Data management in project planning and control

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Abstract: The paper focuses on the importance of an early engagement of stakeholders to manage the project along its entire life cycle. An increasing level of uncertainty and complexity tends to generate an increasing level of unpredictability, since it is difficult to anticipate all the possible dynamics, internal and external, affecting a complex project. Improving the forecasting/ planning process requires the usage of all the data available to the project team, in particular when facing a high level of uncertainty and complexity. In fact, stakeholders are the main sources of knowledge about the project and their early engagement may significantly increase the amount of knowledge, both explicit and tacit, available. As a consequence, project planning and control may be considered as a participatory process resulting from the interaction of the project team with all the stakeholders involved in the project.

Keywords: data management; project planning and control; project uncertainty and complexity; forecasting process; knowledge sources; early engagement of project stakeholders.

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1 Introduction

In general, a project will be exposed to complexity, uncertainty and ambiguity. All of them are mainly related to a lack of knowledge and require gathering further information to better address the future. Note that lack of information may be a very practical issue (information missing, documentation not completed, documentation unclear, documentation delayed, reviews not performed, contractual provisions unclear, plans unclear or missing, governance framework unclear or missing, etc.).

From uncertainty may derive risks – i.e., anticipated possible events such as threats and opportunities – for the project (Perminova et al., 2008). Complexity is mainly related to the high number of elements normally involved in a project and, specifically, the high number of interrelationships between them (Williams, 1999). Complexity may be the source of unanticipated events or conditions during the project life cycle, deriving from unexpected interaction patterns among the different processes – operational managerial and organisational – developed in the project. Moreover, project complexity may be increased by a fast-track approach, owing to strict schedule constraints. While uncertainty relies on the forecasting process to identify risks and suitable response actions, complexity requires a high level of freedom to adapt project processes to emergent situations. Ambiguity is mainly related to the possible existence of multiple interpretations of the project situation, which requires a consensus-building process, based on the direct interaction of the stakeholders involved, to identify common objectives and strategies (Weick, 1995). Weak signals, for instance, are derived from the interaction of people with the operations as signals that someone has considered to have some special foresight value. We can only know retrospectively if the detected signal was accurate foresight knowledge or misinterpretation. In this context, leadership plays a decisive role. For instance, the same situation may be interpreted as a threat or an opportunity, depending on the risk-taking attitude of the decision-maker. Moreover, uncertainty, complexity and ambiguity are interacting and mutually reinforcing each other. As a consequence, all the knowledge available should be used to address the planning and control processes for a complex project (Caron, 2014).

2 Project planning and control

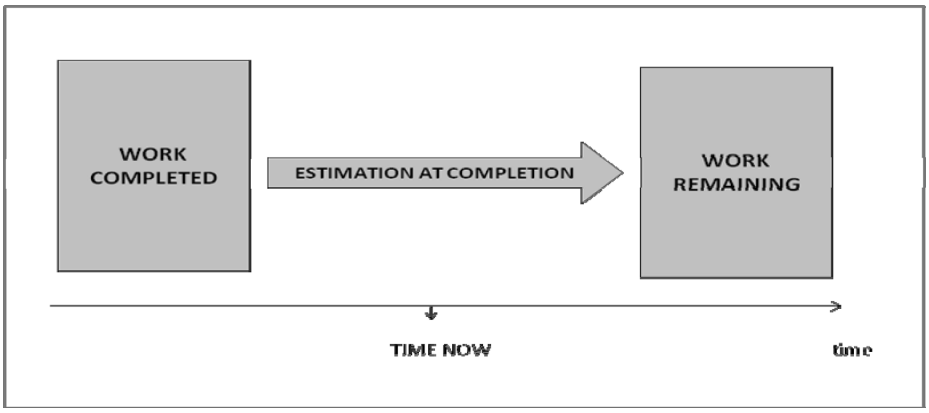
When complexity increases, project planning and control becomes an increasingly hard task. On the one hand, it is impossible to approach a journey, and a project may be thought of as a journey, without figuring out some sort of schedule and budget. On the other hand, planning should be a continuous process to address new conditions as they emerge (Dvir and Lechler, 2004). In fact, instead of 'project planning', 'project re-planning' should be considered as the actual process extending throughout the project life cycle. Moreover, continuous re-planning implies making assumptions about the future, to develop a more realistic plan (Soderholm, 2008). For instance, a resource-loaded schedule, which is a very common planning tool, may anticipate a future work overload requiring immediate outsourcing measures.

