AN APPLICATION OF PROJECT MANAGEMENT IN THE SOLAR ENERGY INDUSTRY

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ABSTRACT

Optimizing solar photovoltaic (PV) systems installation with efficient, accurate scheduling of work flow and materials is critical to success. The following analysis characterizes PV installation processes and describes Gantt and PERT/CPM methods of scheduling. Future analysis will field apply these tools to generate increasingly accurate timeframes for tasks and projects.

Keywords: Project Management, Solar Energy, PERT/CPM, Microsoft Project

INTRODUCTION

As with many construction and building trades, solar photovoltaic electrical systems installation contractor EverGreen Power & Electric, LLC is highly dependent on accurate estimation of scope and duration of projects. In a highly competitive, emerging industry, the author is looking for every edge to ensure that best competitive prices are offered to customers while still ensuring profitability for the company. The largest companies active in large projects in any construction market, not just renewable power or even the energy industry in general, may utilize varying levels of project management techniques and tools. Yet wide-spread adoption in mid-sized and smaller firms has not been rapid, and the impact has remained small. Given this backdrop, the author will investigate basic work flow and scheduling procedures that can be utilized to improve the performance of this niche of the industry.

LITERATURE REVIEW

Extensive surveys of academic literature uncovered no evidence of research into the application of traditional project management (PM) techniques to the emerging field of solar energy. Especially during the emergence phase of a new industry, maximization of efficiency and accuracy is exceedingly critical. The solar energy industry faces powerful, entrenched competition in the traditional utility supplied electrical supply in the United States (EIA, 2010). In this context, it is critical that every available tool be utilized to provide maximum positive impact.

There is fair sized body of literature that references project management as it applies to general construction. Robichaud and Anantatmula (2011) concentrate on the sustainable aspect of construction, but not on how to optimize planning and scheduling a solar installation. Omar (2009) confirms the applicability of PERT/CPM (Program Evaluation and Review Technique/ Critical Path Method) tools to construction overall, which by reference indicates that these PM tools are applicable to the solar energy industry. Ahuja and Thiruvengadam (2004) assert that utilizing these well-developed tools will improve construction scheduling, and the accuracy and impact can be even further enhanced with more formal stochastic methods as referenced by Ming and AbouRizk (2000). As far back as 1983, Bennett argued that strategic thinking in the construction industry required the use of formal project management. And finally, Lavingia (2003) confirmed the positive impact on the bottom line when project management tools are properly utilized.

Together, the background literature provides a rich justification for expanding this body of knowledge into the burgeoning, critical field of solar electricity. This movement will serve to enhance the breadth of the overall project management field of knowledge as well as improve the tools available to benefit the overall solar power industry. Applying project management techniques that yielded general construction industry improvements to the related but newer field of solar PV energy systems installation will enhance the competitiveness of the industry and of companies and individuals utilizing project management optimization.

COMPANY BACKGROUND

EverGreen Power & Electric, LLC (EverGreen) is a renewable energy and electrical solutions provider founded in 2010, based and operating primarily in Oregon under CCB #192604. The company is fully licensed, bonded, and insured to do any electrical construction throughout the state. In addition, key certifications have been secured, including Energy Trust of Oregon Trade Ally and Oregon Department of Energy Tax Credit Certified Technician, and several trade organizations have been joined, including solaroregon.org, solar-estimate.org, and solar-nexus.com. EverGreen operates from three service sites: one in Eugene, one in Bend, and one in Klamath Falls. These locations allow responsive service to varied customers in broad areas of the state.

EverGreen's founders share a background in power and construction and a common desire to contribute knowledge and skills in a positive way for friends, neighbors, and society. Renewable power holds the promise of improving lives, improving the environment, and providing a new, key industry for the nation’s economy. Initial company focus is on designing and installing solar photo-voltaic (PV) power solutions for agricultural, residential, and small-sized commercial customers within the company’s operating regions. As company resources increase, segment focus will expand to include additional areas and both larger and smaller end-users who are looking to offset utility costs or improve their environmental impact, as well as those wishing to produce an income by selling surplus power to utility companies. These key markets can be enhanced through expansion into various energy storage technologies.

