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Paper submitted for CESUN 2014 - Fourth International Engineering Systems Symposium to be held June 8-11, 2014 at Stevens Institute of Technology.

ESD-WP-2014-09 March 2014 esd.mit.edu/wps

The Role of Subproject Task-Specific Attributes in Managing Enterprise-Wide Projects

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ABSTRACT

Realizing that different types of projects require different styles of management is becoming part of the mainstream theory and practice in project management. This paper addresses the question of whether the same notion is also applicable to the subproject level, and how. We suggest that a project's building blocks exhibit unique characteristics with respect to two major dimensions: Challenge (or difficulty) and vitality (or importance). Specifically, we add to the critical path and critical chain project management concepts a critical component—a unit at the sub-project level that is exceptionally risky to a project's success. We lay out the conceptual framework in which critical component is embedded and demonstrate the theoretical and managerial aspects of contingency at the subproject level by analyzing three case studies.

1. Introduction

Structural contingency theory, which has evolved since the early 1960s, suggested that organizations in different environments exhibit different organizational characteristics. According to Burns and Stalker (1961), organic organizations cope with uncertain and complex environments better than mechanistic organizations, which predominate in simple, stable, and more certain environments. Mechanistic and organic organizations differ also in their capacity to deal with information, with organic organizations being more capable of handling information than mechanistic ones. Different projects must adapt their management styles, namely, "one size does not fit all projects" (e.g., Shenhar and Dvir, 1996; Shenhar, 2001; Crawford et al., 2004). Given this, it is reasonable to ask whether the same principle applies to subproject level. In other words, is it also true that "one size does not fit all subprojects of a project"?

Projects succeed when all their elements are completed and all product parts they deliver function properly. However, projects often fail because one or more of their elements were not completed, failed to function, or were totally absent. When Denver international airport project was initiated in 1989, no one imagined that a construction project could be late by nearly 16 months and that the delay would cost hundreds of millions of dollars. It turned out that a relatively small and low-cost component of the whole project, the algorithm responsible for the accurate function of the baggage handling system was not completed on time, and caused a delay in the entire project. In this paper, we offer a framework for analyzing the subproject level by applying the contingency theory approach to the subproject level in which critical components of a project are expected to be delivered. As the project management discipline is moving towards the realization that 'one size does not fit all' and that different techniques are needed for different types of projects, it seems sensible that the same phenomenon would exist at the subproject level of complex projects. In a complex project (often called a program), where there are many interrelated subprojects, each building block may represent a different project type, requiring a different kind of planning and management style.

This article is dedicated to the impact that certain subproject may have on the overall success of the project. We propose a framework for analyzing the criticality of each subproject through two dimensions: challenge—the difficulty to successfully complete the subproject, and the vitality—the importance of the subproject to the project's success. We begin with a literature survey on previous applications of structural contingency to projects as temporary organizations. We then identify the different relevant kinds of a project's building blocks, and specify and demonstrate the distinct attributes of the challenge and vitality dimensions as they contribute to the criticality of a component.

2. Why does one size not fit all?

While correlates of structural and environmental attributes have been studied thoroughly for a sustaining organization as the unit of analysis, they have been much less investigated in the context of a project as a temporary organization (Shenhar, 2001). Pinto and Covin (1989) and Pinto and Mantel (1990) made a distinction between construction projects and R&D projects in order to identify what set of success factors influences each type of project. They used R&D and construction projects as two very different types of operations, mainly with respect to the dimension of technological uncertainty. Following them, several authors suggested a more contingent approach to project management, abandoning the earlier notion of 'a project is a project is a project' (Yap & Souder 1994, Eisenhardt & Tabrizi 1995, Balachandra & Friar 1997, Crawford et al. 2004).

Once we agree that one size does not fit all projects, a next logical question is: What are the contingencies to be considered when referring to different types of projects? In other words, what are the attributes or dimensions that set groups of projects apart from each other? Two previous works have addressed this question: Loch et al. (2000), and Shenhar and Dvir (2007a). In an important stream of studies, Loch and colleagues studies different approaches to address uncertainty and complexity in projects and their impact on learning processes. For example, Loch et al. (2000) defined five dimensions of a project's uncertainty: complexity, variation, risk, ambiguity, and chaos. They defined the managerial implications derived from each dimension and illustrated the management type accordingly. Shenhar (2001) addressed two dimensions for distinctions between projects: uncertainty and complexity, while Shenhar and Dvir (2007a) defined a set of four dimensions according to which a project has to be distinguished and managed, suggesting the NTCP diamond framework briefly described below.