Planning and forecasting are strictly intertwined both in the early stage when the project baseline must be determined and throughout the entire project life cycle. In particular, the concept of 'estimate to complete' (ETC) corresponds to the core of the planning and control process, which is based on a feed-forward control mechanism, since only the actions affecting the work remaining can influence overall project performance.

At each time-now (TN), a part of the work is completed (WC) and a part of the work is the work remaining (WR) that is still to be done. On the basis of earned value management system (EVMS), the two components of the estimate at completion (EAC), i.e., the overall final cost of the project, are given by actual cost (AC) of the WC and the ETC of the WR. Similar considerations may be applied to the estimate of time at completion (TAC). In the project control process, the role of ETC is critical, since the

information drawn from the ETC, in comparison with the project baseline, may highlight the need for and the type of corrective actions that can change the project plan. This approach corresponds to a *feed-forward* type control loop (Anbari, 2003; Christensen, 1996), since analysis of the future informs present-day decisions (see Figure 1).

Figure 1 Estimation at completion at time now (*internal view*)



At time now, project control requires hindsight, insight and forecasting (Kuosa, 2014), where insight means searching for the emergent. As a consequence, during the project control process, the project manager plays a twofold role: the 'historian', drawing on the wisdom of the past and attempting to grasp the drivers that have determined the past evolution of the project, and the 'wizard', attempting to foresee the future evolution of the project and to exploit all the lessons learned from the past. The 'historian' should help the 'wizard' in forecasting the future (Makridakis and Taleb, 2009; Makridakis et al., 2009; Hogarth and Makridakis, 1981). Future is something that already exists in the present, in the thoughts and emotions of people. In a sense, any proactive action dealing with future uncertainty can be considered a sort of bet. An effective process of forecasting/planning depends on utilising all the available knowledge, in particular when facing a high level of project complexity. Since stakeholders are the main sources of knowledge about the project, their early engagement may increase significantly the amount of knowledge available. As a matter of fact, forecasting becomes a participatory process, based on interactive and participative methods involving a wide variety of stakeholders, increasing legitimacy of forecasting results and a shared sense of commitment.

The robustness of the project plan may be improved by *projecting* the overall available knowledge provided by the stakeholders into the future and so allowing for a more accurate forecast. The stakeholders' roundtable is central to the idea of a collaborative, forward-thinking project organisation. Engaging the stakeholders in the planning process from the project outset increases the accuracy of initial and subsequent estimates, since a larger amount of information becomes available in terms of both data records and experts' judgement (Zuber, 2013). The underlying logic is that by including different stakeholders with diverse views and interests in the project planning process, disruptions to plans during the execution phase are reduced. As a consequence, project planning may be thought of as resulting from the continuous interaction of the project team with the project stakeholders.

Drawing on a series of case studies (Caron et al., 2013a, 2013b), Section 3 focuses on the knowledge sources that may allow for an improvement of the forecasting/planning process in the case of a complex project. Section 4 introduces stakeholders as knowledge sources and stakeholder management as a means for fostering knowledge sharing, and an early engagement of stakeholders in the project planning and control. Finally, some conclusions are drawn.

3 Planning and forecasting

The lack of a realistic project plan is correlated to the inability of the project team to exploit all the available knowledge sources to anticipate the future issues of the project (Williams and Samset, 2010; Williams et al., 2009). On the one side, the project stakeholders are the main sources of project complexity; on the other side, they are the main sources of the knowledge required for the project. This section will address how to integrate their different knowledge contributions to improve the forecasting capability during the project control process.

