A 3rd Party perspective: Professional Consultant, Inc. management of Rexam Automation Line Upgrade

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Abstract

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This case study will review an Automation Control upgrade at Rexam in Princeton completed by Professional Consultants, Inc. (PCI). This case study is presented from a third party perspective, as the writer was a programmer on this project. Primary focus was given to major issues that directly impacted the overall success of the project, with special emphasis on management and their decisions throughout the project. Then some time will be spent summarizing best practices learned from relevant journal articles which are summarized in Appendix J. Discussion on which particular best practices that the author feels PCI should consider adapting as company practices can be found in the Discussion section. Lastly, a review of major issues in the project will be presented with predictions of how they could have turned out differently had these practices already been in place. Suggestions to avoid making the same mistakes on future projects will also be explored, as well as discussions on what elements of the project went well and should be repeated in the future. A literature review section which highlighted numerous articles pertaining to various project management practices that the writer felt was relevant to this project are located in the Appendix. This report is meant to provide an insight into how project management practices at PCI can be altered for improved efficiency and financial success in the future.

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1. Introduction

1.1. General Information

This project describes an automation system upgrade developed and implemented by Professional Consultants, Inc. (PCI) for Rexam Closures (Rexam), a plastic closure production facility located in Princeton, Indiana. The writer of this case study was part of the PCI controls team that worked on the Rexam automation upgrade. Responsibilities included design and programming in the office as well as on-site assistance for the installation and start-up. This case study provides an overview of the project and then reviews the process and progress its development and installation. The literature review assesses various articles discussing project management practices relevant to this project. The discussion section then compares ideas shared in the literature articles with internal PCI project management guides, similarities and variances are noted and discussed. Lastly, the conclusion suggests actions PCI should take with future projects in order to reduce risks and run projects more efficiently and effectively.

1.1.1. PCI

PCI is a full service engineering consulting firm located in Evansville, Indiana. They specialize in controls, facility engineering, mechanical processes, and power and energy management. One of its strongest selling points is its ability to provide integrated engineering, procurement, and construction services to its customers. This project required work almost exclusively from the controls group, but some minor work was completed by the mechanical group. PCI was responsible for organizing and scheduling sub-contractors needed to install all hardware, and to install all control system changes. These sub-contractors remained on-site until all issues were resolved and the production line was operating as described in the original proposal between the Rexam production facility and PCI.

1.1.2. Rexam

This particular Rexam manufacturing site focuses on child-resistant and tamper-evident products, such as chemical container lids and pharmaceutical products. The facility operates approximately twelve plastic molding machines which make a variety of inner and outer caps which are later formed into child-resistant caps. The molding machines all empty into bulk totes. As needed the parts in the totes are loaded into hoppers which feed the assembly and filling machines. There are six such machines on the automation line, which are set up to assemble various diameters of child-resistant caps. In addition to the six assembly machines, two blow-over machines which fill boxes with standard caps blown overhead directly from the molding machines. Boxes are then filled with the caps, sealed and sent to the warehouse for shipment to the customer.

The line that was upgraded is the one which delivers boxes to and takes them from the assembly and filling stations and also the blow-over machines. It has been in use for approximately 15 years with minimal changes being made during this time. For this project, the line was taken completely out of service for two weeks while the hardware and control system were modernized. During this time, additional Rexam manpower was used to replace the line's functionality which allowed plant production to remain largely unaffected.

1.1.3. Installation Overview

To maximize the efficiency of installation, PCI sub-contracted out the hardware installation and chose to have one engineer on-site during the installation and three persons on-site during the start-up. Once the modernization was complete, the line had the same functionality as before but with improvements. Ideally, boxes would be delivered to the stations quicker and more consistently than before. In addition to this, the software program was rewritten to use an algorithm to determine which station had the highest priority for a new box. New alarm displays and other additional features which will be discussed later, were also added to the automation line.

Although this project never had an official schedule committed to by either side, many setbacks occurred during its design and implementation. The first portion of the PCI project was completed separately from the project discussed in this report. This portion of the PCI project was completed in early 2008. Due to limited availability by PCI staff and extensive in-house design work prior to installation, the earliest the second part of this project, which is discussed in this case study, could be installed was December, 2008.

1.1.4. New Web-Interface

One of the most significant changes between the previous system and the new system was the addition of a web-based interface. This system was newly developed by PCI to allow Rexam's customers to place their orders directly into Rexam's computer system through a secure website. The supervisors then can review, approve, and schedule orders at their convenience throughout the day. The main overview of the web interface can be found in Figure 1.

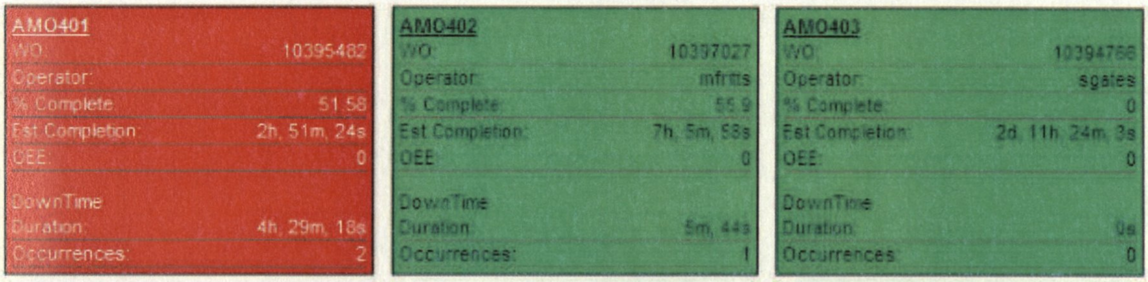

Figure 1: Example data from Website Overview Screen - Source: Rexam – Princeton

With the previous system, this process was handled via phone or fax, with manual input of the orders into the database, allowing various situations in which human error could occur. Once an order is received from the customer, the website reviews each box filling station's specific capabilities and current backlog. Software code was then written to determine which filling station will first be available to run the new order and assigns the new order to the respective filling station. In addition to this, the system allows for manual changes to be made to orders once they have been opened. This usually becomes necessary if an error is found or any values, such as box weight, need to be adjusted during the production run.

This newly developed system also allows for all active warnings and alarms present in any part of the system to be displayed on each of the four new flat-panel monitors installed on the manufacturing floor. A photo of the flat-panel monitor can be seen in

Figure 2. The website, with the help of these panels, replaces a previous scrolling message board. The previous board was only capable of informing employees of one unresolved issue at a time, and only provided very limited information such as the location and a vague description of the issue. The new screens also display the current Operating Equipment Efficiency (OEE) for each station, whether the station is currently running or not, and the current percentage of completion of the order being run; again on a per station basis.

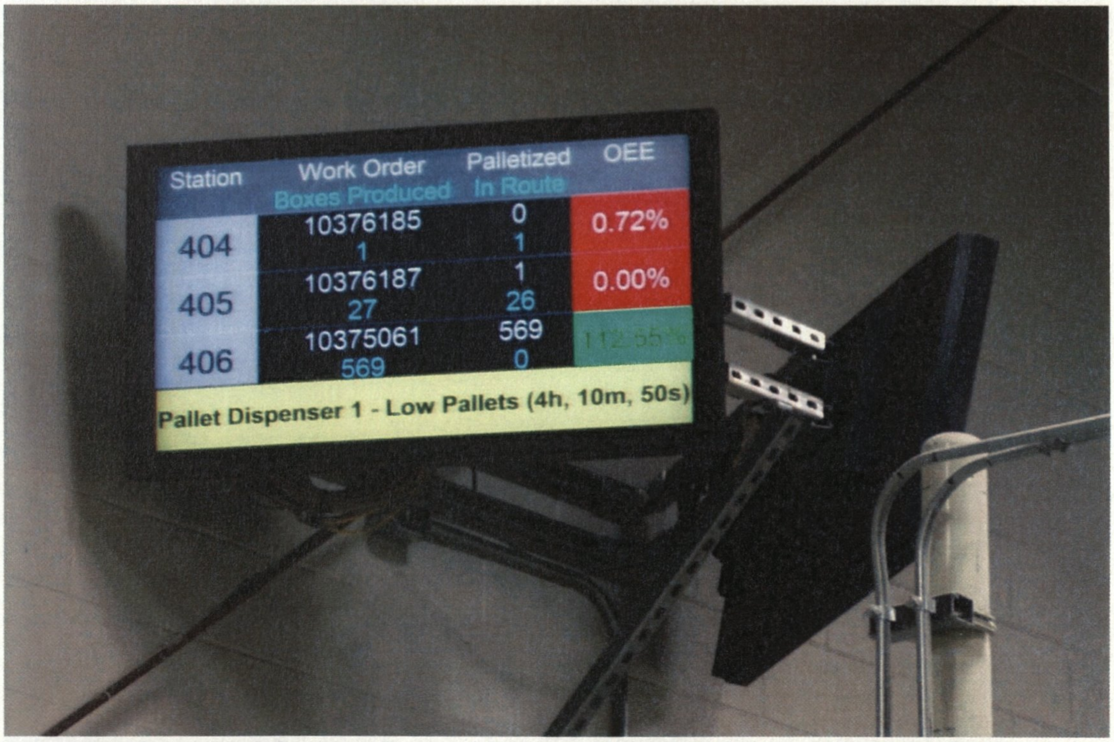

Figure 2: Alarm and System Status Message Boards - Source: Rexam - Princeton

1.1.5. Control Hardware Updates

For the project at Rexam, a programmable logic controller (PLC) is used to run conveyors, push boxes, scan barcodes, and to determine destination locations for boxes. A PLC is a device that controls equipment and monitors values through the use of electrical signal inputs and outputs, referred to as I/O. Using the data received from the I/O, internal software code is written in the PLC to complete such tasks as adjusting temperatures, flows, speeds or to control valves, and motors. In this application, the PLC is also programmed to gather the work order number, box number, location, type of event, and time pertaining to each event from the barcode via barcode readers. This information is then sent to IGear, which is a data storage system linked to both the PLC and website.

1.1.6. New Data Acquisition System

Another feature of this website and its accompanying data acquisition system is the ability to trace box records. A box record is a database entry uniquely made for each box as it proceeds down the line. This system allows for records to be taken every time each box passes each of the fifteen barcode readers stationed throughout the system or if an event (i.e. box pulled into station, box filled, box rejected) occurs to the box.

The box records will remain here as long as Rexam is willing to supply storage for the information; initially the intention is to store the data for up to six months. These records can be viewed in the event of a Rexam customer concern or if any other issue arises which requires further investigation into the box transportation, filling, sealing, and packaging systems. The purpose of this system is to better monitor the system and aid in troubleshooting issues

1.2. Automation Line Overview

The line that was modernized manages all the cardboard boxes being filled in the facility. The boxes are erected, labeled, and sorted to go to one of the eight filling stations on the line. At the box stations, as they are commonly called at Rexam, the boxes are filled with child safety caps for various customers. They then return to the main conveyor and proceed down the line where they are weighed, closed, sealed, and palletized by other stations. A diagram of the line is shown in Figure 3 with a full-page version located in Appendix A.

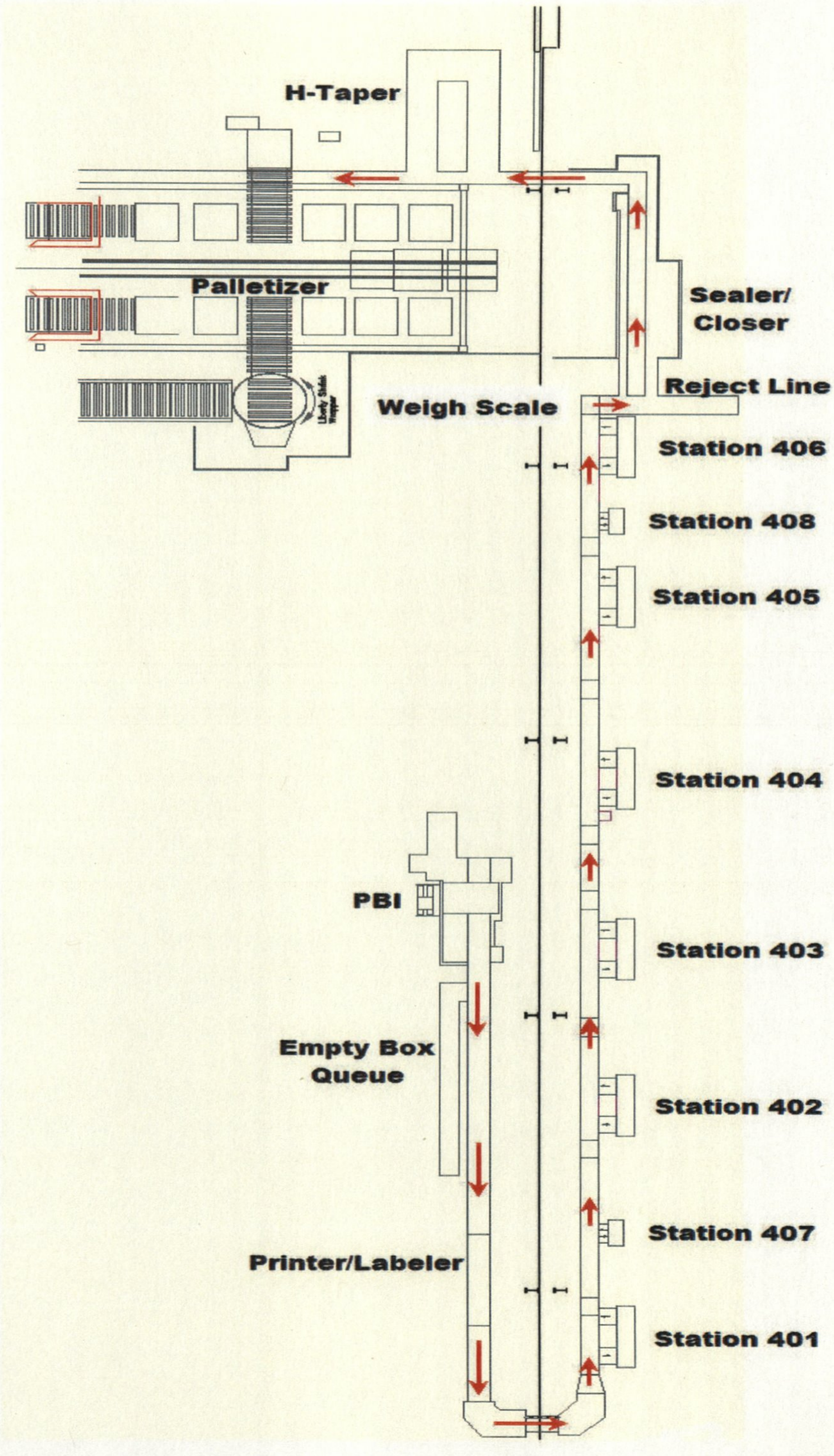

Figure 3: Automation Line Layout - Source: Julie Hagedorn - Work Product

1.2.1. Poly-Bag Injector

The Poly-Bag Injector (PBI) machine is where the process starts. A photo of Rexam's PBI is in Figure 4. It automatically erects boxes as they are requested by the line, inserts a bag into them, and tapes the bottom of the box. The boxes then remain in the empty box queue until a box station requests another box. Photo sensors are placed at the exit of the PBI to verify the box was erected and the bag was placed in it correctly. If the sensors do not sense the bag is in the box correctly, that box is rejected and sent to a separate conveyor. If three consecutive boxes are rejected, the machine faults and will not erect any more boxes until maintenance checks the issue and clears the fault.

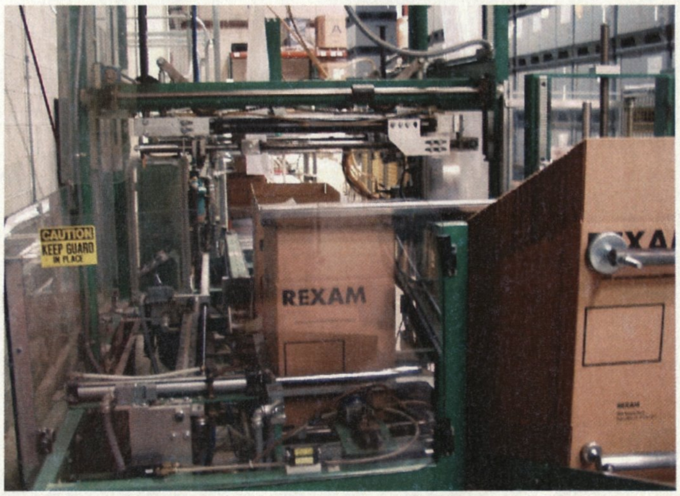

Figure 4: Poly-Bag Injector - Source: Rexam - Princeton

1.2.2. Printer

Once the next station with the highest priority box request is determined, the system searches through the record database to determine which work order number, box number, and barcode configuration to use when printing the box's label. A box is then released from the erected box queue, labeled, the label is verified (via a barcode reader), and the box proceeds down the main conveyor. Figures 5 and 6 show a box traveling past the printer and having the labels applied on them.

Figure 5: Label being pressed onto box - Source: Rexam - Princeton

Figure 6: Label rolled onto side of box by labeler - Source: Rexam - Princeton

Since the nature in which the label was being developed was being altered as part of the project, it was decided to make other changes to the label pertaining to the location, size, and detail of information present on the label. This was done in an attempt to make this particular facility's labels more uniform with other Rexam locations.

Along with the changes to the processors used on the line, it was also decided to update the communications with the printer, which required a new method of transporting up to 400 characters of information from the PLC to the labelers each time a new box is requested to be developed. This required developing entirely new PLC logic and converting the communications protocol from a serial connection to Ethernet through the use of a Real Time Automation® (RTA) converter. Serial connections are larger connectors that transfer information much slower than newer methods, such as Ethernet. Ethernet is the standard cabling used to connect devices to networks, such as connecting a home computer to the internet. The cable looks similar to a standard telephone cable with wider connectors on each end. RTA converters convert a signal that comes in a serial port to a signal compatible to Ethernet communications, and sends this signal out an Ethernet port. The RTA converters were also added to each location where barcode readers are being used, to allow capability of communications between all of these barcode readers and the PLC.

1.2.3. Box Stations

Any time a station is enabled, has an open work order assigned to it, and is not occupied by its maximum number of possible boxes, three in most cases; a box request is made. All the box requests are then analyzed and assigned a rating value; this is completed through the software and the logic within the PLC. This method of determining box printing priority is another system redesigned by PCI as part of this project. It takes into consideration the station's physical location on the line, the fill rate of the work order assigned to it, and the current number of empty boxes already at that station, to determine which station to send a box to next. The use of prioritization is expected to increase throughput and reduce downtime as Rexam expects to continue increasing production demands on the line.

All eight box stations are located at some point on the main conveyor; six stations are filled with a three box queue and one fill location scheme while two other stations merely have one fill location. Stations 407 and 408 only have one fill location, referred to as blow-overs, a diagram is shown in Figure 9 while a photograph appears in Figure 10. The rest of the stations (401-406) are standard box stations, shown in Figure 7 and Figure 8. An "infeed" barcode reader is located before each station facing the main conveyor line. These barcode readers are used to determine if the work order number assigned to that particular box matches the work order assigned to the respective station. If the barcode matches and not all queues at that station are already full, the box is pushed into this station and moved into the first available location nearest the filling station.

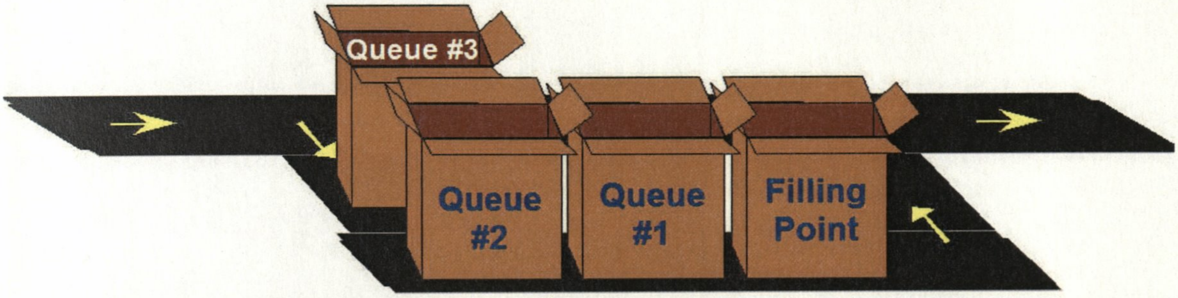

Figure 7: Standard Box Station Diagram - Source: Julie Hagedorn - Work Product

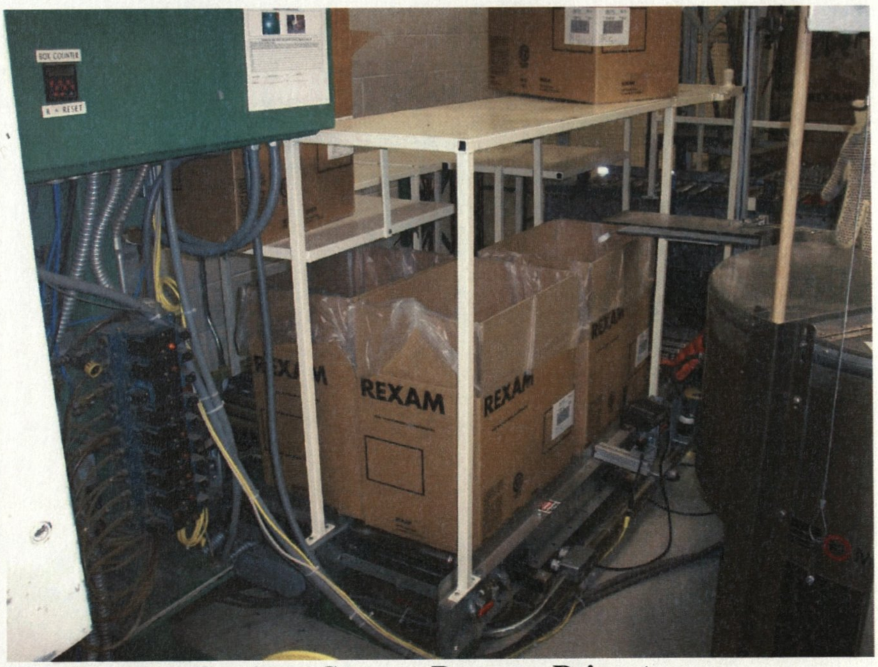

Figure 8: Standard Box Station - Source: Rexam - Princeton

Once a box is successfully placed at the fill station, an electric signal is sent to a different machine in the facility that assembles, inspects, and counts the caps. There is one of these machines at each of the standard box stations. They are also controlled by PLC's, but were not modified as part of this project. This signal tells the PLC controlling the machine to release the assigned number of caps for that box. This signal is required to be sent before each box is filled in order to verify the work order number of the box pulled in. It also checks for accuracy through the use of another barcode reader which is in place at the fill location of each station. This is also used to verify for the filling machine that a box is correctly in place at the fill location. If the box is removed from the filling location, a plunger will immediately drop down into the flow of caps to the box and will remain down until a matching box is again placed at the fill location. This is intended to keep product from being dispensed onto the floor and to assure no customer receives caps intended for any other customer.

When the cap capacity in the box is reached, an electric signal is sent back to the automation controller indicating that the box is full. Upon receiving this signal, the conveyor activates, moving the box in front of another pneumatic pusher. If no other boxes are blocking the station, the box is pushed back onto the main conveyor line and proceeds past the remaining box stations.