3. The 'Diamond of Innovation' framework (NTCP)

The 'Diamond of Innovation' model of classifying projects was originally introduced by Shenhar and Dvir (2007b) and was later enhanced to its present articulation (Shenhar at al. 2013). The model categorizes projects using four dimensions explained below—novelty, technology, complexity, and pace (abbreviated NTCP)—each categorized into four levels.

- **Novelty** – How new is the product to its customers and users? Novelty represents the extent of innovation in the market, and its levels are derivative, platform, new to the market, and new to the world.
- **Technology** – What is the extent of use of new or even non-existing technology at the project's initiation? This dimension represents the extent of technological innovation, and its levels are low-tech, medium-tech, high-tech, and super high-tech.
- **Complexity** – What is the location of the project's product on the scale of clustered systems? This is the level of system innovation, and its levels are component, assembly, system, and array (or system-of-systems).
- **Pace** – How urgent is the project at the time of initiation and how critical is it to complete it on time? This is the urgency of the innovation, and its levels are regular, fast/competitive, time-critical, and blitz.

When drawing connecting lines between the four dimensions on a planar graph, a diamond-like shape emerges, hence the labeling of the NTCP model as diamond. Figure 1 presents a typical diamond of a hypothetical project. The project type is determined by the level of each dimension.

The notion that 'one size does not fits all' suggests that different types of projects exhibit different levels in the NTCP dimensions and must therefore be planned and managed differently in order to succeed (Shenhar, 2001, Shenhar and Dvir, 2007b). NTCP proved to be a successful framework not only for explaining failure and success of a project based on the way it was managed, but also for assisting project managers in determining the type of project with which they are faced and adopt a recommended way to manage it. Figure 2 illustrates the fundamental assertions of the NTCP framework, and the following discussion summarizes the impact of each dimension on specific recommended contingency actions.

The **Novelty** dimension is characterized by the availability of market data and the maturity of the product definition, influencing the timing of product requirements freeze. The market data spans the spectrum from accurate data of previous products and market research, through data for derivatives and unclear market needs, where neither existing experience with similar products nor defined customer base exist, to new-to-the-world products. Similarly, the product definition varies from clear understanding of its functionality, features, and cost for derivatives, to intuition-based definition that requires fast prototype for potential customer feedback in new-to-the-world products.

The **Technology** dimension is influenced by the magnitude of new technologies the product requires. It affects the managerial style and the design process, including design freeze timing. In cases where little or no new technology is needed, the preferred managerial approach is a rigid 'get it done' mindset, while for high-tech and super-high-tech products, the approach should be much more flexible and open to changes, requiring additional cycles of design, more prototypes, and later design freeze.

The **Complexity** dimension pertains to the complexity of the project management, which is tightly correlated with the complexity of the product. The more complex the product, the more complex is the project designed to deliver it. The complexity of the project can be manifested in various aspects, including the project organization, control and reporting, documentation, management style, attitude, and focus. Low level complexity products (components or assemblies) require a small, simple organization, with a limited level of formal control and documentation and relatively simple tools. High level complexity products (systems or arrays) are often created by several organizations in several geographical sites, sometimes having different cultures. They need to use sophisticated planning tools, document meetings and decisions in a formal project atmosphere. These projects produce and rely on technical papers and typically implement rigid and external control.

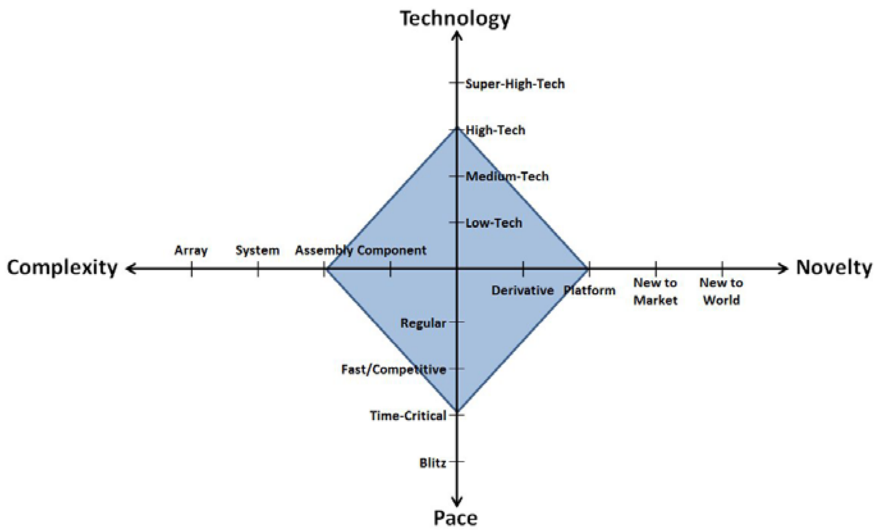

Figure 1: An example of a diamond for a hypothetical project (Shenhar et al. 2013)