In general, the knowledge available to the project stakeholders may be classified in two ways: explicit/tacit and internal/external. Explicit external knowledge corresponds to data records about similar projects completed in the past. Taking into account past experience should mitigate possible 'optimistic' bias in estimating future performance (Lovallo and Kahneman, 2003). Explicit internal knowledge corresponds to data records concerning the current project, i.e., the work completed, allowing for an evaluation of project performance at time now and, through a trend analysis, an estimate of future performance. Tacit external knowledge concerns the identification of similarities between the current project and some past projects to allow for the transferability of past lessons learned and performance data to the current project. Tacit internal knowledge entails the experts' judgements about possible events/conditions affecting the project's work remaining. Note that intelligence may expand tacit internal knowledge. To improve the forecasting/planning process, the information stemming from the different sources must be collected and summarised. The aim is to identify and analyse all the possible trends, patterns, drivers, actors and how they may interact and co-evolve and influence the future development.

The basic approaches available to develop the forecasting/planning process may be summarised:

- Pattern analysis; exploiting the identification of typical patterns, e.g., in terms of *S*-curves describing the progress of a given class of similar projects throughout the life cycle (Bar-Yam and Bialik, 2013). For instance, it should be remembered that progress rate naturally falls away towards the end of a project to avoid an 'over-optimistic' view.
- Simulation of the future development of the project, starting from the current status; a mathematical/logical model of the project allows for building likely future scenarios.
- Trend analysis; based on the extrapolation towards the future of the project performance until time now, e.g., productivity, such as in the EVMS.

Such approaches work on the assumption that it is possible to identify the underlying factors that might influence the variable being forecast, using data records as a basis for estimating future outcomes.

Focusing, for instance, on trend analysis, different performance indexes may be used to highlight current trends and estimate the future performance during the WR (Anbari, 2003). Nevertheless, owing to certain and uncertain events affecting the work remaining, future performance may significantly differ from current performance (Davidson, 1991). In fact, relying only on past performance while developing a forecast could be misleading, since looking only to the work completed is similar to driving a car whilst looking just in the rear-view mirror, so making it impossible to dodge the obstacles that may lie on the route ahead. For example, when a person is planning a journey by car, he or she tries to anticipate possible traffic jams before selecting a road.

Forecasting allows for broadening the boundaries of knowledge in four ways:

- by assessing the implications of current issues, trends, decisions and actions
- by catching early warnings anticipating emergent threats and opportunities
- by considering the consequences of assumptions about the future
- by envisioning aspects of desired future scenarios.

As a consequence, forecasting capability can be improved by integrating all the knowledge sources available to the project team (Liu and Zu, 2007; Goodwin, 2005). While data records are typically related to the WC, experts' judgements are typically oriented to the WR.

We can classify the knowledge sources that may be used for evaluating the ETC into four types:

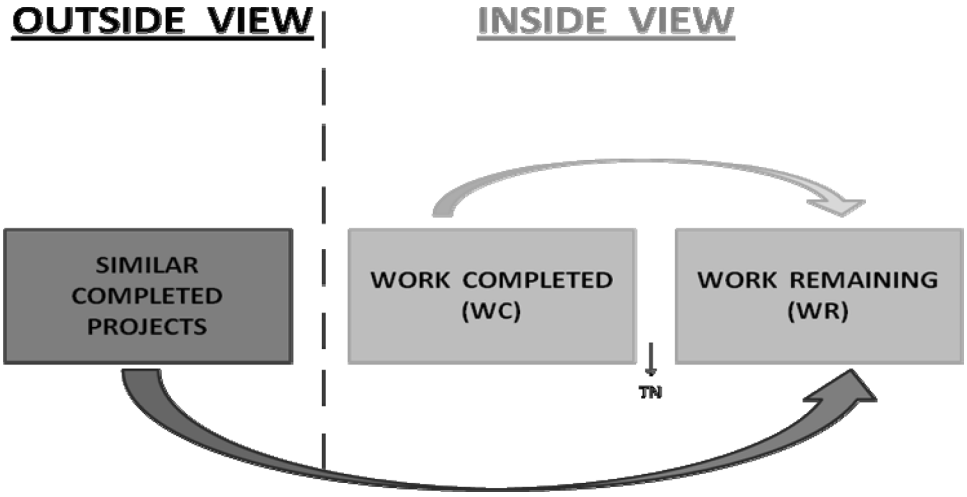
- data records related to the current project, i.e., to work completed
- experts' judgements related to the current project, i.e., to work remaining
- data records related to similar projects completed in the past
- experts' judgements related to the identification of past similar projects.

