								
Rizzani De Eccher USA								
Project Milestones								
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ								
General Area								
CLIN0001-Mobilization and Demobilization								
Project Activity Summary								
No FOW								
Project Key Dates								
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0030	Issuance of Building Permit/SDCA	0	0%	01-Oct-12		16-Dec-10		-138
BPC0050	Project Final Inspection	1	0%	30-Jul-13	31-Jul-13	13-Jan-13	13-Jan-13	-153
BPC0060	Project Substantially Complete	1	0%	31-Jul-13	31-Jul-13	13-Jan-13	14-Jan-13	-153
BPC0061	End Project Complete	0	0%		31-Jul-13*		03-Feb-13	-153
Strobe Lighting & Notification Signs								
		103		12-Mar-12 A	15-Jan-13	17-Mar-12	07-Jun-12	-69

Figure 21 - Project completion date before impact, based on the September, 2012 update

The next image displays the project completion date after computing the impacts of Window 7 delay events. As seen in Figure 22, the impacted project completion date was changed to January 25, 2014, indicating 207 days of delay in Window 7, including the 29 days of unexplained or otherwise non-excusable delay already apportioned in Window 6, along with 178 days of compensable delay. Because the compensable delays in Windows 6 and 7 were concurrent, only the delays found in Window 7 were assessed.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - Window 7								
	Rizzani De Eccher USA	1110		16-Dec-10 A	25-Jan-14	16-Dec-10	03-Feb-13	-354
	Project Milestones	1110		16-Dec-10 A	25-Jan-14	16-Dec-10	03-Feb-13	-354
	RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ	1110		16-Dec-10 A	25-Jan-14	16-Dec-10	03-Feb-13	-354
	General Area	1110		16-Dec-10 A	25-Jan-14	16-Dec-10	03-Feb-13	-354
	CLIN0001-Mobilization and Demobilization	1110		16-Dec-10 A	25-Jan-14	16-Dec-10	03-Feb-13	-354
	Project Activity Summary	1110		16-Dec-10 A	25-Jan-14	16-Dec-10	03-Feb-13	-354
	No FOW	1110		16-Dec-10 A	25-Jan-14	16-Dec-10	03-Feb-13	-354
	Project Key Dates	1110		16-Dec-10 A	25-Jan-14	16-Dec-10	03-Feb-13	-354
	BPC0020 NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
	BPC0040 Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
	BPC0050 Project Final Inspection	1	0%	18-Jan-14	19-Jan-14	13-Jan-13	13-Jan-13	-290
	BPC0060 Project Substantially Complete	1	0%	23-Jan-14	25-Jan-14	13-Jan-13	14-Jan-13	-294
	BPC0061 End Project Complete	0	0%		25-Jan-14*		03-Feb-13	-294
	(Window 1) Qatari Public Holidays	1093		14-Feb-12 A	12-Feb-13			-29
	(Window 2) Strobe Lighting & Notification Signs	95		12-Mar-12 A	09-Apr-13	17-Mar-12	07-Jun-12	-149
	(Window 3) Blast Resistance Design for Windows, Doors and Louvers	77		01-Apr-12 A	04-Oct-12 A			
	(Window 4) Masonary Inspector	0		19-Jun-12 A	31-Jul-12 A			
	(Window 5) Closure of the Air-Base	0		12-Aug-12 A	12-Aug-12 A			
	(Window 6) QIT Additional Work Delay Event	262		17-Oct-12 A	08-Sep-13			-176
	(Window 7) Building Permit/SDCA Delay Event	238		31-Dec-12	19-Oct-13	16-Dec-10	23-Apr-11	-268

