Coping with Project Complexity: The Complexity Based Project Management Framework [1]

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Abstract

This article is about considering key aspects of project complexity to increase the likelihood of success of your projects. Complexity can cause significant issues in project management and might even lead to project failure. According to recent surveys, two of the most critical aspects of project complexity were: structural complexity (the complexity of the deliverables and their means of implementation) and socio-political complexity (the complexity of the project setting notably the effects of many diverse stakeholders). Based on complexity and systems thinking and illustrative case studies, the article proposes a user-friendly framework, which maps these two important project complexity aspects into a project complexity context. The framework highlights five different types of project complexity contexts: structured, complicated, complex, "complexicated" (that is both complicated and complex) and chaotic. It finally calls for attention on key areas that could be critical for project management in the five project complexity contexts. It is suggested that project managers focus on the project plan in structured contexts, on design and expertise in complicated contexts, on stakeholders in complex contexts, on communication between stakeholders and experts in complexicated contexts, and on rapid response and high adaptability in chaotic contexts.

Key words: Project Complexity, Structural Complexity, Socio-political Complexity, Project Complexity Model, Complexity Context, Cynefin

Introduction

This article proposes a framework, the Complexity Based Project Management Framework (CBPMF), to assist managers in (1) assessing the complexity context of their projects and (2) in identifying, for each of the complexity context, key areas to consider to increase the likelihood of project success. Evidence from complexity and systems thinking suggests that ignoring the role of complexity in project management can cause significant issues for many projects, such as the Big Dig (Shenhar & Dvir, 2007; Bentahar & Ika, 2019). Finding ways to understand and cope effectively with complexity remains an important challenge for many project managers (Maylor & Turner, 2017). This article may help as it presents a framework to deal with project complexity.

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Impacts of mis-understood complexity

Take, for example, the Big Dig highway project in Boston, Massachusetts, one of the largest and expensive infrastructure projects in US history. Over the 15 years of construction, and notwithstanding the use of best practices and innovative tools to mitigate risk and control cost, the project went from a budget of $2.6 billion to a final cost of more than $15 billion. As the risk manager of the project notes, "If there is a single cause for the massive cost escalation on the Big Dig, it probably involves the management of the project's complex integration" (Greiman, 2010).

The Big Dig highway, a 12-km (7.5 mile)-long corridor in one of the oldest and busiest cities in the country, involved replacing the elevated highway I-93 with an eight-to-ten-lane expressway, erecting a ten-lane cable-stayed bridge across a river, extending the highway I-90 to Logan Airport through a harbor tunnel, and building four major highway interchanges. This project incurred a significant cost blowout. In addition to the above-described structural complexity, that is the intrinsic complexity of the project itself, its socio-political complexity or the complexity of the project setting including its stakeholders (Geraldi, Maylor, & Williams, 2011) was deemed a major contributing factor in its cost blowout. "This was less the result of corruption than of underestimating various interest groups' bargaining power. Police required substantial overtime payments, affected neighborhoods demanded soundproofing and side payments, and there was pressure to create jobs leading to overstaffing" (Rogoff, 2020).

Some applicable standards and frameworks

Standardized project management approaches such as the Project Management Body of Knowledge from the Project Management Institute (PMI), the International Competency Baseline from the Europe-based International Project Management Association (IPMA), and PRINCE II from the UK Office of Government Commerce, can help managers in increasing the likelihood of success of their projects (Milosevic & Patanakul, 2005; Joslin & Müller, 2015). These best practices being grounded in the Newtonian scientific management, it is assumed that a certain level of predictability and order exists in all projects. While these best practices work well in some circumstances, they do not always offer effective ways to manage complexity (Snowden and Boone, 2007; Stacey, 1996). Hence, it was found that structural complexity and socio-political complexity caused significant issues to practitioners and thus should be considered as important aspects of project complexity to be managed (Maylor & Turner, 2017).

Over the years, a few project complexity models such as the Complex Project Manager Competency Standards of the International Centre for Complex Project Management (ICCPM, 2012), the Navigating Complexity Guide (PMI, 2014) and the Complexity Assessment Framework (IPMA, 2016) have become available to practitioners. Still, the rate of failure of projects remains high (Love, Sing, Ika, & Newton, 2019). It seems that these models or approaches do not adequately deal with many critical issues that confront practitioners in the face of complexity (Whitty & Maylor, 2009). Research findings show that they do not factor in some aspects of complexity notably socio-political complexity, and thus may not fully address the stakeholder engagement challenges faced by practitioners that could lead to project failure (Remington & Pollack, 2007; Geraldi et al., 2011; Maylor & Turner, 2017). Another reference to consider is the Cynefin framework (Snowden & Boone, 2007); the latter is based on complexity and systems thinking, proposes to handle complexity with regard to different organizational contexts, and therefore offers an approach to deal with complexity that could be adapted to projects.