According to the above-mentioned classification of the knowledge sources, three different approaches to trend analysis may be identified:

- utilising data records related to the WC, by extrapolating the current performance trend into the future (Anbari, 2003)
- adjusting the performance trend stemming from data records related to the WC through experts' judgement (Caron et al., 2013a)
- integrating the internal view of the project, i.e., data records related to the WC and experts' judgement related to the WR, with data records deriving from similar projects completed in the past (Caron et al., 2013b).

In the last approach, based on a holistic consideration of all the information generated inside and outside the project, data records are integrated with the experts' judgements, to estimate the actual trend of the project (Palomo et al., 2006) (see Figure 2).

Figure 2 External view and internal view



The Bayes Theorem represents a rigorous and formal approach allowing for an update of a prior distribution, which expresses the experts' preliminary opinion, by means of the data records gathered in the field. For instance, the project team may assume a prior estimate of the final budget overrun, based on subjective expectations about the development of the current project, and this prior estimate may be updated based on the actual performance of the current project at time now (Caron et al., 2013a). In a Bayesian framework, the experts' preliminary opinions are an example of subjective probability, the only statistical approach applicable to non-repetitive processes such as projects. Subjective probability is defined as the degree of belief in the occurrence of an event, by a given person at a given time and with a given set of information. It should be noted that increasing the level of knowledge available may modify the value of subjective probability assigned to a future event (De Finetti, 1937; Caron et al., 2013b).

In particular, the contribution given by tacit knowledge, i.e., by the project stakeholders, about the future development of the project, may regard:

- The impact deriving from drivers, which explain the project development during the WC, and also presumably affecting the WR, i.e., what kind of plausible drivers (e.g., schedule aggressiveness, engineering completeness, owner involvement, turnover in project leadership, unsatisfied stakeholders, new technology, project team integration, project team staffing, front-end engineering adequacy, etc.) may have generated the actual development of the project until time now and how will they also influence the future? (Merrow, 2011). For instance, possible learning effects deriving from project progress or differences in scope of work between the WR and the WC may generate a consequent impact on productivity.
- Possible behaviour of the stakeholders involved in the project, e.g., committed, non-collaborative, opportunistic behaviour, in particular their attitude to share or not the knowledge required for project control. It should be noted that in this case the focus moves from risk events to risk sources, i.e., to the stakeholders.

- Certain/uncertain events or conditions affecting project performance during the WR, which may originate both internally and externally to the project. Certain events may include planned corrective actions or contractual constraints, while uncertain events, i.e., risks, may arise in terms of both threats (i.e., adverse weather conditions) and opportunities (i.e., more efficient solutions developed by the suppliers).
- Weak signals, i.e., risk triggers, indicating emerging situations, which could possibly affect project performance (anomalous bid from a subcontractor, scope creep, subcontractors' work overload, permits delay, engineering not driven by construction, rework rate, missing data, etc.) (Merrow, 2011; Williams et al., 2012).

Besides the use of internal knowledge, both explicit and tacit, external knowledge related to similar projects completed in the past is useful. Note that most of the lessons learned from previous similar projects in a project-oriented company should feed a company's project management system. Considering that data records related to past projects are a basic input to the forecasting/planning process, research shows that knowledge and experiences gathered in different projects are not being systematically integrated into the organisational knowledge base and that there is a great discrepancy between the need for project debriefing and its actual deployment (Reich et al., 2014). Lessons learned are defined as key project experiences, which have a certain general business relevance for future projects. The systematic documentation of mishaps, mistakes or potential pitfalls helps to manage uncertainty and complexity.

The use of data records related to similar past projects has been introduced both at the project outset to improve the initial estimate of the project baseline, or for proposal purpose, and during the project control process at a generic time now, to identify suitable corrective measures (Caron et al., 2013a).

