

Theory of the Triple Constraint – a Conceptual Review

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Abstract – Projects are generally undertaken because they are part of the plans to meet business needs and charter organizations to new levels of performance. Projects are however constrained by conflicting demands and competing priorities within the project environment. Neglecting to manage these constraints accurately and effectively may be sufficient to condemn a project even if all other project management activities are performed to a high standard of excellence. The aim of this paper is to improve the interpretation of the triple constraint and its dynamics and indicate how this may advance the delivery of project success. An integrated model is proposed to facilitate the strategic management of the triple constraint trade-offs as a function of the project higher purpose.

Keywords - Project management, triple constraint, trade-offs, scope, time, cost

I. INTRODUCTION

Products and solutions need to be constructed faster, cheaper and better. Around the world mission-critical projects are being launched all the time involving significant capital investments and high-risk ventures. Projects are becoming the way of the working world. What makes project delivery successful is however a topic of much academic debate, and depends by whom and against which value system the project is being evaluated. It is generally agreed that to be considered successful, a project must be fit for purpose (add strategic value) and it must have achieved its delivery targets [1], [2].

In reality it is not always considered practical to deliver all the project targets exactly as planned. Trade-offs need to be considered and priorities must be set in order to realize strategic decisions. The project management body of knowledge (PMBOK®) endorses that every project is governed by the triple constraint, which reflects a framework for evaluating these competing demands [3], [4], [5].

A. Introducing the triple constraint

The triple constraint is a critical project management concept that originates from the basis for undertaking a project and provides direction for framing the project. The triple constraint constitutes one of the primary building blocks of the project plan and is paramount to the monitoring and controlling process group [3], [4], [6], [7], [8], [9].

Although the triple constraint theme has various interpretations, the literature shows a general agreement

that project scope, time and cost comprise the three key triple constraint variables [1], [3], [4], [6], [10], [11], [12]. Project time addresses the scheduling and duration of the project, cost addresses the budget and resources of the project, and scope addresses the requirements and work of the project. A time-constrained project is bounded by the completion agenda, whereas a cost-constrained project is bounded by the scheduling of expenditure. Scope-constrained projects are bounded by the performance criteria of the deliverables. Project quality constitutes an integral dimension of project management and is supported by the triple constraint [3], [4], [6], [7], [10], [11], [13], [14].

The project management triangle (Fig. 1) is a useful model to illustrate the consequences of change on the triple constraint to key project stakeholders. The triangle reflects the fact that the three constraints are interrelated and involve trade-offs – one side of the triangle cannot be changed without impacting the others. Project quality takes root in all three variables of the triple constraint and is affected by balancing the three factors [4], [10].

It may easily be argued that triple constraint affairs reside at the kernel of the most essential determinations surrounding projects.

B. Introducing the research rationale

According to research by the Gartner Group, only 16% of information technology (IT) projects are completed within the desired time frame and budget and achieve the desired results. More than 30% of projects are cancelled and over 50% of projects will experience cost overruns. Less than 30% of the projects companies employ to change their businesses are successful [1].

The current literature in the project management domain suggests that there exists a lack of appropriate (and consistent) scholarship on the triple constraint and its dynamics [7]. The term ‘triple constraint’ did not even appear in the initial issues of the PMBOK® Guide glossary or index.

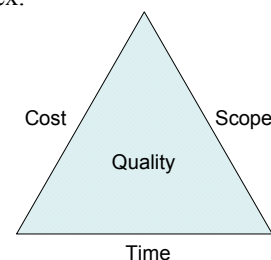


Fig. 1. Project management triangle.

This knowledge gap results in project managers not being able to effectively prioritize and exploit the triple constraint trade-offs. It is proposed that a thorough comprehension of the triple constraint dynamics is paramount to effective project management.

Another problem is that project managers often create an illusion of tangible progress by relying heavily upon traditional on-time, on-budget and on-target measures – yet this tactic fails to address the strategy ambiguity or establish appropriate project goals [15].