The core idea of this article

Building on the above insights and illustrative case studies (Yin, 2013), this paper proposes a Cynefin like framework, the "Complexity Based Project Management Framework (CBPMF)" to help managers in understanding the complexity context of their project and by identifying, for each of the complexity context, key areas to consider in order to increase their likelihood of success. The CBPMF is thus composed of two steps: 1) a project complexity context assessment and 2) an identification of key areas of consideration for project management in the identified complexity context.

In the first step, the project complexity context is assessed by taking into account the complexity of the project deliverables and their means of production (structural complexity) and the complexity of the project setting including stakeholders (socio-political complexity), which again according to many surveys constitute two aspects of project complexity that create significant challenges to practitioners (Maylor & Turner, 2017). Mapping these two aspects of complexity, five different project complexity contexts emerged: structured, complicated, complex, "complexicated" (word that we propose to use for projects that are both complicated and complex) and chaotic. Then in the second step of the CBPMF key areas of consideration to help manage projects effectively in each of the five complexity contexts are highlighted. It is suggested that project managers focus on the project plan in structured contexts, on design and expertise in complicated contexts, on stakeholders in complex contexts, on communication between stakeholders and experts in complexicated contexts, and on rapid response and high adaptability in chaotic contexts.

Assessing the Complexity Context of the Project

Project complexity can be assessed on more than 125 aspects (Bakhshi, Ireland, & Gorod, 2016). However, 246 project managers were asked which ones were the most challenging to deal with and almost 80% of them said structural and socio-political complexities (Maylor, Turner, &

Murray-Webster, 2013). Structural complexity relates to the number, the variety, and the interactions between the different parts that make up the project deliverables as well as to their production processes, the physical environment in which they are to be used, and the pace of execution. Socio-political complexity refers to the complexity of the project setting and notably depends on the stakeholders (people, groups of people, organizations, governments, etc.) having divergent emotions, apprehensions, political agendas, and expectations regarding the project strategy, its goals and objectives, the deliverables to be produced, or their means of production (Geraldi et al., 2011; Maylor & Turner, 2017). The complexity context of a project can be measured by the degree to which managers understand the compounded effect of the cause-and-effect relationships in both the structural and socio-political aspects of its complexity (Snowden & Boone, 2007).

We propose to assess each of these two main aspects of project complexity (structural and socio-political) on a three-level scale (low, medium and high), and their various combinations mapped as shown in Table 1. As noted earlier and following the Cynefin framework (Snowden & Boone, 2007), these five different types of project complexity contexts emerge by mapping two critical aspects of complexity: structured, complicated, complex, "complexicated", and chaotic. The first step of the CBPMF consists in identifying the complexity context of the project using table 1. If the socio-political complexity of a project is low, then its structural complexity determines its complexity context. Thus, in this case, low 'structural' complexity results in projects to be undertaken in a structured context, medium 'structural' complexity gives a complicated context to projects and high 'structural' complexity creates a (technically) complex context.

If the socio-political complexity of the project is medium and its structural complexity low, then the project is considered to be undertaken in a (human) complex context and if the structural complexity is high then it is a (human and technical) complexity context. However, for projects having medium structural complexity and medium socio-political complexity, their context should be considered as "complexicated". From a management point of view, if the focus is on hard aspects of the project in a technical complexity context and rather on soft skills in a human complexity context (Remington & Pollack, 2007), both contexts call for closer experts and/or stakeholders' engagement. Finally, if the socio-political complexity is high, no matter the level of structural complexity, *de facto* the project should be considered to be undertaken in a chaotic context.

The five project complexity contexts presented in Table 1 can be related to the Cynefin framework, which, as mentioned earlier, has been adapted to the project settings, as shown in figure 1. This figure illustrates the five different project complexity contexts with a sixth one, disorder (as in the Cynefin framework), that occurs when the context is unclear to the project team. The "disorder" context is characterized by highly divergent views from stakeholders with regard to the project goal (what is the project all about) causing its halt. In that case, the project team has two choices: 1) break down the project into chunks and match each one of them with the other five complexity contexts or 2) consult the stakeholders and revisit the need statement until it is approved by all thus allowing a more common vision of the project to emerge. The project team should then be able to identify the appropriate project complexity context more clearly. For the purpose of this paper, the disorder context will not be discussed further and we will concentrate on the five complexity contexts already mentioned.

