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Building Success from the Low-Tide of Failure: Project Complexity Analysis – GM Bowling Green

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Abstract

The purpose of this research was to identify the uses of five dimensional project management (5DPM) along with the corresponding methods and complex systems engineering and project management tools when applied to an organization as a whole. Through the course of action research, this paper demonstrates how a significant financial loss on one project opened the door (and the need) for a number of improvements, of which included the adoption of an engineering management process centered around the 5DPM method. This approach was implemented at GENESYS Systems Integrator, an engineering design-build firm in Kansas City, Missouri. The research presented in this paper provides a case study on GENESYS and the General Motors Bowling Green project that created an environment at the company that necessitated improvements. The executive leadership team of the organization decided to move forward with the systems engineering 5DPM approach and has seen close to record company performance in 2013, in part, due to these improvements. This paper will discuss the theory behind the success that the 5DPM approach helped generate and provide a base line through which other companies in industry can implement and recognize similar improvements.

Keywords
Project Complexity, 5DPM, Complexity Map

1. Introduction

"Of 27,536 construction companies, all of which started in 1998, over 70% of them had gone out of business seven years later. The survival rate of these companies is shown in Figure 1" [1]. The company described in this paper was one of those companies that started in 1998, and today remains in business, completing $50M per year in revenue with roughly 100-150 employees [2]. However, the road to success in the construction industry for GENESYS has not been without challenges. This paper will focus on one of those challenges and how the 5DPM method can be used to inform decision making such that similar challenges can be avoided in the future.

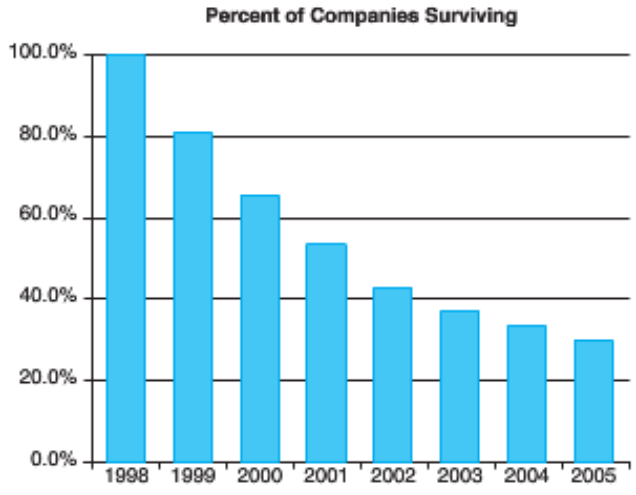

Figure 1: Construction Industry Business Survival by Age

In 2011, GENESYS Systems Integrator accepted a purchase order (PO) from General Motors to perform work at the Bowling Green Corvette Manufacturing Facility. The PO price, including change orders, was roughly $5M. At completion in 2012, the total cost of the project was roughly $7M. The difference was a net loss of $2M for the company [3]. As such, the 2012 fiscal year was a low tide for GENESYS that allowed the organization to see the rocks below the water and make corrective actions accordingly.

This paper will provide a background on GENESYS and show the systems and processes that have been put in place to implement the 5DPM approach as a cost control and profit maximization mechanism. The paper will then focus on five dimensional project management (5DPM) analysis methods and tools, which may have helped further identify the potential risks on the Bowling Green project. The paper concludes that 5DPM had the potential to help mitigate the risks that led to the large loss on the Bowling Green project, and recommends that GENESYS and other contractors adopt the 5DPM approach, especially in the project development phase prior to the acceptance of a PO.

2. Background

GENESYS is a business, process, and technology innovator and integrator specializing in helping manufacturers improve their capital investments through execution of turn-key design, build, and installation solutions [4]. GENESYS accounting principles follow the Generally Accepted Accounting Principles such as conservatism, consistency, the materiality principle, and the matching principle [2]. GENESYS uses the percent of completion method following the cost-to-cost method [2]. Many of the projects that GENESYS take on span multiple months and at times span multiple years. Since the accounting is driven off of the cost, the accounting department recognizes revenues when the company bills the owner, recognizes expenses when the company receives a bill from the supplier or subcontractor, and revenues, expenses, and estimated profits are calculated based on the percentage of the project that is complete [2]. As such, the estimation of the percent of the project that is complete is highly important to the accounting of the organization.