It has also become commonplace in many projects to view the triple constraint trade-offs as organizational problems that have a definitive solution ('either/or' choices) – yet this tactic fails to effectively negotiate the triple constraint and leads to destructive conflict. Collins & Porras discovered that instead of being oppressed by the 'Tyranny of the Or', highly visionary companies liberate themselves with the 'Genius of the And' – the ability to embrace both extremes of a number of dimensions at the same time [16]. This conjecture is supported by the Polarity ManagementTM philosophy [17].

Without the effective management of the triple constraint as an interrelated system, projects run the risk of becoming separated from purpose. A mechanism is needed on how to manage this seemingly contradictory task when it comes to constraint trade-offs. The premise is that if these constraints are managed properly, organizations will be successful in delivering projects and meeting organizational goals.

This paper examines the notion behind the project management triangle and power structure of its constraints. An integrated model is proposed for managing relative flexibility within the triple constraint towards a beneficial outcome in terms of project success.

II. RESEARCH METHODOLOGY

The basic structure of the research process used in the study is presented in Fig. 2.

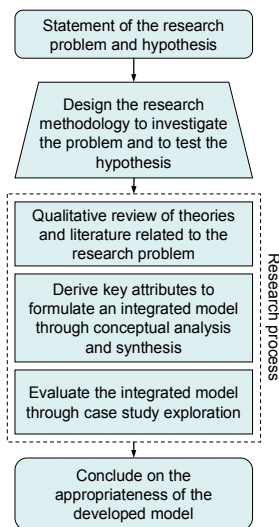


Fig. 2. Research process.

The type of study associated with this paper is primarily non-empirical defined through an extensive literature study, conceptual analysis and construction of an integrated model using secondary data. Theory building in the research occurred through retroductive and deductive strategies. Conceptual explication was used to derive the model through analysis and integration of concepts discovered through the literature study.

The research undertook basic case study analysis as a mechanism to demonstrate that the derived model is valid and useful, which also introduced an empirical element into the research design. The results from the case study analysis have been generalized to refer back to the project management body of knowledge in terms of applicability.

The integrated model presented in this paper is highly conceptual. The emphasis in the study was on qualitative reasoning both in definition, explanation and application, rather than an emphasis on empirical and other quantitative techniques. The findings of the research study should thus be considered as preliminary rather than conclusive, pending further research.

III. THEORETICAL FRAMEWORK

A substantial range of literature has been considered in the study with reference to more than 100 sources representing authoritative knowledge across the fields of project management [7]. This section provides an overview of some of the key concepts surrounding the triple constraint, and concludes with a consolidated triple constraint model.

A. Dynamics of the triple constraint

The triple constraint continuously faces conflicting demands and competing priorities within the project milieu. For example, if the project is working to a fixed level of scope then the cost of the project will largely be dependent upon schedule availability. Similarly, when the project time is fixed, the scope of the end product will depend on the budget or resources available.

Project management researchers and authors widely recognize that the inherent trade-off dynamics of the triple constraint can be described by the following three key relationships [3], [9], [12], [18]:

$$S \uparrow \propto T \uparrow C \uparrow \quad (1)$$

$$T \downarrow \propto S \downarrow C \uparrow \quad (2)$$

$$C \downarrow \propto S \downarrow T \uparrow, \quad (3)$$

where the up-arrow ($\uparrow$) implies an increase, the down-arrow ($\downarrow$) implies a decrease, and S, T, and C refers to scope, time and cost respectively.

Relationships (1), (2) and (3) denote that any triple constraint variable can be delivered at the expense of one or both of the remaining two variables. Further analysis signifies that when there is pressure on the triple constraint, at least one of the variables needs to be flexible in order to validate a quality balance [7], [11].

The dynamics of these relationships can be illustrated in a variety of ways through manipulation of the project management triangle. For example, if both the schedule and budget of the project are negatively affected as a result of an increase in project scope, the relationship may be graphically illustrated as shown in Fig. 3.