Note that the selection of the cluster of similar projects is basically subjective since it depends on the similarity criteria adopted (Savio and Nikoloupolos, 2011; Green and Armstrong, 2007), just as the estimation given by experts about future events that may impact on the project success. Some cases, in fact, may express strong ambiguity. For example, if a company has to estimate the costs of an investment in a new technology and in an unfamiliar context, should it take into account the set of highly innovative projects developed in different contexts or the set of barely innovative projects but belonging to the same context? Neither the former nor the latter option may be the best solution but both might be considered (Kahneman and Tversky, 1979).

In summary, the use of data related to past similar projects should reduce significantly the bias of the forecasting/planning process. In fact, even though project management systems have been extensively implemented in recent years, project failures in meeting planned objectives are common, in particular in large engineering and construction projects such as in the oil and gas industry (Merrow, 2011). However, it remains an open question whether these failures are due to a lack of project efficiency during execution or to a biased forecasting process during the planning phase. In the former case, both positive and negative deviations against the baseline should be expected, depending on the evolution of each project. On the contrary, a systematic overrun in terms of cost and time may be explained as a weakness of the forecasting process since the project's outset, weakness normally owing to an optimistic bias (Hogarth and Makridakis, 1981).

Kahneman and Tversky's studies (1979) show that a major source of planning failure, which influences the forecast of final cost and duration, is linked to an exclusively '*internal'* view approach, i.e., based only on data deriving from inside the current project.

Subsequently, the focus has moved to the psychological and political factors affecting the internal view (Lovallo and Kahneman, 2003), and, in particular, two main sources of influence have been identified (Flyvbjerg, 2006, 2009).

First, the *cognitive illusions*. These entail two major aspects: *over-optimism*, i.e., the common attitude to assess future projects with greater optimism than justified from previous actual experience, and *anchoring*, i.e., to deal with complex decisions by selecting an initial reference point (the anchor stemming from past experience) and anchoring the estimate onto it.

Second, the *strategic and political pressures*. These may typically emerge during proposal preparation. Indeed, the approval of a project pre-supposes a competition involving different proposals, which often causes a voluntary underestimation of cost and duration by the project proposers to make their own proposal as attractive as possible.

In response to the above-mentioned risk of bias in forecasting/planning, it is necessary to exploit all the available knowledge: tacit, explicit, internal and external. Innovative and creative approaches to handling project complexity require input from many knowledge sources. Cooperation among the stakeholders is essential to exploit all the knowledge available to the project.

4 Stakeholder management

The process of stakeholder analysis and management is a critical success factor for the project. It has been included as an additional knowledge area in Project Management Institutes (PMIs) "A guide to the project management body of knowledge" (PMI, 2013), consisting of two basic processes: planning of stakeholder management and managing stakeholder engagement. According to PMI BoK (PMI, 2013), "Managing stakeholder engagement is the process of communicating and working with stakeholders to meet their needs/expectations, address issues as they occur and foster appropriate engagement in project activities throughout the project life cycle".

In fact, large engineering projects (LEPs) are characterised by a large number of stakeholders (Flyvbjerg, 2009). Project stakeholders may be defined as organisations or groups that have an interest or a functional role in the project and can contribute to, or be impacted by, the outcomes of the project (PMI, 2013). Examples of project stakeholders can be sponsors, managers, suppliers, subcontractors, partners, clients, shareholders, financial institutions, insurance companies, governments, labour unions, mass media, pressure groups, consumers, local communities, etc.

Stakeholders are probably the major source of complexity for the project but, on the other hand, they are the major source of knowledge for the project. Therefore, a major output of stakeholder management should be knowledge sharing.

The contribution of the project stakeholders in terms of knowledge may affect both initial planning and subsequent project control throughout the project life cycle. Engaging the stakeholders in the planning process from the project outset increases the accuracy of initial and subsequent estimates, since a larger amount of knowledge becomes available earlier in terms of both data records and experts' judgement (Zuber, 2013). In particular, the early engagement of stakeholders allows for anticipating threats and opportunities possibly affecting the project throughout its life cycle.