The GM Bowling Green project in 2012 was miss-estimated and, as such, the percentage complete was miss-reported. When the project started to exceed the estimated project cost, this caused major issues for the accounting department as the project overran the budget and made a recognized profit in previous months no longer available. Following the conservatism principle, accounting had held back on recognizing a significant portion of the profit but the project manager kept ensuring the accounting department that the project was not going to take a large loss [2]. When these events unfolded, accounting had a large, unexpected loss that they had to reconcile at the end of the job creating a cash flow crisis for the organization.

Since the completion of the Bowling Green project (2012 Fiscal Year), GENESYS has made a number of improvements to drive profits and cash flows while simultaneously mitigating the likelihood of a project with miss-estimated costs or a high risk of cost overruns from occurring. At the conclusion of the Bowling Green project, a lessons learned meeting was held. Action items from the meeting were implemented to mitigate unnecessary future risk. A number of these action items and the resulting effects are listed below.

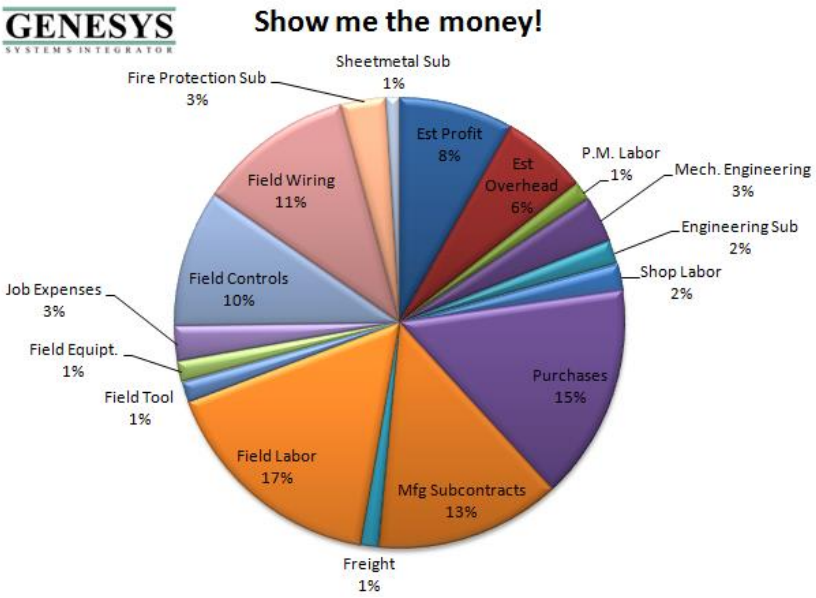

Figure 2: Show me the Money Pie Chart

One take-away from Bowling Green was to always identify the biggest financial impact to the project and focus effort and attention there. The "Show me the money" pie chart in Figure 2 was a result of this lesson learned [3].

The team also identified that during the estimate development they should always bring in a resource outside the project team (another field superintendent, another project manager, etc.) to check projections when there is uncertainty. Business Unit teams have been created to provide these dedicated resources for the review of estimates prior to the acceptance of a PO. To further enhance this collaboration, the company has implemented a weekly Business Unit Execution meeting to provide an environment for joint solutions among the business units described above. The meeting brings together the solutions development team leaders, chief engineers, and business unit leaders to focus attention on developing action items to impact the project results [4]. In addition, real-time costs have been added to the job tab of the estimate to flag the project manager when the costs are exceeding the projected costs for that point in the project [3]. An example of these indicators is shown in Figure 3.

	P.M. Labor		Mech. Engineering		Shop Labor		Mild Steel		Purchases
Actual Hours / Composite Rates	△ 337	$53.43	◆ 3,059	$47.02	● 2,624	$34.92	● $18,964		●$134,277
As Bid Hours / Composite Rates	364	$100.00	2,219	$44.45	3,541	$33.00	21,805		156,522

Figure 3: Example of real-time hours versus projected hours with key indicators

The biggest issue of high risk jobs is to not to let them get kicked off without first identify and mitigating the risk. GENESYS has put in place a system that looks at the risk relative to the reward of the job. A process has been developed to work with the client to remove risk from jobs as well as work internally with the project team to remove risk from jobs when a high risk job is identified [4]. The system looks at the Project Type, Scope Type, and Predicted Profit and calculates the risk of the job and flags the project team accordingly (Figure 4). Jobs with high risk relative to the reward are flagged as gray, and jobs with high reward relative to the risk are flagged as orange.