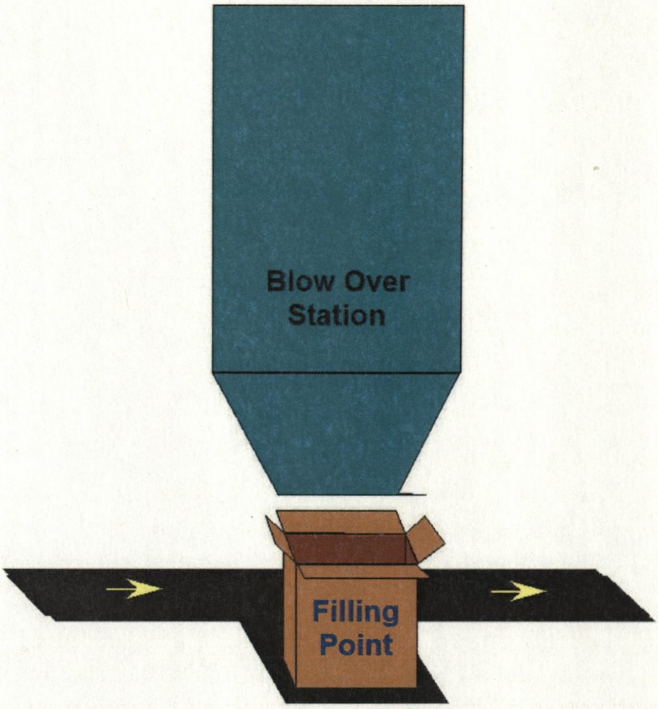

Figure 9: Blow-over Station - Source: Julie Hagedorn - Work Product

The blow-over stations, box stations 407 and 408, work slightly different. Since their caps do not require safety ratchets or liners to be placed in them, they are blown via compressed air overhead directly from the molding machines into a hopper above the blow-over filling station. The hopper has two filling bins inside of it, with a gate that selects one side or the other for the caps to fill. A counter is programmed to count up to the cap capacity per box for that order, is located by the molding machine, right before the caps fall into the pipe that blows them overhead. Each time the counter reaches its setpoint, an electric signal is sent to the blow-over PLC and the pneumatic gate that blocks cap flow from entering the tube at the end opposite the blow-over station goes down. This counter is used to assure the number of caps in each box is consistent, so the customer is billed accurately for correct quantity of caps.

Once the correct box is verified to be under the hopper, another gate at the bottom of the blow-over hopper opens and lets all the caps from that side of the hopper fall into the box below. The PLC keeps track of when a box is full and pushes the full box back out onto the line. A replacement box is then immediately ordered from the PBI machine. Once it arrives and its order number is verified, the gate opens to the opposite side of the hopper and those caps continue to fill the box until another signal indicating the counter setpoint has been reached. This signal is sent from the molding machine counter. This process repeats until the entire order has been filled. Since there is no queue for these machines, their box request receives the highest priorities.

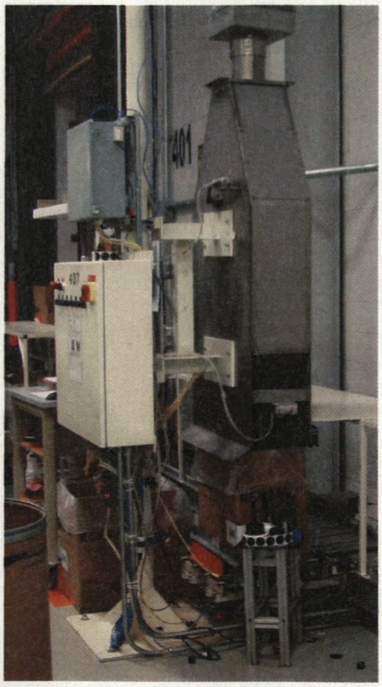

Figure 10: Blowover Station 407 - Source: Rexam – Princeton

1.2.4. Weigh Scale

The next part of the line that all the boxes must travel through is the weigh scale. The scale is located at the end of the main conveyor and was also replaced with a newer, more accurate model during the modernization. The new scale was selected, ordered, calibrated, and installed by PCI as part of this project. Another barcode reader scans each box and searches the work orders to determine the minimum and maximum acceptable weight for each box by referencing its work order number. The scale is also a box elevator. Once the box is weighed; it is raised and rolled onto another conveyor. Once here, it can either proceed to a rejected box line if the weight does not meet approval or be conveyed into the box sealer/closer.

1.2.5. Box Sealer, Closer, and H-Taper

The box sealer is the next machine the boxes travel through on their way down the conveyor. Boxes traveling through the box closer are shown in Figures 11, 12, and 13. Again, a barcode scanner reads each box, this time to determine if the bag must be sealed before the box is closed. The sealer consists of two metal bars that clamp the bag together once compressed air blows it above the box flaps. All the boxes go through the motions of being sealed, but if the work order does not indicate that sealing needs to occur, no signal is sent to the heating elements in the metal bars to melt the bag together. After a ten second pause for cooling, the bars release the bag and the box resumes its trip down the line.

The box closer does just as the name describes, it closes the top flaps on the boxes. After the bag is dealt with, the machine closes both end flaps, side flaps, and then applies a single row of tape covering the long seam on the top of the box. The boxes are then ready to proceed to packing with one more possible stopover along the way.

Again, the barcodes are read and the work order records are searched. This time the purpose is to determine if a box needs additional taping. If the work order requires, once the boxes are scanned they can be diverted off the main conveyor onto a side conveyor taking them to an H-Taper machine. This machine adds additional tape along the side seams on the top and bottom side of the box, completely sealing the box. The H-Taper conveyor then directs the boxes back to the main line. When the main line is clear, the boxes are pushed back onto the main conveyor line once again.

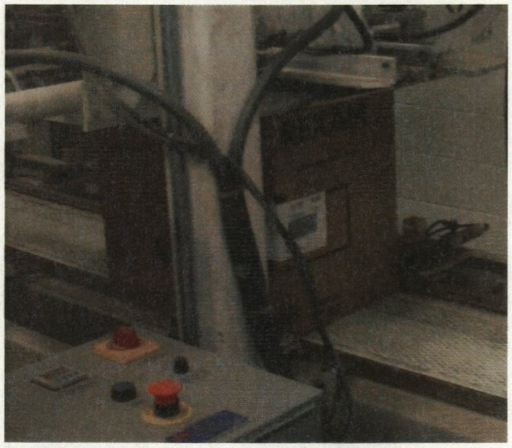

Figure 11: Bag sealed by closer - Source: Rexam - Princeton

Figure 12: Bag pressed into box by closer - Source: Rexam - Princeton

Figure 13: Top seam of box being taped by closer - Source: Rexam - Princeton

1.2.6. Palletizer

The boxes are scanned one last time when they reach a palletizing machine. This allows for the controller to know which of the fourteen possible pallets being filled that the box should be stacked on to. A box being placed on a pallet by the robot is shown in Figure 14. Once a pallet is filled, it is moved to a shrink wrapping machine, where it is wrapped and sent down a set of rollers. Fork truck operators can then take the pallets from these rollers to their respective locations in the warehouse. The programming for palletizer equipment was modernized during the first phase of this project. They have been treated as separate projects though by PCI and this portion of the project will not be considered in this analysis.

Figure 14: Box placed on pallet by palletizer - Source: Rexam - Princeton

1.2.7. New Data Collection System

One of the new features added with this project was traceability data collection. As mentioned earlier, this involved collecting data in the PLC every time any event on the line occurred. This meant gathering data, such as date, time, location, work order number, box number, and a description of the event in the processor. Examples of valid events were good box scanned, box filled, box sealed, and box palletized. This information is then sent one detail at a time to the data collection system. Once the record is received and archived, an acknowledgement is returned to the processor. This record is deleted from the processor and the next record is sent to the collection system.

The processor has been set-up to queue up to one hundred records at any given time. In general, this will all happen so quickly that it is not expected to hold more than two or three records in the processor queue most of the time. This data can then be reviewed and queried as necessary.

1.2.8. Control Hardware Upgrades

Although the intention of the project was for the functionality of the line to remain largely the same, certain improvements are expected to result from the modernization. It is anticipated that the line will become more reliable, with less downtime. This was accomplished though increased data collection capabilities, which will be described in greater detail later, and an improved warning system when problems arise on the line. In order to make these improvements possible, improvements needed to be made to the communications used to interact with the various control systems used on the line.

The physical functionality of the line was not changed although the technology used to control various sections of the line was updated. The PBI machine (PBI in Figure 1) and conveyor between it and the printers (Printer/Labeler in Figure 1), were all controlled by a small independent processor. After the conversion, only the controls for the PBI machine specifically were left in the existing processor while all the printer, labeler, and conveyor controls were reprogrammed in a new processor. This new processor, or Automation Controller, is also programmed to control all the conveyors, box stops, and pushers throughout the entire system up to the palletizing machine. Separate processors which were previously being used to control the box closer and H-taper remain after the modernization. They were updated to a newer model, giving them the capability to report downtime and warning messages to the information database, IGear. The palletizing machine processor was also updated slightly during this phase of the project, but the primary change was to add downtime reporting capability.

Prior to the modernization, the processors communicated via DH-485, a networking method first designed in the late 1980's. This communication system is reliable but limits the amount of data being transmitted at any given time and is not as fast as newer methods commonly used in industry today. For this project it was decided to convert most of the communications to Ethernet. By using this method all the processors could communicate with each other more quickly than before and also be available on the plant's network to connect with for programming and monitoring purposes. The facility does have an active wireless network, making it possible for the engineering and maintenance staff to connect to multiple processors wirelessly at any given time from anywhere on the plant site. In order for this to happen, the processors for the PBI machine, box closer, H-taper, and stretch wrapper were replaced with a slightly newer revision that allowed for Ethernet communications, as mentioned earlier. These processors were provided by Rexam but installed and updated by PCI.

The primary processor used to control the line was also replaced with the newer hardware which is capable of faster processing, storing more memory, and also communicating via Ethernet in addition to other communications methods. Initially, the plan was to connect the main processor to the facility's Ethernet network to communicate with the other processors and barcode readers on the line. All the box stations' individual components; such as pneumatic solenoids, box stops, and photo eyes, are still wired to the main control panel. They are communicated with the use of remote I/O blocks. With this plan it was believed that all primary parts of the line could be successfully communicated with and monitored via Ethernet.

A different communications card was selected to communicate via DH-485 with two microprocessors on the line that were not capable of communicating via Ethernet. It was decided not to upgrade at the time. These processors control the two single capacity box stations on the line, the blow-over stations. All the existing hardware for these stations was previously wired directly to the microprocessor and was not altered while new hardware inputs being added were wired directly to the Automation Controller via remote I/O.

1.2.9. Alarm Improvements

Another addition to the system is box tracking programming that has been added to the processor. This is similar to the prior mentioned traceability records but is not sent to the data collection unless an alarm results from the data collected. A box tracking record is added to a queue each time a label is printed and verified or when a full box leaves any of the box stations. These records again contain the work order number, box number, and location; but they also retain the location of origin (printer or one of the box stations) and time-stamp when it was at that location. Then as each box passes each barcode reader, the processor looks up the record for that box and updates the current location. Next, the current location, current time, origin location and origin time are cross-referenced with a hard-coded table in the PLC to determine if the box is on schedule. These records are continuously scanned to search for any boxes which have not reached their next location in an acceptable amount of time.

Once a record like this is found, an alarm with the box's last location is sent to the web interface to notify the operators of a potential issue. This alarm is then displayed on the alarm interfaces and archived in the alarm database. These alarms must then be acknowledged by an operator or supervisor before they will be removed from the display. If the box travels through the line without any unexpected stops, then once it reaches the station it is destined for or the palletizer, the record for this box is removed. Since it is impossible to accurately predict how long a box may remain in the station, it was decided to remove the record created at the labeler once the box reaches its destination station. A new record is created once it has been filled and pushed back onto the main conveyor. The box record is also removed if the weight verification on the box is not passed, as the box is rejected by the weigh scale when this happens.

Alarms from several different areas on the line can appear on the display screens. In addition to the tracking alarms, there are also new alarms in place to detect box jams at each specific box station, and specific alarms pertaining to the specialty equipment on the line. Examples of these alarms are low or no boxes from the PBI, or low tape at the box closer. All these alarms are displayed on the monitors and archived in the alarm database.

1.3. Installation

Actual hardware installation was preliminarily set to take approximately one week. A local electrical contractor was chosen to install the new hardware, run all conduits and wiring, move any existing components, and handle any other electrical issues as needed during the installation. This project required the addition of several new electrical panels; one primary automation panel that is approximately 5'x6'x1', one PBI control panel (2'x2'x1'), and twelve barcode interface panels, which are roughly two cubic feet in size. Eight new box clamps and ten new photoeyes were also installed during this project, they were used to better control the boxes as they entered and exited box stations.

Several issues arose during the initial installation. To reduce production downtime as much as possible, the subcontractor came onsite a week prior to the scheduled installation to pre-install all hardware possible. During this week, they installed all the panels, ran all conduit and wiring. This left only a minor amount of rewiring and actually applying electric power to the hardware as the expected hardware-related tasks left. Unfortunately, upon applying power to the various panels, many fuses were blown. This was a result of either wiring or electrical print mistakes where power was sourced from the wrong locations and signal wires were mislabeled and also wired incorrectly. All of the barcode boxes contained many errors, requiring approximately five hours of corrective work to each box. The subcontractor was brought back in to correct the oversights but PCI still had to dedicate engineering time and effort to clarify the necessary changes. Even after the rework was completed, an additional PCI engineer was brought in for two days to test, straighten up, and correct the panels as necessary. Several other wiring changes were also found but they too were handled by PCI as they arose.

Once all the main power supply wiring issues were verified, PCI began verifying all the new input and output wiring connections. During this time, additional errors were found and corrections applied. This delayed the expected completion time of this task which then limited potential progress on dependent tasks. By the time all the hardware and I/O was tested, the project installation was approximately two weeks behind schedule. Also, overtime was not included in the original project planning but an average of 15-20 hours per engineer per week was being charged to the project.

It is also important to note that this phase of the project took place the last couple of weeks of 2008. Because of this PCI lost two days of work out of the regular weekly schedule for Christmas Eve and Christmas day, while the subcontractor worked Christmas Eve to finish up their corrective work. PCI engineers worked New Years Eve and New Years day since production did not run these days in an attempt to decrease the schedule extension. The original plan was that if the installation was proceeding along at a pace comfortable to Rexam engineers, all parties involved could have the holidays off.

Once the hardware and wiring was lined out, it was time to begin testing and debugging logic. One PCI engineer was dedicated to debugging label printing logic while another person, the writer of this case study, dedicated time to configuring barcode readers and debugging the logic that controls boxes as they travel to and through the box stations. After approximately one week, labels could be printed and one by one the stations were slowly tested and converted from hand packing back to receiving boxes via the automation conveyor. Once full boxes were leaving the filling stations again, logic used near the end of the line was then debugged. This included logic pertaining to the weigh scale, sealer, closer, and H-taper.

At this point, stations 401 through 406 were running using the automation line conveyor and it was decided to wait until later to debug stations 407 and 408 as they are significantly different than the other stations and the number of orders needing to run on them was minimal. It was anticipated that because of the large amount of poorly documented code from the original program, software code debugging would take 2-3 days per station. The predicted and actual amount of time required to get the automation system programming to a point where it would be operational again were within a couple days of each other. Several additional weeks were spent correcting sporadic issues on the box stations and other pieces of equipment at the end of the line, although it was never necessary to return any of the stations back to hand packing due to overwhelming control issues.

1.4. Printer Issues

The most problematic issue during this project was printing accurate and fully formatted labels reliably. It is estimated that the man-hour equivalent to roughly $40,000 was spent troubleshooting printer issues; this was by far the largest drain on the project. The first issue was getting a valid, updated label format from Rexam; it was nearly a month after the initial request was made for this information before it was ever given to PCI. Then, once it was received, several errors were found while trying to program it with each error requiring corrective actions by Rexam, each with an average lead time of two days between responses.

The program used to print labels and increment boxes through the application process was quite complex and required an adequate amount of troubleshooting. Roughly 30% of the time spent on troubleshooting this issue was dedicated to trying to understand the previous printer programming logic, which was poorly documented. Ultimately, it was decided to completely abandon the idea of duplicating the existing logic in a newer processor and the logic was rewritten in a more straight-forward way.

Another challenge relating to this issue was the age of the printers being used; they were installed roughly fifteen years ago and were not modern at that time. Since they are so aged, it was believed that there was no way to get feedback from them to know if they have received the label format correctly. It was only discovered in mid-February, 2009 that an output existed that would signal when a print was complete. This was used to shorten the cycle time of the labelers which was a main concern of Rexam management as it is the main bottleneck on the automation line.

The method used to communicate with the labelers was changed from a serial cable to a serial-to-Ethernet converter which then communicates directly with the PLC. Two main companies produce items capable of these requirements, Real Time Automation (RTA) and Comtrol. The RTA model is significantly cheaper, costing approximately $625 each while the Comtrol units are around $1200 each. Because of this and the amount of converters needed, initially all RTA units were purchased to interface with the labelers and barcode readers. The most challenging aspect of the printer issues was the random recurrences and severity of the errors. After all possible PLC programming changes to resolve the issue were exhausted without a solution; it was decided to test a Comtrol converter unit in the printer communications. Before the decision to try new communications hardware was made, RTA technical support was contacted but did not provide any additional support as to why their unit could not meet the necessary requirements. Although some programming changes were required and the setup of the actual converter was different, using the Comtrol unit immediately resolved all issues of label printing errors. All the characters correctly printed on the labels in the correct location and with the desired format.

After monitoring the printers for approximately one week, a meeting was held to discuss current outstanding issues. The intention of this meeting was to update Rexam management on the status of the project and to discuss the priority of the remaining issues in addition to defining what Rexam IT needed to do to aid in the completion of the project. Production line cycle time was also discussed during this meeting with a new urgency placed on minimizing cycle time as significantly increased demand on the line was anticipated. Again, the label printing was determined to be the bottleneck. Once more the logic for printing was rewritten in attempts to increase label output.

PCI was then able to contact the manufacturers of the printers and learned that an output was available to indicate when the printer had completed a label print. Through the use of this output and with the logic changes, print time was decreased from approximately 45 seconds between labels to approximately 10 seconds when a new label request entered into the system. The original project functional specification document did not specify printer efficiency. The increased demands by Rexam management is likely another instance of scope creep in this project. Unfortunately, the printer efficiency was never recorded prior to the modernization so there is no definitive way to prove scope creep existed in this part of the project or to quantify the amount of additional work completed to improve this issue.

Also during a phone call to the manufacturers of the printers, it was discovered that they no longer support or sell replacement parts for the models currently at Rexam. Because of this, Rexam is now looking into new printers. Had they decided to purchase new printers prior to this project, countless hours could have been saved by PCI. The new printers would have the proper manuals and documentation with them making interfacing with them much easier and faster. With this information PCI would have data coming from the printers to work with. This would allow for a quicker route to the cycle time reduction and increased warning and fault reporting, as the new printers likely have output signals for such events. The age and condition of the printers should have been evaluated more closely before bidding the project, as negotiations with Rexam to update the printers sooner could have dramatically reduced the troubleshooting time required on the entire project.

1.5. Manpower

Several different people were utilized by PCI throughout the life of this project. Although the use of multiple resources increased the amount of production being completed at that time, efficiency was hurt when workloads were transferred from one team member to another. Two people worked on this project consistently from beginning to end, with another three people working on portions of it as time allowed. Due to installation date deadlines, at times up to five people were working on the project for up to 65-70 hours weekly for the last month before installation. Two employees were restricted to 40 hours per week on the project and didn't incur any overtime costs on the project. The project manager (PM) holds a salaried position which also did not add any additional cost per hour worked over the standard 40 hour week. He did put in on average 60 hours per week on the project through a bulk of its life. If other hourly individuals would have had to do this work, the manpower costs would have been significantly higher. The final two employees working on the project were dedicating all their time to the Rexam project, which resulted in additional costs to compensate for the overtime being worked. These two employees were also part of the installation and start-up team, with one remaining on-site for four weeks and the other for approximately twelve weeks. Luckily, only eight weeks on-site involved overtime costs.

During the development phase in the office, one contract employee was brought in to design the web interface. This included portions pertaining to the alarm inputs and display and the web interface used to open, close, or suspend work orders to each of the eight stations. This individual was only slated to work twenty-four hours weekly on this project but ran into interface issues and worked additional hours the last five weeks. This individual also received overtime pay for any work in addition to forty hours weekly. Once installation started though, the PM took over the responsibilities of installing and troubleshooting the web interface and this contract position was eliminated.

Unfortunately, several problems and issues were realized during the installation, and ultimately approximately 70% of the development effort was reworked. This added approximately 180 hours to on-site installation time.

1.6. Facts and Figures

Table 1 shows a general detailed explanation of the expenses incurred during the project and the budgetary amounts allotted for each category. Overall, the project exceeded its budgeted cost by 35%, making the total 135% of the budget. Actual costs exceeded the predicted expenses across the board, with some being much more significant than others. Labor was higher than expected due to the increased staff dedicated to the project, the increased duration, and overtime that was billed but not anticipated on the project. The wiring issues and having to pay additional overtime for work on or near holidays put the subcontractor budget over its intended cost.

Due to the prolonged start-up, more trips had to be made from Evansville to Princeton, with each trip costing $22; this budget was 150% of its anticipated cost. Items categorized as equipment were all the actual control panel enclosures and the eight box stops, which were custom made by a local mechanical shop. Rexam requested an extra box stop be made with the set so they had a back-up. This was provided at no additional cost to Rexam. Material refers to all the software, hardware, and contract employment work that were utilized throughout the project; it is uncertain why this number surpassed its expected value by such a significant amount. The media used to communicate with the two separate processors on box stations 407 and 408 was upgraded during the project, again with PCI deciding to absorb this expense. This may account for a couple thousand dollars worth of the loss.

Table 1:

Actual Project Expenses

Expense	Budget	Actual	Difference	Percent of Budget
Labor	$254,595	$347,055	-$92,460	136%
Subcontractor	$24,650	$28,502	-$3,852	116%
Travel	$1,000	$1,576	-$576	158%
Equipment	$9,000	$11,873	-$2,873	132%
Material	$110,282	$148,438	-$38,156	135%
TOTAL	**$399,527**	**$537,444**	**-$137,917**	135%

Source: Professional Consultants Project Records

As can be seen, many more dollars were dedicated to this project than originally anticipated, but at no point was stopping and accepting failure an option. It is believed that Rexam Princeton will have several substantial job opportunities coming up in the next few years that will help to recoup and ideally overcome the financial loss suffered during this project.

The purchase order for the Automation upgrades was awarded to PCI early in 2008. Due to an already full portfolio of work, this project was pushed back several months before starting development. Once Rexam began to push for the project to proceed, it was squeezed into the portfolio. This is part of the reason so many people worked on the project. It all depended on who had a few hours to spare whenever possible. Instead of beginning Phase 2 right after Phase 1 was completed in early 2008, it was not started until September, 2008. Rexam wanted the project to be installed by the end of the year. No official installation date was selected until approximately 60% of the development was completed in-house. The preliminary installation date was November 20, 2008. As this date neared, a request to delay the shutdown was made by PCI and accepted, with an additional two weeks to work in the office granted. The sub-contractor started installing hardware December 4, 2008. Ten days later the automation line was shut down and all the stations were switched to manual packing. It was at this point that Rexam officially incurred extra expenses due to the automation upgrade.

No absolute schedule was ever given for this project, but the goal and intention was to be finished with the entire start-up in six weeks. This would have had the project complete in mid-February, but did not specify the manpower necessary on-site in order to achieve this schedule. Instead, three and, at times, four PCI employees were on-site from early December until the end of the year. At this time one employee resigned. Two remained on-site working on troubleshooting until early March when it was decided that work only existed for one person on a daily basis. This one person remained on-site until June, 2009. Considering all of this, the original goal would have had the project complete by early February, 2009, instead PCI support remained on site, fine tuning the various software applications for an additional four months. It is important to note though that the actual downtime experienced by Rexam was no longer than anticipated. If necessary the project could have been completed faster but with a light workload in the PCI office, it did not make sense to have additional manpower or overtime dedicated to the project. A Gantt chart of the preliminary schedule developed by PCI for this project prior to starting work on the project can be found in Appendix B. Another Gantt chart displaying the actual schedule is located in Appendix C. No active schedule was maintained during the project, the writer created this chart once the project was complete.