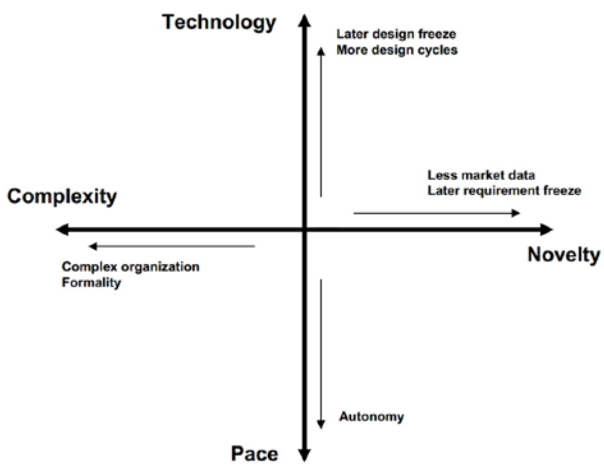

Figure 2: The NTCP dimensions influence on the planning and managing of a project (Shenhar & Dvir, 2007b)

The **Pace** dimension is determined by how much time is available to complete the project. The more constrained the project, the more authority is typically handled to the project manager and less project bureaucracy is implemented. Failing to observe this guideline can turn a fast, competitive, or time-critical project into blitz, where meeting the time goal becomes an emergency.

Several lessons learned from the contingency discussion at the project level can serve as indications for the subproject level. First, the difficulty of completing a project successfully is manifested in some way by each one of the four dimensions. Novelty and technology are measures of uncertainty, complexity poses organizational and formal difficulties, and pace-related issues often become difficult constraints. Second, a complex project is decomposed into subprojects, each with different levels of difficulty and importance. This poses a need to handle specific subprojects individually. Finally, better understanding of the subproject level can impact the managerial style and organization of the entire project. This realization leads to examining the subproject level, the topic of our next discussion.

4. The subproject level

Before discussing the dimensions at the subproject level, it is necessary to define what this level is. Although a common terminology is used to distinguish between different elements of a project, no distinction has been established so far about contingency factors of these elements. Thus, for the purpose of this research, in what follows, we review accepted project-related definitions required to define the subproject level.

WBS (Work Breakdown Structure) – A deliverable-oriented hierarchical decomposition of the work to be executed by the project team, with each descending level of the WBS representing an increasingly detailed definition of the project work (Project Management Institute, 2013).

Component – A constituent part of a complex whole. Product components are the building blocks integrated to “build” the product, which endow structure to the development and manufacturing processes. There may be multiple levels of product components (Ebert, 2011).

Deliverable – A unique and verifiable product, result, or capability, which must be delivered before a process, phase, or project can be completed (Project Management Institute, 2013).

Work-Package – A deliverable at the lowest level of the work breakdown structure. A work -package may be divided into activities (Ebert, 2011).

Subproject – A portion of the overall project created when a project is subdivided into more manageable components or pieces (Project Management Institute, 2013).

Create WBS – The process of subdividing project deliverables and project work into smaller, manageable components (Project Management Institute, 2013).

Traditional methods of project management show how to decompose a project into its basic elements using the process of creating WBS as specified in Chapter 5 of the PMI's Project Management Body of Knowledge—PMBOK (Project Management Institute, 2013). PMBOK treats the various subproject levels as equal, implying that a 'one size fits all' approach is applicable to the subproject level. Clearly though, large, complex projects are comprised of many components, and at least some of them can be large enterprises by themselves. A project succeeds if the final product’s components are built, completed successfully, and integrated into the final functioning product. However, it is conceivable that one unfinished or flawed component can result in complete or partial failure of the project and possibly the product it aimed to deliver. Not all the project components are equally important to its success. Failure to successfully complete certain components in time will only result in minor consequences to the final product, rendering their overall impact on the final product marginal. Some components are likely to be more difficult or challenging to complete than others due to different levels of uncertainty, technology, or lack of resources. Hence, we suggest differentiate each component by assigning to it two attributes: challenge and vitality. The *challenge* attribute is characterized by the *difficulty* to achieve the specific component. The *vitality* attribute is related to the *importance* of the component to the success of the product or the project as a whole. Together, these two attributes define the level of difficulty-importance of each component, providing for the identification of the more critical and the less critical components.