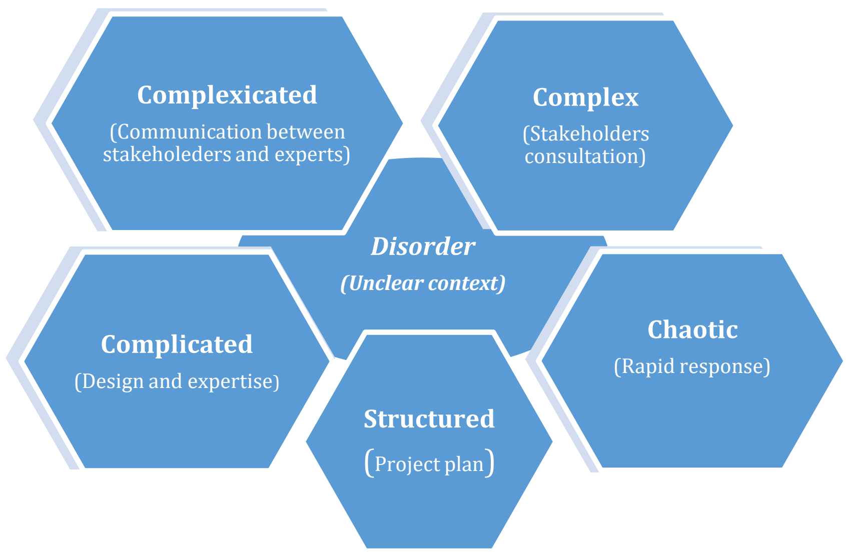
A structured context exists when there are few stakeholders who all agree about the project, and when the deliverables are made of few parts or subsystems with clear cause-and-effect relationships that laypersons can apprehend. A complicated context results from a situation where the solution is technically challenging and not obvious, leading to many possible options whose cause-and-effect relationships can only be dealt with by experts.

Table 1: Assessing the Complexity Context of a Project

	Socio-political Complexity		
Structural Complexity	***Low*** There are few stakeholders, their expectations are clear, well known and aligned; interactions among stakeholders are easily manageable; the project objectives are well defined, understood, accepted by all and should remain quite stable over time; the solution (i.e., the deliverables) is well understood and accepted	***Medium*** There are many stakeholders, their expectations are not all known, clear, or well aligned; the project objectives are defined but not necessarily accepted by all and might change over time; interactions among stakeholders could be numerous and could lead to conflicts; the solution (i.e., the deliverables) might not be understood nor accepted by all the stakeholders	***High*** There are many stakeholders expecting / needing a quick response from the project team, project objectives could be difficult to establish clearly up front, there is limited time for project planning because of the emergency of the situation, the scope of the project could be difficult to assess
Low The deliverables are composed of few parts or sub-systems, and the cause-and-effect relationships between them are known or knowable and can be dealt with effectively by the project team, few and well-known technologies are involved	**Structured**	**Complex (human)**	**Chaotic**
Medium The deliverables are composed of many parts or sub-systems, and the cause-and-effect relationships between them are knowable through expert analysis, there is no obvious best way to produce the deliverables, some of the involved technologies require well-trained experts and sometimes must be developed	**Complicated**	**“Complexicated”**	**Chaotic**
High The deliverables are composed of numerous parts or sub-systems, and the cause-and-effect relationships between them are not all known or knowable beforehand, the solution is not obvious but emerging patterns may guide the way, the involved technologies must be capable of dealing with the numerous and possibly unknown interactions between the components of the deliverables	**Complex (technical)**	**Complex (human and technical)**	**Chaotic**

In a complex context, the numerous interactions between the stakeholders and/or the parts of deliverables or the subsystems make the right solution less obvious and more difficult to sell to all stakeholders. However, emerging patterns should guide the project teams. A complexicated context refers to a situation that is both complicated *and* complex. In a chaotic context, the urgency to act leaves less time to the project team to plan the project and many decisions will have to be made on site; thus, many cause-and-effect relationships about the solution being implemented are unknown and might even change during project execution.

Figure 1: The Complexity Based Project Management Framework
(adapted from the Cynefin Framework, Snowden & Boone, 2007)



Critical Project Management Issues Related to Each Complexity Context

Using table 1, projects were identified in each of the five complexity contexts and an analysis on how they were managed and the extent to which they were successful was done. We then identified, for each type of the complexity context, what were the main management issues encountered by the project team. Based on these illustrative case studies, recommendations are made in the following sections, leading to the CBPMF.

Project Management in a Structured Context: Focusing on the Project Plan

In a structured context, the aim of the project team is to achieve the project goal (i.e., meeting the project needs) by producing high quality products or services (the deliverables) on time and within budget and by satisfying all the stakeholders' expectations. Because the needs are well defined and stable and because the stakeholders should share a common vision of the project, finding a solution to meet the needs and specifying the project objectives should be straightforward and should lead to a well-accepted project plan that would later bind the stakeholders. Projects such as website development, construction projects or those that involve few well-known technologies such as creating a CD player, or a coffee machine should be considered as structured projects. These projects can be managed using best practices or a rational/straightforward project management approach (Saint-Macary & Ika, 2015).