In reacting to an uncertain, complex and ambiguous project status, the process of making sense of the situation and then building consent about an agreed response strategy

is critical (March, 1978; Daft and Weick, 1984; Weick, 1988, 1995; Kaplan, 2008; Alderman et al., 2005). A consensus from the key stakeholders is needed about what should be done and how it should be done. Uncertainty, complexity and ambiguity can result in different interpretations about what is going on and what actions should be undertaken. Moreover, weak signals may be interpreted in different ways, which makes it difficult to take timely measures. For instance, a decrease in construction productivity may be interpreted as a radical shift in project performance or just a short-term downturn? To deal with uncertainty, complexity and ambiguity, people interact, search for meaning, settle for a plausible solution and, eventually, take action (Weick et al., 2005).

Obtaining the engagement of stakeholders in the project, and consequently the contribution of their knowledge, is the main objective of stakeholder management. In particular, stakeholder management aims at reducing the probability of actions carried out by the stakeholders that might adversely affect the project, and encouraging support to project objectives particularly in terms of knowledge sharing (Cleland, 1998; Aaltonen, 2011). In general, the process of project stakeholder analysis and management can be broken down into the following basic sub-processes: stakeholder identification, classification, assessment and management.

First, the focus is on identifying who the stakeholders really are, rather than relying on a generic stakeholder list or a generic stakeholder breakdown structure, deriving from similar past projects.

For effective stakeholder identification, a detailed breakdown is required to identify specific stakeholders that can be effectively managed. For instance, the government as a whole can rarely be managed but a particular department probably can be. A newspaper may generally be against a project but after breakdown it may become clear which specific staff is positive, neutral or negative and what is the newspaper's potential for interfering with the project's development (Ackermann and Eden, 2010).

Second, to classify the project stakeholders, different criteria may be applied. On the basis of their type of involvement in the project, it is possible to differentiate stakeholders into either primary or secondary (Clarkson, 1995). *Primary* stakeholders should have a contractual or legal obligation to the project team (Cleland, 1998), such as client, main contractor, suppliers and subcontractors. *Secondary* stakeholders include, for instance, government (note that government can be a client as well), local authorities, media, consumers, competitors, local communities, etc. Project management has normally focused only on primary stakeholders that are important with regard to the financial project performance. The current trend is towards an increasing importance of, and consequently an increasing attention to, the secondary stakeholders, such as the local community living around the plant to be built. Secondary stakeholders may also be classified into: external champions, economic actors, competitors, technological actors, socio-cultural actors and political/regulatory actors.

The level of attention devoted by the project team to each stakeholder depends on the stakeholder's salience. First, the salience of the individual stakeholders can be assessed in terms of the presence of one or more of the following attributes: power, legitimacy and urgency (Mitchell et al., 1997). Power refers to the ability of a stakeholder to influence the decision-making process; legitimacy refers to the legal context supporting a stakeholder's claim, and normally legitimate claims are often emphasised in connection with secondary stakeholders, and urgency refers to the criticality and time sensitivity of the claim raised by a stakeholder. Second, the level of salience usually depends not only

on the individual attributes of a single stakeholder, but more generally on the type of interaction it has with other stakeholders. For example, if a secondary stakeholder lacks resource-based power in its relationship with the project, it is more likely to employ indirect strategies through an ally that has power to influence the project.

When assessing a stakeholder, first, it should be acknowledged that he or she has general *interests* and, consequently, specific *objectives* concerning the project. On the basis of these objectives, the stakeholder formulates the corresponding explicit *requirements* and implicit *expectations*. Depending on whether these requirements and expectations are taken into account and satisfied, the stakeholder shows different *attitudes* and consequent *behaviours*, cooperative or obstructive, with respect to the project. Note that, not only a withdrawal of resources, but also a non-committed attitude might be sufficient to place the project in serious difficulty. By using the *resources* corresponding to their base of power, the stakeholder can take actions to exert a potential *impact* on project performance and success (Olander, 2007). Beyond expectations, interests are the real drivers behind stakeholders' attitude and behaviour. Once the project team possesses such insight, it becomes easier to predict stakeholder's behaviour and press the right button to encourage a positive attitude. Examples of influencing strategies are: participatory engineering, best available technology solutions, standardised solutions, media exploitation, risk sharing/allocation, introduction of incentives, communication plan, creation of alliances, etc. For instance, lobbying may be a way to exercise influence for or against laws, regulations or trade restraints.