Proj Type	Scope Type	Pred Prof	Rel Pot
CA-SS	FS	15%	16.20
RFQ-Resp	WDS	15%	3.60
CA-SS	FS	15%	16.20
CA-SS	FS	14%	15.12
RFQ-w/Cust	FS	14%	10.08
RFQ-Resp	WDS	14%	3.36
CA-SS	TM-C+	14%	25.20
RFQ-Resp	WDS	13%	3.12
RFQ-Resp	WDS	13%	3.12
RFQ-w/Cust	WDS	13%	6.24
CA-SS	WDS	13%	9.36

Figure 4: Risk-Reward Relative Potential System

Since the implementation of these tools, GENESYS completed the year with a positive net variance in 2013, gross margin percent trending back to historical highs, and revenue trending towards the projections for the year [4].

While GENESYS is confident that the lessons learned and the action items that were a result will continue to improve GENESYS to an even stronger company than before the recession, the next section of this paper will focus on 5DPM methods and tools as an affirmation of this confidence and a complimentary risk mitigation solution.

3. Complex Project Management Dimensions

According to Winter and Smith in *Rethinking Project Management*, Project Management is "…aimed at extending and enriching mainstream project management ideas in relation to developing practice" and "…what the five directions represent are the principle areas in which new thinking is needed to guide practitioners in the management of projects" [5]. Likewise, when viewing a project in the conceptual framework of the three dimensional model, sometimes known as the "Iron Triangle," Cicmil, Cooke-Davies, and Crawford note that "the situation gets extremely complicated and paradoxical if other, equally justifiable and important key performance indicators (KPIs) such as environment, community, health and safety, future/longer-term opportunities for learning, and collaboration, are at play" [6]. This thinking then requires a shift in project management from the three-dimensional model of cost, technical, and schedule to a five dimensional model of cost, technical, schedule, context, and financing [7]. From

these five dimensions, a project can be analyzed and a complexity map can be created [8]. The Bowling Green project will be broken down by these five dimensions and the three factors that had the greatest impact in that dimension.

3.1 Cost Dimension

The project manager on the Bowling Green Project identified Risk Analysis, Estimate Formation, and Owner Resource Cost Allocation as the three cost factors that had the greatest impact on the cost dimension. Estimate Formation was one of the largest impacts on the project and the project manager claims, with only a slight amount of exaggeration, that "not one thing on the estimate was accurate" [3]. The project manager gave the cost dimension on this project a 95 in complexity, and perhaps if the high emphasis on this dimension had been identified prior to the acceptance of the PO the company would have submitted a revised proposal with much more accurate costs. The project manager felt that risk analysis was another factor impacting the cost dimension given the "low reward for the risk based off the amount of money that the company stood to make." The next highest ranked factor was owner resource cost allocation. This factor developed into a large impact on the project complexity due to the lack of funds available which translated to having no resources to allocate. An example would be that a project manager can make a decision to send five highly paid superintendents to a jobsite to ensure the job runs smoothly but then has to incur the extra costs for the decision. However, with no additional resources to fund such a decision, the project manager on the Bowling Green project always defaulted to the lowest cost option due to the fact that the project did not have adequate cost to perform the operation, although that option might not have been at the greatest value.

3.2 Schedule Dimension

The project manager assigned the Schedule Dimension a complexity ranking of 75. One of the largest impacts on the schedule of the job was resource availability. Bowling Green, Kentucky is not near another major city; both Nashville, Tennessee and Louisville, Kentucky is roughly an hour and a half away. GENESYS has a Millwright Union shop and utilizes labor from the local union halls for field installations. The rates for these union halls vary by location. The GM Bowling Green Project that GENESYS took on occurred during a production shut-down at the Bowling Green Manufacturing Facility. As such, GM had multiple projects going on at that time that were pulling the workforce from the union halls. Thus, the availability of labor in Bowling Green was limited, but pulling labor from Nashville or Louisville resulted in a much higher compensation rate for those workers. As a result, finding quality labor at a reasonable rate for the Bowling Green project was challenging.

The second factor encountered by the project manager was the timeline requirements. The job was never scheduled out from the estimate so the PM did not know the manpower required to complete the project or if premium time would be required to complete the project in schedule. The next factor with the most impact on the schedule was the earned value analysis. Due to the resource availability mentioned before, the quality of the labor did not meet prior expectations. The project management team would develop projections assuming a certain number of workers can complete a certain amount of work in a certain amount of shifts. On the Bowling Green project, the output of the labor was consistently lower than perceived which made tracking scheduled work versus actual work performed a constant challenge.