2. Discussion

2.1. PCI Internal Documents

PCI has several reference documents available for all its PMs and offers periodic training sessions for better project management. However, once a project is commenced, the action plan is rarely altered. PCI offers separate internal documents on each of the following subjects: managing time, managing risk, managing the client, managing quality, project management standards, and PCI's PM role. These documents are reviewed in this section.

2.1.1. PCI's Project Manager's Role

The project management standards document, "PCI's Project Manager Role" is a 50-page guide focusing primarily on the documentation requirements and decision-making expectations of the PM. It has sections explaining suggested actions for starting and setting up a project, including tasks such as setting up a reference location on the internal network for documentation, compiling the project team and schedule, and organizing a project kick-off meeting. Sections also exist detailing what data needs to be gathered from the customer and lists PCI policy information (i.e. billing rates, standard work hours) that must be presented to and approved by the customer. Standard terms and conditions that the PM needs to make the customer aware of are provided. Tutorials on how to use project management and tracking software utilized by PCI are also provided in this document.

The "PCI's Project Manager Role" document is also intended to help a person decide if project management is something that they are interested in and gives a general description of responsibilities of a PCI PM. It describes skills required and personality traits a good PM generally possesses. A list of duties and responsibilities is given with tasks such as communicate, coordinate, and delegate listed. Another section lists "Requirements, Duties and Responsibilities for a Project Manager". The PM's role document can be viewed in Appendix E.

2.1.2. Managing Your Time

"Managing Your Time" is the title of the next internal PCI document related to project management. This guide attempts to explain the extreme importance a PM needs to put on time management, stating it is the one resource that cannot be purchased. It goes on to state that before committing to do anything for anyone the manager should consider it as a request to give up part of the most valuable thing he has.

Meetings are also discussed, as they are the most time-consuming activity for a PM. Suggestions are given on when a meeting is actually necessary or if other communication forms can suffice, followed by best practices when the PM is the person conducting the meeting. As the guideline suggests unless more than three people need to be involved in the conversation, a meeting does not need to be conducted. This was generally true for the Rexam project so very few formal meetings were held. Those that were held were on-site near the completion of the installation and organized by Rexam; all the suggested practices by meeting attendees were practiced by PCI personnel at the meeting.

Other sections in the document have topics such as controlling interruptions, which suggests how to minimize time delays throughout the day particularly when people drop-in for a quick question or break, how to best utilize the telephone, and keeping a to-do list. All portions of this document relevant to this project are found in Appendix F.

2.1.3. Managing Quality

"Managing Quality" is the next PCI internal document listed in the appendix, it is located in Appendix G. One of the first points made emphasizes the importance of quality, especially when working in a consulting position. It states that customers generally do not bother complaining about poor quality but instead the customer will simply not offer future business to the company that was not satisfactory. Popular terms used when discussing quality such as quality control, quality assurance, and total quality management are defined. Furthermore, it is explained that factors used to evaluate product quality are often different for the customer and the consultant.

Various sources of pressure that commonly lead to skimping on quality are explored. Reasons such as tight budgets, pressure from competition, and foot-in-the-door projects are among the most tempting reasons to skimp on quality. Multiple reasons and potential problems that will cause quality to be compromised are listed such as project complexity, inadequate information, poor communication, or inappropriate staff.

Once project quality has been defined, several suggestions are offered about how to improve it. If possible, it is suggested to incorporate quality assurance/quality control (QA/QC) into the project's budget, make realistic staff assignments, beware of project complexity, and develop realistic schedules among other suggestions. A series of quality control documents are described. The quality control plan seemed the most appropriate for a project such as this one. As described, a good quality control plan will define which documents need to be reviewed, who needs to review them, when the reviews should be done, what errors will be sought after, the budget amount allotted for review procedures, and the schedule and budget allotted for error corrections to be made. Had this quality control plan been completed, it could have very likely caught the oversights in the drawings and saved several days of troubleshooting during the installation. Five suggested reviews and a detailed description of the reviews are listed in the PM guide.

A different section discusses "Design Change Timing", it details the real cost of a change at various stages in a project. An example is a design change 35% of the way into the project. It may only cost $4,000 but if it is not caught until construction, the price to correct the change may increase up to $100,000. No actual suggestions on how to avoid this are detailed but the importance of the issue is reinforced.

"Managing Quality" suggests visiting with all members on the team at least once a day to monitor progress. This seems a bit extreme and a waste of the project manager's time. On a large project it would take up a large portion of the day to meet with all members of the team. It also would add additional interruptions into their work day. The last idea is to exercise the principle of single statement, meaning the fewer places that the same information is repeated the better. It decreases the likelihood of an oversight when design changes do occur, leading to inconsistent documentation.

2.1.4. Managing Risk

Managing risk is such an important topic when discussing any sort of project management. A separate document is offered to cover this topic. It can be viewed in Appendix H. Any risk that may result in a dispute will have a negative impact on the project, regardless of whether the customer or consultant are impacted with additional costs. "Managing Risks" suggests to "view liability risk as a problem-solving process; a process by which one identifies or recognizes risk, comes to understand risk, and takes action to minimize risk".

One of the lists in this guide is "The Golden Rules of Risk Management". Most of the rules mentioned are somewhat obvious when reading the list, but could easily be overlooked at the beginning of any project. It mentions 1.) Never to accept work that cannot be quantified 2.) Do not bet the company on a single project 3.) Do not take on uncontrollable risks. Nearly all of the suggestions here can be found in one of the articles discussed in the literature review as the main focus of several of them was risk management.

Another section in "Managing Risk" explains the struggle between risk vs. reward. Project risk management's main goal is to maximize the results of positive events and minimize the consequences of adverse issues. A plan should be put in place and referenced with each new project to assess the risk in this project. This plan should include a listing of all risks associated with the plan, which team member is responsible for managing the risk and a contingency plan to implement if the risk turns out badly. The article by MacCormack (2004) about NASA is a prime example of what can happen if risk is not evaluated at all. No assessment of risk was conducted at all before completely revamping the program's entire mentality. The end of the article does spend some time suggesting actions to avoid future mistakes such as this. They seemed like another form of postmortem analysis which is one major area overlooked in the "Managing Risk" document.

One of the most important factors in risk management is the ability to identify risk. This paper suggests several factors for PMs to consider when identifying risk like the nature of the project, specific client attributes, contract provisions, and sub-consultants. The severity level of each risk needs to be determined. This is done by considering the degree of complexity of the project, the technological requirements, associated codes and regulations, and any other factors that will directly impact the project. Several additional paragraphs in "Managing Risk" are dedicated to identifying risks and special circumstances which may also be a factor in determining if the risk is worth taking.

2.1.5. Managing the Client

The last PCI project management related document pertains to "Managing the Client". It suggests considering oneself as part of the clients team during a project and as an extension of the clients organization. Considering the duration of the on-site time during the Rexam project, the overall client relationship was quite strong with all members of the PCI project team and the entire Rexam staff. Another suggestion was to exhibit professionalism and technical competence, and also to demonstrate project control and to develop effective communications. Lists of seven methods that can be used to exhibit professionalism are listed and can be found in Appendix I.

Another section seems to state some obvious suggestions but again could be realistically one of the most helpful sections for a PM. It describes the little things that can be done to strengthen the client and consultant relationship. Common traits that clients feel the project manager should offer is listed. It refers to documentation and services mostly, instead of just stating characteristics that are appreciated. Some items a good client should offer, such as quick payment, contacts/networking, and to make themselves available for meetings can be found in this document. "Managing the Client" offers a fast and straight-forward way for PMs to understand what expectations exist for everyone.

Several helpful insights into project communication are discussed. It emphasizes that "the primary purpose of a service-oriented company is to provide meaningful information to clients. Effective communication is a key to that objective." A separate section is given to each of the three ways people communicate; verbal, written, and through body language. The verbal communication section states that studies have shown when using face-to-face methods, 7% of the message is sent by the words said, 38% by voice tone, and 55% by body language. A separate section is devoted to body language best practices, pointing out seven important gestures and another seven suggestions for improving body language when communicating with someone face-to-face. Items such as eye contact, positive hand gestures, and impacts of your posture on the conversation are discussed.

2.2. Project Review

This section will review in more detail what went well and what went badly during the automation upgrade; in essence it will be a post-mortem for the project. When applicable, suggested actions to prevent future similar mistakes will be provided. A summary of events in the project will be bypassed in this section, as it has already been covered in the introduction.

The first area for improvement, when considering the automation upgrade, was the failure to gather all required information from the customer prior to the start of the project. Also, a detailed list of requirements and expectations to declare the project complete should have been obtained from and signed off by Rexam.

2.2.1. Printers

From preliminary discussions with Rexam, it was noted that some issues may present themselves when trying to establish reliable communications with Rexam's existing label printers, but not nearly to the degree that issues actually occurred during start-up. It was realized that some issues would likely arise when establishing communication between the PLC and the printers, but the estimate on manpower to handle this issue was greatly under-estimated. Initially, the schedule allowed for one week in-house to work with a spare printer Rexam provided for PCI. Another two to three days was scheduled for on-site fine tuning the printer programming. In reality, two to three weeks were dedicated to the printer configuration in PCI's lab, with approximately five weeks on-site dedicated to troubleshooting printer issues throughout the life of the project. PCI did realize that establishing stable printer communications was a potential issue but were not able to accurately predict the risk level that needed to be assigned to this issue.

The downfall is that proper communication between PCI and Rexam could have prevented this issue nearly all together, reducing the cost of the overall mistake by potentially 90%. Rexam's IT department experimented with serial converters at other facilities in the past, and was aware of potential issues and also knew what brand they felt worked best. They conveyed this information to the plant engineer responsible for the automation project but he failed to pass the information on to PCI. Had he forwarded their suggestions or developed a communication link between IT and PCI, countless hours, dollars, and headaches could have been spared. In future projects similar to this one, more time should be spent researching the hardware that it will be necessary to interface with. The lesson to be learned from this is that more questions need to be asked prior to the start of the project. Had this been done better on this project, maybe the information that the IT department had could have been conveyed to PCI at this time.

2.2.2. Scheduling and Manpower

One of the first scheduling issues was created by PCI management; they accepted more work than they had staff to complete in early 2008. Because of this, there was a lengthy duration between the bidding and winning of the project and when work actually started on the project. Even more of a delay existed before the installation actually began. This allowed for internal factors and expenses to change after the project budget was already permanent. Some of these changes pertained to manpower availability and overall company billing rates.

Once work on the project actually started, more scheduling issues arose. The preliminary schedule developed for this project during the planning phases was not maintained and updated as the project progressed. In addition to this, weekly status reports were not written or distributed. This practice was listed as a best practice in the Project Manager's Role document. These steps were skipped in this project due to lack of time as the PM was expected to dedicate all of his time to technical work on the project. It's uncertain as to the impact correctly managing these tasks could have made on the overall project outcome.

Throughout the life of the project several staffing changes occurred at PCI. One full-time employee working on the project left PCI completely while another was added mid-project once progress started falling severely behind schedule. A contract employee worked on an as-needed basis. Everyone working on the project charged overtime to it, which was not in the original schedule or budget for the project. Also, additional PCI personnel helped for a short period in the middle of the project. This was also never reflected on any sort of schedule. Luckily, the additional assistance was given specific tasks that did not require them to have a clear understanding of the entire project, so time spent orienting them was minimal. All of these manpower changes impacted the schedule negatively. Ideally, it would have been best to establish a smaller team of individuals dedicated solely to this project. If this is not possible, it is suggested to minimize the amount of work reallocated to different resources during the life of the project.

In an effort to minimize downtime during the installation, the subcontractor did a large portion of their work when PCI was not yet on-site; making it harder for them to discuss any open issues they ran across while working. Many of these issues could have been avoided if more quality was put into the design and drawing verification phrase of the project.

Part of the hardware was delivered to the office while other supplies which were needed relatively soon were sent directly to Rexam. This made it hard to keep track of what supplies had came in and to assure the entire quantity ordered was delivered. Later in the installation, this added even more time which was spent trying to find missing parts and led to some extra items being ordered when the original supply was misplaced.

2.2.3. Project Management

It is important to focus on what the PM specifically did well during the project in addition to noting areas which could have been handled better. The PM put forth much effort to effectively communicate with the client throughout the entire design, development, and installation process. At no point did the client seem at all frustrated about a lack of information.

The PM, along with the other engineers that were on-site for the installation, made themselves available 24 hours per day and 7 days per week for troubleshooting. If the line went down for some unknown reason in the middle of the night, minimal amounts of downtime would be suffered. This service was utilized seven times during the project. This was not originally promised in the scope but was a way to show the customer how dedicated PCI was to having them satisfied throughout the life of the project.

The PM himself did not have too many time management issues. The project as a whole could have improved in this area. As mentioned earlier, the PM chose not to require daily status updates from every team member on the project. He decided to leave the responsibility on them to come to him if they were low on work or had issues that needed to be discussed. Of course, if no updates were given by the teammates for a few days then time would be taken to communicate with the team members to get a status update. To follow the suggested best practices, status updates should have been provided. In this case, monthly editions would have been sufficient.

In addition to this, the PM is also the control systems department manager. He is responsible to allocate work for the eight individuals in this group. To do this, he must consider the factors mentioned in many of the articles when choosing the project team such as availability, skill level, and hourly rate. Naturally, this leads more people to his door than the average worker as he is in charge of distributing work assignments. Questions about what projects need worked on, how much time can be dedicated to particular projects, in addition to any other time and/or skill issues that arise, all come to him.

It is the writer's opinion that regardless of who was declared PM on this project, oversights would have occurred. A project of this scale with the allotted budget could not be finished thoroughly with the consultant making any profit at all. As the article "Why

Good Projects Fail Anyway" (Matta and Ashkenas, 2003) stated, in highly technical projects it is almost inevitable that things will be left out of the scope. This project did fall victim to "white-space risk" as described in this article, as some details between major tasks were overlooked and missing.

2.2.4. Quality

The quality levels in this project remained high throughout the life of the work and left the customer satisfied once the project was complete. For this project no formal quality assurance plans were made. In general, it was assumed that the customer would convey concern if they were not happy. Until they were satisfied with the quality, efforts were made to improve whatever issues they had. The pressure for PCI to profit from this project was minimized since one of the main goals for this project was to show Rexam what PCI's abilities were to hopefully earn future work from them. Still, the severity in which the project went over budget has been noted within PCI. The PM did a very good job in not becoming distracted by the pressure for the job to be profitable for PCI. A change order request was issued to Rexam once the project was complete. It only listed a very small portion of the overall scope creep that existed during the project installation and start-up. At best it would recapture 20-25% or up to $25,000 of the expenses incurred by PCI to complete this project. After a meeting discussing these issues, Rexam only agreed to provide an additional $8,000 for the extra work completed.

2.2.5. Drawing Review Issues

One of the main actions discussed in the quality section that would have likely helped with the Rexam project is a section in PCI's "Managing Quality" document called "Review of Design Drawings". In this project many drawing corrections were found in the field either by the sub-contractors or in project start-up and check-out phases. Simple errors such as electric power coming from the wrong panel and incorrect wire color were found. Issues not specified on the drawings added days to the installation. These errors were all slowly found, corrected, and then drawings marked up accordingly to reflect the as-built corrections.

In this scenario a system designer laid out the overall hardware and wiring components and the drawings were supposed to be reviewed by the PM. Unfortunately, the PM was overloaded with other project details at the time. So another team member quickly reviewed the documentation and then ordered any necessary hardware.

Because of this, one of the areas in which improvement on the PM's responsibilities could be made in future projects is related to design drawing checks. Approximately 45% of the wiring issues that came up during the installation and start-up could also have been spotted and corrected during the drawing approval stage. Improvements could have been made to the drawings to minimize the risk of the issues occurring. Issues such as power for equipment and PLC cards sourced from the wrong power supply could have been noted on the drawings, while adding specifications such as wire size and color to the prints would have minimized the chances of wires being crossed. This was also an issue found during start-up. Standards exist but the electric designer did not specify them on the prints. When the sub-contractor arrived on-site to do the wiring, without this information specified, the lowest acceptable wire gauge size was utilized regardless of the desired color code.

2.2.6. Client Issues

The PM has very good people skills and is able to manage clients effectively, successfully achieving all five keys to success with the client, as specified in Appendix I. Knowing more about the label printer communication suggestions from IT would have made the printer issues much less severe although no hints of such information were mentioned by the plant engineer. The Rexam engineer should have communicated better by passing on the knowledge that their IT department gave him about serial communications to PCI. This would have been much more effective than PCI having to learn what product would work. This would have allowed Rexam to remain consistent in the hardware being used corporate wide. Unfortunately, since the Rexam engineer is the client there is nothing he absolutely has to do to help the contractor on a project, although one would think it would also be in his best interest to resolve installation issues as soon as possible. This is an example of how the client could have been more helpful during the project. Instead, the client was not providing information nor being very responsive. These are two bulleted items on the list of what clients can offer, also in Appendix I.

Another client-related problem that occurred in this project was the issue of multiple persons to satisfy within the client company. In this situation there was one plant engineer officially assigned ownership of this project, so seemingly this would be the person to satisfy. In addition to him though, the plant manager and a senior plant engineer often felt compelled to inform PCI of what they felt were issues of high priority. Often they tried to use their status within Rexam to force PCI resources to be used on issues they felt most important. Lastly, the maintenance technicians responsible for keeping the automation system running and who had worked with the equipment for over 15 years also provided suggestions on how the project should be completed. It was clear that overall the maintenance technicians understood what needed to be accomplished and how to best complete the project. Often times they were unable to successfully plead their case to Rexam management and engineering.

PCI was involved in situations in which it was impossible to please all parties involved. This is a prime example of people related issues which Pyra and Trask discussed in their article. In a situation like this it is suggested to make an effort for all the customers to come to a consensus about what needs to be done before major work is continued in any direction (Pyra and Trask, 2002).. If this is not possible, for better or worse, one must follow the orders of the official owner of the project. It is advised to make it clear to all parties involved that any rework will involve additional funding. PCI should not have to pay for internal customer differences of opinion and direction.

The Rexam engineer also should have put more effort towards getting quicker replies from the corporate IT representative who was working on the label format. During the time lapse between responses, key issues pertaining to troubleshooting the main problem at hand were easily overlooked. It seemed as if PCI was supposed to immediately provide results on the project while certain Rexam departments could respond at their leisure. A clarification of lead times on information from Rexam would have aided in scheduling and provided them with a deadline and hopefully some sense of urgency in responding to questions.

Another recurring issue during the project was an unclear explanation of how parts of the line needed to function. As touched on earlier, the engineer was relatively new to the facility and not completely aware of how all systems work. Instead of forwarding questions onto more knowledgeable individuals, PCI was given "best guess" answers from the Rexam engineer and had to program according to these unverified answers. In multiple situations, once on-site PCI was able to converse with more knowledgeable individuals and was told how the line actually needed to run. This often times led to program rework, sometimes requiring two to three days of corrections per incident. Ultimately, no list of every incident of rework such as this was recorded, so accurate calculations pertaining to the extra work and lost profit because of poor communication by the client cannot be performed.

2.2.7. Software Issues

Several different software programs had to be able to interface with each other in order to make the system operate as described in the functional description. Specifically, the risk was in devices being inconsistently "named" by individual team members in their specific part of the project. Names of devices must be consistently referenced throughout the system for all the components to successfully interface with each other. At times, device names were being changed and updated in some, but not all, of the areas in which it was used in the project. So in effect, one part of the project was being fixed while multiple other parts were being broken. Increased documentation in the future could prevent this from happening. A spreadsheet developed before any portions of the project were programmed could easily define the specific names for devices in all programs. This could then be presented to all programmers as a resource and cross-reference.

2.3. Best Practices

Every article reviewed provided suggestions on how to best manage projects. This section will discuss the activities that the writer feels should be best practices in project management at PCI. Section 2.1 reviewed the current guides provided to PCI managers; this section will recapture some of the best practices already noted in internal PCI documentation or suggest new best practices from the articles reviewed.

When discussing project management, it is important to start with a strong foundation by choosing an effective PM. When considering future PM's, it is to give preference to employees that aren't in PCI management positions already. Expecting one individual to manage a department, a major project, and to work on technical tasks in the project is stretching them too thin. Inevitably, something will suffer; it is suggested to limit management to either projects or internal company responsibilities, not both.

Once a good PM is selected, the writer believes that PCI needs to take a more aggressive stand on project management in all phases of the project. Instead of just assigning a PM to sign expense reports monthly for a project, they need to require organized meetings, status reports, and archiving of lessons learned for each project. It is believed that benefits of these actions could greatly and consistently impact projects in a positive way. The knowledge gained doing this would also make new project estimating more accurate as it would be looking at actual work already completed by PCI employees.

The writer promotes the use of pre-mortem and post-mortem reviews. The post-mortem would not change the outcome of the active project, but could be reviewed by future project teams for similar projects to reduce the likelihood of the same errors being repeated. They could also be used in new project estimations and for promotional material as it would provide a snapshot of how the project went. As mentioned, it provides an opportunity to review new skills individuals learned during the project and provides closure to team members in addition to identifying project risks.

The pre-mortem would immediately aid in the success of current active projects. It would help to identify possible oversights in the initial planning phases of the project, which saves significant time and money in the long run, as was discussed in the literature reviews. It would also help to solidify team members to work on the project, which should make the overall project schedule more accurate and useful.

"Five Ways to Build Quality into a Project", part of the "Managing Quality" document, lists suggestions that should be enforced as best practices. Several of these ways seem similar to suggested actions in other documents covered in the literature review section. The first suggestion is to know your team, and assign tasks to the individuals best suited to do the work. Time should be spent determining the most logical sequence of events for the tasks. It stated that there is a natural sequence of events for each project that will result in optimal efficiency. The next two suggestions are to anticipate problems and stay close to the work. The actions described to anticipate problems seem similar to conducting a premortem as was discussed in the literature review, further emphasizing the necessity for pre-mortem analysis to become a best practice.

Specifically, the writer feels the idea of having the team members restate their understanding of the project to the PM is vital. Often times, simple misunderstandings of expectations or responsibilities can cause severe negative impacts on a project. "Learning in the Thick of It" (Darling, Parry and Moore, 2005) provided a more detailed list of physical activities suggested to assure quality in a project. This article describes in greater details the correct procedure to follow when having all team members recite their overall understanding of the project and their particular role in the project. It seems like an excellent way to guarantee quality work will be done and makes that team member accountable for the responsibilities they take ownership over.

"Five Keys to Success with your Client", part of "Managing the Client" offers other suggestions that should be made best practices when dealing with the client. The first suggestion is to treat the client as a person instead of an agency or organization. One should focus on the client's interests, gauging how much and what type of communication the client prefers, and how formal of a relationship the client is comfortable with. Having a relationship the client is comfortable with will make all communications during the project more effective

One of the first actions to take when starting a new project is to sit down with the customer and define what exactly they expect to consider the project a success. Having a list such as this can spare debates on what is scope creep later in the project. A list of suggested questions to cover is provided in the "Managing the Client" guide. Once this is established, a detailed functional specification needs to be written and signed off by both PCI and the customer before any actual design and programming begins. If at any point after this the customer requests additional work to be done, it will be easy to determine if the requested work is part of the original work agreement or not. If the work is not part of the original agreement, additional documentation should be written. This documentation should detail changes requested by the customer and the expense to make these changes. It should be signed by the customer prior to execution of the work. Practices such as this will allow for the budget and schedule to remain accurate throughout the life of the project and will overall eliminate confusion and potential disputes with the client.

Once these expectations (functional specification) are established and formalized, it is suggested to share them with the rest of the project team, so that all members are aware of what needs to be done to make the project a success. Also, status reports need to be written and distributed consistently throughout the life of the project. The PM of this project did a good job of keeping team members informed of project status and noting risks that deserved concern throughout the life of the project. Had best practices been followed though, these status reports would have been written down, distributed, and archived. Although each project varies, it is important to determine the frequency in which status reports need to be developed. Once this schedule is established, it is important to commit to meeting the schedule. The best practice would be to not space the status reports more than one month apart.