In structured projects, the project plan becomes the focus of the project manager whose job is to control project execution rationally and technically and to smooth project delivery. While risk is always present, monitoring and control shall facilitate detecting important deviations and correcting the project plan and/or its execution. Project management should be facts based, and communication should not be a major challenge because team members know each other well and communicate daily with limited formality and documentation (Shenhar & Dvir, 2007).

Nevertheless, many issues might arise in projects undertaken in a structured context. First, the needs might have been incorrectly assessed, wrongly categorized and/or oversimplified. This is what happened to the National Basketball Association (NBA) when the need to replace the leather basketball with a new microfiber composite ball, introduced in the 2006 season, failed and led to backpedaling by the NBA, mainly because the players did not feel sufficiently consulted and filed a complaint (socio-political complexity). Secondly, scope creep may happen, especially, when the plan is insufficiently detailed and/or contains poor estimation. Third, the project plan itself could be considered as the essential document to achieve project success, hence the project manager might overfocus on the project plan to a point at which it is perceived as the reality. In parallel, project managers who rely mainly on the project plan may develop a "tunnel vision", causing them to micro-manage and to become complacent due to their past successes (the "Icarus Paradox") (Saint-Macary & Ika, 2015). Thus, even though a lot of time would be spent on planning the project in detail, deviations could still occur during execution and be ignored up to a point at which the project plan becomes unrealistic. Therefore, many issues might arise, even in a structured context, and a risk management plan could significantly reduce the occurrence and/or the impact of these.

While a structured context implies low project complexity, it should not be assumed that the risk is also low. Thus, as it is the case for all project complexity contexts, developing a risk management strategy should be done and ultimately a risk management plan should be elaborated. As well, resources should be allocated to monitor risk and to implement risk reactions if and when needed (Remington and Pollack, 2007).

Project Management in a Complicated Context: Focusing on Design and Expertise

In a complicated context, while the needs are well understood, the options are quite technical and require field experts to define them and to find ways to produce them. For these projects, the need statement (or the why) should lead to functional requirements and then to specifications (quality attributes) that should be used to develop and assess options. Cost and time do matter but achieving high quality deliverables and meeting stakeholders' expectations could become the main focus of the project team. The Cartivator's SkyDrive project, funded by Toyota and aiming at developing a flying car, is an example of a complicated context as it involves new technology requiring field experts (according to Toyota engineers, the project is likely to be quite expensive). Other examples include developing a smartphone, a central processing unit (CPU) or an OLED television.

Complicated project contexts usually require a fair level of expertise in terms of design, engineering, integration, testing, logistics, maintenance, and spare parts. The project manager should act as an integrator by maintaining clear communication between technical and non-technical stakeholders. The project manager's job is to get the right experts and to make them focus on finding a solution that meets the needs and then to sell that solution to all the stakeholders. The stakeholders should be kept informed of the progress or the technical difficulties encountered by the project team and how they plan to overcome them. Once an appropriate option and its means of production have been identified, the activities needed to realize the project deliverables can be identified and a project plan elaborated. Best practices should help (Shenhar and Dvir, 2017).

Many issues might arise while managing projects in a complicated context. First, experts might put too much emphasis on the technical aspects of the project and forget about the time and cost objectives or even the needs for which the project was created. This may lead to the "*money is no issue*" syndrome. This was the case of the Apple Lisa project, a desktop computer with the first graphical user interface developed by Apple and released in 1983. Second, as the technical specifications are a translation of the functional requirements, they do not necessarily correspond accurately to the needs. However, during project execution, meeting 'not necessarily accurate' technical specifications could become the main objective of the project team and the real needs for the project could fall out of sight. Third, overdesign and paralysis by analysis might also occur because so many solutions are available, which in turn, could cause the organization to miss time-to-market and to fail strategically. Fourth, experts, because of their specialty and technical background, could be prone to bias (e.g., selective perception, groupthink and optimism bias), which is, along with scope changes, complexity and uncertainty, one of the main reasons why many projects in a complicated context experience cost and time overruns (Love et al., 2019). Therefore, in a complicated project, the risk management plan should focus on all aspects of the chosen technical solution while still considering all project success objectives (Browning and Ramasesh, 2015).

Project Management in a Complex Context: Focusing on Stakeholders

In a complex project context, the needs, the expectations and the interactions between the stakeholders are often not all known or understood. Hence the stakeholders' needs and expectations would not necessarily be well aligned (some might even decide not to communicate their expectations or might have hidden agendas). Consequently, there could be disagreements with regards to the project goal, objectives, deliverables and their means of production. These disagreements could even be unknown to the project team members. Issues could also happen over time due to changes in the balance of the decision-making power between the stakeholders (Geraldi et al., 2011). This was the case for the Canadian Firearms Registry project undertaken by the Canadian Firearms Program of the Royal Canadian Mounted Police (RCMP).