3.3 Technical Dimension

The technical dimension came in ranked at forty showing that the technical dimension for this project was slightly less complex than other projects executed by the organization. The project manager had high confidence in the technical capabilities of the execution team and, to this day, GM commends the work that GENESYS completed. Although the technical dimension was not overly complex, the PM did identify existing conditions, design method, and owner's internal structure as the three factors that contributed the most to the technical complexity. The structural limitations in place at the manufacturing facility led to site constraints regarding where the project had to run through and where the execution team had to get equipment to. Beyond the structural limitations, the design did have some components that the execution team had not implemented before. The execution team was also limited by the owner's internal structure that the union crews could not work overtime otherwise the manufacturing plant

would have to offer overtime to the plant crew. This led to complexity in the design of the working shifts as no one individual could work more than 40 hours in one week but work had to be continually performed around the clock seven days a week. To complete the technical scope within schedule, under the owner's internal structure constraint of no overtime, led to an excessive number of required shifts.

3.4 Context Dimension

The context factors seemed to play a role throughout the entire project but the project manager contributed most of the complexity that some may place within the context dimension to other dimensions such as cost and schedule. For example, the project manager identified demographics as one of the factors driving the context complexity due to the quality of the local work force which was described previously in the schedule dimension. Designer(s) was identified as a factor under the PM's interpretation of Designers as the designers of the contract. The contract being poorly designed with no contingency or qualifications to cover cost overruns was described in the cost dimension. The last factor identified in the top three factors impacting the context complexity was the Jurisdictions related to the inability for the unions to work overtime which was discussed in the technical dimension. Overall, the Context dimension was given a complexity rating of twenty-five.

3.5 Financing Dimension

The financing factors had little to no impact on the complexity of the project in the view of the project manager. The funds for the project up to the PO value came from the client. If any factor did play a part in the complexity of the financing dimension, that factor would be the risk analysis. Once the cost got out of control, the company did not have a means to finance the cost due to the fixed contract amount. This drove the company to have to withhold payments to vendors and take funds from other projects in order to finance the completion of the Bowling Green project. GENESYS has since caught up with payments to all of its supply base and is developing a positive cash flow environment which allows the company to deliver projects that help clients produce their products better, faster, safer, and a greater value. The project manager gave the financing dimension a complexity rating of ten on the Bowling Green Project.

3.6 Complexity Map

Developing the complexity map (Figure 5) allows for discussion of critical project issues at the early stage of project planning and definition. The tool also provides a shared understanding of the complexity dimension that is driving the project (cost for the Bowling Green project) and allows the team to allocate rational resource allocation to maximize project success [7]. If the complexity map below had been portrayed to the solutions development and execution team prior to the acceptance of the PO from GM, the complexity map may have been able to spur discussions on issues such as the inability for the field crews to work overtime, the accuracy of the costs in the estimates, and the quality of labor available for the project. Once these areas were identified, the methods and tools described in the next section may have helped bring the project in with a more favorable outcome.

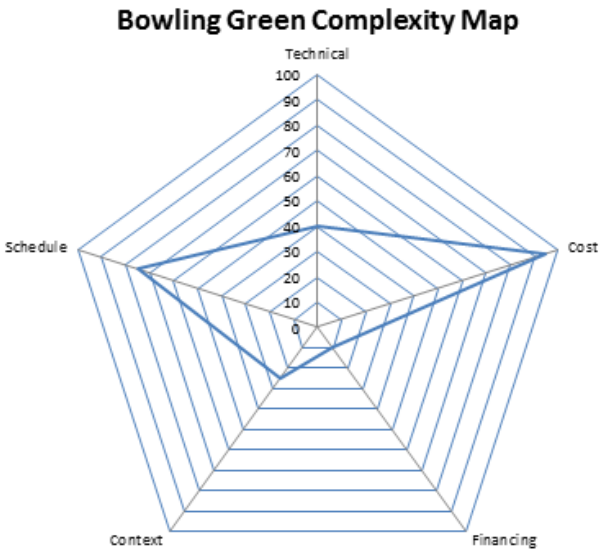

Figure 5: Bowling Green Complexity Map

4. Complex Project Management Methods

The five Complex Project Management Dimensions that need to be considered for every complex project are Define Critical Success Factors, Assemble Project Team, Project Arrangements, Early Cost Model and Finance Plan, and

Develop Project Actions. This section will discuss if each method was used on the Bowling Green project and if so, how it was used, or if not, how that might have impacted the project.