Near the beginning of the project, before any actual work is completed, quality control documents need to be written. In the "Managing Quality" document a list of preferred quality documents is provided. This list should be reviewed and the most appropriate documents, for the specific project being worked on, should be selected. Once it is determined which documents are preferred, they should be written by the PM or a qualified team member and reviewed by the customer. This review will help ensure a satisfied customer at the end of the project. Also during this time, the PM should determine if any additional documentation needs to be developed to complete the project as efficiently as possible. Examples of this may be spreadsheets, databases, or templates to be reused throughout the life of the project. In the Rexam project a spreadsheet cross-referencing equipment names would have been helpful and saved time throughout the project.

Once work has actually begun on the project, more time should be spent specifying requirements for the electrical design. PCI employees in design positions need to verify all data on the drawings before they are issued for construction or passed on to a sub-contractor. In addition to this, guidelines and best practices in place at PCI need to actually be applied to the project work at this point and throughout the life of the project. An example of a guide to be used is the "Review in Design Drawings" found in the "Managing Quality" document.

The next practice to adopt is risk analysis and the use of this information in progress reports throughout the project. By analyzing risk throughout the project, the likelihood of being blindsided by a sudden problem is greatly reduced. It also allows for more time to be spent deciding who the actual owner of the risk or problem is. Although creating and distributing status reports does add more responsibilities to the project manager, it will force them to remain more attentive to the project status. In doing this, they can apply other preventative measures mentioned in the literature reviews, such as adding additional staffing as soon as a problem is realized instead of waiting until the project is past due or over budget.

"Risk Management Post Analysis" was perhaps one of the most helpful articles related to risk, it provides a structured method to use when categorizing risk. As an example of this, many things about the Rexam project can be examined more closely using terms referenced in this article. Some examples of internal risks that occurred in the Rexam project were staff changes and unexpected overtime billing to the job. External risks that hampered the project were delayed delivery of barcode format from Rexam, interfacing communications with an obsolete printer, and hardware wiring mistakes by the sub-contractor. It would be helpful to record the risks that affected this and other projects. This list could then be used to determine if the same risks repetitively cause problems in PCI projects. This list could easily be incorporated into the project post-mortem document.

The last issue to be addressed is not specific to a project, but instead is a time related issue often experienced by PCI PMs. It is the assignment to handle multiple project portfolios. No suggestions on how to best handle this are offered in the internal project management guides. A couple of the articles discussed in the literature review mention the issue. "Why Good Projects Fail Anyway" (Matta and Ashkenas, 2003) suggests how the rapid-results initiative can be adjusted to adapt to multiple project portfolios. It suggests identifying the issues that are fairly certain to fail if not closely monitored and coordinated with related tasks. It is also suggested to welcome input from other team members as to what deserves the most concern. The article "Bringing Discipline to Project Management" (Elton and Roe, 1998) states that its only suggestion pertaining to this matter is to exercise extra caution when allocating resources across projects so as to "minimize the constraints on the shared resources." This is a matter the PCI management should explore in greater detail. They could consider either assigning more individuals the role of project managers so fewer people would be managing multiple project portfolios. They could also inform PMs in which order projects need to be given priority so they can better plan schedules and budgets to satisfy management's preference.

2.4. Project Planning

Three Gantt charts appear in the Appendices, allowing for comparisons to be made of various paths which the project could have taken. The first chart (Appendix B) displays how the project was predicted to go by the project manager prior to its start. This was the only schedule made by PCI for this project. The next chart (Appendix C) is the actual schedule as to how the project was completed. The last chart (Appendix D) was produced by the writer and is a prediction of how the project could have improved if best practices would have been followed. Although they are not listed on the best practices Gantt chart, monthly status updates and meetings would have been held with all team members. These would not directly impact the schedule of the project but would have allowed for any potential issues to be realized. Any impact these issues would have had on the schedule could then be accounted for and the schedule adjusted accordingly.

The best practices schedule results in a manpower total of approximately 220 hours, which is very close to the initial manpower hours of the PCI schedule. The actual project used 528 manpower hours, or 158% more hours than predicted. Although the predicted and best practices schedules total near the same amount of hours, the allocation of hours is different. In the best practices schedule, more time is dedicated to initial planning and organizing before actual work is done. It can be seen that the main reduction in hours between the best practices and actual schedule pertains to the actual system installation and start-up. Had all relevant information been known during the development phase of the project, the hours spent on-site for installation would have been greatly reduced.

Considering each day on-site entailed an hour of commute for each team member plus traveling expenses, it is strongly suggested to have projects as complete as possible before beginning installation. These hours further negatively impacted the schedule and budget un-necessarily. In this project, an estimated 207 extra hours was billed to the project for team member travel to and from Rexam-Princeton. The best practices schedule predicted 45 trips were necessary, while in actuality 252 trips were made. This added approximately $7,000 to the overall project expenses without considering other travel expenses such as gasoline.

Without considering travel, the difference between the actual schedule and best practices schedule equates to roughly $134,000 in additional expenses. This is using an average hourly rate of $60 for all team members and assumes no overtime was incurred. The difference between these predicted figures and those listed in Table 1 are due to using actual pay rates for each team member in the table calculations, actual overtime expenses incurred, and a potential variance in sub-contractor fees. Sub-contractor fees predicted in the preliminary schedule were also used for the best practices schedule; it was assumed that there was no change in this part of the expense breakdown. The best practices schedule is set-up for no use of overtime, if resources overlapped, additional manpower would be brought in to cover the additional work.

Rexam also would have incurred savings had the project proceeded along more quickly, as in the best practices schedule. The variable expenses incurred by Rexam resulted from additional staffing during the installation. Approximately five additional employees were brought in for each shift during the installation phase of the project. These additional employees were necessary so that multiple people could be assigned per station since boxes were filled manually. The preliminary schedule had 11 days in which extra Rexam employees were needed. Using an average hourly rate of $15/hr this would have resulted in approximately $6000 in additional labor expenses for Rexam. In reality, manual packing was required for 19 days, costing $10,300, a difference of $4,300. The best practices schedule predicted 7.5 days required for installation, costing Rexam $4050. It can be concluded that the best practices schedule would have been most advantageous for the customer also. Part of the original contract stated that Rexam would be responsible for their own labor expenses during the installation so these additional expenses were not passed onto PCI.

To further evaluate the alternate schedules, Table 2 shows a breakdown of expenses based on initial PCI project planning documentation. It can be seen that from these figures a profit of $140,178 was anticipated, with only 65% of the budget accounted for. Clearly this budget was not adequate, as several factors were under-estimated or skipped completely. For example, no time was added in the initial schedule for CAD drawings to be developed, but in reality approximately $6,000 was billed towards drawing development. Also, the estimated cost of design development was $2,304 while reality $55,713 was spent designing the system. Situations such as this happen in nearly every category that time and cost were estimated when bidding this project.

Table 2:

Predicted Project Expenses

Expense	Budget	Predicted Cost	Difference	Percent of Budget
Labor	$254,595	$113,352	$141,243	45%
Subcontractor	$24,650	$25,680	($1,030)	104%
Travel	$1,000	$880	$120	88%
Equipment	$9,000	$4,500	$4,500	50%
Material	$110,282	$114,937	($4,655)	104%
TOTAL	**$399,527**	**$259,349**	**$140,178**	**65%**

Source: Julie Hagedorn – Work Product

Similar to the previous tables, Table 3 shows the expense breakdown had the best practices schedule been followed. Looking at the figures in this table, it can be seen that some variation exists between its figures and the initial predicted expense figures. The labor expense is $100,000 higher but still under the budgeted amount. As mentioned previously, the subcontractor fee was not adjusted in the best practices scheme. Travel and material both exceeded the budgeted allowance, while equipment was estimated to have cost $2,500 less. Overall, it is believed that this project had the potential to earn a profit of $18,317 instead of losing $137,917.

Table 3:

Best Practices Project Expenses

Expense	Budget	Best Practices Cost	Difference	Percent of Budget
Labor	$254,595	$213,055	$41,540	84%
Subcontractor	$24,650	$25,680	($1,030)	104%
Travel	$1,000	$3,375	($2,375)	338%
Equipment	$9,000	$6,500	$2,500	72%
Material	$110,282	$132,600	($22,318)	120%
TOTAL	**$399,527**	**$381,210**	**$18,317**	**95%**

Source: Julie Hagedorn – Work Product

PCI management assumed that certain oversights existed in their original predicted costs, which is why the budgeted amount is so much greater than the predicted cost. Some profit was hoped to be achieved, but generally the difference between predicted cost and budgeted value are much closer together. This was the first major project of its kind that PCI undertook, so extra funds were added to compensate for oversights.

Had the project went as shown in the best practices graph, a profit would have been earned by PCI and they would have successfully been able to show PCI's engineering capabilities to Rexam in Princeton. These were the two main goals of the project. Luckily, although a profit was not realized, the customer ultimately was very happy with the work done for them and has offered future job opportunities to PCI.

Although there is no way to definitely conclude the exact impact using the best practices schedule would have had on the overall project figures, it can be concluded that savings would have been incurred by PCI. Hopefully, the knowledge gained during this project can serve as a guide to project managers on how to best manage projects in the future. If all project managers took time to review the end-of-the project figures in tables such as these, they could easily conclude where funds were allocated incorrectly. Once mistakes are realized, it is much easier to work towards minimizing or preventing them in the future.

3. Conclusion

This project was intended to be a way for PCI to get their foot in the door and hopefully be rewarded future work at Rexam in Princeton. This project went very badly when considering budget and schedule, by going over budget over $100,000 and taking four months longer than planned to complete. Fortunately, from a quality and client satisfaction standpoint it was a great success. When it comes time for Rexam Princeton to award a contract for the next big project, these are the things that Rexam engineers will remember. Over time the hope is that the revenue that was given up to make this project a success in quality and satisfaction areas will be more than replaced with profit from future projects with this facility.

As mentioned in several of the postmortem articles, trying to place the blame on any particular individual does not benefit the overall cause of growing a successful company. Although it would be easy to place blame on the PM, the experiments conducted in "The Experience Trap" (Sengupta, 2008) reinforce the idea that even if a more experienced PM had been managing this project, the outcome would have likely been the same. As they found in their testing, it is unlikely that even the most senior PM would have made extreme enough changes at the correct time to improve the project's outcome. Overall, it was a very large project that was bid tightly to beat out competition and allow PCI to get their foot-in-the-door for future control systems projects at Rexam in Princeton.

If there is one thing that PCI could benefit immensely from with all future projects, that is conducting project postmortems after each project is concluded. Although it may seem like a way to waste extra time once the project is complete, especially if the project is already out of time, many lessons can be learned from postmortems. As stated in some of the articles, it is also an excellent method to use to define new skill sets and experience that team members achieved during the project. Postmortem meetings provide official closure to a project, and in this case would be a good opportunity to assure all documentation, software files, and electronic copies are archived appropriately. During the postmortem, it could be discussed which elements of the project could be easily reconfigured to fit other applications, potentially saving time in future projects of redeveloping something that has already been completed and tested.

As stated in "The Project Postmortem: An Essential Tool for the Savvy Developer" (Gunderloy, 2009) it is necessary to take action from the lessons learned during the postmortem and to make the formal documents resulting from the postmortem available to everyone. Taking action may be as simple as realizing certain software or skills in which not enough people are properly trained, to developing new standards or best practices. Like most companies, PCI had an internal network where project postmortem documents could easily be archived for reference.

From a quality standpoint, this project was a success. The client is happy with the work provided and is discussing future work with PCI. If and when future projects arise, a different individual will be manager, one that is not doing actual work on the project. It is believed that this will reduce the likelihood of scope creep as a member of the project team will not be determining what can be done without confirming additional compensation. Although the project went severely over budget, countless lessons were learned and skills gained by the project team. There is no immediate way to quantify the gains of this but hopefully the benefits of the experience will be realized in future projects.

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Appendix A - Rexam Automation Line Layout

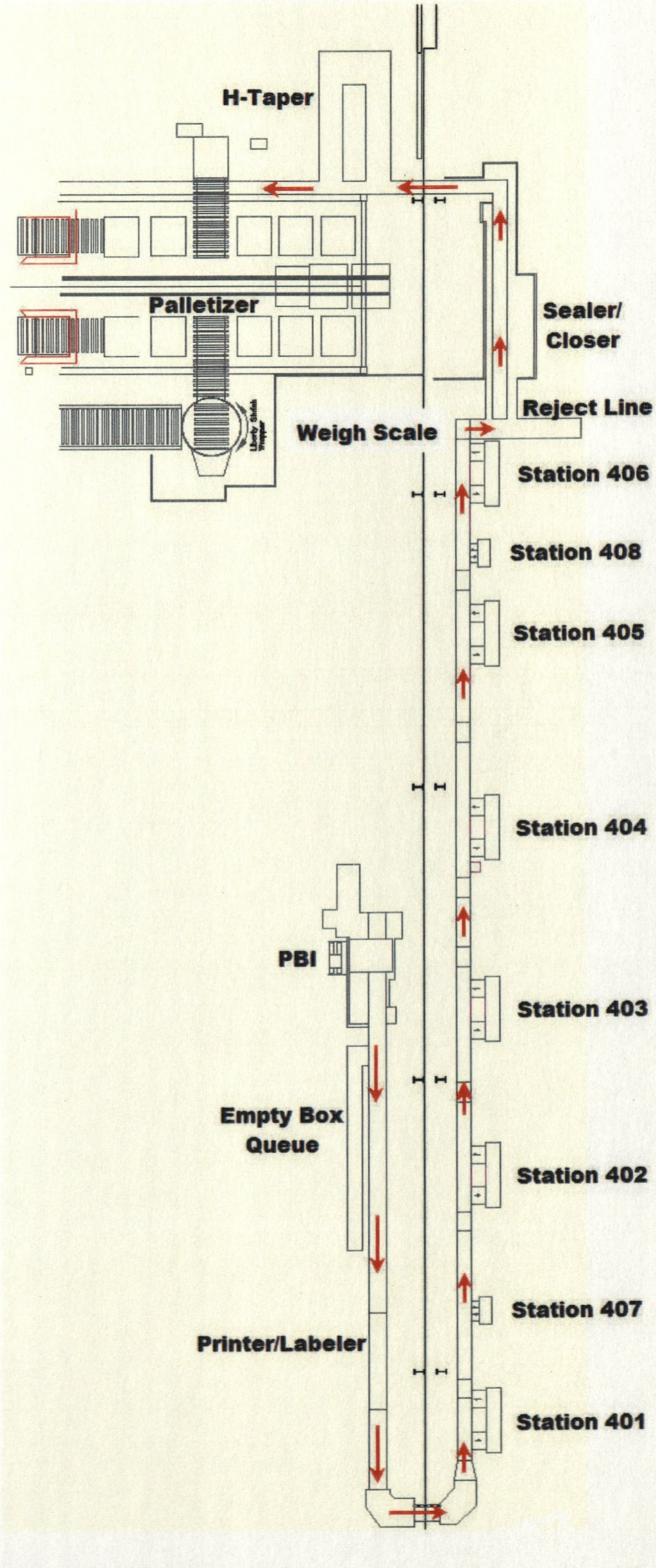
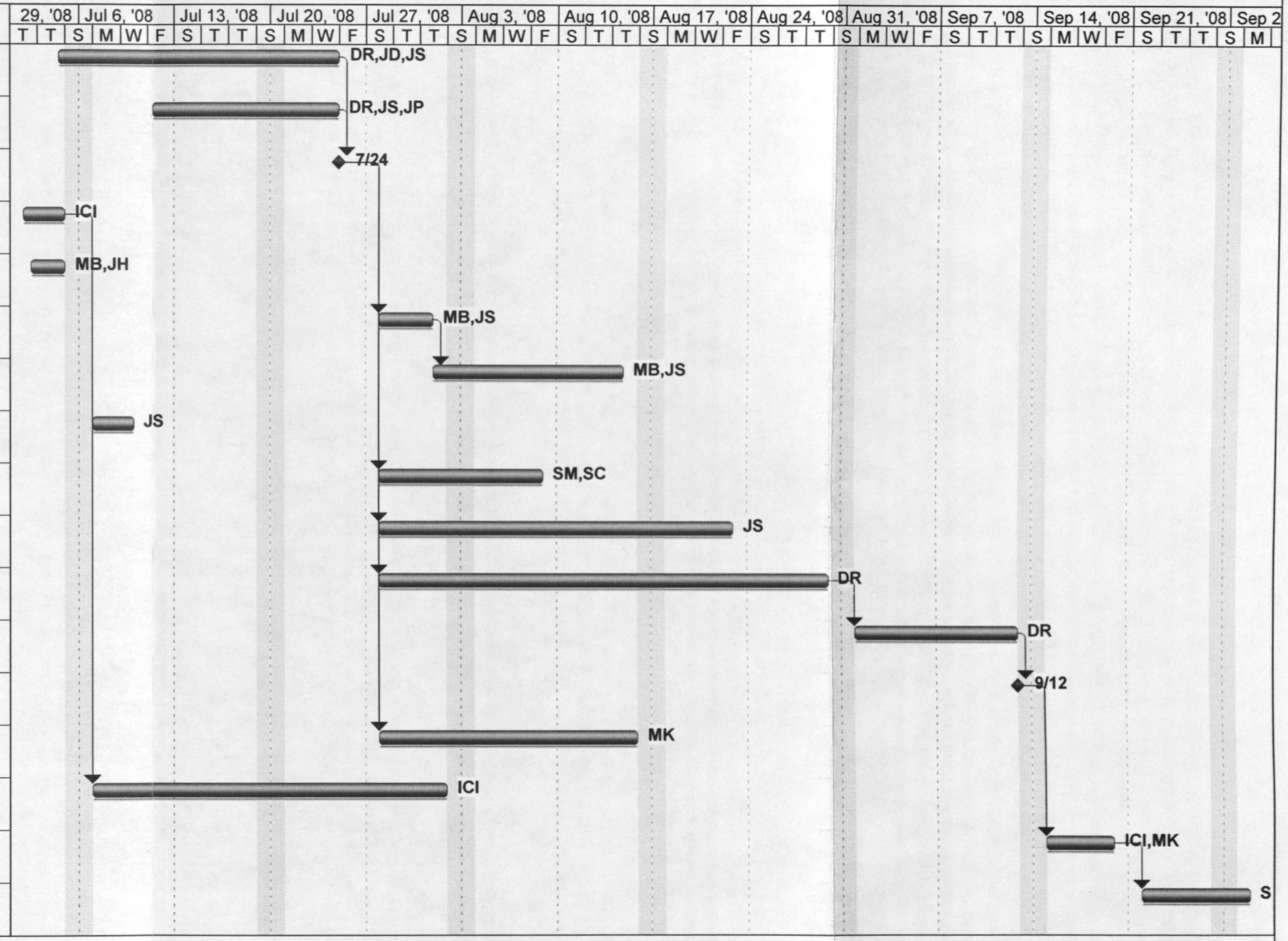


Figure 15: Full Page Automation Line Overview - Source: Julie Hagedorn - Work Product

Appendix B – Rexam Project Preliminary Gantt Chart

Appendix B - Rexam Project Preliminary Gantt Chart

ID	Task Name	Duration	Start	Finish	Predecessors
1	Software Design	14.5 days	Fri 7/4/08	Thu 7/24/08	
2	Electrical Design	9.75 days	Fri 7/11/08	Thu 7/24/08	
3	Design Review	0 days	Thu 7/24/08	Thu 7/24/08	2,1
4	Prototype Stop Testing	3 days	Wed 7/2/08	Fri 7/4/08	
5	SLC Program Conversion	2.5 days	Wed 7/2/08	Fri 7/4/08	
6	PLC Template Development	4 days	Mon 7/28/08	Thu 7/31/08	3
7	PLC Template Integration	10 days	Fri 8/1/08	Thu 8/14/08	6
8	Label Development	3 days?	Mon 7/7/08	Wed 7/9/08	
9	PBI Conveyor Separation	10 days?	Mon 7/28/08	Fri 8/8/08	3
10	Automation PLC Development	20 days	Mon 7/28/08	Fri 8/22/08	3
11	Web Development	25 days	Mon 7/28/08	Fri 8/29/08	3
12	Exhibio Development	10 days?	Mon 9/1/08	Fri 9/12/08	11
13	Software Review	0 days	Fri 9/12/08	Fri 9/12/08	12
14	Panel Building	15 days?	Mon 7/28/08	Fri 8/15/08	3
15	Stops Fabrication	20 days	Mon 7/7/08	Fri 8/1/08	4
16	Installation	5 days	Mon 9/15/08	Fri 9/19/08	13
17	Startup	6 days?	Mon 9/22/08	Mon 9/29/08	16



Project: Post project schedule
Date: Mon 2/8/10

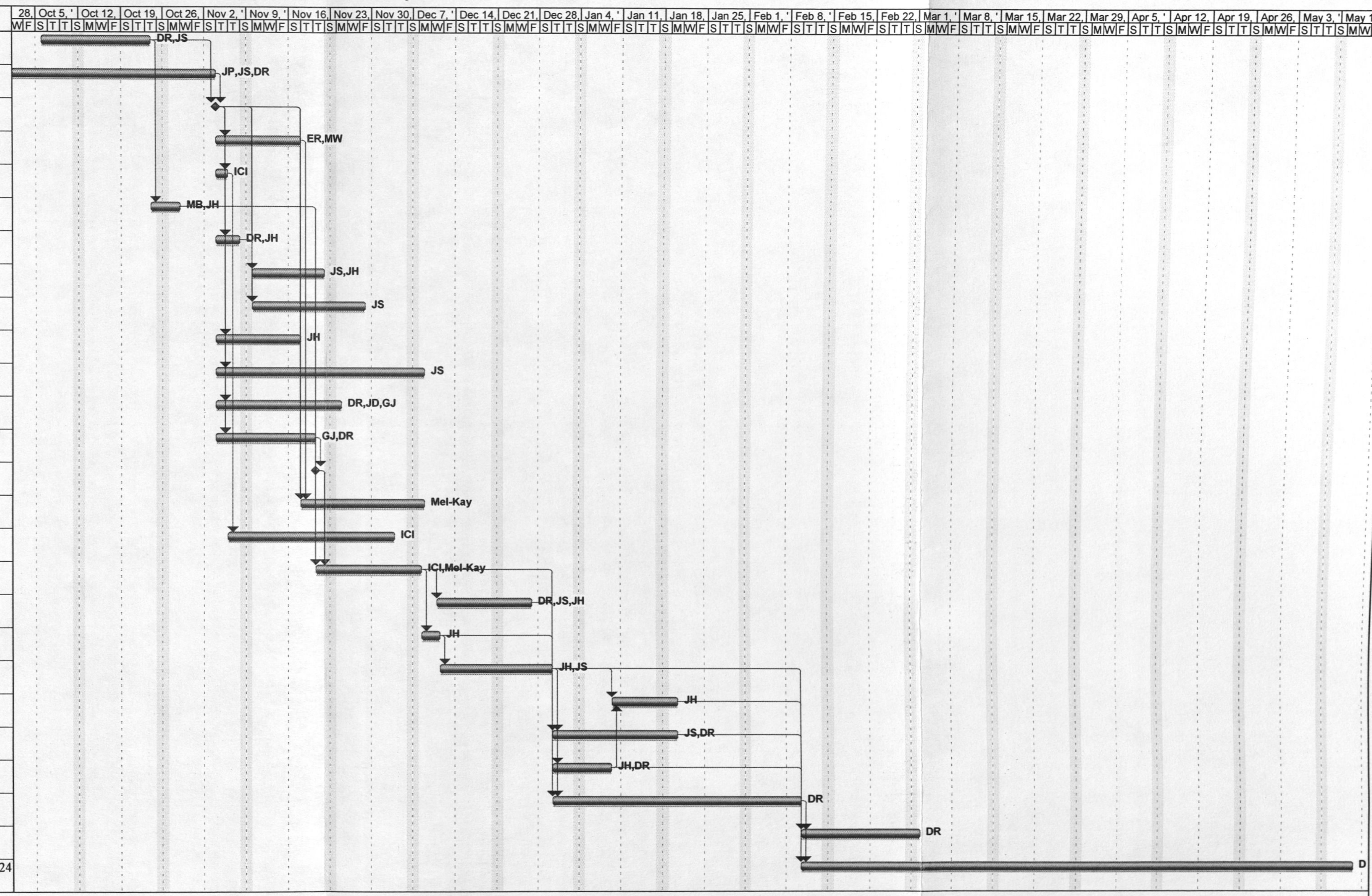
Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

Source: Dave Rettberg - Professional Consultants, Inc.