Fig. 3 is only one of many possible ways of how to illustrate these dynamic relationships. The illustrations also depend on which factors are fixed and which are flexible. It should be highlighted that the changes are not always symmetric, i.e. if two variables need to increase, one may increase proportionally more than the other – for example, more resources may need to be added in order not to exceed the deadline by too much.

The important consideration is that a connected triangle must be maintained at all times. Fig. 4 illustrates that it is not possible to maintain the triple constraint as a triangle when all three variables are pursued simultaneously [9].

B. Good, fast, or cheap? Pick two

Within the project management and consulting environment, the adage ‘good, fast or cheap - pick two’ is commonly encountered. Good, fast and cheap respectively refer to the three key elements of the triple constraint namely the extent of work (scope), the schedule (time) and the budget (cost). The notion is that projects are generally constrained to choose two of the three elements and sacrifice the other in order to gain the chosen two.

The ‘good, fast or cheap - pick two’ impression is a manifestation of the ‘Tyranny of the Or’ – the rational view that cannot easily accept paradox, that cannot live with two seemingly contradictory forces or ideas at the same time [16]. This concept pushes people to believe that things must be either A or B, but not both. That is to say, in terms of the triple constraint, one can choose either good-and-fast, or good-and-cheap, or fast-and-cheap; but critically not all three (Fig. 4).

The ‘good, fast or cheap - pick two’ trade-off can be demonstrated with an adaptation of Barker & Cole’s seesaw model as illustrated in Fig. 5. If pressure is put on timescales (fast) then costs can be expected to go up; alternatively, if pressure is put on costs (cheap) then timescales can be expected to go up. From the seesaw example it is clear that, with the scope of work (good) remaining pivotal, the project cannot be delivered simultaneously fast and cheap as well; one of the elements has to be flexible [5], [7].

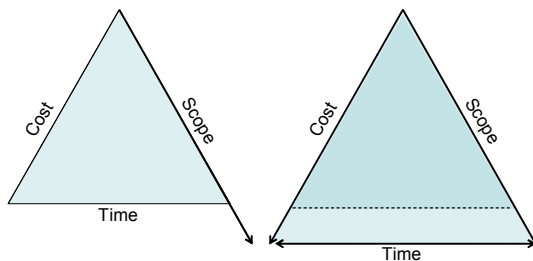


Fig. 3. The triple constraint relationship $S \uparrow \propto T \uparrow C \uparrow$.

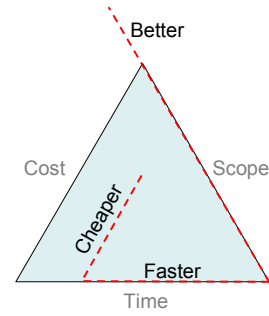


Fig. 4. Better, faster, cheaper – is this really possible?

The following analogy may be drawn between the ‘good, fast or cheap - pick two’ permutations and the key triple constraint relationships [7]:

1) Relationship 1, $S \uparrow \propto T \uparrow C \uparrow$, implies that the effect of increasing scope ($S \uparrow$), or effort (pressure) to achieve scope, necessitates an increase in time ($T \uparrow$) and/or cost ($C \uparrow$). If cost remains unchanged, then the project can be delivered good (because $S \uparrow$) and cheap (because C fixed as planned) but not fast (because $T \uparrow$);

2) Relationship 2, $T \downarrow \propto S \downarrow C \uparrow$, implies that the effect of reducing time ($T \downarrow$), or effort (pressure) to achieve time, necessitates a reduction of scope ($S \downarrow$) and/or an increase in cost ($C \uparrow$). If scope remains unchanged, then the project can be delivered fast (because $T \downarrow$) and good (because S fixed as planned) but not cheap (because $C \uparrow$);

3) Relationship 3, $C \downarrow \propto S \downarrow T \uparrow$, implies that the effect of reducing cost ($C \downarrow$), or effort (pressure) to achieve cost, necessitates a reduction of scope ($S \downarrow$) and/or an increase in time ($T \uparrow$). If time remains unchanged, then the project can be delivered cheap (because $C \downarrow$) and fast (because T fixed as planned) but not good (because $S \downarrow$).