While moving from the project level to the subproject level in complex projects, it is reasonable to assume that different components require different managerial styles, depending on their challenge and vitality, and that a 'One Size Does Not Fit All' may also be required at this level. Just like in the overall project level, there is no one best way; the management of the subproject level has to be adapted to the unique characteristics of each component. A component that poses a high level of challenge (difficulty) to the project, and/or considerable vitality (importance) to the success of the product, should be managed in a different, more careful way from a component that poses no real challenge and is not vital to the product success.

The next issue to be resolved is what are the attributes (dimensions) of the subproject? Are they similar to the ones comprising the diamond or are they different and specific to the subproject level?

5. Identifying subproject attributes

For the purpose of identifying subproject attributes, it makes sense to look first at the four dimensions of the project’s diamond: novelty, technology, complexity, and pace. We next analyze the applicability of these dimensions to the subproject level. **Novelty** refers to the product, which is the outcome of the entire project. The definition of novelty, namely, how new the product is to the customers and to the market, is focused on the project's end result – the whole product. The level of novelty is measured against the functionality of the product in its entirety. Examples include the Walkman, iPhone, Segway, and the first PC, all of which were new-to-market or new-to-world products. The customers of these products were interested in the complete product rather than is some specific component of it, making novelty irrelevant at the subproject level. **Complexity** focuses on the processes involved in the project management as a result of the complexity of the product as a whole. The more complex the product, the higher the level of complexity involved in the project management. As with novelty, there is no point in ascribing complexity to each subproject. **Pace** reflects the time-to-market (or level of urgency) at which the product has to be delivered. As pace combines elements stemming from both the project and the product, it too is an attribute of the product as a whole, and is reflected by the project schedule aimed to achieve the time-to-market goal. Finally, the **Technology** dimension may apply to both the whole product and its components, since different components usually require different levels of technology. At the project level, technology refers to the highest level of any component of the product. For example, the recent commercial aircraft Boeing 787 can be regarded as a high-tech project on the technology dimension, since most of its body is built from composite materials (a new technology) rather than aluminum (current technology). However, some of its other components, such as the passenger seats, may use traditional design, requiring a lower level of technology. As technological barriers can challenge the completion a particular component or the entire product, technology is part of the challenge aspect. But is technology the only dimension of the challenge aspect, and what are the dimensions that can distinguish the vitality aspect? We address these questions next.

6. The dimensions of the challenge aspect

The challenge aspect pertains to the difficulty that a specific component poses to the project. We saw that technology is one dimension of the challenge, but difficulties can arise from other origins as well. For example, constraints that are imposed on a specific component, e.g., due to new regulations or scarcity of resources, are another type of difficulty to the project. With this in mind, we summarize the two aspects of a component challenge as follows:

Technology – similar to the definition of technology in the project's diamond, the technology level of a component is the extent of use of new or even non-existing technology for the design or building of the specific component. The newer or less developed the technology, the more difficult it is to successfully complete a component, increasing the challenge.

Constraints – these are the requirements of the component imposed by exogenous factors, including regulation (e.g., legal restrictions promulgated by the government, social norms, or industry standards), excessive bureaucracy, and limited resources of time, budget, professionals, and management. Constraints increase the difficulty of a specific component to be completed successfully on time and within budget. For example, regulations or limited resources can prolong the time required to successfully deliver a component; bureaucracy can lead to a waste of time, while shortage of management resources can hinder smooth project execution.

Based on this analysis, we define the challenge aspect as being comprised of two dimensions: *technology* and *constraints*. The technology dimension pertains to the internal project difficulty in successfully delivering a specific component, while the constraints dimension represents all the external demands that pose difficulties caused by factors that are exogenous to the project organization. Both technology and constraints have three possible values: low, medium, and high. Figure 3 presents the three levels of the challenge aspect, as they emerge from combining the technology and constraints dimensions. If either dimension is high, the challenge is high, regardless of the other dimension. The three challenge levels are as follows.