Appendix C – Rexam Project Actual Gantt Chart

Appendix C - Rexam Project Actual Gantt Chart

ID		Task Name	Duration	Start	Finish	Predecessors
1		Software Design	14 days	Mon 10/6/08	Thu 10/23/08	
2		Electrical Design	24 days	Wed 10/1/08	Mon 11/3/08	
3		Design Review	0 days	Mon 11/3/08	Mon 11/3/08	2,1
4		CAD Drafting	10 days	Tue 11/4/08	Mon 11/17/08	3
5		Prototype Stop Testing	2 days	Tue 11/4/08	Wed 11/5/08	3
6		SLC Program Conversion	3 days	Fri 10/24/08	Tue 10/28/08	1
7		PLC Template Development	4 days	Tue 11/4/08	Fri 11/7/08	3
8		PLC Template Integration	10 days	Mon 11/10/08	Fri 11/21/08	7,3
9		Label Development	15 days	Mon 11/10/08	Fri 11/28/08	3
10		PBI Conveyor Separation	10 days	Tue 11/4/08	Mon 11/17/08	3
11		Automation Controller Development	25 days	Tue 11/4/08	Mon 12/8/08	3
12		Web Development	15 days	Tue 11/4/08	Mon 11/24/08	3
13		Exhibio Development	12.5 days	Tue 11/4/08	Thu 11/20/08	3
14		Software Review	0 days	Thu 11/20/08	Thu 11/20/08	13
15		Panel Building	15 days	Tue 11/18/08	Mon 12/8/08	3,4
16		Stops Fabrication	20 days	Thu 11/6/08	Wed 12/3/08	5
17		Hardware Installation	12 days	Thu 11/20/08	Mon 12/8/08	14,6
18		Hardware Debug	12 days	Thu 12/11/08	Fri 12/26/08	17
19		Processor Replacement	3 days	Mon 12/8/08	Thu 12/11/08	17
20		Normal Box Station Debug	13 days	Thu 12/11/08	Tue 12/30/08	19
21		Blowover Box Station Debug	7 days	Fri 1/9/09	Tue 1/20/09	20,23
22		Initial Printer Debug	15 days	Tue 12/30/08	Tue 1/20/09	18,19,20
23		Auxiliary Equipment Debug	8 days	Tue 12/30/08	Fri 1/9/09	20
24		Website & Label Debug	30 days	Tue 12/30/08	Tue 2/10/09	20,17
25		Offline Printer Integration	14 days	Tue 2/10/09	Mon 3/2/09	22,24
26		Misc Issues Investigation & Debug	68 days	Tue 2/10/09	Fri 5/15/09	20,21,22,23,24



Project: RXP Upgrades Phase II Sche
Date: Mon 2/8/10

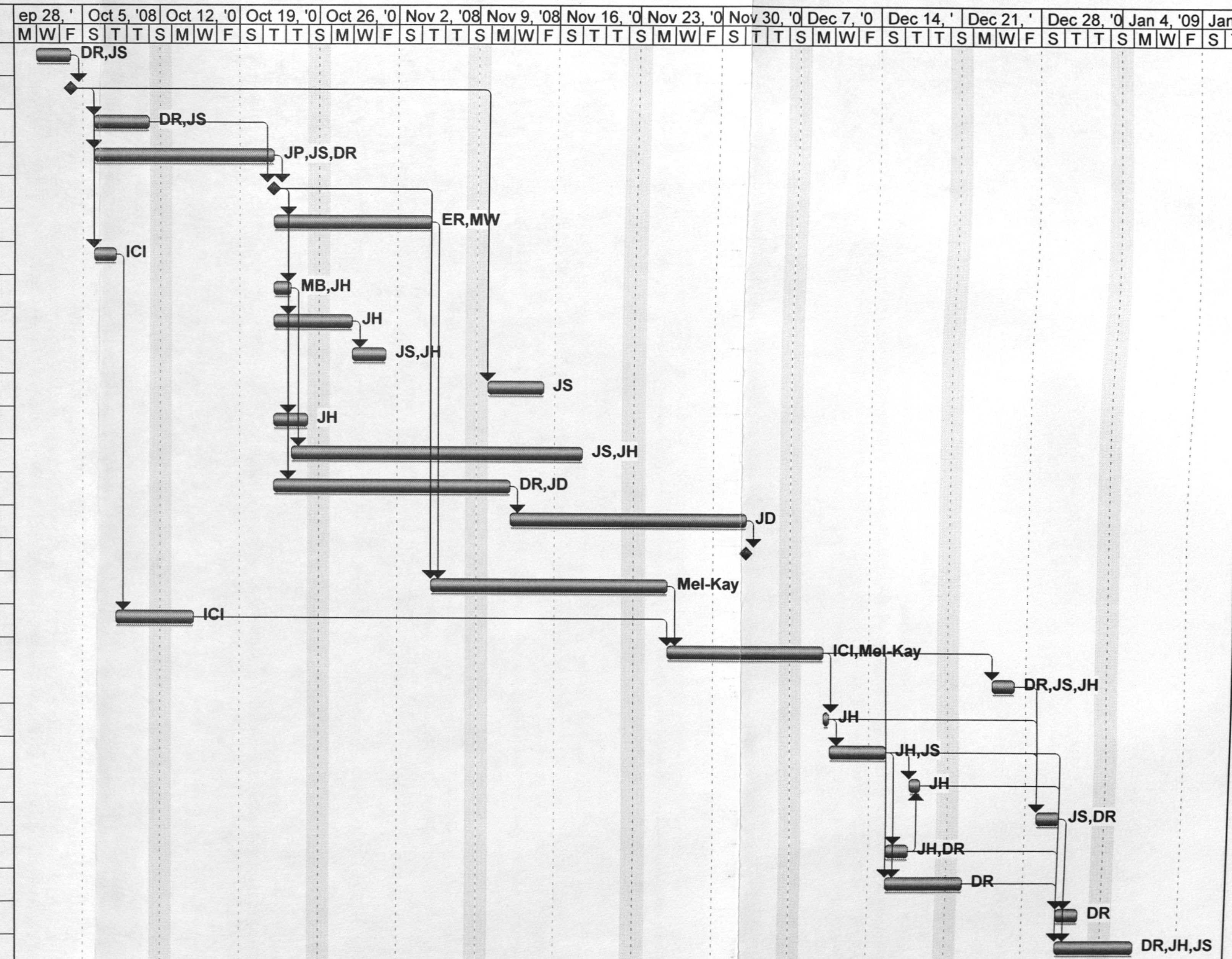
Task | Critical Task | Progress | Milestone | Summary | Rolled Up Task | Rolled Up Critical Task | Rolled Up Milestone | Rolled Up Progress | Split | External Tasks | Project Summary | Group By Summary | Deadline

Source: Julie Hagedorn - Work Product

Appendix D – Rexam Project Potential “Best Practices” Gantt Chart

Appendix D - Rexam Project Potential "Best Practices" Gantt Chart

ID		Task Name	Duration	Start	Finish	Predecessors
1		Project Kick-off Tasks	3 days	Wed 10/1/08	Fri 10/3/08	
2		Project Kick-off Meeting	0 days	Fri 10/3/08	Fri 10/3/08	1
3		Software Design	5 days	Mon 10/6/08	Fri 10/10/08	2
4		Electrical Design	12 days	Mon 10/6/08	Tue 10/21/08	2
5		Design Review	0 days	Tue 10/21/08	Tue 10/21/08	4,3
6		CAD Drafting	10 days	Wed 10/22/08	Tue 11/4/08	5
7		Prototype Stop Testing	2 days	Mon 10/6/08	Tue 10/7/08	2
8		SLC Program Conversion	1.5 days	Wed 10/22/08	Thu 10/23/08	5
9		PLC Template Development	5 days	Wed 10/22/08	Tue 10/28/08	5
10		PLC Template Integration	3 days	Wed 10/29/08	Fri 10/31/08	9
11		Label Development	5 days	Mon 11/10/08	Fri 11/14/08	2
12		PBI Conveyor Separation	3 days	Wed 10/22/08	Fri 10/24/08	5
13		Automation Controller Development	18 days	Thu 10/23/08	Tue 11/18/08	8
14		Web Development	15 days	Wed 10/22/08	Tue 11/11/08	5
15		Exhibio Development	15 days	Wed 11/12/08	Tue 12/2/08	14
16		Software Customer Review	0 days	Tue 12/2/08	Tue 12/2/08	15
17		Panel Building	15 days	Wed 11/5/08	Tue 11/25/08	5,6
18		Stops Fabrication	5 days	Wed 10/8/08	Tue 10/14/08	7
19		Hardware Installation	10 days	Wed 11/26/08	Tue 12/9/08	17,18
20		I/O Checkout/ Hardware Debug	2 days	Thu 12/25/08	Fri 12/26/08	19
21		Processor Replacement	0.5 days	Wed 12/10/08	Wed 12/10/08	19
22		Normal Box Station Debug	3 days	Wed 12/10/08	Mon 12/15/08	21
23		Blowover Box Station Debug	1 day	Wed 12/17/08	Thu 12/18/08	22,25
24		Printer Debug	2 days	Mon 12/29/08	Tue 12/30/08	20,21,22
25		Auxiliary Equipment Debug	2 days	Mon 12/15/08	Wed 12/17/08	22
26		Website & Label Debug	5 days	Mon 12/15/08	Mon 12/22/08	22,19
27		Offline Printer Integration	2 days	Wed 12/31/08	Thu 1/1/09	24,26
28		Misc Issues Investigation & Debug	5 days	Wed 12/31/08	Tue 1/6/09	22,23,24,25,26



Project: RXP Upgrades Phase II Sche
Date: Mon 2/8/10

Task		Milestone		Rolled Up Critical Task		Split		Group By Summary	
Critical Task		Summary		Rolled Up Milestone		External Tasks		Deadline	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary			

Source: Julie Hagedorn - Work Product

Appendix E - PCI's Project Manager Role

PCI's Project Manager Role – PCI Internal Documentation

1. Key Responsibilities

1. Develop the project management plan.

2. Develop and maintain the project budgets.

   - Develop design budget by getting input from disciplines and outside consultants, and estimating other project expenses.
   - Review estimate with project sponsor to determine the firm's proposal to the client.
   - Track weekly progress of the percent complete relative to the project budget and target profit.

3. Develop and monitor the project schedule to meet the client and the firm's time objectives.

4. Develop and maintain project coordination meeting schedule.

5. Prepare for, notify appropriate personnel, and chair project kick-off meeting.

6. Notify the client of changes in project scope, and prepare estimate for additional design fees.

7. Keep the client, project sponsor and the firms accounting department informed on the status of the project.

   - Review and approve monthly billing sheets used to prepare invoices.
   - Provide recovery plan to put project back on track in terms of deliverables to client, and profit with respect to budget.

8. In regards to new work, the PM must:

   - Ensure terms of contract are followed and secure supplemental agreements as required.
   - Prepare proposals or assist in preparation of proposals. Meet with clients to discuss proposals.
   - Assist in presentations for potential jobs.

9. Accept professional responsibility in their area of expertise, for projects completed under their direct supervision. When appropriate or manpower scheduling requires,

the PM may need to contribute specific work projects or technical assistance in his or her area of expertise.

10. Assure quality control procedures are implemented and maintained for each of the technical areas required to complete the job.

11. Provide guidance and training of technical support personnel in related discipline.

12. Have sole responsibility to coordinate as required with other divisions or consultants for project support.

13. Assure that project correspondence and design documentation is kept orderly and complete at all times.

14. Assure project is properly closed out on accordance with the established procedures.

15. Make recommendations to the project sponsor on personnel needs, advertisement and hiring of staff as required.

16. Conduct employee evaluations which may include providing input to appropriate supervisor if not under the PM's direct supervision.

17. Ensure that personnel under the PM's direct supervision observe company policies.

18. Issue warnings or recommend disciplinary action to project sponsor and/or department manager as required.

2. Specific Tasks during Project Phases

1. Schematic design and Design Development Phase

a. Schedule design meetings with the Department Managers, and schedule appropriate staff for the project.

b. Arrange for preliminary construction estimate.

c. Coordinate design presentations.

d. Consult with all appropriate Authorities (Client representatives, Client insurance carrier, Public Authorities, etc.) and determine that their observations and inputs have been secured prior to commencing the contract document phase.

e. Determine what codes and regulations are applicable to the project; determine what permits, licenses and authorizations will be required and how each is to be secured.

2. *Construction Document Phase*

a. Review contract documents with appropriate public officials.

b. Attend public meetings and/or hearings, as necessary; assure that all public authority approvals are obtained.

c. Perform independent review of all contract documents and specifications for completeness and coordination. Ensure that corrections and clarifications are made if required.

3. *Bidding Phase*

a. Compile selected list of bidders with client.

b. Compile and issue addenda, if necessary.

c. Tabulate bid results and participate in contract bid negotiations.

d. Assist client in the preparation of the construction contract.

4. *Construction Phase*

a. Interpret the intent of the contract drawings and specifications for the client, general contractor, building inspector, and other interested parties.

b. Schedule and attend job meetings.

c. Obtain from contractor and distribute a schedule of anticipated shop drawings and samples.

d. Schedule personnel for job site visits, and obtain site visit reports.

e. Review all requests for modifications of the contract drawings and specifications whether initiated by the client or the contractor.

f. Consult with lead designers on all modifications and design changes.

g. Prepare change drawings, as required using project team.

h. Review and approve all change estimates; prepare and sign all change orders.

i. Review and approve all contractor monthly requisitions for payment, including requisitions for final payment.

j. Inform lead designers of status of construction.

k. Arrange for appropriate personnel to prepare punch list.

l. Oversee the preparation and distribution of clients' operation and maintenance manuals and record drawings.

m. Collect all warranties, guarantees, and other specification close-out requirements.

n. Prepare a project summary and critique.

o. Return to meet with the client in approximately one year following occupancy for project evaluation.

3. The Project Manager's Roles

Regardless of the firm's organization, a strong PM has eight basic roles:

1. Technical Supervision

The technical role of the PM is listed first because most design and construction firms depend on technical expertise in a particular field. The PM must be technically competent and directly involved in the technical aspects of the project.

A firm's success depends upon the application of proper technical expertise in each of its practice areas. A PM must deal on a sufficiently advanced level of technical sophistication to gain the respect and cooperation of the client and of the members of the project team.

Clients will not respect a PM who cannot respond to technical questions without first consulting the project team to obtain the correct answers. After all, in making any consumer complaint, one prefers speaking with product salespeople who can respond to specific inquiries immediately, rather than those who always have to "consult the factory."

Clients feel the same way about PMs who are not technically proficient. In addition, studies show that technical competence is the single most influential factor in determining how project team members are PMs. This factor can dramatically affect the PM's ability to motivate the team.

2. Contract Negotiation

The PM must meet with the client to define client concerns, requirements and key target dates. Using this data, he/she must develop a scope of services, estimate manpower effort and expenses, develop a project schedule and negotiate the agreement for professional services, all of which must meet the client's needs and the firm's profitability goals without subjecting the firm to unacceptable risks.

3. Project Planning

Planning takes the overall project requirements and divides them into manageable elements in a logical sequence. Effective planning avoids unnecessary crises and anticipates unavoidable ones, enhancing crisis control. Common problems that can be overcome by proper planning include:

- Inadequate definition of requirements
- Unwillingness to specify objectives
- Undefined end point of the project
- Poor communication about project requirements and changes

4. Project Organization

The PM must work with the department managers and project sponsor to organize the team and assign individual project responsibilities to team members. The project team can extend beyond the limits of the firm to include outside consultants as well as client staff members. It is important that the PM is involved in the selection of the project team as the talents and work habits of the team members will influence the organization and scheduling of the project.

During the project, the manager must also provide feedback on each team member's performance. This feedback should be dispersed not only to department heads and principals, but also to individual team members.

5. Direction

After the project is planned and organized, the PM will expend considerable effort to direct and coordinate the activities of team members, principals, outside consultants, clients and third party review agencies. Effective communication is the key task, making sure that project work is done efficiently and that nothing "falls through the cracks."

The PM must coordinate work among the various disciplines, keep everyone informed of changes, and make sure that required input is available when needed.

6. Control

As the project progresses, it is PM's responsibility to control:

- Technical quality
- Budget
- Schedule
- Client satisfaction

The control function can be successfully accomplished through the use of various techniques, such as design reviews, formal progress reports, and informal milestone reviews. The PM's ability to delegate work to other team members also calls for adequate control measures.

7. Financial Management

Another role of the strong PM is participation in project budgeting, cost proposal preparation and the negotiation of change orders with the client. The PM is most familiar with the project and the client. Having this in-depth knowledge ensures that job costs are properly accounted, that invoices are prepared quickly and accurately, and that accounts are paid promptly.

8. Marketing

The PM must contribute significantly to the firm's marketing efforts in all areas of the firm's practice. The PM's marketing role with existing/previous clients is to sell additional work in these ways:

- Expand the scope of existing contracts
- Get the client to hire you again (especially by doing a good job)
- Actively secure referrals
- Maintaining contact with previous clients to identify new projects

His/her roles in securing projects with new clients are:

- To establish a program for a potential project that meets the client's need
- To help to attract new clients
- To close the deal with new clients
- To sell all the services your organization has to offer

The PM's ability to sell ideas (both actively and passively) can be one of the most significant factors in the final selection process.

Active Marketing to Existing Clients entail asking them about:
- The next step or phase in your present project at that facility
- Related work (new types of service) at the facility
- Other capital or O&M expenditures at the facility (There's no law against generating leads for other parts of your organization)
- Any of the above at other facilities within the client's organization

Ways to Passively Market to Existing Clients:
- Send client an interesting clipping or article, especially those written by your staff.
- Add client to newsletter list and seasonal card list.
- Invite client to your social outings.
- Invite client to attend in-house seminars.
- Deliver a seminar at the client's office on a topic of your expertise.
- Get actively involved in trade/professional/business associations frequented by your clients. Become a leader in these associations.

4. Five Keys to Effective Project Management:

The effective project manager is able to:

1. **Accomplish Rather than Excuse** — Numerous excuses can be identified for any project that does not meet budget, schedule or quality needs. For example:
   - "I had too many other things to do."
   - "The budget was unrealistic."
   - "I couldn't get enough help."
   - "The schedule was unrealistic."

   However, none of these excuses are a satisfactory substitute for performance. The successful PM views difficulties as challenges and gains the respect of clients, supervisors and peers by accomplishing the project's objectives in spite of problems. It is the ability to overcome external difficulties and still make the project a success that leads to rapid professional advancement.

2. **Know When to Take Charge** — to be most effective, recognize that the project team is looking to the PM for guidance and direction. However, each member of the team must be allowed to exercise judgment and creativity within the constraints of the project and their role on the team.

3. **Serve the Client** — The key phrase is "serve, but don't be servile." The PM must sometimes tell the client things he/she doesn't want to hear (for instance, that the cots to construct a favored design concept exceeds the budget). The ability to manage client relationships successfully is one of the PM's most important skills.

4. **Meet the Schedule** — This means doing everything possible to complete the project within the contractual time frame. Despite one's best efforts and through no fault of the project team, there are times when external forces cause the schedule to slip. The client or third party review agencies often cause such delays.

   In such cases it's essential that the PM make an effort to:
   - Inform the client of the consequences of any delays.
   - Make up any lost time by increasing the productivity of the project team.
   - Confirm with the client that the delay was in no way caused by the design firm.

5. **Make the Planned Profit on Every Job** — Unfortunately, many PMs don't understand why design and construction firms must make a profit. Contrary to popular belief, profits are not funneled directly into the pockets of the principals.

   Here's a partial list of the uses of profit earnings in a typical E/A firm:

   - Profits, in the form of retained earnings, provide a cushion that enables the firm to operate through the lean times without going out of business or laying off its key staff. The cyclical nature of the design business demands that considerable retained earnings be available to assure stability.

   - Profits are the source of investment in new equipment, furniture and other capital goods that are essential for the continued growth of the firm. In today's environment, the increasing importance of computers, word processing equipment and computer-aided drafting equipment makes the need for capital investment more important than ever.

   - A record of consistent profitability is a key measure that all banks use to determine the line of credit available to finance day-to-day operations. If the borrowing capacity of a firm is insufficient, its ability to grow will be severely impaired.

- Continued profits provide the money to compensate the top performers with pay increases, improved benefits, bonuses, and profit sharing.

- A firm's profits must provide the investors with a rate of return greater than one that can be obtained from more secure investments, such as treasury bills, money market funds and high-quality bonds. If the return fails below one that can be realized from these more secure investments, sources of needed capital will soon evaporate.

- Finally, profits are the reward to owners for the tremendous risks of ownership, such as financial commitment and professional liability considerations.

The PM is the person in the firm who most directly affects profits by controlling project budgets.

5. Impediments to Effective Project Management

These issues most commonly prevent an individual from becoming a strong PM.

- **Lack of Education** — Most PMs are promoted from technical positions, and their training neglects managerial techniques. Yet finance, communication, leadership and negotiation are among the skills needed to succeed in project management.

- **The Principals** — Responsibility for project management must be accompanied by authority. Principals who won't delegate authority can hurt the PM's effectiveness.

- **Too Many Projects** — Too many projects may prevent the PM from giving enough attention to each one, especially when management tasks take second place to technical and other responsibilities.

- **Clients Who Don't Understand Project Management —** Unseasoned clients on a "cost-plus" basis balk at paying for time they don't see as advancing the technical work.

- **Lack of Commitment** — Many PMs accept their position not from love of the position's duties, but because they see it as the only way to get ahead in the firm.

- **Lack of Authority —** Responsibility without the accompanying authority leads to frustration.

- **Lack of Participation During Negotiations —** Project managers who have fees handed down to them from above don't have the same commitment to maintaining those budgets as those who negotiate the fees.

- **Lack of "People" Skills —** PMs who don't stay in touch with their clients and the production staff always have problems. Frequent conversations and the required paper trail must be in place.

- **Lack of Knowledge About the Client —** PMs who don't understand their client's business and goals can't deliver a good project.

Appendix F - Managing Your Time

Managing Your Time – PCI Internal Documentation

1. Controlling Interruptions

Unscheduled interruptions can be a major source of frustration and lost time. The key to avoiding them is to control your contacts.

- At certain periods, close the door or block the entrance area to your workspace. Place a chair with a sign hung on it, or swing a plant into the entrance space.
- Learn to say "no" nicely. "Sorry, I'm busy. Please come back after ________."
- If you're interrupted and must meet with a person, go to his/her office or workspace. It will be easier for you to leave when the business is concluded.
- Ask a drop-in to walk along with you on your way to a meeting or another office. He/she will have to be brief to finish the conversation before you arrive at your destination, or make an appointment for a later time.
- Consider trading off priorities. In return for conferring on his/her priority, which may not be yours, ask that you be allowed time on your visitor's calendar for one of your priorities.
- Encourage the use of e-mail, the telephone and written notes when personal contract is not necessary. They can be better controlled.
- Establish a time limit for all drop-ins when they arrive. Ask them if it is sufficient. If it is not, ask them to make an appointment when you have more time available.
- Keep a clock in full view of yourself and visitors.
- Prepare a file folder for your regular drop-ins, and keep items for discussion with him/her when they arrive.
- The physical arrangement of your office may be attracting drop-ins. Your office chairs may be too comfortable or the furnishings too enticing. Do not sit facing the door of your office, as it will attract potential drop-ins who can easily catch your attention.
- To let drop-ins know you want to finish soon, use such phrases as: "Before we wrap it up," or "Before I let you go."