C. Supporting factors of the triple constraint

Within the context of this paper the three prime elements of scope, time and cost are considered central to the triple constraint. Project management literature, however, sporadically indicates quality and performance as an adjunct to or substitute for scope, and occasionally designates customer satisfaction and project risk as ancillary constraints [7].

Project scope encapsulates capability and grade attributes. Quality and grade are not the same. Grade refers to the set of attributes on which the quality of a product will be judged [19]. Quality constitutes an uncompromising and inherent objective of the project specification that takes root in all three properties of the triple constraint.

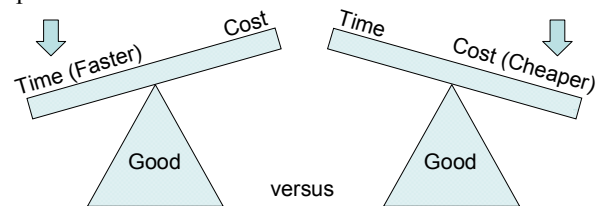


Fig. 5. Good-and-fast vs. good-and cheap.

A lower-grade material, for example, is not necessarily a lower-quality material, as long as the grade of material is appropriate for its intended use. Performance is an operational assessment metric for the triple constraint in terms of project accomplishment, which should be continuously monitored and controlled throughout the project. Performance and quality are hence not substitutes for scope [4], [9], [14], [19].

Customer satisfaction is fulfillment of the consumer requirements, expectations and needs, and constitutes a performance measure in terms of quality or excellence. Risk impacts the performance of the triple constraint, which may precipitate change in terms of the triple constraint trade-off dynamics [6], [10], [11], [20].

This paper presents a classic interpretation of the triple constraint, focusing on the ‘big three’ of scope, time and cost without adding or subdividing.

D. Power structure of the triple constraint

One of the challenges project managers face is the iterative and infringing requirements of the customer. A good starting point is thus to understand the customer’s priorities in order to identify the most important aspect of the project and obtain an optimum balance between the constraints [5], [9].

Dobson’s theory on the Hierarchy of Constraints defines a project by listing the triple constraint variables in order of flexibility [6]. Dobson proposes that exploitation of flexibility in the weaker (more flexible) constraints can be used as a tool to meet the absolute requirement of the driver (least flexible) constraint in order for the project to succeed. The driver constraint is derived from the *raison d’être* of the project and is the constraint that has to be met otherwise the project fails. There can only be one project driver at any given time. The weak constraint has the greatest flexibility, but is not necessarily the least important. The middle constraint normally has a small amount of flexibility and can either be very close to the driver in importance to the project mission, or may sometimes have flexibility more akin to the weak constraint.

It is important to note that flexibility, and not importance, serves as the ranking criterion. Importance is the relative merit of the constraints considering the long-term value of the project. Flexibility is the extent to which the project manager can manipulate the constraints in order to successfully deliver the project [6].

It is presupposed that the effective management of the triple constraint power structure and its dynamics is central to project success. Details pertaining to trade-off strategies and exploitation considerations are documented in [7].

E. Key attributes of the triple constraint

The following fundamental characteristics were consolidated in support of the physiology of the consolidated triple constraint model [7]:

- 1) Effective projects bring form and function to ideas or needs, and yield beneficial change or added value.
- 2) The higher purpose of a project is fundamentally the driver of the project.
- 3) The triple constraint constitutes a balance of the three interdependent project elements of scope, time and cost as a function of the project higher purpose.
- 4) The concepts of quality, customer satisfaction, performance and risk have an impact on the triple constraint, but do not inherently constrain the project.
- 5) The cause and effect of new or changing triple constraint requirements are constantly negotiated during all phases of a project.
- 6) Change within the triple constraint is compensated through proportional trade-offs.
- 7) Failure to deliver all three triple constraint variables on target does not necessarily imply project failure.
- 8) Flexibility is an indispensable triple constraint requirement in order to accommodate shifts in project emphasis, and to ensure a beneficial project outcome.
- 9) The three key triple constraint relationships signify that at least one of the triple constraint variables must be constrained (otherwise there is no baseline for planning), and at least one of the variables must have capacity for exploitation (otherwise quality may be affected).
- 10) The triple constraint can be prioritized into a power structure by ranking the variables into a hierarchy of flexibility (capacity for exploitation).
- 11) The power structure derives from the project objectives and higher purpose and may be influenced by environmental change.
- 12) Capitalizing on the pliability of the two more flexible constraints can be used as a mechanism to achieve the essential demands of the primary triple constraint variable (the driver).