The project aimed at developing a register of every gun owned in Canada. From the beginning, the project faced major political opposition, particularly outside of Canada's major cities. A few provincial governments wanted the project to be terminated, arguing it exceeded the federal government's mandate and that it was too expensive. The dispute went to the Supreme Court which ruled in favor of the registry and allowed the project to continue. However, most civilians owning firearms were against gun registration and waited until the last minute to apply, causing major backlogs in registration. There was also significant disagreement between stakeholders on the effectiveness of the Gun Registry from a public safety standpoint (the proposed solution was not accepted by all stakeholders). The project experienced significant cost overruns and was abandoned in 2012.

The project manager should act as a facilitator by actively listening to all stakeholders and by allowing clear communication between all technical and non-technical stakeholders. Interactions between stakeholders throughout the project will significantly influence the direction that the project could take. The project manager should be prepared to update, on a regular basis, the project documents (the project plan, risk management, etc.) in light of the new information obtained from the stakeholders with regards to their expectations. However, any change to the objectives must still be approved by the sponsor and upper management. The project management approach should become more formal with more extensive documentation and communication with and among stakeholders (Shenhar & Dvir, 2007).

In a complex context, several issues might occur. First, it is possible that stakeholders agree on a need to be met but not on the solution to be implemented. The Waste Disposal Project in Gatineau, Canada, aiming at using the Abitibi-Bowater factory boilers to burn waste, failed because no agreement could be reached between stakeholders (particularly the city and the citizens). Second, as project success includes meeting stakeholders' expectations, the project manager should pay special attention not to fall into the louder stakeholder's bias (listening mostly to loud stakeholders to avoid conflicts). This can significantly reduce the chances of reaching a consensus among stakeholders and finding a "satisfying" solution.

The Canadian Navy Shock Trial that was conducted in November 1994, on the Canadian warship HMCS Halifax, at about 180 NMs off the coast of Halifax, Canada (Gibson, 1996), is a good example of a complex project that had a very detailed risk management plan, which was evolving on a regular basis. Despite intense preparations by a fully dedicated team for the preceding two years, the risks were still very high, the plans kept changing (even on the day of the trial significant adjustments had to be done), and even the report period which lasted almost one year after the trial was a challenging technical and management exercise. This trial was highly successful because the complex nature of the project was well understood by all levels of stakeholders, particularly corporate executives, and was managed accordingly.

Generally speaking, for a complex context project, a risk management plan should be developed with a special emphasis on stakeholders' expectations and influences to assess the likelihood that the project goal will ultimately be met (Browning and Ramasesh, 2015).

Project Management in a Complexicated Context: Focusing on Communication between Stakeholders and Experts

Projects undertaken in a complexicated context inherit the characteristics of projects in both the complex and complicated contexts. They have numerous stakeholders whose needs, expectations, agendas and level of acceptance of the proposed solution are not necessarily known or well aligned. Their potential interactions could also be numerous and hardly predictable. As well, the deliverables are composed of numerous parts or sub-systems, with some unknown cause-and-effect relationships and their means of production involve technologies that must be implemented by well-trained experts. Considering the stakeholders' expectations, the project team must conceive a feasible working solution that is acceptable to most if not all. For example, the Alaska Pipeline (from Prudhoe Bay on Alaska's Northern Coast to the Port of Valdez) project undertaken in 1975 by the Alyeska Pipeline Service Company encountered major opposition from conservation groups, environmentalists and natives because the pipeline was perceived as an incursion into one of America's last wilderness and would cross native lands without any benefit accruing to them directly.

Adding to these major issues, the means of production might involve not well understood technologies. Available options could differ significantly with regard to their time, cost and quality objectives and their level of risk. Feasibility studies should be undertaken to identify the option that meets best the project goal as well as stakeholders' expectations. The buy-in of the selected option by most if not all stakeholders is of paramount importance. But changes to the project goal, objectives, or deliverables can happen throughout the project lifecycle (Geraldi et al., 2011; Maylor & Turner, 2017) due to negotiation between the stakeholders or changes in their decision power.

Even though many years of careful planning and analysis by experts has allowed the development of the Airbus 380, this project was done in a complexicated context. The structural complexity of the Airbus A380 was tremendous. This was attributed largely to the wiring of the cabin, the concurrent design and production and the high degree of customization for each airline. Also, the project was managed jointly by French, German, English and Spanish teams while aircraft parts were made in France, Germany, England and Spain, adding to its socio-political complexity. The project encountered major communication issues as different versions of the design software were used. CATIA version 4 was used by the German and Spanish Airbus facilities and version 5 by the British and French sites, causing major configuration management problems.