Mission Statement

EverGreen provides expert energy services that deliver ongoing value to its customers while positively impacting our society and world. EverGreen consistently strives to exceed internal and external expectations in implementing power solutions that provide consumers with reliable, clean, and cost-effective energy independence, every time. EverGreen is committed to high standards of client service, staff development, ethical practice, and a sustainable, long-term business operation. Clients seek out the company as the renewable and electrical provider of choice due to its carefully nurtured reputation of setting standards of excellence its customers, suppliers, employees, and all other stakeholders (EverGreen, 2012).

Company Objectives and Goals

The company's mission is not a canned marketing tool but, rather, encapsulates the personality of the founders. Think not of what is, but of what can be. Accept not what is good enough, but strive for what is better. The growing energy demands of the world, the United States, and the State of Oregon, are being merely adequately met largely by aging systems and technologies that must be expanded and improved upon to keep up with a growing population's ever increasing electrical demand. EverGreen provides customers with opportunities to improve this situation, even one system at a time, without relying on duplicating the inefficiencies or negative consequences of past solutions. A blossoming renewable energy field creates the opportunity to radically alter the American landscape – politically, economically, and environmentally. Despite the opportunity for fundamental change, hooking up solar electricity to serve consumers power needs uses the same fundamental tools EverGreen has spent decades polishing. The company believes that by responding to current trends it can rapidly become a premier regional renewable energy service provider. By applying the blend of skills, knowledge, and commitment it possesses, the company has the opportunity to have a dramatic beneficial influence on individuals, organizations, and, by extension, societies.

INSTALLATION PROCESS

At its roots, EverGreen performs similar functions to various trades in construction and other industries. When a potential project is discovered or presented, steps are undertaken to understand the need as well as how the organization's unique skills and knowledge may apply to the opportunity. If a project is confirmed or accepted, specialized knowledge, labor, and/or materials are brought to bear to perform the specific tasks needed to complete the project. Process details vary significantly even within a single field, depending on the specifics of each project, but the general concepts are quiet repeatable.

General Discussion

Typically, a broad series of preparatory tasks must be done before the first direct project task is undertaken. This work includes communication with the customer or client to understand the goals, data gathering and analysis, design and material needs assessment, cost and pricing estimates, and other planning steps. During this discovery segment of the project, several opportunities are typically given to assess the practicality of the project in the particular application. Finally, authorization to proceed and scheduling allow the project to continue.

Presuming a project goes forward, there is still significant prep work required to ensure labor and materials are where they are needed before work begins, and that critical planning has been completed to ensure resource flow to required areas throughout the timeline. Beyond scheduling and procurement, there are other issues such as authorization or permitting that also will often follow the assessment steps but precede the actual project start. When all feasible planning and preparation have been addressed, the actual project implementation is ready to begin. Depending on the project and application, the planning and preparation steps briefly described here can account for a significant amount of overall project time and cost.

When the direct project tasks are complete, several important tasks likely require wrap-up. Often, documentation and other paperwork issues remain incomplete. Sometimes financial loose-ends persist as well. As before, nearly every organization shares the necessity of completing significant and important tasks even after the specific goal-related tasks have already been completed.

EverGreen Specific

In the case of solar PV electrical systems, EverGreen must go through these same three basic pre, construction, and post tasks. Appendix A contains an abbreviated, top-level flowchart, broken down into these three categories, of the major steps to be addressed in a typical project. In general, each of the major steps consists of multiple sub-tasks to be completed.

In the preparatory stage (shown in Appendix A, Figure 1), information regarding a specific potential customer's electrical demand and solar availability at the desired site are considered with respect to the possibility of installing a system to meet the need. In-depth calculations will assess the applicability of PV in the given situation. If the solar resource available at a site is insufficient, the project must be rejected. If the project itself is determined to be viable but the customer is not able to financially or in some other way support the installation, the project also will not go forward. Even capable customers presented with viable solutions may elect to eschew the project completely or pursue some other option or provider.

The actual job tasks described in Appendix A, Figure 2 are generalized processes that broadly apply to many solar installations. When preparing a schedule for a specific project, items like "Roof Prep" (for smaller residential or commercial installations) may be replaced with "Pole Prep" or a similar description if the specific project happens to be a ground-based rather than roof-based system (for larger agricultural or industrial implementation). Depending on customer requirements, the optional backup generator shown could be deleted or perhaps replaced with battery backup. For a stand-alone system, the grid tie-in would be eliminated. For diagram simplification some tasks that could be partially parallel are shown linearly, but in actual field practice with sufficient labor resources work could progress simultaneously. These example modifications do not materially change the overall documentation of how the actual construction progresses.