Figure 22 - Project completion date after impacted by delay events in Window 7

Window 8: Design Delay – Fire Sprinkler Systems Approval

To analyze delay in Window 8, the impacted schedule from Window 7 was copied over as “BPC Window 8” and used to create a fragnet to demonstrate delay. Next, Window 8 was updated according to the progress in the closest schedule update developed by the contractor, dated December 31, 2012. In order to assess the effect of this delay event, the fragnet in Figure 23 was introduced into the schedule by inserting the missing activity named “Fire Sprinkler System” (in black) and establishing logical links.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - Window 8_Fire Sprinkler System		134		31-Dec-12	06-Jun-13			-170
- Rizzani De Echer USA		134		31-Dec-12	06-Jun-13			-170
- Project Milestones		134		31-Dec-12	06-Jun-13			-170
- RDE USA - BLATCHFORD PRESTON COMPLEX (BPC) PROJ		134		31-Dec-12	06-Jun-13			-170
- General Area		134		31-Dec-12	06-Jun-13			-170
- CLIN0001-Mobilization and Demobilization		134		31-Dec-12	06-Jun-13			-170
- Project Activity Summary		134		31-Dec-12	06-Jun-13			-170
- No ROW		134		31-Dec-12	06-Jun-13			-170
- (Window 8) Fire Sprinkler System		134		31-Dec-12	06-Jun-13			-170
BPC0341	Issuance of Change Order for Fire Sprinkler System_Billets Buildings	0	0%	31-Dec-12				-234
BPC0351	Submission of Shop Drawing for Fire Sprinkler System_Billets Buildings	6	0%	31-Dec-12	07-Jan-13			-234
BPC0391	Issuance of Change Order for Fire Sprinkler System_Warehouse Building	0	0%	31-Dec-12				-170
BPC0401	Submission of Shop Drawing for Fire Sprinkler System_Warehouse Building	6	0%	31-Dec-12	07-Jan-13			-170
BPC0361	Submission of Fire Sprinkler System Materials_Billets Buildings	6	0%	08-Jan-13	14-Jan-13			-234
BPC0411	Approval of Shop Drawings for Fire Sprinkler System by COE_Warehouse Building	26	0%	08-Jan-13	06-Feb-13			-164
BPC0421	Submission of Fire Sprinkler System Materials_Warehouse Building	6	0%	08-Jan-13	14-Jan-13			-170
BPC0431	Approval of Shop Drawings for Fire Sprinkler System by COE_Billets Buildings	26	0%	08-Jan-13	06-Feb-13			-228
BPC0371	Approval of Fire Sprinkler System Materials by COE_Billets Buildings	26	0%	15-Jan-13	14-Feb-13			-234
BPC0481	Approval of Fire Sprinkler System Materials by COE_Warehouse Building	26	0%	15-Jan-13	14-Feb-13			-170
BPC0381	Purchasing of Fire Sprinkler System Materials_Billets Buildings	96	0%	16-Feb-13	06-Jun-13			-234
BPC0471	Purchasing of Fire Sprinkler System Materials_Warehouse Building	96	0%	16-Feb-13	06-Jun-13			-170

Figure 23 - Window 8 fragnet shows the delay event inserted, along with its sub-activities

To measure the impact of the schedule changes in Window 8, before and after images of the final completion date were captured. The expected completion date before impacted by the delay event was January 25, 2014, which was the same date established in Window 7. Figure 24 displays the project completion date after computing the impacts of Window 8 delay events. Despite 30 days of delay to Fire Sprinkler System activities, the impacted project completion date remained as January 25, 2014. This indicated that there were no impacts to the project's critical path. Therefore, the delay assessed to the project completion date in Window 8 was zero days.

Activity ID	Activity Name	Original Duration	Activity % Complete	Impacted Start Date	Impacted Finish Date	BL Project Start	BL Project Finish	Total Float
Blatchford Preston Complex Project - Window 8_Fire Sprinkler System								
Rizzani De Eccher USA								
Project Milestones								
RDE USA , BLATCHFORD PRESTON COMPLEX (BPC) PROJ								
General Area								
CLIN0001-Mobilization and Demobilization								
Project Activity Summary								
No FOW								
Project Key Dates								
BPC0020	NTP Administration	0	100%	17-Dec-10 A		16-Dec-10		
BPC0040	Contract Award	0	100%	16-Dec-10 A		16-Dec-10		
BPC0050	Project Final Inspection	1	0%	18-Jan-14	19-Jan-14	13-Jan-13	13-Jan-13	-290
BPC0060	Project Substantially Complete	1	0%	23-Jan-14	25-Jan-14	13-Jan-13	14-Jan-13	-294
BPC0061	End Project Complete	0	0%		25-Jan-14*		03-Feb-13	-294
	(Window 1) Qatat Public Holidays	1093		14-Feb-12 A	12-Feb-13			-29
	(Window 2) Strobe Lighting & Notification Signs	95		12-Mar-12 A	09-Apr-13	17-Mar-12	07-Jun-12	-149
	(Window 3) Blast Resistance Design for Windows, Doors and Louvers	77		01-Apr-12 A	04-Oct-12 A			
	(Window 4) Masonary Inspector	0		19-Jun-12 A	31-Jul-12 A			
	(Window 5) Closure of the Air-Base	0		12-Aug-12 A	12-Aug-12 A			
	(Window 6) QIT Additional Work Delay Event	262		17-Oct-12 A	08-Sep-13			-176
	(Window 7) Building Permit/SDCA Delay Event	238		31-Dec-12	19-Oct-13	16-Dec-10	23-Apr-11	-268
	(Window 8) Fire Sprinkler System	134		31-Dec-12	06-Jun-13			-170