The project manager should act as a negotiator to resolve likely business conflicts between technical and non-technical stakeholders and to make them agree on a satisfying solution and the ways to implement it. While many traditional project management tools and techniques can be useful, the project manager should pay special attention to major challenges such as stakeholder management, project design, and communication. Extensive documentation is required to gain the support of all stakeholders and experts (Shenhar & Dvir, 2007). The project manager must be a facilitator by allowing stakeholders and experts to communicate and be understood.

Several issues might arise in a complexicated context. First, while learning opportunities exist between stakeholders and experts, there may be a lack of fit between the stakeholders' expectations and the experts' technical solutions. For example, the Tata Nano project, undertaken by the Indian automaker Tata Motors and aiming at designing and commercializing the Nano, a very affordable Indian's People's Car, was faced with major opposition from many stakeholders: farmers (who had to sell their land for the factory to be built), lobbyists, politicians, environmentalists, and several non-governmental organizations. Protests stopped the work at the Nano plant and forced Tata Motors to relocate the factory from Singur, West Bengal, to the Western Indian state of Gujarat, costing the company a tremendous amount of money. Second, considering that meeting stakeholders' expectations and experts' specifications are key to success, the project manager should pay special attention not to fall into both the louder stakeholder's bias and experts' bias, as explained earlier.

The Canadian Space Agency Radarsat-2 project (1998-2008), one of the world's most advanced radar-based earth observation imagery satellite, can be considered a complexicated project. The project was a collaboration between the Canadian government and industry but involved many other national and international stakeholders. The project was to take three years from implementation approval (1998) to launch (planned for 2001), and to cost about $240M Cd. The satellite was eventually launched very successfully (in December 2007), and it is recognized worldwide as a significant asset for disaster management and other earth observation uses; but the project cost almost doubled, and the project duration almost tripled, with a modified business case, compared to original approval to implement.

A late decision to use new technology added significant technical but also legal, business, procurement, political and management difficulties, contributing to making the structural complexity aspect of this project as medium (see table 1). It can also be seen that this project had high socio-political complexity. Combining the two complexity aspects we find that the project complexity context was "complexicated". There were so many high-level stakeholders involved, particularly several Canadian and US and other government departments and companies providing parts and taking part in the launch, each with their own political, financial and legal considerations. Therefore, the relations between stakeholders became quite tricky and contributed to significant changes throughout the project lifecycle.

Project Management in a Chaotic Context: Focusing on Priorities Assessment and Rapid Response in a Constantly Changing and Unknown Situation

In a chaotic context, there are usually many stakeholders expecting or needing quick response from the project team. However, all their needs are often hard to assess before the project team is on site. Thus, the urgency to act and the lack of knowledge about the needs and expectations of all the stakeholders make developing a detailed project plan difficult. There is also no guarantee that a specific cause will produce a specific effect. Sometimes effect could hardly be associated to a cause as so many factors (often not under the control of the project team) might be involved directly or indirectly and may never be fully comprehended. There are so many things happening so fast at the same time and in no evident order that cause and effect shift constantly and in an unpredictable manner; and, with much turbulence. Sometimes, it is nearly impossible to understand what is happening during the project or even in retrospect (Snowden & Boone, 2007). The Hurricane Katrina Response project, the Boston Marathon Manhunt, and the Earthquake in Port-au-Prince Recovery projects can be considered as projects undertaken in a chaotic context.

What matters the most in a chaotic context is to re-establish essential services and to restore order quickly. Fully assessing the project scope can be very difficult. There can be an enormous time pressure, particularly if human lives are involved. Time matters to reduce casualties and there is little time to plan what should be done and, once priorities have been established, the project team must act quickly. The urgency of the situation implies a quick response. The project management approach is to assess rapidly the priorities and to act quickly. The project manager should act as a transformational leader by trying to get the big picture to better grasp the extent of the crisis and make the most balanced decisions. Indeed, the project manager shall look first for what works, not patterns, to stanch the bleeding and then search for emerging patterns to guide following actions (Snowden & Boone, 2007).

Several issues might occur in a chaotic context. First, the pressure to identify the needs and the priorities and to act quickly might lead to inadequate or unsafe intervention. Second, the project team might overreact. This is likely what happened when thousands of law enforcement officers participated in the Boston Marathon Manhunt to capture just two terrorists.

The Ice Storm Emergency Shelter Project undertaken by the Canadian Space Agency in 1998 offers a good example of a project in a chaotic context. On the 4th of January 1998, many employees of the Canadian Space Agency (CSA) had arrived late to work due to ice on the roads. Later that day, the CSA closed early so that the personnel could go home to take care of their houses and families, since the entire region was covered with ice and had no electrical power. The Ice Storm had started, and a state of emergency would soon be declared for a very large region, including parts of Ontario and northern USA. That ice storm affected millions of people and brought other risks (possible lack of potable water for the city of Montreal, hospitals almost inoperative, police services extremely limited due to the large number of emergencies, absolutely no electricity in the middle of winter for days to weeks depending on location, etc.).