F. Consolidated triple constraint model

The integrated model was realized through conceptual synthesis of the key derived triple constraint attributes discussed in the previous section. The matured model is presented in Fig. 6. The consolidated model has been dubbed the TRIJECT model (an acronym created from the titles ‘TRIple constraint’ and ‘proJECT management’).

The project management triangle, which constitutes the heart of the TRIJECT model, is supported by the two more flexible constraints (time and cost in this instance) and forms the foundation of the triangle. The primary triple constraint variable (scope in this instance) aligns the triangle with the project higher purpose. The triangle projection is dynamic and can pivot about its axis to accommodate change within its power structure. The triple constraint hierarchy may be influenced by the project environment, which impacts the higher purpose and objectives of the project. The model embodies three dimensions, in which each facet of the triple constraint may drive the project.

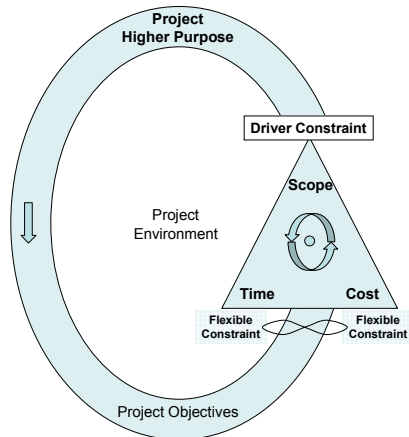


Fig. 6. TRIJECT model.

The central presence of quality is signified by the outline shape of the TRIJECT model, which, using some imagination, resembles a capital letter 'Q'.

The rationale of the TRIJECT model is based on the achievement of the primary triple constraint variable through the exploitation of the two more flexible constraints and alignment with the project higher purpose.

The continuous cycle implied by the model represents the ongoing and interrelated nature of this process as change is introduced into the system. Monitoring and controlling hence manifest a requisite part of this cycle. The model also accounts for the ancillary issues such as 'the why' of the project and change within the project environment as well as quality and control.

In practice the TRIJECT model is expected to overlap and interact dynamically with the project management process groups. Details pertaining to the proposed protocol and application of the consolidated triple constraint model are documented in [7].

IV. CASE STUDY ANALYSIS

Evaluation of the TRIJECT model was limited to the exploratory review of the theoretical model and protocol against a simplified case in order to facilitate a conceptual understanding of the integrated model in practice. The observed case was the building project of the Smithsonian Institution, National Air and Space Museum (NASM) [6], [7]. There is no claim that this case is representative of the general project management milieu.

A. Case paraphrases and system definition

The NASM project mission, essentially, was to build a world-class aviation and space museum for a budget of approximately USD 40 million and open it on July 4, 1976. The project mission statement satisfies the triple constraint, which is defined as follows:

- 1) Time constraint = July 4, 1976
- 2) Cost constraint = USD 40 million
- 3) Scope constraint = World-class museum.

A key part of the Smithsonian's ability to get congressional funding unlocked for the project involved the national focus on the upcoming Bicentennial celebrations. National attention would be focused on Washington, D.C., and the National Mall during the festivities, and the President of the United States would be on hand to cut the ribbon. The consequences of missing the Bicentennial would have been hugely humiliating for the Smithsonian and for the NASM team. The time constraint has therefore been assigned in the lead position as the driver for this project. Before settling on the primary triple constraint variable, the critical question of why this project is being undertaken needs to be reviewed.