Figure 24 - Project completion date after impacted by delay events in Window 8

Window 9: Permit Delay (Part 2) – Issuance of Building Permit

The project expected completion date of January 25, 2014 was calculated in Window 7 based on a claim submission cutoff date of January 31, 2013 for issuance of the building permit. However, while the remaining documentation for the project was incomplete, it was clear from email exchanges between the contractor and government that the permit was issued no earlier than March 31, 2013. Furthermore, there was no indication from any available project documentation of any other sources of delay. Therefore, the expected completion date was delayed until March 25, 2014, and 59 days of compensable delay were assessed within Window 9.

Window 10: Design Change – Fan Coil Unit

Although no further project schedule updates were available for schedule analysis, other project documentation found in RMS provided additional details

concerning project delay events. On July 16, 2013, the contractor submitted claim 0151 to the government requesting an extension of 91 days to the Period of Performance, as well as additional funds (indicating a compensable delay), due a design change made by the government regarding the fan coil units. The government acknowledged the extension of time and a negotiated payment in the contract modification P00013, dated February 27, 2014. Therefore, 91 days of compensable delay were assessed within Window 10.

Summary of Delay Impacts

Table 4 shows the aggregated results from the analysis windows. The first two columns label the analysis periods. The third column shows the date from each event that was used in its respective window to run the fragnet in Primavera. The fourth column displays the Rolling Finish, which is the impacted project completion date from the preceding analysis window. The fifth column shows the expected completion date of the project based on the contemporaneous schedule update that includes as-built progress, but before consideration of any impacts from the delay event. The sixth column shows the delta, number of days between the Rolling Finish and the Date Before Impact. The Delta Before Impact will typically indicate unexplained delay or non-excusable delay, if a positive integer, or acceleration if a negative integer. The seventh column shows the expected completion date of the project based on the impacts of each delay event inserted into its respective fragnet. The final column shows the delta, number of days between the Date Before Impact and the Impacted Date. This number indicates the total number of delay days for the window. Note that Table 4 shows two values that are struck through in

Windows 6 and 8, representing delays that were apportioned, but later removed to prevent double-counting in Windows 7 and 9, respectively. Those delay days apportioned to Windows 6 and 8 were overcome by the delay events in Windows 7 and 9.

Table 4 – Summary of delay impacts for Project 1

Window	Delay Event	Data Date	Rolling Finish	Date Before Impact	Delta Before Impact	Impacted Date	Delta After Impact
1	Additional Qatar Public Holidays	31-Jan-12	3-Feb-13	3-Feb-13	0	3-Feb-13	0
2	Strobe Lighting; Notification Sign	29-Feb-12	3-Feb-13	3-Feb-13	0	3-Feb-13	0
3	Blast Resistance Windows, Doors	31-Mar-12	3-Feb-13	11-Feb-13	8	2-May-13	88
4	Provide Masonry Inspector	31-May-12	2-May-13	15-Apr-13	-17	2-May-13	0
5	Al Udeid Air Base Closure	31-Jul-12	2-May-13	10-Jun-13	39	10-Jun-13	39
	Time Extension		10-Jun-13	10-Jun-13	0	2-Jul-13	22
6	Power Upgrade Project	30-Sep-12	2-Jul-13	31-Jul-13	29 0	22-Aug-13	22 0
7	Permit Delay (Part 1)	31-Jan-13	2-Jul-13	31-Jul-13	29	25-Jan-14	207
8	Fire Sprinkler Systems	31-Dec-12	18-Nov-13	18-Nov-13	0	18-Dec-13	30 0
9	Permit Delay (Part 2)	31-Mar-13	25-Jan-14	25-Jan-14	0	25-Mar-14	59
10	Fan Coil Unit	27-Feb-14					91

Next, Table 5 shows the total number days of delay based on classification, as described in the previous sections. The total number of delay days was determined by subtracting the original contract completion date, February 3, 2013 from the actual substantial completion date of December 30, 2014. The number of unaccountable days was determined by subtracting the known subtotals of delay from the total number of delay days.