- **Low challenge** – the difficulty imposed by both technology and the constraints is minor.
- **Medium challenge** – certain use of new technologies or commonly known external constraints may exist. This level characterizes the majority of the projects.
- **High challenge –** extensive need for using at least one new technology or to develop it and/or hurdles with regulation, bureaucracy or management. This level characterizes projects whose technology or constraints is high.

A new car development illustrates the challenge levels. Consider four features of the car: A new engine aiming at lower gas consumption, highly stylized headlights, high-end safety, and seats. Taking advantage of latest developments in engine technology, the new engine technology is at a high level. From the constraints perspective, engines are highly regulated and must meet stringent standards, such as the Euro-5 European emission standard. Since failing to meet regulation requirements would disqualify the car, the constraint level of the engine is high, so the overall challenge level of the new engine is high. The headlights technology is well-established, with LED lights replacing most traditional halogen bulbs. Therefore, the technology level of the headlights is low. While from the constraints perspective headlights need to meet some regulatory demands, such as brightness and lighting angle, this regulation is less strict than that of the engine. Thus the constraint level in this case is medium, yielding a challenge level as medium.

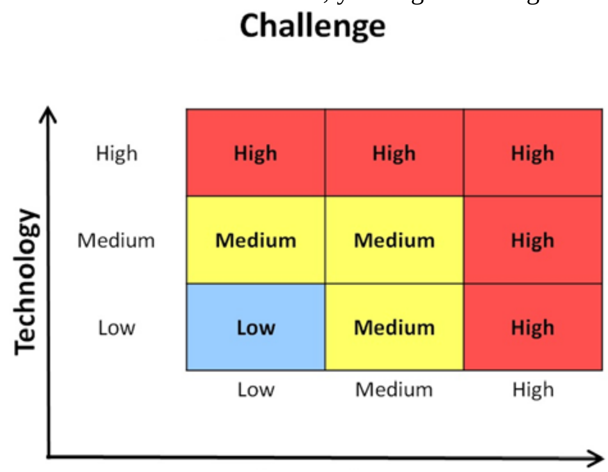

Figure 3 – The challenge map of a component as comprised of the technology and constrains dimensions

The high-grade (5-star) safety is a technological challenge, but from the constraints perspective, there is no strict regulatory demand, resulting in a low constraint level. Nonetheless, the combined challenge level for safety is high. Finally, ergonomic seats do not use a new technology, so their technology is low, and since no regulation is imposed on passenger seats, the constraints level is low too, yielding a low challenge.

7. The dimensions of the vitality aspect

Like challenge, the vitality aspect has two dimensions: centrality and competitive advantage. To consider the vitality aspect (Orhof et al., 2013) for a project success, we note that not all the components of a project are equally important to success. Some components, such as the control tower in a new airport construction project, are 'must have' at project completion, while others, such a garden in the same project, can be accomplished later, with minimal or no impact to the project success. Thus, the first dimension of vitality is centrality—the importance of a component to achieving functionality of the end product that the project is expected to deliver. In the new car example, the steering wheel and engine are critical to the functionality of a car. Headlights are also critical, as no headlights means unusable car. Conversely, since lower grade safety systems or non-ergonomic seats are allowed, they are not critical.

The second part of vitality is competitive advantage – the contribution of the component to the value that the customer attributes to the product having this component. A highly effective engine with low gas consumption may provide substantial competitive advantage, as is the 5-star safety grade, while ergonomic seats and stylized headlights add less competitive advantage. In non-competitive environments, such as the public sector, the value each component creates is also important. For example, an interchanges in a highway construction project is vital. The higher the value is, the higher the vitality of the specific component. Figure 4 presents the three levels of the vitality aspect as comprised of the dimensions of functionality/centrality and competitive-advantage/value. To demonstrate the vitality and its dimensions, we consider again the new car example. The new engine's functionality is high as is its competitive advantage. Hence, according to Figure 4, the vitality of the engine is high. The headlights functionality is high, while its competitive advantage is medium, comprising a high vitality. The high-grade (5-star) safety is of low functionality level while its competitive advantage is medium, yielding a medium level of vitality. Finally, the ergonomic seats are of low functionality and medium competitive advantage setting its vitality level to medium.