For instance, LEPs normally may have some sort of impact on the surrounding environment, which could possibly create a conflicting relationship with local communities and environmental groups. The main interest of a pressure group, such as a pro-environment NGO, may be to be recognised by the authorities. If some aspect of the project concerns the group's social mission, i.e., the impact on the environment, or simply offers an opportunity to enhance its visibility, the group might propose an alternative technology, demand more stringent environmental constraints or request a meeting with managers in the presence of experts and authorities. As long as these requests remain unsatisfied, the group will threaten to mobilise all its resources, local community, media, lawyers, researchers, etc., or to organise actions such as demonstrations, blockades and media campaigns to increase their credibility. All these actions may lead to a potential impact on the project causing for instance an unexpected design change and a consequent completion delay and budget overrun.

PMI (2013) defines project stakeholder management as "the systematic identification, analysis and planning (*and implementing*) of actions to communicate with and influence stakeholders". The influence on the stakeholders may be exercised by different ways: collaboration, bargaining and confrontation (Chinyio and Akintoye, 2008). Stakeholder management aims at identifying stakeholders who have stake in the success or failure of a project and developing a plan for managing their interests, their influence and their involvement in the project to gain their support. In particular, by stakeholder engagement we mean involving them in practices that help to align stakeholders' knowledge (Reich et al., 2014). Knowledge sharing is essential to the concept of knowledge alignment because congruence of knowledge – i.e., a mutual understanding among the stakeholders – cannot be achieved without sharing. Communication is a key component of a stakeholder engagement initiative.

In this context, the communication strategy plays a critical role for the social acceptability of a project. Note that there are several communication approaches for

sharing information among project stakeholders: interpersonal/impersonal communication and push/pull communication. A unidirectional approach to communication towards the general population, i.e., a push approach without any feedback process, may prevent any adjustment of the project to meet the expectations of the various social participants. Participatory engineering is a typical approach to bidirectional communication. For example, in the case of a LEP, during the planning and design phase, the involvement process should be a two-way process allowing the stakeholders to influence the decision-making process. On the contrary, during the construction phase, it may be only a one-way process normally focused on the dissemination of construction-related information to the public (El-Gohary et al., 2006).

Shohet and Frydman (2003) claim that the achievement of project goals is highly dependent on the effectiveness of the communication process with the main stakeholders involved in the project, in particular in terms of accuracy, understanding, timeliness and completeness. Olander and Landin (2005) claim that an important issue for project management is to identify those stakeholders who can determine a significant impact on the project and manage their expectations through a suitable communication process from the early stage of the project.

5 Early engagement

From the perspective of improving the planning capability of the project, stakeholder management means identifying the stakeholders that can provide a significant knowledge contribution to the project, and engage them to obtain such contribution.

In particular, the early engagement of all the stakeholders independently from the stage of the project life cycle in which they may be involved in or be impacted by the project is an important success factor for the project (Rowlinson and Cheung, 2008). The main decisions related to a project (e.g., size, location, technology, financing, schedule, etc.) are made during the early stage. After this stage is complete, it is more difficult to take into account stakeholder claims that would have a major impact on the definition of the project. The early stage of the project plays a critical role and requires active stakeholder management during the project's shaping phase to choose a strategy accommodating stakeholders' interests (Miller and Lessard, 2001; Kolltveit et al., 2004; Flyvbjerg et al., 2002; Aaltonen and Kujala, 2010).

In general, the early stage of the project life cycle is the most critical, since at this time strategic decisions are to be made, even though the available knowledge is limited. Since uncertainty and complexity arise from a lack of knowledge, it is strictly linked to the inability of the project team to exploit all the available internal/external knowledge, in particular stemming from the stakeholders (Williams and Samset, 2010; Williams et al., 2009).