Table 5 – Summary of delay apportionment for Project 1

Type of Delay	Description	Number of Days
Compensable	Design Delay (Blast Doors)	80
	Design Change (Masonry Inspector)	17
	Other Project (Power Upgrade)	22
	Building Permit	237
	Design Change (Fan Coil Unit)	91
	Subtotal	447
Non-excusable	Window 3	8
	Window 5	39
	Window 7	29
	Subtotal	76
Excusable		0
Unaccountable	No documentation available	172
	TOTAL DELAY	695

PROJECT 2 – Replace Fuel Line

The second project selected for analysis was the replacement of a fuel line at Al Dhafra Air Base, United Arab Emirates (UAE). Its identifiers included a Contract Number of W912ER-09-C-0050, and a Project Number of 321566. The project replaced an existing, expeditionary fuel line with a new, permanent fuel line that connected Al Dhafra Air Base to an off-base fuel source. This project was awarded at \$5.6 million and began construction on July 20, 2009. 371 days were provided as a Period of Performance, with an original contract completion date of July 26, 2010. However, execution of this project suffered several delays, and the project was not completed until December 16, 2010. In total, the project suffered 143 days of delay, resulting in 38.5% schedule growth. In addition to the significant delay, the project suffered cost growth of nearly \$650 thousand, or 11%. Although there were relatively few projects to choose

from in the UAE that met the project selection criteria discussed in Chapter 1, this project was selected for analysis due to its significant schedule growth.

The first step of analysis was a thorough review of project documentation. A review of the documents available in RMS provided the history and background of the schedule issues. Understanding the original purpose and scope of the project created the requisite paradigm for analysis. Additionally, the document review step enabled identification of key sources of project activities that impacted the final project completion date. The significant milestone dates were readily available in the RMS project file. However, no project schedules were made available in Primavera.

Without an as-built or as-planned schedule for review, the Replace Fuel Line project was wholly analyzed using a review of project documentation within RMS to identify the various sources of delay. As such, the opportunities to independently validate and verify the accuracy of each delay impact by utilizing methods established in the RP/FSA were unavailable. However, unlike the BPC project analyzed as Project 1, the documentation for Project 2 allowed the researcher to account for the entirety of the 143 days of delay, and therefore complete the apportionment of delay for the project.

As previously discussed, the burden of proof for compensation in delay claims belongs to the contractor. Therefore, the project documentation review continued by examination of claims submitted by the contractor to the government for compensable delay. The contractor submitted three separate claims that requested compensation for a total of 107 days of delay. These claims were validated by the government through a negotiated settlement on January 7, 2011, which occurred three weeks after the project completed. In that negotiation, the contractor requested an extension of time to the

contract completion date, as well as additional funds as compensation for the delays caused by the government. However, while the government agreed to the extension of time for all of the delays claimed by the contractor, they were not all considered compensable. During the negotiation, the government showed that more than half of the delays were concurrent with delays caused by the contractor. Accordingly, the parties bilaterally apportioned the delays as compensable, excusable, or divided between the two categories. The following table lists the delay events, the number of compensable days claimed by the contractor, and then the apportionment of delay days between compensable and excusable categories, as agreed to by both parties.

Table 6 – Summary of delay impacts for Project 2

Delay Event	Original Claim	Compensable Delay	Excusable Delay
No Host Nation Agreement for construction	79 days	40 days	39 days
Badge Pass Processing	4 days		4 days
Gate Access Delays	3 days		3 days
Design Change – revised pipeline alignment	17 days	2 days	15 days
Ramadan Delays	4 days		4 days
Total	107 days	42 days	65 days