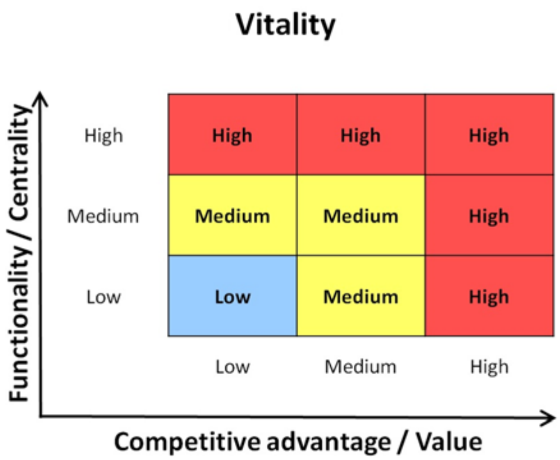

Figure 4 - The vitality aspect of a component as comprised of the dimensions of functionality/centrality and competitive-advantage/value

8. The component criticality: Combining challenge and vitality

We have presented two distinct component aspects: challenge and vitality, each of which can be categorized using a three-by-three matrix. The combined challenge-vitality value is the criticality of the component to the overall success of the project-product. We define a critical subproject as a part of the project that is expected to deliver a critical component. A critical subproject poses an exceptional risk to the success of the entire project. Absence or partial availability of that component jeopardizes the project success.

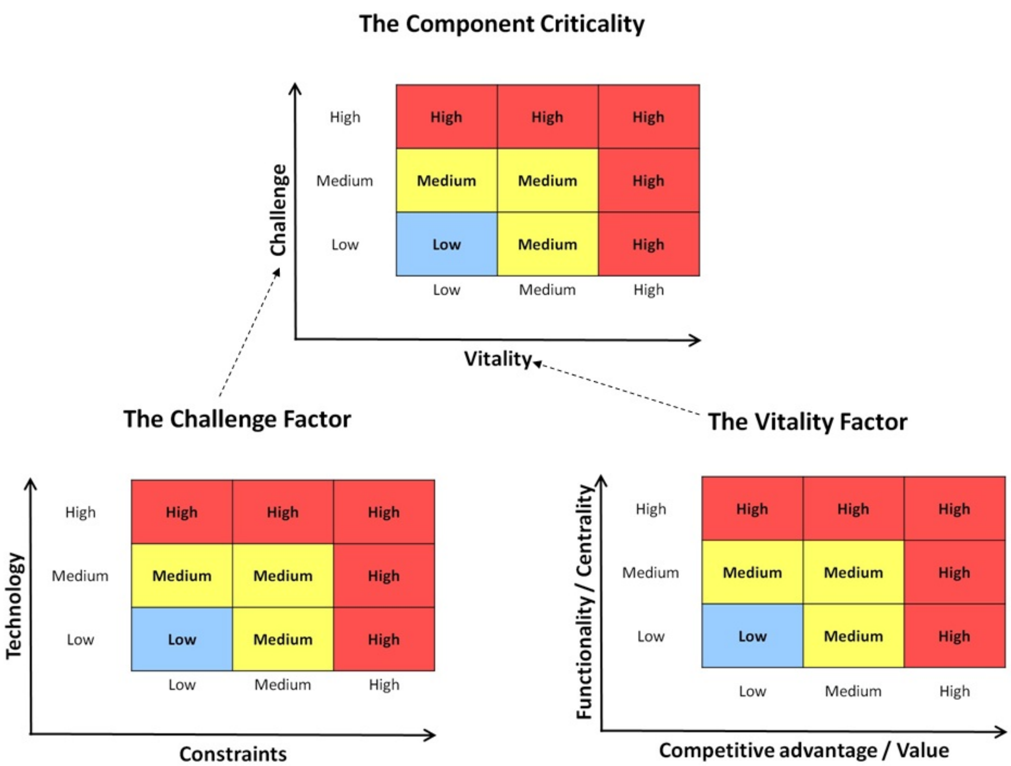

Figure 5 – The criticality factor of a component as a confluence of challenge and vitality

Figure 5 presents the levels of challenge and vitality of the four features/components and the subsequent level of criticality. Conclusion

We have addressed project contingencies at the subproject level and demonstrated that the components delivered at the subproject level can present different values of criticality to the success of a project, measured by (1) the challenge to achieving the successful component and (2) the vitality—the importance of each component to the success of the product that the project delivers.

In large and complex projects, the subproject level demands a particular type of management that fit to its specific characteristics. The challenge and vitality of specific components determine its way of management. The higher the criticality, the riskier the component, requiring more management attention to properly plan, manage, and monitor its delivering subproject. A components' criticality becomes more severe if that component in on the project's critical path. A meticulous criticality analysis of each component can thus be key to a successful project.

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