Making stakeholders' knowledge accessible to others creates new knowledge. Regular inter-stakeholder knowledge-sharing sessions allow for creation, integration and transfer of specialised knowledge and generation of innovative ideas (Hadaya and Cassivi, 2012).

Without adequate stakeholder engagement, the project team may miss critical information and possible future events that may impact on project performance. The project team should involve the stakeholders, including the stakeholders intervening in the last phase of the project, as early as possible. This results in anticipating possible

issues that the project may face along the whole life cycle. For instance, involving construction expertise early in the design stage is a prerequisite for improving constructability.

As for project control, stakeholders play a decisive role throughout the entire project life cycle in capturing the weak signals that anticipate emerging issues for the project. Focusing, for instance, on project risks, the risk triggers are an example of weak signals that anticipate the risk event (Hartono et al., 2014). Ansoff (1975) stated that a strategic surprise does not appear out of the blue; it is possible to anticipate its occurrence by the aid of weak signals (triggers, early warnings, symptoms, clues, etc.). A weak signal has been defined as "imprecise early indications about impending impactful events. All that is known of them is that some threats and opportunities will undoubtedly arise, but their shape and nature and source are not yet known". For instance, earned value management uses changes in the trend of performance indicators at time now – which may be considered as early warnings – to anticipate future issues requiring immediate proactive measures (Haji-Kazemi et al., 2013).

Many weak signals may be observed along the project life cycle and must be interpreted, and made sense of, by the project team to take proactive measures able to minimise the impact. The evidence of the signals improves in time but the time available for taking effective measures decreases, since the issue's occurrence time does not move farther.

In this complex context, leadership plays a critical role. Leaders who seem to be able to function very effectively in a complex environment are effective cognitive integrators. The role of the project manager is central in orchestrating the knowledge sharing among and between various organisational stakeholders. Knowledge sharing can be difficult because each profession, department and organisation has its own language, ethos, organisational responsibilities and physical barriers. A plan for structuring intra-organisational and inter-organisational knowledge sharing is necessary. So, core stakeholders may be defined as those who dominate the knowledge-sharing structure in the project network.

Two different views of the role of the project manager, as a project leader, may be identified:

- In the first case, the project integration relies mainly on the project plan, as a set of detailed planning and control procedures concerning all the stakeholders/organisational roles involved in the project. In this case, the project manager performs the role of 'the owner' of the project plan;
- In the second case, a decentralised approach to project management may be implemented, based on relevant degrees of freedom to each organisational unit. The project manager, as a project leader, undertakes the role of integrator of the various autonomous groups with different culture and focus, and becomes 'the bridge' between diverse 'languages', supervising the interface relationships between different organisational units. Project managers must communicate and interact with stakeholders so that the *perceived* strengths, weaknesses, opportunities and threats of the project are identified and realistically acknowledged across the project organisation (Olander and Landin, 2008).

The main advantages of the second case are:

- fostering cultural diversity, as a way of allowing each organisational unit to monitor and adapt in a more effective way to its own environment, so improving overall project's responsiveness
- developing innovation opportunities through the direct interaction of different organisational units, across the project.

6 Conclusion

The paper focuses on project planning and control. Since every project is exposed to uncertainty, ambiguity and complexity, all of them deriving from a lack of knowledge, an effective process of forecasting/planning depends on utilising all the available knowledge. The paper proposes a Bayesian integration between explicit and tacit knowledge and highlights the contribution of knowledge given by the project stakeholders.

Project stakeholders are not only the main contributors to project progress and the main sources and bearers of risk but also the main knowledge sources for the project. The role of stakeholders is very important both in project shaping at project outset and in catching weak signals to anticipate possible issues throughout the project life cycle.

The contribution given by the stakeholders, about the future development of the project, may concern: the impact from drivers, which explain the project development during the past and also presumably affecting the future, possible behaviour of the stakeholders involved in the project, certain/uncertain events or conditions affecting project performance in the future, which may originate both internally and externally to the project, and weak signals indicating emerging situations, which could possibly affect project performance.

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