During the final major category, post-job (shown in Appendix A, Figure 3), EverGreen will need to ensure that all activities are wrapped up, documentation is completed, and all financial aspects of the project are finalized. Again, for chart readability purposes, simplification assumptions have been made. For example the financial aspects are shown linearly and presume that all invoices are received per schedule. In actual practice, recursive tasks may be required to issue late-due notices, negotiate with suppliers while waiting for customer payment, etcetera.

USE OF PROJECT MANAGEMENT

As indicated, this overall flow chart is somewhat simplified and does not list every sub-task and doesn't address the interactions between activities nor the impact that the status of one task may have upon another. The described processes EverGreen utilizes for a project are well suited for analysis using CPM strategies. Judicious application of this operations management tool will allow optimization of scheduling – a beneficial effect for many involved parties including EverGreen, its customers, its suppliers, authorities having jurisdiction, and others.

Task Definition

With this goal in mind, the first step of the analysis is a thorough investigation of the tasks and sub-tasks that compromise the full scope of the project. This consists of determining the details for each step from the Appendix A flow charts, as well as any intervening tasks or sub-tasks that may have been left out of the overview. These steps are ordered and given precedence in table format using the software application Microsoft Project (Project). This format is the basis of the Gantt chart, a horizontal bar chart visually representing when a task will start and stop. A sample of the Pre-Job Gantt table data and chart format that Project produces is shown in Appendix B, Figure 4.

Task Analysis

For each task generated, the time required to complete each function is estimated. Because this cannot be known with certainty ahead of time, optimistic, pessimistic, and most likely durations are generated. When entered into Project, estimated durations and predecessors are used to determine estimated start and finish times for each task. An example of this data and the resulting calculations is shown in Appendix B, Figure 5. Also consequentially impacting the schedule is the availability of required resources. Project allows consideration of labor and other resources assigned to a task when determining the schedule.

Project can then be used to analyze the table data in a PERT chart. The chart will consist of one node for each task in the list for the entire project and the precedence relationships defined will be indicated by arrows connecting the nodes. The PERT chart is used to visually represent the interaction of tasks and schedule impacts. It can help to determine which tasks may have some independence and may be able to be delayed without impact on the schedule, as opposed to tasks that are critical to have completed on time to prevent deleterious results for the overall project schedule. Depending on the validity of the initial time estimates, taken together, these steps can be used to provide optimum scheduling estimates for the project as a whole and for individual tasks within the project. A sample of the PERT analysis for this project corresponding to the Gantt data from Figure 4 is included in Appendix B, Figure 6. This analysis of an individual PV project allows identification of critical tasks, where excess time may be available, as well the best available schedules.

One issue to be addressed in the PERT analysis process is how to address the time requirements between tasks. As described above, while the task itself may be considered to have variability in the expected time required to complete it, the amount of time that a project can "lead" or "lag" another project can only be treated as fixed in Project. To get around this issue, dummy tasks described as "DELAY" are entered into the project between some tasks. As shown in Appendix B, Figure 7, these delay tasks can then have variability attached to them to allow the time between tasks to be treated as a variable.

Results

The final results of the project analysis using the estimated task processing times indicate that the project is expected to take 79 days, with a variance of 70 days. These values can then be used to calculate the probability that the project will be done by any desired date. Any number of possible date values can be tested to develop a promise date for project completion that is likely to be met.

SUMMARY

This paper has presented an application of project management tools in the solar energy industry, specifically used in planning for and monitoring the installation of PV panels and solutions for various users. Based on the literature review this appears to be a unique application that could be widely used in the industry to provide efficient and effective installations.

EverGreen will conduct a full audit of this process to ensure no tasks are overlooked and the duration estimates are valid. This tool will then be used in the field on projects to enhance accuracy of quotations. The tasks and times will then be adjusted by new information gained during performance of the project process. Scheduling accuracy information gleaned from actual install work will be applied to the initial estimate numbers used on ensuing projects. Identification and mitigation of schedule confounding factors using these operations management tools will allow EverGreen to generate highly accurate schedules that will provide an important advantage over competitors.