Within days, the CSA was asked by the Canadian Federal Government to turn its building into an emergency shelter and provide heat and hot meals to locals and workers trying to re-establish services to the population. Thus, the Ice Storm Shelter Project started (Steuter-Martin et Pindera, 2018). There was no plan to follow, and most of the available personnel was not trained for that new function. A plan had to be set up and it evolved as the shelter was being established and operated. Luckily, there were some people with emergency management experience who were given the authority to act. The performance objective was clear: to provide emergency shelter to the local population. But what did that mean and what should be done with normal or routine CSA operations? The time objective was completely out of whack, the project began implementation as it was being initiated, and it would last the time needed. The cost objective would be sorted out after. A supply chain had to be invented for fuel, food, etc. Within days, local residents could come to the Shelter but then volunteers had to learn how to welcome them, ensure they have their medication, and establish a behavior protocol (and how to enforce it), etc. Lucien Bouchard, who was Premier of the Province of Québec, Canada, at the time, said he was in an unpredictable situation: "The rules were unwritten; we didn't foresee something like this happening. There was no security plan that was drawn up. It was [so] unlikely. We had to invent everything, improvise everything. We used our instincts", he told Radio-Canada (Steuter-Martin et Pindera, 2018). In that overall perspective, the CSA Shelter project, which also was part of a much larger Emergency Management Program, was partially based on instinct, in a chaotic context.

The Complexity Based Project Management Framework

The proposed Complexity Based Project Management Framework (CBPMF) is composed of two steps. In the first step, the complexity context of the project is assessed according to the criteria set in table 1. Then in the second step, key areas that might cause significant issues are identified as shown in the first column of table 2. Those keys areas were selected based on the literature review in this paper as well as our analysis of the case studies. The next five columns in Table 2 suggest, for each of the five complexity contexts, ways to address these issues, again based on the literature review and the case studies. By looking in the column corresponding to the complexity context of the project as identified in step 1 of the CBPMF, project managers are made aware of critical issues of their project and how they can deal with them. The project team is invited to pay special attention to these keys areas whether a traditional, agile, hybrid, or even extreme project management approach is used.

Table 2: The Complexity Based Project Management Framework

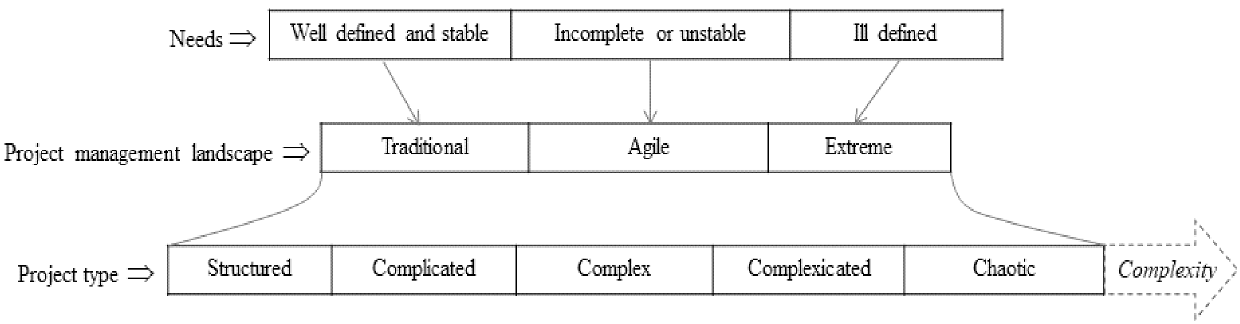
	Project complexity context				
Key Areas to consider	**Structured** ↓	**Complicated** ↓	**Complex** ↓	**Complexicated** ↓	**Chaotic** ↓
1. Stakeholders' expectations	Expectations generally clear, well known and aligned	Expectations generally clear, well known and aligned, but technical difficulties could be underestimated, the feasibility study should closely assess technical difficulties	Expectations not all known, clear or well aligned; frequent consultations with stakeholders are needed to elucidate their expectations and/or involve them in the project	Expectations not all known, clear or well aligned; frequent consultations with stakeholders and experts are needed to elucidate their expectations or involve them in the project; also, technical difficulties must be closely studied in the feasibility study to avoid underestimation	Team must offer quick and safe response, and make best effort to identify specific expectations or needs on site
2. Setting quality (Q), cost ($) and time (T) objectives*	Objectives and their priority can be established and should be approved by the stakeholders	Objectives can be established but experts might over-prioritize Q with negative impact on $ and T, verify the feasibility of the quality objective with regard to the	Objectives can be established but could be hard to sell to all stakeholders, expect changes to Q, $ and T, a feasibility study should substantiate the Q, $ and T objectives,	Objectives can be established but experts might over-prioritize Q while stakeholders might have different opinions, expect changes to Q, $ and T, verify the feasibility of the	Goal is clear (restore order), but the objectives could be hard to establish because of the numerous unknowns, allow flexibility for Q, T and $,