- When the time is up, use a firm but courteous closing technique, such as "I know you have to get back to your work and I do, too, so I'll let you go now."

2. Keeping a To-Do List

Most PMs have learned through experience that "If it isn't written down, it won't get done." The importance of keeping a to-do list can't be overemphasized. Here are some tips to make yours more effective:

- Use the same paper size for all your to-do lists.
- Keep you old lists for reference.
- Combine personal and job tasks where possible.
- Highlight today's tasks along with any other urgent tasks.
- Utilize an easy-to-use, portable, easy-to-reference tool such as a Franklin Planner or an electronic means, such as Outlook.

3. Delegate

Another way to save time is to make sure you're not doing work that can be done as well by others. Be sure the person is qualified to do the task, and then trust him/her to do it within an acceptable degree of quality and effectiveness.

Keys to Successful Delegation:

- Consider gradually increasing authority and responsibility.

- Set clear, realistic goals for the task to be delegated.

- Communicate the assignment clearly.

- Give your support person complete information on organizational policy and procedure as it relates to the assignment.

- Define the limits of responsibility as it relates to the assignment. After the delegate thoroughly understands the limits of authority, allow him/her to go ahead.

- When a subordinate has the responsibility for a decision, allow him/her to make it. Resist making decisions for your support staff.

- Take enough time to help a delegate solve an emergency problem so when it comes up again, he/she can go ahead without interrupting you.

- When a support person comes to you with a question concerning a delegated task, do not answer the question, but help him/her think it through.

- Set up a system that requires interim reports or check points so you can review progress.

- Establish a realistic completion date.

- Delegate to the lowest level that can do the task within your jurisdiction. If the subordinate of your subordinate could do the task, then say so, but delegate to your own subordinate. Let your subordinate re-delegate the task if he/she so chooses.

- If a subordinate's decision must be reversed, permit him/her to reverse it. Never openly countermand your subordinates' orders. Back up your support people in their relations with their subordinates.

- Give the delegate the authority needed for carrying out the assignment, and inform others that he/she has this authority. This will lessen the resistance of co-worker when the delegate seeks information and/or help from them in carrying out the assignment.

- Don't expect the result to be exactly as you would have done it.

- Give credit where credit is due.

4. Time vs. Communication

In this section we have presented a number of ideas that can be used to save time. But a word of caution: there is often a direct contradiction between the goal of good communications and that of proper time management.

The regular Monday morning meeting, terrible from a time management perspective, may be essential for good communications. Many similar examples can be cited.

Before blindly following anyone's suggestions for improved time management, ask yourself if you are willing to pay the price in reduced communications.

Appendix G - Managing Quality

Managing Quality – PCI Internal Documentation

1. Quality

The quality of service provided is an essential element in attracting new clients, and often the most important factor in assuring that an existing client will offer you the opportunity for additional work.

When faced with inferior quality, many clients don't complain. They simply switch consultants. Poor quality work is costly, whether it results in the loss of a client, the payment of a claim, or the need for re-doing faulty work.

These is much confusion about various quality definitions. Although different people interpret these definitions somewhat differently, quality experts generally use the following definitions:

Quality Assurance (QA) is a firm-wide program that defines the level of quality that is required and how it will be achieved. QA also includes a method of monitoring compliance with the firm's quality requirements.

For example, a firm that performs planning studies might have a quality requirement that no report goes to a client without an independent internal peer review. That firm's QA program would assure that everyone understands the requirement and that there is an audit system to assure compliance.

Quality Control (QC) is a plan conducted at the project level with the firm's (and client's) quality requirements. In the above example, the project QC plan would identify the best person to do the peer review and schedule the proper time for that review. The QC plan would also identify how much budget should be allocated to the peer review and how much should be allocated for making corrections resulting from that review.

A Quality Improvement Program (QIP) is a firm-wide system for continuously improving the quality of the firm's projects.

For example, if the above-described QC reviews frequently identify problems of inconsistency between data in tables vs. the same data described in the text, the firm's QIP should seek to discover the systemic causes of such problems and devise systemic solutions.

If successful, these solutions will prevent the problem from occurring in future reports so that time and money is not spent in identifying and correcting the problem during the QC effort.

Total Quality Management (TQM) is the "umbrella" that encompasses QA, QC and QIP into a firm-wide program.

2. The Pressure for Profit

Errors are often blamed on the pressures of making a profit. Budgets are low because the client does not understand the scope or simply does not trust the professional's estimate.

Economic pressures of competition may encourage the PM to propose an artificially low budget when the client is influenced by price. Even the best-planned budgets can become strained near the end of the project, when internal and external pressures compete for the remaining fee.

Wherever the pressure on the budget comes from, the project manager cannot afford to delete the cost of assuring quality in the finished product. The avoidance of such costs is not acceptable to the firm, nor is it worth the potential loss of the client, the potential legal or financial risks, or the potential for risking the professional reputation of the firm.

3. Project Related Factors

Naturally, errors are the results of much more than budgeting constraints. Some of the factors that pose a potential for problems in assuring quality are unavoidable and must be planned for appropriately. These include:

- Project complexity
- Multiplicity of disciplines required
- Time constraints
- Inadequate information

Other potential problems or weaknesses that may be the PM's fault and must be avoided or corrected when discovered include:

- Inappropriate staff
- Poor communication
- Inadequate or non-existent checking procedures (quality control)
- Self-imposed time constraints (poor scheduling)

4. Defining Project Quality

It's usually not the poor quality of the design, but the poor quality of the service that hurts the client/engineer relationship on most projects. Clients tend to measure the quality of a project in terms of the impact of schedule, budget, and the deliverables on the project.

It's the promise not kept, the communication not delivered, the milestone date ignored that leads to the enduring perception of poor quality in the client's mind.

When planning your project, define what constitutes quality for your client. Since most problems have to do with the working relationship between you and your client, focus on that aspect of the project.

The first stage is to sit with your client and develop a detailed list of expectations about how the project will be accomplished from his point of view. Questions to be answered include:

- When will meetings occur?
- How will communications be documented?
- What are the critical dates (or milestones) when the client needs information from you?
- Who are the individuals from your firm who will be assigned to the project?
- What are their capabilities and do they match the needs of the client?
- When and how will you deal with problem issues that arise between you and the client?
- How will you address design and construction change orders?
- How will you communicate with the client if there is a crisis on the project?

Document these quality expectations and review them with the project team. Make everyone accountable for maintaining these standards, and reinforce them with your own action every day. A client who is made to feel that you care about his/her project will go out of the way to cooperate.

5. Improving Project Quality

1. **Incorporate Quality Assurance/Quality Control (QA/QC) into your budget —** The PM is expected to make money on the job, but you, as the project manager, are responsible for the budget.

   Include QA/QC as a line item in your budget, and sell your client on its importance both in the proposal and in early meetings. Following the firm's QA/QC program is not an option, it's a requirement, regardless of whether the client expects to pay for it or not.

   Should you be assigned a project that is already underway, check the budget. If QA/QC has not been accounted for, discuss an amendment with the client. If this isn't possible set aside a portion of every task budget to be used for QA/QC, and discipline yourself and your task leaders to use it appropriately. When properly carried out, good QA//QC practices and planning during project development will reduce overall project costs.

2. **Make realistic staff assignments** — Assign responsibilities to qualified individuals who can handle them. Many employees are not prepared to handle the technical aspects of a project because they lack experience and good judgment. The correct match of employee to each task is important.

   It is not always possible to have the perfect employee available for every task. As project manager, you must be aware of the limitations and strengths of your team, compensating, where necessary, with a higher level of supervision. This may mean daily or twice-weekly assignments, instead of weekly or bi-weekly assignments.

3. **Beware of project complexity** — When projects are complex or of long duration, the ensuing difficulty in coordination invites error. Employee turnover on a long project can hinder communication, and a small, undetected mistake passed on to other teams or multi-discipline projects can magnify the consequences over time.

   Each discipline must be responsible for its individual sub-area of quality control. The project manager should assign that responsibility to a task leader who has the knowledge or support to assure that the required quality control procedures are carried out within that discipline, and who can communicate clearly what is needed for the task.

   When information is shared between disciplines, the PM should ensure that each task leader is aware of the level of detail involved and the impact of the correct information on other disciplines' tasks.

4. **Develop realistic schedules**

5. **Provide and cultivate an enjoyable working atmosphere**

6. **React quickly to symptoms and problems**

6. Quality Control Plan

No matter how well it's planned every project will have errors and omissions. The purpose of quality control is to find and correct these errors before the design goes to the field or the study goes to the client. A good QC plan should define:

- Which documents should be reviewed?
- Who should review them?
- When documents should be reviewed.

- What kinds of errors will be sought?
- The budget allotted for review.
- The schedule and budget allotted for corrections.

One of the most common mistakes made in quality control is for a reviewer to be given a set of documents without explicit guidance as to what kind of review is expected. Here are several different kinds of quality control reviews commonly conducted on design and study projects and included in the Quality Control Plan.

1. **Interdisciplinary Review —** An experienced person from each discipline who worked on the project checks the applicable calculations, drawings, and specifications produced by that discipline.

2. **Interdisciplinary Review —** One or more individuals from the project team perform a detailed review to assure consistency and identify obstructions between disciplines.

3. **Drawing-Specification Cross-Check —** Conducted by the project team member who reviews the specifications page by page. He/she will identify information that will also appear on the drawings and check for inconsistencies between the drawings and the specifications.

4. **Multi-Facility Cross-Check —** On projects involving multiple buildings or facilities, this review will identify inconsistencies between buildings located in the same complex. For example, a pipe shown leaving one building as an eight-inch pipe should not be shown to enter another as a six-inch pipe.

5. **Vendor Review —** Equipment and material suppliers are asked to identify equipment incompatibilities, out-of-date specifications, and inappropriate materials. They're also able to provide other information, such as cost and delivery status.

7. Review of Design Drawings

Drawings should be reviewed to ensure that:

1. The scope of the drawing is satisfactory, and all work intended to be covered has been included.

2. The structures, units, or equipment have been considered from an overall operational standpoint, and all necessary components are included.

3. Results of engineering studies, reports, and calculations have been properly factored into the design criteria of the respective group.

4. Interfacing between drawings is correct, and the discipline drawings are in agreement with other drawings.

5. Previous comments on check prints have been incorporated into the completed drawings.

6. The design conforms to applicable codes, standards, etc., in effect at the time the design was prepared.

7. Constructability of the item and potential interference with other construction has been considered.

8. Where applicable, consideration has been given or provisions have been made for keeping existing facilities operational during construction.

9. Accessibility for maintenance, repair, and in-service inspection has been considered. Review equipment catalogs and drawings and determine that the design shown on the drawing provides adequate access for these activities.

10. Material selection is proper.

    a. Determine that the materials specified on the drawing match those selected by the design engineers.

    b. Determine that the materials selected by the design engineers will perform adequately in service.

    c. If materials or equipment specified in the specifications must be further specified on the drawings, see that this is accomplished.

11. Dimensions are correct and consistent.

12. Drafting practices conform to the firm's CAD standards.

13. Drawings are legible.

14. Drawings reproduce satisfactorily.

15. The appropriate technician has signed the drawings.

16. Title and drawing numbers agree with the drawing list.

17. Revisions are adequately identified as to what was changed and the correct revision numbers, dates, and approval by the project manager are shown.

18. All sheets are signed and sealed in accordance with the firm's policy.

8. Quality in Specifications

- Start specifications early in design. Do not wait until the last week of the project.
- Do not specify untried or untested materials without research. Use of materials new to the firm must be discussed with the chief designer prior to specifying.
- Develop or adopt standard master guide specifications or use client-furnished specifications.
- Edit master copies for each project.
- Do not use specifications from similar or past projects.
- Do not insert a complete manufacturer's specification that you do not understand.
- Require the lead designer to prepare technical sections for his or her portion of the project.
- Require the lead designer to review completed technical specifications with the appropriate QA team member at the end of the project prior to printing.
- Have the project manager coordinate the compilation of the specifications and prepare the non-technical sections.
- Evaluate all proposed substitutions for acceptability.

9. Design Change Timing

The basic design QC approach is to provide quality professional design services on time and within budget. During the execution of a project, changes will often be required during the design process for various reasons, including client concept change, revised assumptions, budget changes, etc.

The later in that the design process changes are made, the more costly those changes will be either to the client or the firm. A design change made before the 35 percent review might have an associated cost of $4,000. The same change made at final review could easily cost $20,000, and up to $100,000 if changed during construction.

These costs are incurred because the original design effort that was completed must now be abandoned and started over. The changes will require redrafting, which can affect multiple sheets and even disciplines. Changes at a later date could also cause delays to delivery of the finished product.

Acceptable costs for design changes are those identified at conceptual design stages, as well as those identified up to the and including the 60 percent design review process.

Unacceptable costs are those associated with required design changes that are identified at the 90 or 100 percent review, or by the client after the plans have been released. Worst of all are those required design changes that are discovered by the contractor on the site.

10. Five Ways to Build Quality into a Project

The best way to eliminate quality problems is to minimize the opportunities for mistakes with good planning and preparation.

1. **Know Your Team** — To overcome the quality problems often associated with a less than a perfect project team, the project manager should review each individual and identify his/her strengths and weaknesses, then use these traits to the project's best advantage.

2. **Plan the Work Systematically** — Every project has a natural sequence of activities that lead to the most efficiently produced product. Deviations from this natural sequence introduce errors that cost time and money to correct.

   After determining the natural sequence of activities, the project manager can evaluate the impact of design changes throughout the project. Changes can be made at relatively low cost during the early stages of a project; however, once the expenditure curve begins to steepen, every minor change potentially generates many costly errors.

   One way to avoid this is to incorporate the aforementioned Lead Discipline Management Plan and execute the project so that virtually all the design changes are made during the early stages.

3. **Anticipate Problems** — At your Internal Start-Up Meeting ask your team members the following question: "What can go wrong that will hurt the quality of this

project? List all the responses on an easel pad, and ask for ideas that can prevent the problem or mitigate its impact. Distribute this list to everyone on the team.

4. **Stay Close to the Work** — Purposely visit with everyone on the team at least once a day to monitor their progress. This is especially important for drafters, designers, and specification writers generating the drawings and specifications. Such routine observation uncovers quality problems as they occur and corrects them before major rework becomes necessary.

5. **The Principle of Single Statement** — Every time information is repeated, the odds increase that an inconsistency will occur. The more times an item of information appears in the drawings and/or specifications, the harder it is to assure that the impacts of each design change are fully identified.

   For instance, if the same dimension appears on 14 different drawings, it is likely that a design change will fail to be picked up in at least one of these drawings, leading to a design error. The best way to avoid this problem is to adopt the principle of single statement; in other words, "Say it once, be sure it is right and don't say it again."

The principle of single statement is somewhat controversial. Construction contractors don't favor this method because it hinders finding information. It is also more difficult to subdivide the drawings and specifications for use by subcontractors and suppliers. Clients often complain that it is more difficult to review a design prepared using the principle of single statement.

Careful planning of where to show each item of information can do much to make the information easier to find. However, due to pressure from clients and contractors, compromises must often be made. But remember: the farther one strays from this principle, the greater the chances of inconsistency in the design.

Appendix H - Managing Risk

Managing Risk – PCI Internal Documentation

This section offers suggestions for identifying, assessing, and managing the risk of professional design/consulting practices.

Design professionals often think the solution for dealing with risk is professional liability insurance. Remember, however that all disputes will have a negative impact on your firm, regardless of whether they result in claims or not. When risks are ignored or mismanaged, disputes are invited.

In order to be successful, you must view liability risk management as a problem-solving process. It is a method or procedure by which one identifies or recognizes risk, comes to understand risk, and takes action to minimize risk.

1. The Golden Rules of Risk Management

- Never accept a risk you cannot quantify.
- Don't take on risks for things you can't control.
- Don't accept responsibility for things that are someone else's fault (e.g. your client or contractor)
- Be sure the rewards justify the risks.
- Don't bet the company on one project.
- Don't publish QA/QC policies and procedures unless you are serious about enforcing them.
- Don't think your attorneys will keep you out of trouble.

2. Risk VS. Reward

Project Risk Management includes the processes concerned with identifying, assessing, and managing risks associated with projects. It also includes maximizing the results of positive events and minimizing the consequences of adverse issues.

Each time the firm makes a commitment to a client, it assumes some degree of risk. Before doing so, you must determine that the rewards of accepting each potential project are worth the associated risks.

This determination must be a conscious decision, made with the approval of your firm's senior management. Consider the following:

- The risks that are most likely to affect a project.

- Their likelihood of occurrence.
- The firm's ability to control or prevent their occurrence.
- The dollar value of a worst case-scenario.

Your firm's goal should be to establish equitable allocation of risks in any project so that they are proportional to the benefits received, and so that the entity that bears a given risk has both the authority and the compensation to provide the solution to any problem that arises.

3. Elements of a Risk Management Plan

A risk management plan must provide:

- Documentation of the procedures to be used to manage risks associated with the project.
- Identification of the person(s) responsible for managing various areas of project risk.
- Contingency plans to be implemented as adverse situations occur.

4. Identifying Risk

Experience and judgment are invaluable in recognizing risk. Each project has a unique potential for risk, but certain elements of a project should always be examined closely. Some elements of a project that should be examined closely from the standpoint of risk recognition are:

- The nature of the project
- The firm's capabilities and experience
- Specific client attributes
- Construction industry factors
- Contract provisions
- Subcontractors

Certain types of project have greater potential risk than others. In evaluating the severity of the risk, consider:

- The degree of difficulty or complexity of the project.
- Its technological requirements.
- The controlling codes and regulations.

- Its geographical location and other local factors.

On projects where there is a higher-than-usual risk of worker injury, remember that the contractor is protected from lawsuits by worker's compensation laws, and so a worker may attempt to hold the design firm responsible for not preventing his injury.

The firm needs to determine that it has the appropriate design expertise, the time, and the staff necessary to adequately perform the contracted services. The risk factors associated with providing the contracted services must be evaluated by reviewing the firm's technical expertise and its available resources.

The owner is an important ingredient in evaluating risk, and your relationship with him/her should be examined with this in mind, as well as the owner's relationship with the public and with governmental entities that must approve and review the project.

If the owner is knowledgeable, sincere, financially capable, fair-minded, and willing to provide adequate budgets and time for design and construction, your risk of having problems on his project is lessened.

Risks related to construction contractor availability, construction contractor selection process, and the construction economy in the project area must be evaluated. If there is a significant amount of similar construction in the area, construction costs may be higher than expected due to lack of available resources. In situations where the competition for each job is high, prices may be driven down and, in such cases, claim potential may go up.

Contract provisions provide abundant sources of potential risk. Provisions in the professional services contract which require you to assume more liability than that legally required, or to indemnify or hold harmless other parties, or, on the other hand, which fail to adequately define responsibilities or give proper authority, are causes for concern.

Appendix I - Managing the Client

Managing the Client – PCI Internal Documentation

1. Five Keys to Success with your Client

There are five goals to strive for that, when achieved, contribute to a successful client relationship.

1. **Treat the client as a person.**
   The most effective way to establish a strong relationship with a client is by relating to him/her on a personal level. Treating the client as a person rather than as an agency or an organization will make him/her want to work with you again. Clients are people too.

2. **Focus on the client's interest.**

   Seeing the world from the client's perspective is the key to putting the client's interest first. By understanding, and even empathizing with, a client's problems, you indicate that you are concerned with his or her needs. Using these methods to convince the client that you always think of his interests first builds trust and confidence.

   For instance, being too formal or distant in a presentation can make the client uncomfortable and less willing to select you for the project. The client may also be concerned about your ability to relate to the city council, planning commission, citizen's groups, or other within his/her company that may be involved with the project. Try to make the client feel comfortable even in naturally uncomfortable situations such as contract negotiations.

   During the project, you should consider yourself and your team as a part of the client's staff, and promote this concept with the client. The best projects occur when you are looked upon as an extension of the client's organization. One of the most powerful things you can do to impress your client and to secure repeat business is to surprise him/her by completing the assignment ahead of schedule.

3. **Exhibit professionalism and technical competence.**
   If service is the driving force in the success of a relationship, then the backbone of service is professionalism and technical competence. Professionalism is manifested in many ways. One way is to deal in an honest, straightforward manner with the client at all times. This is done by:

- Showing your respect for the client by being on time for appointments.

- Conducting efficient meetings.
- Presenting advantages and disadvantages for each alternative or recommendations.
- Admitting when you do not know the answer, but explaining how you intend to find out.
- Admitting mistakes as soon as they occur.
- Providing thorough follow-up on every detail of the project.
- Spending the client's money so that he gets the best value for the services required by the scope of work.

4. **Demonstrate project control.**
   One of the most effective ways to solidify a good relationship with your client is to demonstrate that you have thoroughly considered everything needed to complete the project and that you have a plan to meet those needs. Ways of demonstrating project control include a detailed schedule that's easy to understand, budget tracking methods, contingency plans and other reassuring efforts that you have considered for successful completion of the project.

5. **Develop effective communications.**
   Client relationships are based on communications. Effective communication is not a random occurrence, but something that must be consciously developed. You must establish effective communication channels and maintain them before, during, and after completion of the project. This sometimes may mean adjusting your style of communication to that of your client.

   The emphasis is on flexibility. Always be prepared to adjust your style to match that of the client, in order to make him feel more comfortable with you.

2. Little Things Matter

Client rapport primarily stems from confidence in the project team's technical ability and the successful results the team achieves; for this reason, rapport can be severely damaged by seemingly trivial mistakes. It's difficult to anticipate all such blunders, but here are some general guidelines to follow that might help to allay them.

Always:

1. Conduct your business with the client in an unhurried fashion.

2. Sincerely offer to work late or extend the visit to the next day if things can't be completed as planned.

3. Allow sufficient time after presentations or meetings for informal discussion on specific points or questions.

4. Seek feedback from the client on their views of your responsiveness to the project's requirements.

5. Be available for the client's questions relating to the project. Return calls. Don't leave your client to wonder what's happening with his/her project.

Never:

1. Leave a bad impression by showing disinterest in the project or by giving the appearance of being busy on another job.

2. Take sides in a dispute within the client's organization.

3. Set tight departure schedules that give the impression you have to rush off.

4. Tell the client, "I don't know." instead respond with "I'll find out."

5. Give the client the impression you are being inconvenienced or bothered by simple questions or repeated questions.

3. Impressions to Create

- You are an equal partner.
- You anticipate not just react.
- You are responsive.
- You meet your commitments.

4. What Clients Feel You Should Offer

- Copies of previous reports/data
- Experts to serve on design teams or assist in emergency situations/problem solving efforts
- Information for cost estimates
- Project presentations to client's staff and to the public
- Feedback to improve the client's standards
- Feedback on field problems.
- To meet schedules

- To double check work before submittals
- To follow scope
- CAD files
- Copies of software (when legal)
- Demonstrations of techniques/technologies
- To pass along names of contacts
- To assign requested individuals to jobs (when possible)
- To invite client representatives to in-house training sessions
- Use of facilities
- Technical manuals/data
- Lessons learned on prior projects

5. What Clients Can Offer

- Quick payment
- To provide information
- To be responsive
- To waive internal fees
- To provide technical manuals
- To make themselves available for meetings
- To subsidize training (e.g., provide training facilities)
- Technical assistance (e.g., computer models)
- Standardized formats for submittals
- More repeat business
- Recommendations to enhance reputation
- Consideration for future work
- Contacts/networking
- History/background on jobs

5. Project Communication

Real and potential problems can occur from misunderstandings caused by ineffective communication and by the failure to focus on communication. Your primary purpose as a service-oriented company is to provide meaningful information to clients. Effective communication is a key to that objective.

If you fail to communicate well, expectations may not be met, resulting in problems that that time and money to correct. In addition, clients can be lost. Regardless of the medium, to communicate effectively express your thoughts and expectations, in a straightforward, clear and concise way.