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APPENDIX A

ABBREVIATED PV PROJECT FLOW CHART

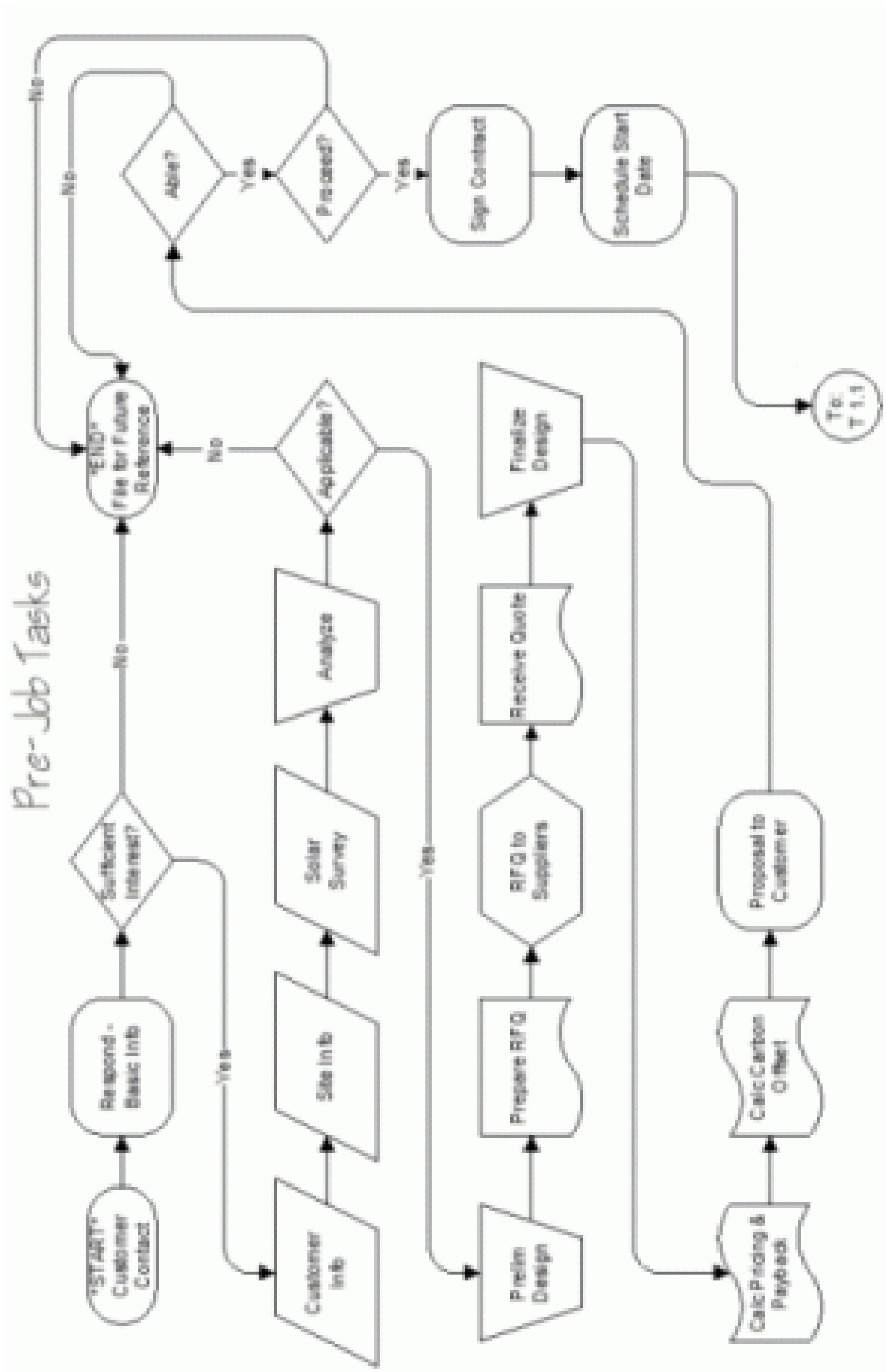

Figure 1 - Flow Chart T1.0; Pre-Job Tasks

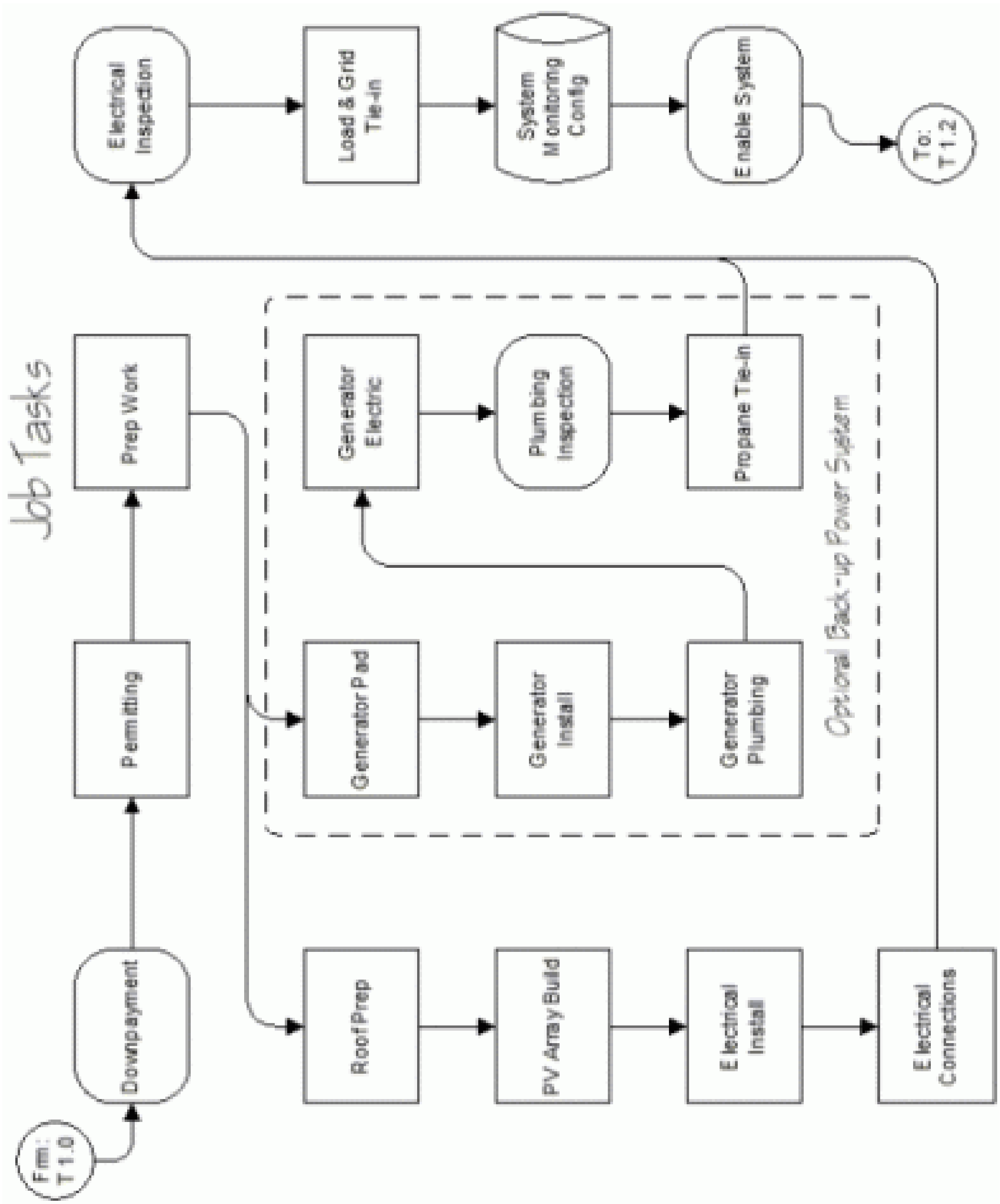