The term 'world-class' may constitute a variety of potential meanings, each with different consequences for time and cost. For example, how many air and spacecraft should hang in the new building, or how complicated should the audiovisual exhibits be. The distinction between the work of the NASM and the project of the NASM needs to be considered. The project ends, but the work is ongoing. What must be done to meet the demands of opening day is only a prelude to the indefinite lifespan of the open museum. It can therefore be argued that the scope constraint, although probably the most important, is also the most flexible (weak) constraint for this project.

The USD 40 million federal appropriation is a definite number, but not an exact one. Major construction projects often have a contingency reserve of up to 10% of the budget for change orders and other problems. Considering flexibility and following the process of elimination, cost may thus be identified as the middle constraint for this project.

B. Case investigation and system analysis

The triple constraint compromise to manage was identified as the trade-off between the exploitation of the USD 40 million budget (the cost constraint), and the requirements / features that constitute a world-class museum (the scope constraint). The success of this project was driven by the deadline (the time constraint) to open the museum on the nation's Bicentennial celebration July 4, 1976 in order to attain national focus (the higher purpose). With the project mission and triple constraint power structure defined, the TRIJECT model for the NASM project can be delineated as shown in Fig. 7.

Exploitation of the project budget ($C\uparrow$) alleviates the pressure to rollback on the museum's scope requirements, and supplements the effort to ensure that the deadline for opening the museum is met (more money and resources can be spent to get the same or more work accomplished within a limited period of time). The cost constraint includes both cash and non-cash resources. Exploitation of the project scope ($S\downarrow$), on the other hand, alleviates the pressure to add additional cost and resources to the museum budget, but also supplements the effort to ensure that the deadline for opening the museum is met. Exploiting flexibility in the scope constraint should however not compromise quality, i.e. the museum's

world-class criteria, which Congress values. One mechanism for exploiting the scope of the museum building program is to downsize selected objectives and quality metrics that do not add customer value.

Because it was simpler to exploit the ‘world-class’ scope requirements than it was to exploit the congressional budget, the system was initially located in the right half of Fig. 8, i.e. the flexibility of project scope outweighed the flexibility of project cost. The kinetics of Fig. 8 constitute a reverse congruency with respect to Fig. 5, focusing on exploitation causality rather than on constraints. The risk for the NASM case is that excessive manipulation of the scope requirements may eventually result in the benefits of this effort to disperse as the system moves into its downside (R-). This may put the project at risk to not deliver a world-class aviation and space museum, with inadequate artifacts and exhibits. As these disadvantages are being experienced, an increasing awareness may develop towards the advantages of budget exploitation (L+). This awareness may shift the focus of manipulation by sliding the exploitation weight up the seesaw from R- to L+. Accordingly, excessive manipulation of the budget requirements may again transition the system into its downside (L-). The consequent risk is that the project may be completed substantially over budget, and the project schedule may also be expected to slip due to the restoration of additional artifacts and the incorporation of complex exhibits. What is called for is a dynamic mechanism that may equilibrate the system as exploitation weight shifts and trade-offs are compromised during the project.

C. Case discussion and system guidelines

In order to effectively manage the exploitation trade-off, the project manager needs to consider each of the benefits in the upper quadrants and define how to gain or maintain these advantages. A risk strategy is also required. The flexibility in the weaker constraints is not unlimited since there is always a minimum that must be achieved. The project manager needs to consider each of the disadvantages in the lower quadrants and define indicators that will alert the project team when the project dips into the red zone of over focusing the exploitation effort.

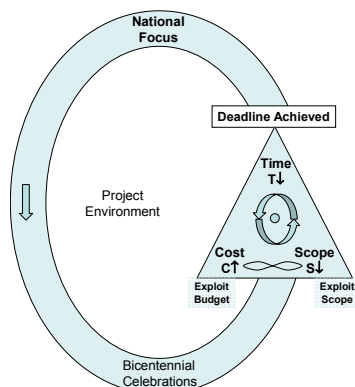


Fig. 7. TRIJECT model for the NASM case.