As seen in the table above, the contractor was able to prove that the government was liable for at least a portion of two delay events that impacted the critical path of the project. Typically, without the delay impact analysis, liability for four of those five delay events might be attributed to the government. The responsibility to obtain a Host Nation Agreement to proceed with construction always belongs to the government. However,

the government was able to prove that the contractor concurrently caused delay to the critical path during 39 of the 79 days of delay caused by that event, though the details of the contractor-caused delay were not specified. Likewise, liability for delays to the badging process and access to the site through the base gate were not discussed in great detail. While both processes are controlled by the government, the contractor should anticipate a reasonable amount of delay associated with those activities when creating the project schedule. Without explicit descriptions indicating whether those “site access” delays were extraordinary, it was reasonable for the government to consider those two events excusable, but not compensable. The next delay event, a design change by the government issued in Contract Modification P0001, revised the alignment of the pipeline, and impacted the critical path by 17 days. However, the government demonstrated, once again, concurrent (but unspecified) delay by the contractor along the critical path, and thereby divided the delay into 2 days of compensable delay and 15 days of excusable delay. Finally, as the project completion date shifted from July 26, 2010 to December 16, 2010, the project schedule included the 30-day period of Ramadan. In 2010, the dates of Ramadan extended from August 11 to September 9. While religious observance of Ramadan does not preclude work activities, there are restricted hours of construction work in GCC countries in order to limit the exposure of laborers to direct sunlight during the hottest periods. Typically, those reduced hours are reflected in project schedules, but the original schedule for this project ended before Ramadan, 2010. The apportionment of delay to the critical path caused by Ramadan was therefore classified as excusable, but not compensable.

Next, there were 36 days of remaining delay not accounted for in the agreement negotiated on 7-Jan-11. Because the agreement was negotiated after the completion of the project, and there were no further claims by the contractor, the remaining days can be apportioned as non-excusable delay. There was no project documentation in RMS that provided any explanation of the cause of the contractor delay. The final count of apportioned delay for Project 2 is shown in the table below.

Table 7 – Summary of delay apportionment for Project 2

Type of Delay	Number of Days
Compensable	42
Excusable	65
Non-excusable	36
Total	143

Discussion of Results

The methods discussed in Chapter 3 were successfully applied to two projects completed by AFCEC and USACE in the GCC and provided useful results. All of the delay events that affected the two projects (that were accountable from available records) fell under the categories of delay factors that were expected based on the literature review in Chapter 2. Significance of these findings are discussed further in Chapter 5.

V. Conclusion

This chapter provides some additional discussion on the results from the analysis completed in the previous chapter. It discusses the significant findings from the analysis by grouping delay factors into meaningful categories, and then identifies the dominant construction delay factor affecting large-scale military projects based on the two analyzed projects. It also includes recommendations to the sponsor based on the literature review and analysis results, and provides suggestions for additional future research efforts in order to better understand the causes of delay in military construction projects.

Review of Findings

Review of the results from the schedule delay analysis of Projects 1 and 2 reveal several significant findings. By using the delay factor categories established by previous literature, several of the delay events can be grouped to provide meaningful descriptions. Together, the top two delay factors from Projects 1 and 2 account for 62% of the total delay and are discussed in further detail.

Obtaining building permits was the dominant delay factor for Projects 1 and 2, a responsibility of the project owner, or in this case, the government. Between the two projects, this factor was the cause of 316 combined delay days, or 38% of the total delay between the two projects, as well as the accompanying cost overruns. However, the significance of this finding is slightly tempered after considering the following two points.

As project managers have little influence to affect schedule delay caused by construction permits that are controlled by host nation offices, the natural solution is to

postpone contract award or Notice to Proceed until permit issuance. However, it is unknown regarding these two projects if the project managers might have had a reasonable expectation for the permits to be issued before they would impact the critical paths, either based on precedence for that location or for that specific type of permit.

Second, even if the impact of the delay factor was recognized or anticipated, the priority of the mission may have driven the government to award the project contract and issue Notice to Proceed regardless of the anticipated delay and associated costs. Even though delaying the Notice to Proceed until all necessary permits are secured would reduce the total period of performance, shorten the duration of the project, and save the government substantial funds in compensable delays paid to the contractor, it would not have improved the completion date of the project. If the mission requirement that drives the project prioritizes the earliest possible completion date, then the government is likely still better off issuing the Notice to Proceed as early as possible and face the risk of this dominant delay factor. Nevertheless, an important takeaway from this result is that large-scale military construction projects can significantly reduce schedule overrun by obtaining all required permits before the projects begin. While permit delays are not unique to construction projects in the GCC, the geopolitical landscape and contingency environment likely exacerbate the problem.