Figure 2 - Flow Chart T1.1; Job Tasks

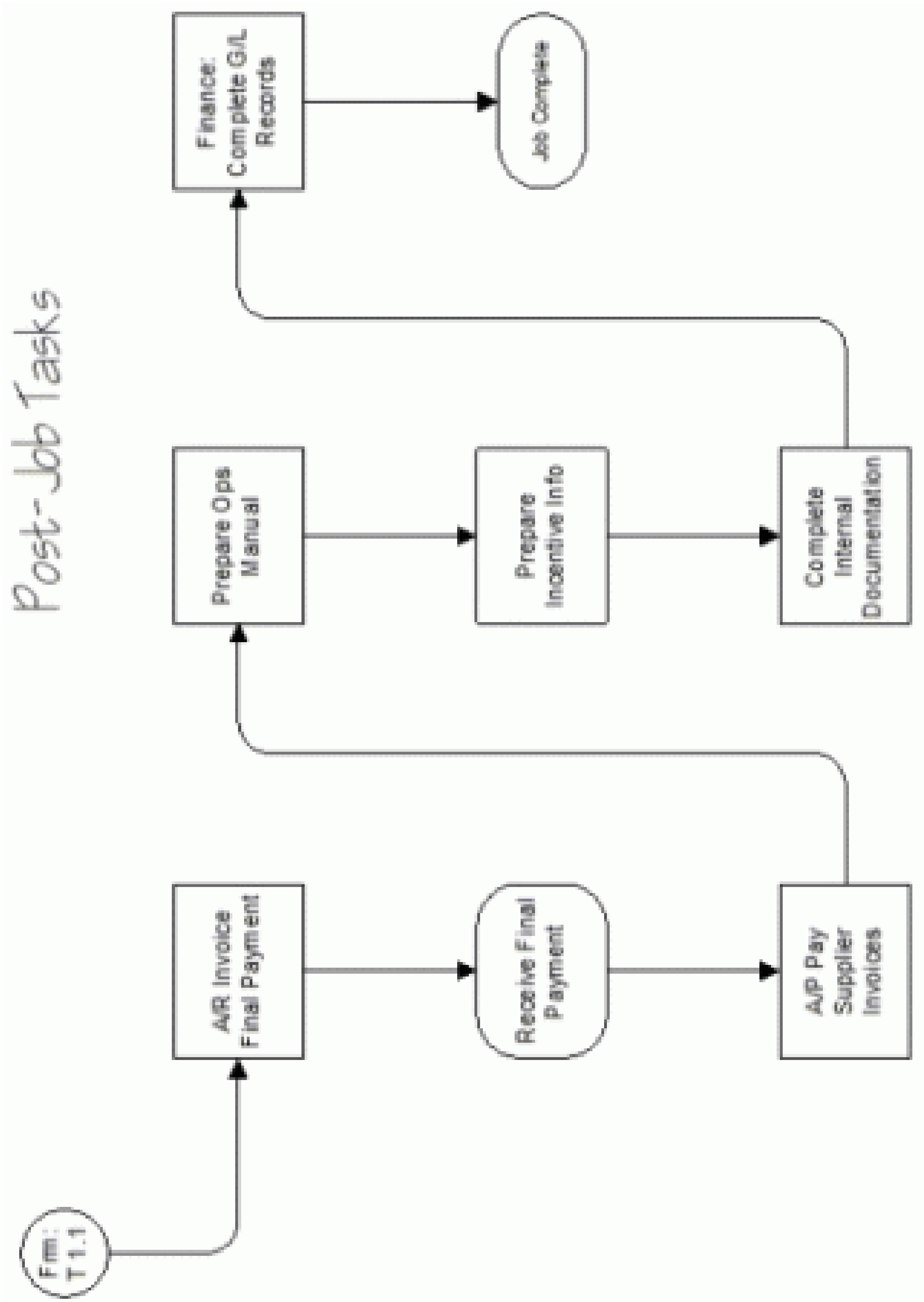

Figure 3 - Flow Chart T1.2; Post-Job Tasks

APPENDIX B

PV PROJECT GANTT AND PERT CHART DOCUMENTATION

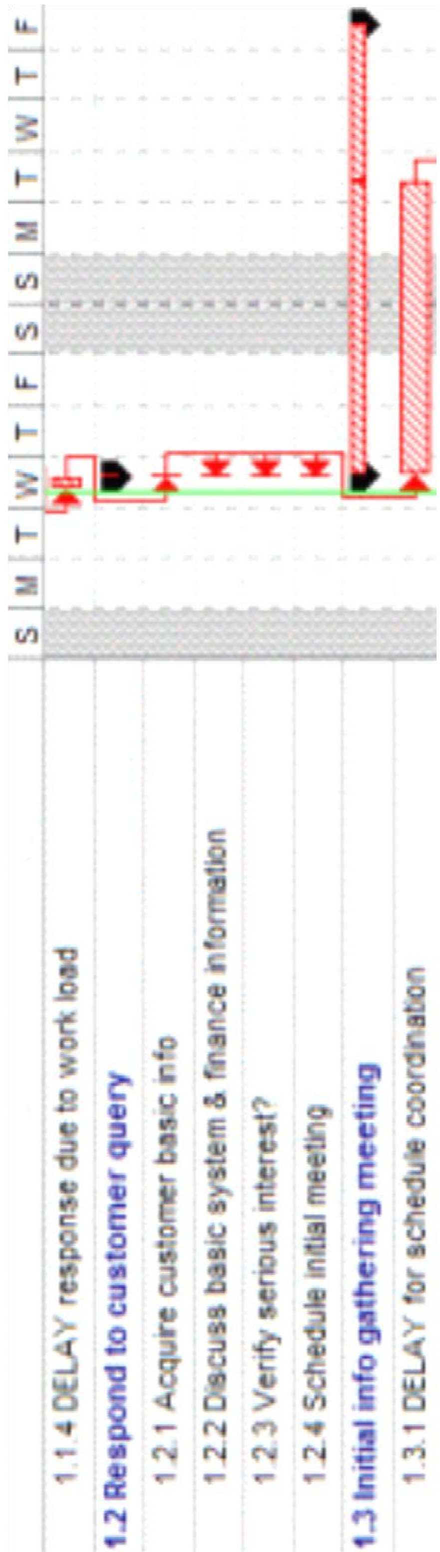