People communicate in only three ways: verbal, written, and through body language. Enhanced communication requires that one form be reinforced with another. For example, speaking is more effective if graphics are used to explain the message. By using written communication, (the graphics), you reinforce the verbal communication (the speech). Speech is even more effective if the speaker is animated, using body language for additional reinforcement.

Similarly, written communications (such as letters and memos) should always be reinforced by verbal communications (for example, calling to be sure the memo was received and understood).

6. Verbal Communication

Effective spoken communication requires the sender to form a clear concept. Pick the proper words and deliver them with a punch. A firm tone of voice, varied volume, the proper body language, and direct eye contact can help get your message across.

Studies have shown that in face-to-face communications, 7% of the message sent is our words, 38% our tone of voice and 55% body language.

Verbal communication is a two way street. As a receiver, you can help by actively listening, using eyes and facial expressions to show interest and asking questions for clarification.

Some thoughts and guidelines for making verbal communications more effective:

1. All things being equal, the person whose voice is too high is taken less seriously.

2. Use voice inflections to your advantage. Inflections that go up indicate excitement. Those that go down sound authoritative.

3. Volume usually increases with anger but if over used can come across as simply a loud mouth.

4. Pacing your sentences and words can create interest. Stepping up the rate will generate enthusiasm.

5. Stretching out sentences will result in a boring delivery. An elongated word can indicate emphasis or sincerity. "I am really sorry about the delay." Pauses in a presentation can have a positive effect to drive home a point.

6. Messages may not get the attention they deserve due to poor language. The language you use of the arrangement of your words may not be consistent with your intentions. Mispronunciations, poor grammar, and unclear speech can also be weaknesses:

   - "I was just kind of wondering…" could be changed to "I think we should try…"

   - "Well what if maybe we place the fill over there…" could be "Let's place the fill over there."

8. Use of words such as "you know" or "uh, well" detracts from your ability to communicate effectively.

9. Don't put yourself down with qualifiers. "Maybe this is wrong…," I know this sounds stupid but…" could be "Tell me if I'm on target with this…"

10. Don't make a statement sound like a question. "Hello? This is Bill? I'm calling about our meeting tomorrow?

11. Adding an extra sentence or unnecessary explanation will detract from the strength of your message and give you a defensive appearance.

The key to changing your speech habits is to be aware of what you are doing now. Listen to yourself more carefully and watch for patterns. When you see how they are interfering with your ability to communicate, you will be motivated to change.

7. Listening

Effective listening is the flip side of verbal communications and it requires effort to accomplish. There are three levels of listening effectiveness: marginal, evaluative, and active.

1. **Marginal Listening** is the lowest level. Concentration is low and distracted by passing thoughts. Symptoms include a blank stare and nervous gestures. This is sometimes referred to as the "yes, dear" syndrome.

2. **Evaluative listening** is the next stage of listening. At this level, you are concentrating on the speaker's works rather than understanding the intent. The evaluative listener is analyzing the statement and preparing the response. They are hearing the words only of the statements, not looking for the underlying meanings and unspoken thoughts.

3. **Active listening** is the most effective form of listening. You must try to see the other person's point of view. To do this, listen naively. Clear your head, and listen for voice inflections and the thoughts and feelings they are conveying.

8. Helpful tips for effective listening:

- Reduce background noise to avoid distractions. Listen intently, and reduce the number of passing thoughts that can clutter the incoming message.

- Take notes on key phrases and ideas. You don't need a verbatim record; you can expand on the notes later.

- Ask probing, open-ended questions. Repeat what you think you have heard, and seek confirmation or clarification.

- Respond physically to the conversation by nodding, shaking your head or sitting up straighter after an important point.

- Don't pass judgment on what you are hearing.

9. Body Language

It is said that body language attributes to 55% of the message sent in face-to-face communications. Many people are sensitive to voice intonation, gestures or lack of gestures and changes in mannerisms. This awareness can either be at a conscious level or just an intuitive feeling, but either way, there is another message being conveyed in addition to the words being spoken.

The ability to read body language can be invaluable in situations where enhanced communication is critical. Basically, every gesture has some meaning to it. Here are a few of the most important:

1. Head tilted forward or sideways is receptive, while a face turned away slightly acts to distance (perhaps an embarrassing comment). A head tilted backward so a person can look down their nose at you is just what it seems.

2. Eyes that blink rapidly or constrict are signaling distress or disagreement. A stare of longer than two seconds can be seen as a challenge; removing glasses while making a point intensifies eye contact and humanizes the face.

3. Mouth movement, such as licking or biting the lips is a sign of discomfort. Thinning lips is a negative response. Yawns can mean some level of discomfort or boredom.

4. Shoulders that roll or shrug are a strong sign of receptiveness or submission. Squaring of shoulders indicates authoritarian attitude.

5. Arms on the chair with palms up indicate goodwill and honesty. Self-clasping, that is, holding or pinching an arm or finger, indicates the need for reassurance. And hand pinching the back of the neck is a sign of discomfort with the listener.

6. A body that leans forward or toward someone show attention. Angling the body is a cutting off gesture.

7. A tie that is loosened slightly will portray openness.

8. To improve your body language, try:

    a. Shaking hands firmly and facing the other person directly. Make sure your hands are dry. Keep good eye contact.

    b. Sitting on the open side of the other person's desk.

    c. Keeping your briefcase visible.

    d. Sitting as if someone were pulling your hair to the ceiling.

    e. Not invading the personal space of the other person.

f. Not crossing your arms in the sign of defense.

g. Dressing appropriately for the occasion.

Appendix J – Literature Review

Literature Review – Work Product

1. Learning in the Thick of It

The main focus of this article written by Darling, Perry, and Moore is used to discuss management methods used by the United States Army to identify past mistakes and plan to avoid similar future mistakes. Considering many of the tasks assigned to the Army may include combat or other dangerous tasks, it is extremely important that mistakes are not repeated. This article discusses the proven methods used to succeed in just such things. These ideas have been translated into methods that relate to industry and have been used in companies such as Colgate-Palmolive, DTE Energy, and Harley Davidson. The article considers the lesson to be totally learned once it is successfully applied and validated to a future project.

One of the first ideas presented in "Learning in the Thick of It" is "after action reviews", known as AARs. In the article, AARs are defined as, "a method for extracting lessons from one event or project and applying them to others". Over a dozen corporations "lessons learned" processes were reviewed with the generalization that most companies have both formal and informal methods in place to review a project after its completion and evaluate what could have been done differently for a more positive outcome. The difference between the methods discussed here and the methods used in the Army is that in the corporate scenarios success is declared once the errors and corrective measures are identified instead of requiring seeing the new lessons learned applied to future projects before declaring success.

The article explained a cycle commonly used in the AAR process. The first step of the cycle is for someone in a management position to draft an article referred to as "operational orders". There are four different sections to this document; task, purpose, commander's intent, and end state. The task explains what actions need to be taken with the purpose explaining why such actions should be taken. Next, the commander's intent is an opportunity for the person in charge to more clearly state why they feel the project needs to be done or informally answer other questions related to the project that may arise or cause concern to subordinates. The end statement is used to define exactly what the end result is supposed to be. Once this is complete, it is shared with all subordinates involved in the project. They are expected to review the document and then provide a "brief back". This is a verbal discussion with the commander about their interpretation of what the project is, and what their specific role in the project will require of them. This assures that all team members understand their place in the overall project and assures no confusion pertaining to an individual's responsibility exists.

After this process has been completed with all subordinates, a rehearsal takes place. This is another method used by the army to assure all roles are well understood and to verify that the original planned actions are reasonable. When dealing with larger missions and/or projects, it is suggested to break the overall project up into phases and to conduct each AAR individually. Upon completion of the rehearsal, each unit involved reviews the prior activities privately and later with the rest of the group. These reviews are used to discuss what they predict will occur in the real situation, what could possibly go wrong, and what contingency plans need to be in place if such actions happen. One of the military officers interviewed for the article believes that this method "creates a very honest and critical environment well before they begin". [2005: 88]. This concludes the preparation work done for each AAR project prior to the actual project activity, whatever it may be.

The thoroughness of the AAR process is not complete at this point, many activities occur after completion of the physical project. It is emphasized in the article that during all the post-performance activities much effort is made to focus on improving future performance instead of pointing blame to others. The first post-project meeting is again supervised by the commanding officer or someone of authority. The meeting immediately compares the predicted and actual results by reviewing the mission, plan, and expected end state. This is immediately followed up by the actual end state and a brief recap of events and any other relevant information. Four main questions are addressed and discussed as a group in each meeting:

1. What were the intended results?
2. What were the actual results?
3. What caused our results?
4. What needs to be sustained or improved?

The idea is that by considering these questions, methods of correct thinking will occur instead of just realizing technical and logistical corrections that could be made. To assure that lessons were actually learned though, numerous small experiments and training sessions are developed to give subordinates an opportunity to directly apply the lessons presented to them. It also emphasizes the vast variety of situations in which the same lessons can be applied. The information gathered during this meeting is summarized and written in a report that is shared with other army sections along with details on how experiments were conducted.

The article then emphasizes the comparison between the AAR post-project review and standard project post-mortems. Project post-mortems are often a standard item to be completed by corporations after any major project. It is implied that often something that may make the post-mortems less useful is that they evaluate the entire project, regardless of size, in a single analysis. The article explains that after a few independent phases are discussed it may become overwhelming and reduce the effectiveness of the entire meeting. It then spends some time reviewing current popular practices in corporations and compares them to parts of the AAR process. It explains that processes such as operational orders can sometimes be referred to as "brief backs" or in the corporate world "before-action review" (BAR). Again, similar questions used by the military are posed to corporate team members with the intention that this will put them on the right track to complete the project as efficiently as possible.

In the article's conclusion it re-emphasizes four key ideas:

1) Lessons must benefit the team that extracts them
2) The AAR process must start at the beginning of the activity
3) Lessons must be linked to planned future actions
4) Everyone must hold themselves accountable for learning.

All of the concepts in this article seem like a sensible approach to reducing issues and downfalls in projects. The key to the success of the entire AAR and/or BAR systems is to follow through with the tasks described consistently throughout the life of the project. It provided good insight into possible methods for what could be considered continuous learning in nearly any type of organization. Being used by the army, one would believe it must have been examined and tested heavily before the concept was implemented as part of standard practice.

2. Just-in-Time Project Management

The main intention of this article is to offer advice on how to best handle Just-in-Time Project Management (JITPM). The author, McDowell (2001), presents two case studies: one which ended in success while the other ended in failure. It defines the ideal approach to project management as when all planning documents pertaining to scope, time, cost, quality, communications, human resources (HR), risk, and procurement are finalized before any real project work begins. In both case studies, all these documents could not be completed prior to the project starting. They explain that the plan of action in both situations was to complete the tasks promising maximum benefit to the project long-term first. This usually meant tasks that could be completed in a short time period while still retaining a high level of quality. Then, the overall project was quickly re-evaluated with the next most beneficial task selected and some informal JITPM happening at this time.

The author spends some time describing the JITPM in these cases. It can be considered as three different tasks but in reality they often overlap each other. The first step is to "clarify the expected resources and timeframe for the project." (This makes it possible to link the tasks needing to be completed to competent and available individuals.

Then effort needs to be put forth to address and manage all open issues, this is intended to force the PM to get in control of the schedule and resources. The last stage was simply to implement what had been determined in steps one and two, it was referred to as integration management and without the completion of this step the first two steps were useless.

The article then breaks up the stages and discusses them in greater detail, allowing a chance to better elaborate on the occurrences in each case study and to provide the author's insight as to why the outcome most likely occurred. It was pointed out that the greater the uncertainty of the scope, the more likely it is that unanticipated costs will surface. It is stated that the scope must first be defined and then managed throughout the life of the project.

The next section discussed control; this part was intended to explain how it is best to use the scope and other documents once they are developed. It is suggested that the ongoing list of tasks and outstanding issues are often a good reference when creating the agenda of status meetings. It assures that the major issues are not overlooked and that all individuals involved in the project are aware of the status of critical items. Discussing the issues critical to the success of the overall project are also suggested topics for all status meetings. It is considered a proactive approach to risk management. These issues are actually considered part of the Critical Path of the project. It is important to note that the author is describing his own version of a "critical path"; it is not the same path as widely accepted in management as the Project Evaluation and Review Technique (PERT) critical path. Items could be considered critical if they met any of the following criteria:

serious schedule delays could result from this issue, success could be affected, or the budget could expand. They were considered make or break issues.

The last section discussed potential management methods to use. It emphasizes that in JITPM situations it is not completely necessary that the project plan is exhaustive but it does need to have enough detail to conclude whether or not a project is still on course. It explains that in the case study resulting in a failure, due diligence had not been performed. By the time meetings were actually held, well into the start of the project, it was concluded that the product did not have the capability to achieve the desired results.

Overall this article presented some interesting suggestions on how to best handle a bad situation. It was helpful but ultimately did not provide enough detail to guide a person through such a situation with enough information to make them comfortable about the status of their project. It was still a beneficial article to read, more detail of proven and suggested JIPTM methods would have been useful.

3. Beyond PM 101: Lessons for Managing Large Development Programs

The intent of this paper, written by Graham (2000), is to offer suggested lessons on how to best manage large, complex development programs. The twenty lessons listed were compiled from over 100 consulting studies of "programs that used an extensively evolved and validated series of dynamic simulation models." The lessons resulting from this are meant to be rules of thumb for planning and starting a program and responding to the unexpected in projects of all sizes. Of the companies that have adapted these lessons into their management schemes, many have seen cost and schedule improvements of 20% and higher, in addition to less quantifiable quality improvements.

The lessons have been divided into three primary areas: team architecture, managing rework, and managing the plan. This makes it easier to remain focused on the same general idea when evaluating the specific lessons presented in the paper.

3.1. Team Architecture

The first section discussed team architecture through the use of four lessons. It was said that along with developing the right team for a project, it is equally important to constantly look for potential mistakes as rework usually has a costly impact on both schedule and budgets. A rule of thumb is provided that states an increase in time by a factor of ten for each development stage that passes where a mistake is not caught, meaning that if a mistake is not caught until the testing or fourth phase of the project it can add up to 1,000 hours to the project. The first lesson stated is that one should always strive to hire the best people. Various studies conducted for this paper concluded that 20% of the total employees account for roughly 50% of the productivity within a project group or organization regardless of the industry.

The second lesson suggests to "Put customers on the team", meaning that it is extremely important to always retain frequent and constructive communication with the customer throughout the life of a project. This will greatly reduce the risk of encountering mismatches between formal requirements, the deliverable product, and other assumed deliverables.

The next lesson in this category is to "Include all the functions in integrated product teams" stating that cross-functional integrated product teams (IPTs) are a proven best practice in numerous industries. The intent is that by using IPTs the amount of rework is reduced as it allows for a better understanding of design issues throughout all members involved in the project. If all departments are involved throughout the development phases of the project, it is reasonable to assume that errors will be caught earlier, before the "ripple effect" can fully set in. The last lesson in this section is more of a forewarning for companies not currently using cross-functional teams. It stated that there will likely be a decrease in performance during the first few months of the method conversion. It urges teams attempting this not to give up too soon, as then they would have already suffered through the painful learning stages and should not quit before reaping the benefits of the change. In situations such as this, it's even likely that additional expenses will be incurred to de-implement the changes. This section is concluded by stating that cross-functional teams are most beneficial when rework is necessary.

The next three lessons were used to discuss redesign and rework. The first lesson in this section states that a dedicated cross-functional team needs to be used when major design rework is necessary. The point of this lesson is to clearly state that once a project reaches a point in which rework, especially major rework, is necessary that this is one of the worst times to start skimping on resources. Another lesson discusses budget planning when rework is in the picture. It suggested that "when redesigning for affordability, assume the redesign cost will be several times the direct cost." An example provided explains how reworking one small section of a large project will likely result in necessary rework for several other seemingly unrelated parts of the project. This led to the final lesson of the section; mitigate redesign by focusing on the essentials.

3.2.Managing Rework

The managing rework section includes five more lessons along with some initial discussion on the topic in general. It is stated that the average line of software code, at least in defense software programs is reworked three times during the development process while pieces of engineering work is usually done at least twice. Some factors that attribute to this is when the project requires that the engineering tasks be done out of sequence or if once mistakes are found. The engineering staff is expected to continue with the overall development of the project while correcting the flaws simultaneously. To handle this, it is stated that one should leave time for rework because "Planning for success" invites failure.

No steadfast rule in predicting how much rework should be planned for but time is taken to warn against padding a schedule too heavily, referencing "Parkinson's Law: Tasks expand to fill the time available." [2000: 12]. This section of the paper is largely filled with examples and scenarios but no real suggested actions. Another lesson is to "put rework detection and correction" [2000:12] first, since mistakes propagate until corrected. This means that when issues arise, engineers are suggested to put new development tasks currently being worked on aside in order to focus on reworking and testing problems. This is reemphasized by the author's suggestion that, if at all possible, development phases should be executed serially instead of in parallel. The reader is reminded that in some situations concurrent engineering, or working on various portions of the project at the same time, is appropriate but much consideration should be taken before deciding to go down such a route. The author suggests that it works best if dealing with varying disciplines and not necessary in the same department on the same project.

The next few lessons seemed self-explanatory but still worth mentioning:

- Under-staff the front of phases so that resources are available to overstaff the finish in order to eliminate the rework as it arises.
- Do not slip testing, even with a slow start-up.
- Always take time to do process improvements.

The paper states that process improvements are more beneficial to projects with deeper issues than those that ran smoothly. It stated that program setbacks increase work pace while decreasing quality which ultimately leads to an increase in rework that will have to be done. Some of the suggested actions to succeed in this lesson are to utilize peer-reviews, teaming, micro-planning, and incentive schemes.

3.3.Managing the Plan

The last section of this article discussed managing the plan, since a plan is not near as useful as it could be if properly managed. The first lesson in this section suggests to "mitigate slow start by building up the leadership team, the core specifications, and vendor knowledge" [2000:15]. In other words it advises not to waste a lot of time getting indians lined up at the beginning of a project. Focus should be set on finding the best chiefs. The main issue that seems to be overlooked is what to do if there are no highly qualified chiefs available. The next lesson is "Mitigate slow start-up by slipping interim milestones" [2000:15], and further declares that rushing to complete early stages is a mistake. It is believed that insufficient time and resources create mistakes that will return later in the form of more serious delays in development and production. The author believes that by following this lesson the entire project will come out faster, cheaper, and higher quality.

Another lesson reminds us of Brooke's Law which states "adding labor to a late software project makes it later" [2000:15]. The theory is that adding personnel to a project once it has been well established creates confusion on roles, gives tasks to people unfamiliar with them, creates hidden quality and rework products, and throws in people with little or no experience. If additional work needs to be done, it is not suggested to add additional staff. One might think having all existing members to work overtime might be the solutions. Unfortunately, the next lesson deems this idea as not good stating that overtime spans lasting longer than three months will result in productivity and quality issues which often lead to fatigue, morale, and turnover issues. A study discussed in the article determined that an engineer working twelve hours of overtime weekly after as little as two months will be actually accomplishing less than if they were merely working the standard 40-hour week.

"Better risk management means having contingency plans in place, and monitoring the triggering conditions that will initiate those plans." A key concept is to "go all the way with mitigation planning." [2000:16]. The author then provides some insight in various practices used to develop contingency plans along with discussing who needs to be included into such conversations. The final two rules intertwine to an extent; one being to react to problems as soon as possible as there is no benefit in delaying a solution. The other suggests not shrinking the schedule without expanding the budget. A classic example is given to emphasize this issue, it says that nine guys and one woman can't end up with a baby in one month like one woman can do in 9 months. In general, crashing the schedule will mean a more aggressive work schedule for people involved and the increase in employee work hours will result in more expenses than necessary. Statistics provided in the paper from a software program development concluded there was a 20% reduction in total program duration and an increase of over 50% to the total labor expenses. The last lesson of this article simply says to react to problems sooner rather than later. Nobody benefits from a delay in discussing open issues. Care is taken to specify that this means one must also share any "bad" news to the customer as soon as it is brought to the attention of the engineers so that it can be discussed quickly and efficiently resolved.

Although not all lessons in this article seemed totally necessary, several were thought provoking and interesting. They were broad enough to be applicable in a variety of situations yet specific enough to understand the message the author was trying to get across. Some of these lessons will be compared to situations in the Rexam project in the discussion section of this report.

4. Bringing Discipline to Project Management

In this article, Elton and Roe (1998), review a book called *Critical Chain* by Eliyahu M. Goldratt. It discusses what the authors consider to be useful and other elements of the book they feel are lacking. One of the first items discussed is a theory of constraints where the book author suggests ways to boost overall performance of a process which involves multiple independent steps that must be done in series. The lesson being taught is how it is best to focus on bottlenecks in the series when planning improvements. Furthermore, the audience is reminded that bottlenecks are often actions on the critical path further supporting the idea that finding ways to make these processes more efficient will widen the bottleneck and help the overall process's efficiency.

Another constraint the book is credited for highlighting pertains to scarce resources needed on various projects both on and off the critical path. The term "critical chain" is then introduced to refer "to a combination of the critical path and the scarce resources that together constitute the constraints needed to be managed" [Elton and Roe, 1998:154]. To manage this, it is suggested to allow extra time for tasks that are critical or feed into critical tasks, so that all critical path tasks have plenty of time to proceed. It is also suggested to allow extra time for tasks not on the critical path but that feed into a scarce resource task.

The review believes that the book is useful mainly to PMs, specifically those handling multiple projects at once. The primary message passed on to the PMs is to "remain focused on a few critical areas and do not divide your attention among all of a project's tasks and resources." [Elton and Roe, 1998:156]. The suggestion is to identify potential sources of failure and plan around them by adding any additional resources required to ensure maximum throughput and to provide an acceptable amount of buffers in case issues arise. The book's author feels that managers need to know how to manage multiple projects, but the only advice offered is to practice caution when allocating resources so as to minimize the constraints on shared resources. Furthermore, whether managing a single project or multiple ones, it is important to assure at least someone in the department has the skills necessary on the project. Another concept introduced by the book and re-emphasized in the article is that the progress of any individual project is limited by factors often out of the control of the PM.

One of the last topics discussed in the article is perhaps the most relevant to the Rexam project and the differences in project management practices used in a project such as this versus process projects. They concluded that the fundamental difference between the two types of management is that one of project management's main goals is to eliminate variability while project management must accept variability as every project is unique. It is also stated that "projects involve much higher levels of uncertainty than processes do and depend much more on the contributions of individuals." [Elton and Roe, 1998:158]. This brief section of the review seemed to be the most relevant to the project being discussed in this report. It indicates why not all articles discussing project management can be applied to a development or a consulting project if it is written with process management projects in mind.

5. Risk Management Post Analysis: Gauging the Success of a Simple Strategy in a Complex Project

This article by Pyra and Trask (2002) is a case study intended to discuss the evolution of the priority level assigned to several risks over the life of a project. By the end of the article some general conclusions are established about common risk categories involved in highly technical projects. The goal is that the system developed from looking at this case study could be reused on future similar projects, which will likely vary in scope and size from this particular project. The project being evaluated was a system developed to improve message reliability, speed, and access to soldiers in the Canadian Army. The project's life span was seven years in which $1.4 billion was spent developing a communications management system (CMS). By the end of the project the sub-contractor evaluated in this case study was singled out by the Canadian Military being given the "Most Responsive Contractor" award in 1996.

Specific details of the project will not be discussed in this review, although key topics relevant to the discussion will be conveyed. One of the first important keys to pass along is that this project was delivered by a team geographically away from the customer, and was the largest project ever delivered by the group working on it. Also, an entirely new group was formed for this project so none of the individuals on the project team had worked together previously. Also, this was a fixed-price contract, so risk management had to be handled at the beginning of the project and had to be kept in mind throughout the project. An overlooked risk could easily affect cost control and company profit.