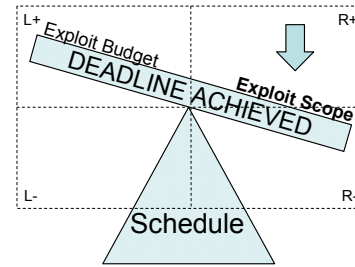


Fig. 8. System diagnosis of the NASM case [17].

The following considerations have been identified for obtaining and sustaining the positive results of the L+ quadrant of the NASM case: Find out what degree of budget overrun will be acceptable; Find out if contingency funds are available; Investigate if additional staff and equipment can be borrowed; Determine which costs will not be charged to the project; Establish how political influence can be achieved in order to pursue budget flexibility; Examine the consequences that the various interpretations of the ‘world-class’ requirement may have on the project; Identify the air and spacecraft which possess overwhelming historical significance; Discern how time and cost of artifact restorations can be optimized; Determine the appropriate requirement and level of complexity for the museum’s audiovisual exhibits; Take the law of diminishing returns into consideration.

Retrospectively, the considerations to obtain and sustain the positive results of the R+ quadrant include: Establish effective and proven practices to efficiently manage and control the project budget; Identify those aspects of the project scope requirements that are not quality related; Target areas for exploitation where scope creep is detected; Reach a common understanding with the stakeholders on the importance they place on the delivery of each scope requirement, and ascertain the could-have’s and would-have’s; Ensure that the ‘world-class’ criterion is not dismissed due to excessive artifact and exhibit cutbacks; Investigate where initial objectives may be downsized, for example lowering the planned number of air and spacecraft for opening day; Determine quality metrics that do not add customer value, for example trimming back on complicated audiovisual exhibits.

The following red zone indicators (early warnings) have been identified for when the project falls in the L- quadrant of the NASM case: Resistance from Congress regarding the increased project cost; Spending additional money and resources have reached the point where it no longer adds value to the project schedule, i.e. recognizing the law of diminishing returns; Artifact restorations and audiovisual exhibits fall behind schedule. The red zone indicators for when the project falls in the R- quadrant include: The ‘world-class’ requirement of the museum comes into question; Criticism regarding the appropriateness of artifacts and degree of exhibits.

The project team needs to monitor these dynamics within the triple constraint power structure throughout the project life cycle. The timely identification of divergences

from the project higher purpose followed by the appropriate corrective actions is crucial.

The NASM project might have benefited more by sustaining the positive results of both upper quadrants (green zone) and minimizing the time spent in the lower quadrants (red zone) – thus, delivering the project fast as well as relatively good and cheap (Fig. 9). A possible solution that effectively addresses this challenge is proposed in [17].

V. CONCLUSION

The study of the triple constraint is believed to be one of the most overlooked fundamentals of project management. As a result of the various perspectives and interpretations across literature that surround the project management triangle and triple constraint, the need for a unified model has been identified. The TRIJECT model supports an understanding of finite resources and facilitates a mechanism for managing the competing triple constraint requirements. The model encourages the creative exploitation of the triple constraint to improve project performance by considering the relative flexibility between the key elements. The goal of the model is to maintain the focus of the triple constraint power structure on the project higher purpose.

The case study presented has demonstrated that the integrated model may furnish the instruments that enable project teams to manage their work in line with the absolute requirements for project success. It should be taken in consideration that every project will experience its own unique limitations to exploitation capacity, which needs to be assessed through appropriate 'cost' vs. value impact analyses. Projects should however aim to always deliver to a much greater extent in terms of value than the sacrifice of the exploitation effort.

An integrated framework is suggested in [17], which evolves the strategic management of the TRIJECT model using Polarity ManagementTM techniques. Supporting quantitative studies may be justified to conclude the real world pertinence of these conceptual models.

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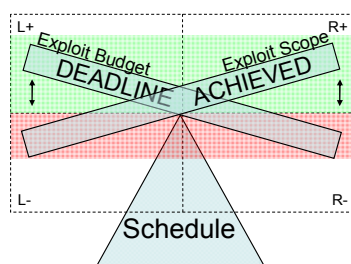


Fig. 9. Effective management of the NASM case [17].

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