Figure 4 – Microsoft Project Gantt Chart Partial Example

Critical	Expected	Variance	Total Slack	Optimist	Likely	Pessimist	Early Start	Early Finish	Late Start	Late Finish
Yes	7mins	0	0mins	2mins	5mins	20mins	Fri 3/4/11	Fri 3/4/11	Fri 3/4/11	Fri 3/4/11

Figure 5 – Microsoft Project PERT Data and Date Calculations Example

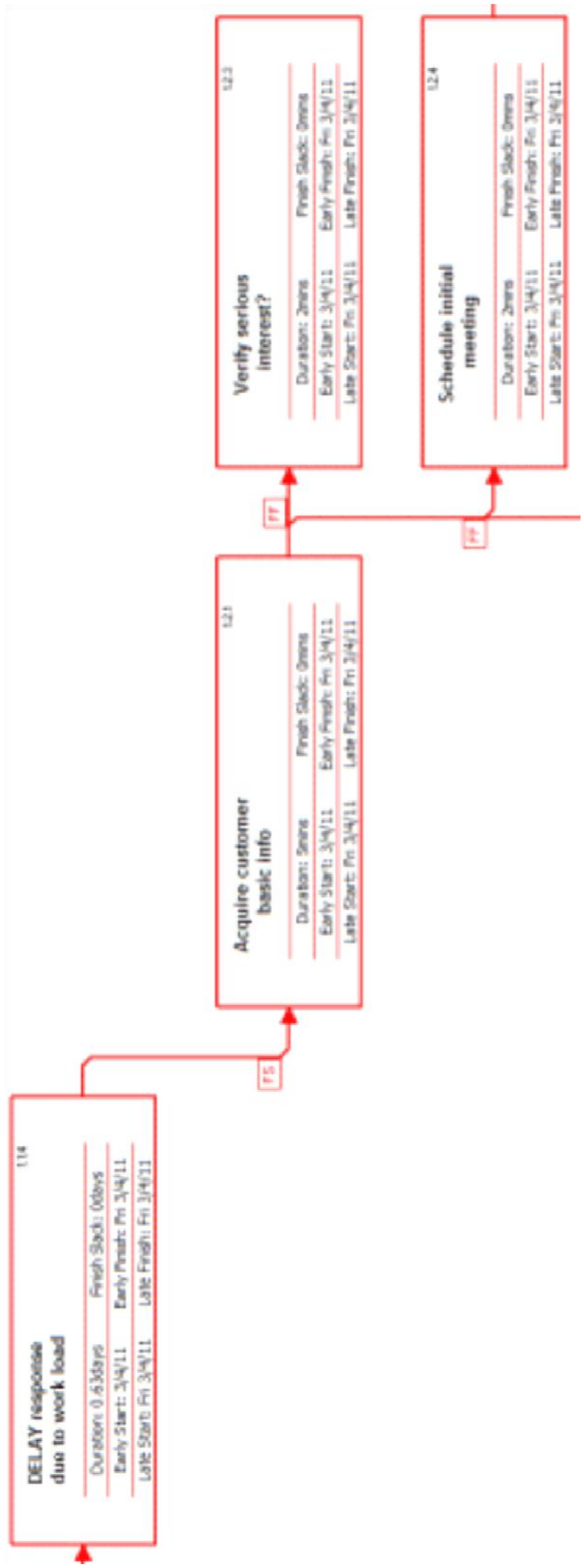

Figure 6 – Microsoft Project PERT Chart Sample

Figure 7 – Microsoft Project PERT DELAY Variation Example