4.1 Define Critical Success Factors

As shown if in Figure 2, the "Show me the money" pie chart was created after the completion of this project. The reason for the pie chart is that it quickly identifies which areas of the project are most likely to contain the factors critical to the project success based on the percentage of the total project budget. For this project, the critical success factors were identified, but they were identified too late in the project life cycle. The critical success factors were determined a couple months into the project once the project manager started to realize the project was not on track to complete the project according to the criteria set-out in the five project dimensions. The lack of defining critical success factors until late in the project lifecycle was identified by the project manager as one of the major reasons this project failed. Thus, the "Show me the money" pie chart in Figure 2 and the Relative Potential calculation in Figure 5 have since been implemented to spark the discussion of critical success factors by all project leaders prior to submitting a project proposal.

4.2 Assembling Project Team & Project Arrangements

The project manager for the Bowling Green project felt that the correct project team was assembled to complete the project according to the required project arrangements. However, this team was assembled after the acceptance of the purchase order and, as described in section 4.1, did not have a clear understanding of the critical success factors. As such, the team did not have buy-in on the plan from the start of the project and many departments found that the budget allotted for them to complete their portion of the project required them to significantly overrun the budget. Since the completion of this project, GENESYS now assembles the project team in the development of the project plan and prior to the acceptance of the PO so that the correct individuals are on the team with the correct project arrangements and the correct critical success factors identified for them to achieve.

4.3 Early Cost Model and Finance Plan

GENESYS has a process that maps cash inflows and outflows based on the cost codes and what percentage of the total cost for that cost code will be spent by GENESYS or paid for by the client in a given month. To protect the proprietary nature of this process, only the output has been show in Figure 6 below. The figure shows that GENESYS would need slightly over $30,000 in the form of a bridge loan or line of credit in the first month of the project, and from then on the project would be funded with payments from General Motors. However, as the project progressed, significant cost overruns occurred in each cost code, and the project could no longer be supported by the General Motors financing. As can be seen, the project went from one month of negative cash flow in Figure 6 to only one month of positive cash flow in Figure 7. However, at the time of the project, the cost model and finance plan to generate the results shown in Figure 7 had not been generated. Thus, the project manager knew that the costs were increasing but did not realize that they were to the extent that the General Motor's funds were no longer enough to finance the project. This required the company to take profits from other projects in order to fund the completion of the Bowling Green project. Since the completion of this project, the project managers now update their cash flow statements every two weeks to have a good understanding of the project financing and cost model for the project. This also allows the financial department to better forecast the required financing to support all company projects at any given time. So, while a cost model and finance plan were present from the Bowling Green project, the extent to which they are accurate and benefit the company has been significantly improved since the Bowling Green project.

Cash Flow		Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	TOTAL
BEGINNING CASH		$0	($30,403)	$319,608	$435,300	$1,248,329	$1,486,542	$1,150,176	$1,037,791	$764,997	$726,031	$1,606,158	
CASH COLLECTED		$0	$451,558	$483,348	$1,311,942	$910,907	$183,409	$112,307	$46,889	$543,085	$1,164,790	$0	**$5,208,235**
TOTAL CASH AVAILABLE		$0	$421,156	$802,956	$1,747,241	$2,159,236	$1,669,951	$1,262,484	$1,084,680	$1,308,083	$1,890,820	$1,606,158	
TOTAL CASH PAID		$30,403	$101,548	$367,656	$498,912	$672,694	$519,775	$224,693	$319,682	$582,052	$284,662	$0	**$3,602,077**
REMAINING CASH		($30,403)	$319,608	$435,300	$1,248,329	$1,486,542	$1,150,176	$1,037,791	$764,997	$726,031	$1,606,158	$1,606,158	
CASH FLOW	NEUTRAL	NEG	POS	POS	POS	POS	POS	POS	POS	POS	POS	POS	NEUTRAL

Figure 6: As Bid Cash Flow Analysis

Cash Flow		Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Sep-12	TOTAL
BEGINNING CASH		$0	($139,570)	$16,464	($380,167)	($137,371)	($163,325)	($705,008)	($918,481)	($1,892,548)	($2,413,462)	($1,741,406)	
CASH COLLECTED		$0	$451,558	$483,348	$1,311,942	$910,907	$183,409	$112,307	$46,889	$543,085	$1,164,790	$0	**$5,208,235**
TOTAL CASH AVAILABLE		$0	$311,988	$499,812	$931,775	$773,537	$20,084	($592,701)	($871,592)	($1,349,463)	($1,248,672)	($1,741,406)	
TOTAL CASH PAID		$139,570	$295,524	$879,980	$1,069,145	$936,861	$725,092	$325,779	$1,020,957	$1,063,999	$492,734	$0	**$6,949,642**
REMAINING CASH		($139,570)	$16,464	($380,167)	($137,371)	($163,325)	($705,008)	($918,481)	($1,892,548)	($2,413,462)	($1,741,406)	($1,741,406)	
CASH FLOW	NEGATIVE	NEG	POS	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEG	NEGATIVE