		T and $, negotiate for $ and T contingencies	negotiate for Q, $ and T contingencies	quality objective with regard to the T and $, negotiate for Q, $ and T contingencies	
3. Approval of the proposed solution	The need is well defined and the option analysis should lead to one well accepted solution	The need is well defined but the solution could only be evaluated by experts, feasibility study should lead to one well accepted solution	The stakeholders' needs and expectations are not necessarily all known and defined, the feasibility study should elucidate the stakeholders needs and expectations, negotiation between stakeholders with regard to the possible solutions should lead to a satisfying solution	The stakeholders' needs and expectations are not necessarily all known and defined, the feasibility study should elucidate the stakeholders needs and expectations, discussion between stakeholders and experts with regard to the possible solutions should lead to a satisfying solution	Most solutions will be identified on site according to urgency
4. Stakeholders' interactions	Interactions generally positive because of the common vision of the project but should be monitored	Potential conflicts between stakeholders and experts can happen, monitor closely the interactions and rapidly deal with conflicts	Potential conflicts between the numerous stakeholders as there is, most likely, no common vision of the project, closely monitor and rapidly deal with conflicts	Potential conflicts between the numerous stakeholders and experts as there is, most likely, no common vision of the project, closely monitor interactions between technical and non-technical stakeholders and rapidly deal with conflicts	Numerous but unknown interactions, capability to deal with onsite requests
5. Project planning	Planning should be straightforward as there is one well accepted solution with well-defined deliverables	Planning must deal with the many unknowns with regard to the technologies to be used; ensure that the contingencies identified in # 2 are included in the plan	Planning must deal with possible unknown stakeholders' needs and expectations that might become apparent as the project is being implemented, allow flexibility	Planning must deal with the many unknowns with regard to the technologies to be used, ensure that the contingencies identified in # 2 are included in the plan, must also deal with possible unknown stakeholders' needs and expectations that might become apparent as the project is being implemented, allow flexibility	There is little time to prepare a plan, there are many unknown, assess priorities on site, if needed

6. PM management style	PM is a pace setter; establishes the rate of action for team members	PM is an integrator; maintains clear communication between technical and non-technical stakeholders	PM is a facilitator: active listening, maintains clear communication between stakeholders	PM is a negotiator; resolves business conflicts between technical and non-technical stakeholders and makes them agree on a solution and the ways to implement it	PM is a transformational leader, seeing the big picture to better grasp the extent of the crisis, establishing what should and could be done with the resources available
7. PM focus	PM is implementing the project according to the plan, updating the plan when needed, keep stakeholders informed	PM is vulgarizing technical achievement or issues to non-technical stakeholders, avoiding the 'money is no object' syndrome, keeping stakeholders informed	PM is consulting stakeholders regularly, and adapting the project plan to emerging needs or expectations	PM is consulting stakeholders regularly, and adapting the project plan to emerging needs or expectations, vulgarizing technical achievement or issues to non-technical stakeholders, keeping stakeholders informed	PM is to establish some order to move away from the chaotic situation
8. Implementation bias	Managing the plan instead of the project	Focusing mostly on technologies	Dealing mostly with louder stakeholders	Focusing mostly on technologies, and dealing mostly with louder stakeholders	Overreacting and or wasting resources on non-priority items
9. Risk management	Standard project risk management, with a balanced consideration of all objectives and stakeholders	Standard project risk management, with special attention to stakeholders with technical interest to avoid experts' dominance.	Standard project risk management, with special attention to stakeholders' expectations, influences, and conflicts	Standard project risk management, with special attention to stakeholders' expectations, influences, and conflicts (particularly between technical and non-technical stakeholders)	Little time to assess risk up front; crisis management approach; balancing risk responses to the benefits to the project objectives which themselves are evolving with the situation

[*]: Q stands for achieving Quality, T, completing the project on schedule, and $ on budget.

Figure 2: The project Management Landscape



Conclusion

Complexity is present, at varying degree, in every project and it should not be ignored. Mismanagement of complexity can fail projects. Project managers should be aware of the complexity context of their projects and how to effectively deal with them. The proposed Complexity Based Project Management Framework (CBPMF) can provide guidance to the project team in terms of how to determine the complexity context of their project, and on how to match the assessed level of complexity with a contextually adequate approach that is likely to lead them to project success. As today's business is more and more complex, the CBPMF would be a great element to put in the Project Leader and Project Manager toolboxes.

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