Unsurprisingly, design issues were the second most substantial delay factor in Projects 1 and 2. Delays caused by design issues accounted for 24.5% of the total delay. For the purpose of this research, the term “design issues” encompasses two sub-factors. The first consists of changes to the initial design. The changes may originate from design errors or omissions, or emerge during construction as customer needs and mission

requirements evolve—not unusual during the course of large-scale projects with long durations. The second design issue sub-factor was government delay to approve submittals. Submittals entail any kind of document or sample that the contractor provides to the owner for verification and approval; common examples include shop drawings, material data, samples, and product data.

Just as with permit delay, design issues are unique to neither the type nor location of the projects analyzed in this study. Still, it is rational to expect that the extremely high turnover rate of personnel and the relatively dynamic nature of mission requirements in contingency environments magnify delays caused by design issues. In order to reduce schedule delay to GCC projects caused by design issues, a number of recommendations can be made.

Assuming that all design change orders that cause delay in construction projects are actually necessary changes and cannot be simply prohibited, the attention for delay mitigation shifts to prevention. Preventing design changes requires improvements to various aspects of project management. Several management areas, as delineated in the “Guide to the Project Management Body of Knowledge” (PMI, 2013) can specifically affect the quality of construction designs and reduce delays from design changes. These include scope management, schedule management, quality management, and change management. There are many proven industry tools and best practices that can increase the toolbox size of schedule control management skills and techniques available to government project managers. It is important to note here that the methodologies discussed and utilized in this research were retrospective analysis methods, which are appropriate for identifying and understanding the causes of delay after project

completion. Different methods are available and better suited to use as prospective tools, concurrent with the project life to enable delay analysis predictively and proactively.

To reduce delays related to submittal approvals, project managers can take two approaches. First, they can reduce the amount of time required to review and approve submittals by improving processes. Communication, subject matter expertise, and resources (time and manpower) all play important roles in those processes. Second, they can improve project schedule estimates by incorporating more accurate durations for submittal review and approval activities. Once submittal approval delays cannot be further reduced due to resource constraints, or when approval processes reach their maximum optimization, then more realistic durations must be utilized in project schedules. A failure point in many project schedules is the false assumption that submittals will be immediately approved.

These findings establish the need for the government to improve its project management training program, specifically in the area of schedule control management. Limitations on time, resources, and data accessibility generated momentous constraints for this research effort. High fidelity schedule analysis on complex, large-scale construction projects usually requires hundreds of hours and thorough review of project documents, which may number in the thousands. While this study was limited to examination of two projects, it is clear that project management-focused departments within USACE and AFCEC will benefit by consistently performing forensic schedule analysis on all completed projects that suffer significant schedule delays. Doing so will provide more lessons and reveal areas for improvement, and perhaps expose patterns of

avoidable mistakes. Additionally, collation of such data will provide opportunities for more advanced investigation of project delays by enabling statistical meta-analysis.

In order to improve project schedule management for large-scale construction, it is recommended that USACE and AFCEC develop processes to identify, collect, and record reliable delay data—independent from the contractor. However, it must be acknowledged that by doing so, the government does not wish to take on any additional schedule risk. It is clear that current procurement strategies emphasize use of delivery methods that shift risk to the contractors. But it appears, based on project data reviewed in RMS, that the government relies too heavily on contractors to create and update as-built schedules during the course of projects. Considering the scarcity of details currently tracked by the government, it is a wonder that the government ever prevails in legal disputes about schedule delay that are decided by claims courts. Furthermore, difficulties in actively controlling schedule delay, as well as post hoc analysis, are intensified when the government rejects project schedule updates submitted by contractors simply because they reflect delays to the project completion date. Gannon (2011) identifies and discusses several such schedule management shortfalls in his examination of the federal design-build procurement program. Some misaligned policies are tantamount to closing one's eyes and wishing the problem away. More importantly, it prevents cooperative problem-solving efforts that are critical in project management.

Additional Future Research

While project cost overruns are easy to measure and the impacts are simple to quantify, future qualitative research efforts may discover ways to measure the

significance of actual mission impacts caused by schedule overruns. Such studies may answer a question such as, “Besides financial waste, how do schedule overruns really impact military missions?”

Other questions that future research could consider include:

“Are specific delay factors more prevalent in projects using certain contract delivery methods?”

“Do military construction projects accept too much schedule risk?”

“Do government construction managers receive adequate project scheduling training?”