Figure 7: As Executed Cash Flow Analysis

4.4 Project Action Plans

The Bowling Green project did not have a project action plan. If an action plan had been developed, the project manager may have realized the significant cost overruns earlier in the project which would have brought a stop to the project. The project manager may have also realized constraints like the fact that the field workers could not work overtime as well as the numerous other projects in the area that were drawing the quality labor from the labor pool. If the constraints had been better identified, an action plan could have been put in place to mitigate the effect of these resource limitations (one solution may have been to fly in workers from Kansas City – GENESYS headquarters – due to the lack of quality labor available at the time of the project in the local union hall). Developing an action plan may have also lead to other innovative solutions that could have been used to overcome the roadblocks and speed bumps that GENESYS encountered over the course of the project. The project action plan would have allowed GENESYS to be more proactive versus reactive. Since the completion of the Bowling Green project, prior to the acceptance of a PO, the project leaders are required to develop a "plan for profit" with an internal mission of receiving a letter in the lobby at each project completion.

5. Complex Project Management Tools

According to the *Guidebook: Project Management Strategies for Complex Projects*, 13 project management tools can be used to assist in the execution of managing complete projects [8]. Over the course of the Bowling Green Project, GENESYS used 3 of the 13 Complex Project Management Tools. These tools included evaluating the use of off-site fabrication, developing a dispute resolution plan, and evaluating flexible financing. Since the completion of this project, GENESYS has also started to heavily use the co-locate team tool, and uses other tools based on the project requirements.

Most of GENESYS' projects include off-site fabrication. GENESYS has a 245,000 sq. ft. facility where they fabricate most of the equipment before sending it to the field for installation. This yields a number of benefits. These benefits include that the shop hourly rate is significantly less than the field hourly rate, so any work that can be completed in the shop poses a financial savings as long as the work required is of significant enough magnitude to justify shipping. The shop also allows for a controlled environment to construct the equipment and provides the benefit of the ability to run-off (test) the equipment without the client having to shut down their manufacturing line. This process helps ensure minimal down-time for the client once the equipment is being installed.

While GENESYS prides itself on the number of projects that have been completed with little to no client disputes, the General Motors Bowling Green project required a dispute resolution plan. In developing this plan, many alternatives were considered including a lawsuit. In the end, GENESYS chose to take a look in the mirror and realize that the company accepted a one-sided contract (a bad deal). As such, GENESYS took the high road and completed the project to the client's satisfaction. While this placed a significant financial burden on GENESYS, it created a low tide that allowed the company to see the rocks below the water and make a number of corrections and improvements that has led to GENESYS having one of the company's most successful years in 2013.

Since GENESYS decide to take the high road on the dispute resolution plan, this created a need to evaluate flexible financing. These financing methods included increasing accounts payable and decreasing accounts receivable by working with clients and vendors alike. GENESYS also sold some of the company to bring in capital and the owners further increased their investment in the company (equity financing). All of these methods allowed GENESYS to

weather the financial burden placed on the company by the Bowling Green Project and today GENESYS is back to financial health.

5. Conclusions and Future Work

Since the completion of the Bowling Green Project, GENESYS has begun to review all five dimensions of a project rather than just the traditional three of scope, schedule, and budget. The company has developed methods and procedures to help assemble the correct project team, with the correct arrangements, around the correct critical success factors with the supporting cost and finance model all driven by the project action plan. These methods are supported by tools such as off-site fabrication, evaluating flexible financing, and co-locating teams. Based on GENESYS' success on projects since the implementation of the 5DPM approach with the corresponding dimensions and complex project management tools, GENESYS believes that these procedures would have prevented the acceptance of a project like Bowling Green under the same conditions which the purchase order was received, and suggests other contractors adopt some or all of the improvements that GENESYS has made that are outlined in this paper. This paper also shows that these dimensions, methods, and tools are most effective when they are considered prior to the acceptance of a PO. Future work will entail continuing to grow team members' knowledge of 5DPM, the five Methods of Complex Project Management, and further application of the 13 tools, with the objective of mitigating the risk of complex projects like that of Bowling Green and maximizing the return on each project investment.

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