The team chose to use a process based on *A Guide to the Project Management Body of Knowledge* (PMBOK® Guide, PMI Standards Committee, 1996). This system suggested that the following steps be followed; first, identify the risks that may affect the project and how they might impact it. Next, the authors believe it is important to identify the risk, the probability and the impact of all potential risks called the quantified risk ratio, and then prioritize the risks using the quantified risk ratio. After this, each risk should be re-evaluated to determine risk mitigation strategies. Lastly, each risk should be monitored and controlled.

At this time and periodically throughout the life of the project, it should be explained to team members how: 1) the risk will be monitored, 2) new risks will be identified and handled; 3) mitigation strategies will be updated. All this information is referred to as the "project risk register" and in this case study they were published as part of the formal monthly reports submitted to the customer. This method was used to assure that all parties involved were aware of any apparent risks and could draw attention to any risks not currently mentioned in the documentation. With each report the priority of risks could be adjusted, progress pertaining to the risk or action taken to prevent the risk was shared, and risk resulting from a strategy to reduce another risk could be discussed. Using this method, the document being presented monthly was filled with the most up-to-date information. The risk register identified the priority of each individual risk then briefly described the issue, its quantified value, probability of maturing, and potential impact on the overall project.

The article further classifies the risks into internal and external risks. Some of the internal risks referred to issues in the contractor company itself while external risks involved issues outside of the control of the subcontractor but still affected their overall productivity and success. Another risk mentioned but not specifically assigned as an internal or external risk but was an issue during the project in the case study was scope creep. Scope creep is when an initial price is agreed upon by both parties to complete a specific list of tasks, but then as the project proceeds additional tasks are added without additional financial compensation being offered. In theory, this would be considered an external risk. If proper documentation about agreed upon deliverables exists, additional work could be argued as a reason for additional funding. It could turn this into an internal issue as there will likely be some disagreement on the impact to customer relations of pushing for additional funding related to scope creep issues. This is an issue that frequently arises in the consulting business.

A section was dedicated to issues and their potential impact on contractual relationships. It was stated that priority given to retention of contractual relationships decreases as the project nears completion. Each situation will be different as certain customers may only have the need for services once in a lifetime while others have the capacity to offer future sizeable work on a daily basis. Factors such as these must be considered when prioritizing the importance of a strong client-customer relationship.

For this case study, the research team assigned a risk mitigation strategy for each issue as it arose. In general, there were five different responses that could potentially match up with any issue. They are listed below:

- Further investigate the risk to learn more about the risk and its cause; this should have led to a reduction in uncertainty pertaining to the risk.
- Eliminate specific causes to reduce the probability of the risk.

- Transfer the risk so that the responsibility does not lie on the contractor alone, preferably the risk should be shared with the customer or other parties involved.
- Develop options that lower the risk's probability. This is considered a method to be used to better control the actual risk. If the risk can be controlled, its priority should be reduced.
- Develop contingency plans to deal with the risk as if it had already occurred. This was the most direct and pro-active response discussed.

Furthermore, it was stated that "each strategy was specific to the risk it addressed, but the same strategy was sometimes used for more than one risk. Strategies were intentionally brief and documented in point form to reduce the burden of documentation".

The case study review concluded with several suggested actions and concerns to focus on for future projects. The authors suggest that clients need to be aware of all internal risks as they should be the most manageable. People issues should not be underestimated as risks to any high-technology projects. Recognize the immense impact scope creep can have on an overall project's success. Along with recognizing potential scope creep, one must also realize the tools available to contain, control, and renegotiate such issues. This can be as simple as a checklist verifying that each major task has been lined out and the customer has contractually agreed to pay for extra services or agreeing upon a not-to-exceed time schedule. Lastly, it is suggested to have contingency plans in place whenever possible for all risks identified throughout the life of a project. If contingencies cannot be realized, a fallback position should be identified and planned for. This case study was not specifically related to the project this report discusses but provided a large amount of helpful information on how highly technical projects such as these can be best managed to minimize unexpected issues and maximize profits.

6. What's your Project's *Real* Price Tag?

This brief article discusses the variances in methods used in corporations to determine the overall cost of any capital project. The authors, Fleming and Koppelman (2009), believe that in general the finance departments only considered predicted cost and actual cost, and do not consider the variance in deliverables in the project. In general, if money remains in the budget, then the project is considered ahead of schedule. If all the allotted money has been spent and work remains, the project is over-budget. The authors state that this method completely ignores the value of the work performed. It is suggested that in order to overcome this issue, a project-tracking method called earned-value management (EVM) should be used. A list of organizations and corporations using such methods is provided and the benefit of being able to predict the final project costs years in advance is mentioned.

The article states that the key to successfully using the EVM is the cost performance index (CPI), which is a representation of the relationship between the value of work accomplished and the actual cost incurred to accomplish such work. Generally, it is a ratio that compares the predicted cost of work completed with the actual cost. Assuming the project continues to be completed at the same rate, it can be predicted what the overall project costs will be. It is also stated that the CPI is generally very stable over the life of the project which is what makes such a method feasible to use. If any changes to the CPI do occur, it is affirmed that it generally gets worse over the project's course. The closer a project is to having all the work complete, the more accurate the CPI will be.

7. Management Lessons from Mars

This article, presented by MacCormack (2004), is a research piece discussing some growing changes NASA encountered during the early 1990s when its program initiative was changed. The existing program initiative was abandoned when a Faster, Cheaper, Better (FCB) initiative was adopted. It was designed to "transform the way NASA developed unmanned spacecraft". Part of this initiative forced PMs to invent new processes and procedures including the incorporation of expectations that were to surpass traditional approaches in spacecraft development with regard to budget, schedule, and weight constraints. The impression was that previous methods were not working as well as hoped. So why not throw out everything previously learned about spacecraft development? It was assumed that all PMs already knew everything about previous development efforts so that they would be able to adopt what was proven to work while abandoning what did not. NASA failed to realize that the new FCB method relied on shared learning throughout the organization. In order to make this succeed, methods of knowledge management had to be established, made easily accessible, and utilized by all staff members. Unfortunately, five years after a knowledge database was established, a study concluded that only 25% of managers were contributing to the database. Thus, other members of the organization could not learn from their experiences unless they discussed the issue directly with those individuals which was time consuming and highly unlikely.

By the time this initiative was abandoned, several lessons were learned. The first suggestion was to determine the feedback necessary to make an initiative a success and the likelihood of consistently gathering such information before making any major changes. Also consider the time frame in which the information will be received and evaluate if it will be soon enough to aid the initiative. The next lesson is not to raise the performance expectations on the organization until it is certain that they can be met. One should not expect immediate success and improvement when introducing a major change into an organization. Also, once the initiative is in place, monitor progress and adjust the expectations as needed in order to maximize the probability of success. Prior to implementing a new initiative, develop methods to capture new knowledge and document it accordingly. Systems to capture and share both assumed and stated knowledge need to be in place from the very beginning of the initiative. Also be sure that the staff is aware of the new knowledge sources and is comfortable with using them. Lastly, as suggested in nearly every project management article reviewed, the author emphasizes the benefit of conducting a post-mortem on every project. Successful projects can provide suggested methods to be used on future projects, while failed projects may discourage future project teams from repeating the same problems and issues.

8. Why Good Projects Fail Anyway

It is nearly impossible to predict all tasks necessary to complete highly technical projects and often times this leads to projects ending over budget or past deadline. This is the main theme of the article. The authors, Matta and Ashkenas (2003), discuss potential reasons that this happens and suggests methods to use in technical projects to minimize and ideally eliminate such outcomes. The root cause is believed to be that the end result of a highly technical project is often not well understood. Thus certain tasks vital to its completion are not considered when planning the project.

To explain the types of risks a project could face, the authors discuss three different types of risk. The first type, "execution risk", is the risk that known activities won't be carried out properly. The next type, "white space risk", is if some required tasks are not identified in the planning phases they likely will result in gaps in the overall project plan. The last type is called "integration risk" and is described as the risk that incongruent activities won't mesh together at the end of the project.

The first suggestion offered is a method that can be used to reduce the likelihood of experiencing white space risk and integration risk. The suggestion is to implement "rapid-results initiatives" throughout the life of the plan. Rapid results initiatives are mini-projects in which a team is assigned to a brief but detailed portion of the overall project. The intention is that they assure this part of the project is completed quickly and that the result is a version capable of integration into the overall project with ease. Once one initiative is complete, a new team can be developed and the next portion of the project will be set as the initiative focus. In large-scale projects it is suggested to have multiple rapid-results initiatives taking place at all times.

It is stated that the intention of this method is to produce a measurable result instead of just recommendations, analyses, or partial solutions. It is believed by using a method such as this that there are several benefits. It allows for a preview of results early into the planning phases. If adjustments need to be made, they can be realized in one of the first initiatives instead of the mistake being repeated multiple times and not realized until the project is near its predicted completion date. This method also allows for results to be recognized in smaller quantities but much sooner than if the project was done in one large effort. The last benefit of the method is related to employee and customer morale. By using this method, small accomplishments are achieved and noticed throughout the life of the project, re-energizing the work team, and reminding the customer the benefits gained during the project.

An example given in the article discusses a World Bank project hoping to "improve the productivity of farmers in Nicaragua by 30% in 16 years through the use of rapid-results initiatives. In a situation like this, one team was assigned to increasing milk production in one municipality from 600 to 1600 gallons per day in a 120 day time span while dealing with 60 regional farms. Another team was given a completely unrelated task but one that was working towards the same overall goal, their mission was to increase pig weight on 30 different farms by 30% in 100 days. Since these projects were being done in separate regions, they did not interfere with each other or cause resource limitations issues. Both were still working towards the common overall project goals.

The authors also discuss another benefit of rapid-results initiatives as they describe the tasks as thin vertical efforts instead of lengthy horizontal endeavors. By being vertical, this allows for the effort to be "cross-functional" as they include a slice of several horizontal activities at any given time and will likely require efforts from different departments in an organization. It is believed that the vertical integration helps to lower white-space and integration risks as the current task will not be able to be completed without realizing any overlooked issues between the current task and the last task completed. It is also believed that this method is useful as it reinforces a sense of urgency throughout the life of the entire large project. The intention isn't to imply work should be skimped or quick fixes should be used but is meant to keep pressure for progress on all team members throughout the project.

A shift in accountability is also experienced when using a rapid-results initiative. Instead of management being responsible for determining each individual task necessary to complete a mini-project, it is left to the team to decide what steps are needed and most effective. Consideration must be taken to ensure a smooth transition through the white-space and minimizing integration risks. This is especially true since each individual team will be responsible for this. It greatly reduces the odds of oversight as traditionally one or two PMs would be responsible for handling all these transitions on their own. Post project surveys showed that individuals actually preferred to work on projects such as this as they viewed the work as more rewarding since results-oriented goals are used. Admittedly, some risk is involved and new methods may have to be experimented with, but the team felt that this was more fulfilling than repeating implementation of predefined tasks.

Another benefit mentioned by using this method is that vertical team members were selected from their horizontal organizational departments. Still, the vertical team members often remained working on projects in the horizontal team in addition to the work with the vertical team. As long as these individuals were not given unrealistic demands, this allowed for each team to be aware of and potentially benefit from the activities of the other teams.

A warning is given to individuals trying to manage both horizontal and vertical activities. Special attention must be given about determining where to focus the vertical tasks. It is suggested to look for vertical activities most likely to fail if they are not closely coordinated to the task before and after them. It is also suggested to arrange a meeting between all the vertical project team leaders to review and identify other areas of uncertainty or risk not specifically tied to a particular vertical task.

The article concluded by reemphasizing that managers can't identify every possible issue that could arise in a large project, much less all the variables and people involved. By using a rapid results initiative an ongoing learning process will exist. The author believes that this method is great as it "creates an ongoing process of learning and discovery, challenging people close to the action to produce results – and unleashing the organization's collective knowledge and creativity in pursuit of discovery and achievement" (Matta, 2003:114).

9. The Experience Trap

This article by Sengupta, Abdel-Hamid, and Wassenhove (2008), explores the lessons that a PM can learn through the life of the project and the likelihood that lessons will be taken from the experience. The article begins by introducing the audience to Alex, a senior manager with prior experience working on primary software projects for NASA and other government agencies. Research was gathered from Alex and several hundred other project engineers, varying in formal management training, experience level, and industrial background. All participants were asked to use computer software which simulated a typical project which they were to manage from beginning to end. The software allowed for the individual to set the budget, assign resources, monitor progress, and adjust the plan as needed when unexpected situations occurred. Each individual was given the same project setbacks at the same time and to the same extent as everyone else during the simulated project.

The responses and route Alex chose to take were similar to those of the entire group. His project was started with four team members and focused heavily on development work. This worked for a while until the scope of the project grew, increasing the demand on all the team members. When this happened, Alex chose not to adjust the team any, which resulted in members who were making mistakes and became burnt out. Alex's reaction to this was to hire more team members. This resulted in lost time in bringing these people up to speed and in using resources less familiar with the overall project. His project ended up over budget, past its deadline, and filled with defects. Upon further discussion of the results, it was concluded that the managers failed to learn from mistakes made early in the project, repeatedly making the same mistakes throughout the entire life of the project. It was also noted that on a scale of 1 to 5 related to how realistic the scenario in the game was to real life projects. The average score was 4.32 implying they felt the game was very similar to real situations.

At this point the authors begin to evaluate why a vast majority of the participants in the study all reacted the same way, badly, in this case. The concept of a mental model is presented, which is the pre-existing collection of knowledge in each of our minds specifically about cause and effect relationships in this case. It is believed that the human mind only associates activities to mental models if the situations are very simple. Once situations become complex, the association is no longer made. The authors found there to be three main reasons for this: 1) time lags between cause and effect, 2) fallible estimates, and 3) initial goal bias.

With large projects there is often times a large time lapse between causes and their effects, with countless other project tasks and issues becoming priority during this period. To test this more closely another, more specific, simulation was ran. This time the tests focused primarily on manpower and also to view at what point managers choose to intervene if a project obviously was under-staffed. It concluded that in general, managers fail to consider the time lag between stages of the hiring process. These lags occur between deciding more resources are needed, those resources being located, and when they are brought up to speed. In this simulation there was some minor variability between situations each person was given. Yet, it was concluded that the reaction by the manager was consistently worse. The delay between cause and effect resulted in an 83% increase in effort put forth on the project and an overall completion date 40% later than the individuals whose simulation only required a short period of time between cause and effect.

A post-project debriefing was conducted with each manager in which most individuals acknowledged the mistake in adding staff too far into a project. Upon discussion, alternative actions such as focusing on a few key priorities, reframing the project, or extending the timeline were explored. Unfortunately, the same managers were asked to complete one more simulation in which the same mistakes were repeated yet again. At this point it was concluded that even though the knowledge of what not to do had been acquired multiple times by the managers, it did not mean that any lessons were truly learned from the experience or recalled in future situations.

Another error often noticed in the simulations was fallible estimates. It was determined that initial estimates were often not re-evaluated and the schedule adjusted later in the project. Again, a second simulation was set up and conducted for all the participants. Upon the completion of this test, it was concluded that most estimates always leaned towards the conservative side. Some participants were given situations in which high initial productivity was reported while others were posed with low initial productivity. In both cases the response of the manager remained the same. The authors believe that this was due to a "managers' attempts to game the system to get more resources" (Sengupta, 2008: 96).

Next, a mistake repeated by nearly every participant in the study was initial goal bias. None of the participants wanted to deviate from the initial project goals even when key components of the project changed. To test this further, two groups were formed and asked to manage separate simulation projects. The first group was told to make staying under budget their main priority and the second group was to focus on quality by considering the number of defects in the finished project. Both were expected to complete the project on schedule and knew that the evaluation would be based on the overall outcome of the project.

For this simulation, the scope was increased one-fourth of the way through the project. Neither group adjusted targets when this happened. The "cost" group chose not to hire more people than absolutely necessary, keeping the budget to only surpassing the goal by 59%. In order to accomplish this though, the completion time was 17% longer than allowed and the number of defects in the finished product was 1,950. The "quality" group was much more successful at minimizing defects. They successfully hit this target. In order to achieve this, they over-staffed the team which in turn exceeded the budget by 107% and the schedule by 9%. The lesson in this experiment is that unless forced to change the initial goal of a project, a manager will not reconsider new goals once a project has been started regardless of what new knowledge has been presented. The authors believe that revising targets is viewed as admittance to failure in most organizations. For the sake of the manager's careers they will likely stick to the original goals even if they are no longer the appropriate goals to focus on.

The conclusion of these trials is that little variance is noticed between novice and experienced managers. Neither will learn from past mistakes when dealing with complex projects. The authors believe that in general most managers, regardless of experience, will fall short of their goals. To remedy this issue it was suggested to provide the managers with cognitive feedback. This is feedback that "provides insights into the relationships among important variables in the project environment, particularly as the project evolves." (Sengupta, 2008: 99). It is believed that when managers are supplied with cognitive feedback, they were able to show a deeper understanding of the situation and were able to make decisions that resulted in better overall outcomes. The authors recommend companies invest in making cognitive feedback part of their regular project status reports. In a corporate software company where cognitive feedback practices are used, it has been found that the proportion of problem projects has decreased by 56% during a three year time span.

10. Performing a Project Premortem

In this article Klein (2007) discusses another method that can be used to minimize the number of overlooked tasks when planning for a project. According to research conducted in 1989, it was found that "prospective hindsight – imagining that an event has already occurred – increases the ability to correctly identify reasons for future outcomes by 30%" (Klein, 2007:18). It also named a process such as this conducting a premortem. In a business setting, the premortem comes at the beginning of the project in order to allow time for project improvement instead of merely conducting an autopsy on a complete or abandoned project.

The suggestion is to perform the premortem after the team has been initially briefed about the project. Then it is stated that the project failed miserably, and everyone is asked to spend a few minutes on their own writing down reasons they believe it failed.

Particular attention should be given to potential issues that are not traditionally discussed in such meetings because of fear of being viewed as misguided. Then starting with the highest ranking individuals working on the project, one by one the reasons for failure are listed, discussed, and added to a master list until all issues have had their moment for discussion. This list is then compiled and provided to the project leader, giving him an opportunity to add safe guards to the project plan before anything actually goes wrong.

Several benefits are felt to be realized from this method besides the main goal of finding potential problems. It is believed that this method helps individuals that may be over-invested in the project to view it from varying perspectives. By having each member only list one item on the list, it allows the entire team, an opportunity to share their intelligence and experience with the other team members. This is an easy and effective way to improve company morale. Lastly, it is believed that this method provides an opportunity for the team to be looking for any problems early on in the project by sensitizing them during the premortem. If done correctly, the authors believe that a successful premortem will very well likely avoid any painful postmortem experiences.

11. Conducting a Project Postmortem

This article by Pavlina (2009) is primarily focused on the best methods to use when conducting a postmortem using game development software. Upon review, it was also applied to a broader category of general software development. It was primarily formed with ten guidelines as suggestions to use when conducting a project postmortem. They define a postmortem as a procedure used to summarize the history of a project, including the positive and negative aspects. The goal of a postmortem is to draw meaningful conclusions about what happened so the knowledge can be applied in future efforts.

Several of the suggestions are brief and get directly to what the author feels is a best practice. The first suggested best practice is to involve all contributors. It is suggested to do this in a meeting from where the good, bad, and ugly should be documented. Furthermore, it is suggested to use a system using a three point questionnaire. The first part of the questionnaire should include a ranking from one to ten of subjective feedback, followed by target questions pertaining to specific areas that could use specific improvement. The end of any postmortem meeting should involve an open forum for any additional comments people feel like making. This information should also be documented. The next suggestion is to formally document all the information gathered in the meeting and follow-up knowledge pertaining to any of the major issues. If the project is large enough, it is suggested to add this completed document to a company network or intranet so that others can reference and review it as needed. By using the intranet, the opportunity to electronically link the postmortem review to other electronic documents becomes possible. This could be any documents relating to the issues discussed in the post mortem. The goal is for all the archived postmortem documents to grow into a library of hard-earned wisdom.

The next few suggested actions refer to how the actual postmortem meeting should be conducted. The author suggested beginning with a project overview – initial scope, estimated budget, preliminary schedule, and any other general information that was known at the beginning of the project. Next, project details should be shared with the group; this includes items such as actual schedule, actual budget, resources used, development tools/software used, all project team members and their contribution to the project, and any significant project scope changes. Once this is done, it is suggested to collaboratively make a list of everything that went as expected or good during the project; at least ten items should be on this list before moving to the next step. After this, the group is again supposed to develop a list of at least ten items, but this time it is to focus on what went wrong during the project.

Once these items have been determined, the next step is to assess risk management during the project. Make a list of all risks taken and how they were managed; noting whether a new technology was used, if it affected the schedule, and how extreme of a risk was it. At the end of this, suggestions can be made as how to better handle a situation similar to this in the future. Then, mid-project changes should be assessed. List all changes that were anticipated along with those that were not, along with any positive or negative implications these changes had on the overall project.

The last two tasks are somewhat a compilation or conclusion of all the other items discussed in the postmortem or added to a list in the documentation. As this point meaningful conclusions should be drawn. This is where lessons learned or suggested actions to avoid can be noted. If a person were to quickly review the postmortem document, this would be the most beneficial area to visit. The last suggestion is most helpful if one repeatedly works on similar projects. The author suggests taking action.

Developing an action plan, creating a new checklist or updating an existing one will help decrease the likelihood of the same mistakes to be made on future projects.

In closing notes the author mentions a few other benefits of conducting a postmortem. It is believed that postmortems deliver a sense of closure to the project team. It also allows for each individual to realize personal growth they experienced during the life of the project and possibly get them thinking about new areas in which they would like or need to broaden their knowledge.

12. The Project Postmortem: An Essential Tool for the Saavy Developer

Similar to the last article, in this article, Gunderloy (2009) also offers suggestions on how to best conduct a project postmortem and is written with software development in mind. The first advice offered in this article is to plan for the postmortem. By this it means that the postmortem should be a planned activity from the very beginning of the project. Again a meeting needs to be scheduled and held to review the project and then time needs to be set aside by one individual or a predetermined group to write the report. If it all possible, it is suggested to find an off-site location to conduct the postmortem. The author feels that this allows for people to better focus on the subject at hand and reduces the risk of participants being distracting by daily work tasks or schedules.

It is suggested to encourage team members to take notes throughout the life of lengthy projects so that details or early issues are not overlooked. It is also best to schedule the postmortem meeting within a couple weeks of the completion of the project.

It is believed that this time span allows for emotions to be settled and a clear memory of events to still be fresh in people's minds.

The next few suggestions repeat suggested actions mentioned in the last article. Again, it is suggested to record all details of the project, such as what was known before the project started, and then final statistics about how the project was performed. The intention is that once the electronic document is archived, future teams will be able to easily find and reference projects similar in scope, schedule, and/or manpower requirements. This author also suggests getting everyone associated with the project involved. It is believed that if recaps of what happened come from multiple sources, it is less likely to end up with a biased story of actual occurrences. Also, by having everyone involved, it becomes much more challenging to push the blame onto others as they are likely in the postmortem meeting and would be able to defend their actions as necessary.

Once the postmortem meeting is over, the PM needs to formalize the notes from the meeting into a written report. Again, it is reemphasized to describe in detail the negative, as well as the positive activities that happened during the project. Specifically stating what activities should be repeated in future applicable projects and which ones should be abandoned. Upon completion of the actual postmortem, it is suggested to create an action plan, or a brief document quickly stating what is worth repeating in the future and what efforts will likely result in failure if repeated. All this documentation should then be put somewhere easily accessible to other employees and PMs. The information is not beneficial to the company if it can't be located and used prior to planning future projects.

This article did spend some time cautioning managers, both for projects and organizations about not using a postmortem as a tool to find poor personnel performance. To keep getting honest opinions during the postmortem, it is important for management to "develop a reputation for listening openly to input and not punishing people for being honest." (Gunderloy). If at all possible, it is suggested to schedule postmortems such that they are not near annual reviews. This will help so that individuals do not limit their input during the postmortem for the sake of having a better annual review.