Collation of data from many more forensic schedule analyses will provide further research opportunities of project delays by enabling statistical meta-analysis. Such analysis will explain the frequency, probability, significance, and uniqueness of various delay factors in military construction in the GCC. Additionally, it is recommended for future studies to achieve greater fidelity in results by acquiring project documentation from all parties involved in projects. The source data used in this research effort was based solely on government documentation. While projects that suffer project delay are often disputed and likely impede the willingness of contractors to share controversial documentation, fully resolved cases should provide sufficient and more easily obtainable data.

Summary

This research conducted forensic schedule analysis of delay factors that impacted recent large-scale military construction projects in the Middle East. The purpose of this study was to understand the most significant causes of project delay and how AFCEC

might improve schedule performance. The methodologies for analysis were adapted from the RP/FSA, particularly Method 3.7 Modeled/Additive/Multiple Base, or TIA. The data was gathered from USACE and AFCEC, consisting of Primavera project schedules and project documents from the RMS database. The project delays from two large-scale projects were apportioned as compensable, excusable, or non-excusable based on their liability and their impacts to the critical path. This investigation revealed that two particular delay factors were the most significant contributors to schedule overrun, accounting for 62% of the 838 days of total delay. Obtaining permits, an owner (government) responsibility, contributed to 38% of those delays. Design issues, consisting of change orders and submittal approvals, accounted for another 24% of the delays. In order to reduce schedule delay in future projects, several recommendations were provided to improve project management.

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REPORT DOCUMENTATION PAGE			<i>Form Approved</i> <i>OMB No. 0704-0188</i>		
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1. REPORT DATE (DD-MM-YYYY) 24-03-2016		2. REPORT TYPE Master's Thesis		3. DATES COVERED (From — To) August 2014 – March 2016	
4. TITLE AND SUBTITLE Forensic Schedule Analysis of Construction Delay in Military Projects in the Middle East			5a. CONTRACT NUMBER		
			5b. GRANT NUMBER		
			5c. PROGRAM ELEMENT NUMBER		
6. AUTHOR(S) Forbes, James W., Captain, USAF			5d. PROJECT NUMBER		
			5e. TASK NUMBER		
			5f. WORK UNIT NUMBER		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Air Force Institute of Technology Graduate School of 2950 Hobson Way WPAFB OH 45433-7765			8. PERFORMING ORGANIZATION REPORT NUMBER AFIT-ENV-MS-16-M-151		
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) Air Force Civil Engineer Center Brian Ouellette, GS-14, DAF Chief and Senior Project Manager - Forward AF Contingency Construction Management Langley AFB, VA DSN 312-574-2272 Commercial (757) 764-2272 E-Mail: brian.ouellette.2@us.af.mil			10. SPONSOR/MONITOR'S ACRONYM(S) AFCEC/CFMC		
			11. SPONSOR/MONITOR'S REPORT NUMBER(S)		
12. DISTRIBUTION / AVAILABILITY STATEMENT DISTRIBUTION STATEMENT A. APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.					
13. SUPPLEMENTARY NOTES This material is declared a work of the U.S. Government and is not subject to copyright protection in the United States.					
14. ABSTRACT This research performs forensic schedule analysis of delay factors that impacted recent large-scale military construction projects in the Middle East. The purpose of this study is to understand the most significant causes of project delay and how AFCEC might improve schedule management performance. The methodologies for analysis are adapted from the Professional Practice Guide to Forensic Schedule Analysis, particularly Method 3.7 Modeled/Additive/Multiple Base, or Time Impacted Analysis—Adjusted. The data is gathered from USACE and AFCEC, consisting of Primavera project schedules and project documents from the Resident Management System database. The project delays from two large-scale projects are apportioned as compensable, excusable, or non-excusable based on their liability and their impacts to the critical path. This investigation reveals that two particular delay factors are the most significant contributors to schedule overrun, accounting for 62% of the total delay. Obtaining building permits, an owner (government) responsibility, contributed to 38% of those delays. Design issues, consisting of change orders and submittal approvals, accounted for another 24% of the delays. In order to reduce schedule delay in future projects, several recommendations are provided that focus on various aspects of project management.					
15. SUBJECT TERMS Contingency construction, wartime, forensic schedule analysis, construction delay, schedule overrun, GCC, Middle East					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Maj Gregory D. Hammond, AFIT/ENV
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