How Hard Can It Be?

Actively Managing Complexity in Technology Projects

The complexity assessment tool offers a framework for articulating, assessing, and managing sources of complexity in technology projects.

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OVERVIEW: The business of technology firms depends on the successful delivery of projects. These projects can be complex and, some say, increasingly so. Assessing and proactively managing that complexity can benefit project delivery. Based on a systematic literature review and multistage field research, we sought to understand the nature of different dimensions of complexity and how they affect the development of a project. Working from that research, we generated a complexity assessment tool, which was tested initially with a global technology firm and then with a wider network of large organizations in other sectors. The result is a complexity-based view of project management that enables greater specificity in articulating, assessing, and coping with both generic complexities and particular context-dependent challenges.

KEYWORDS: Project management, Complexity, Active complexity management

There are significant opportunities for organizations seeking competitive advantage through their approach to managing projects, since despite considerable investment in project management systems and training, projects are still reported to have variable success rates across all sectors (The Standish Group 2009; Flyvbjerg, Bruzelius, and Rothengatter 2003). Understanding and actively managing project complexity has the potential to identify better processes, staffing, and training practices, thereby reducing unnecessary costs, frustrations, and failures.

Managing complexity is becoming a more urgent concern for many companies because the complexity of projects and management systems appears to be increasing. Jelinek et al. (2012) note the "perfect storm" of increasing complexity for managers and organizations, induced by increased outsourcing and offshoring of R&D, greater market uncertainty, and greater technological uncertainty; 57 percent of the 3,018 global respondents to IBM's Essential CIO Survey (IBM 2011) expected more complexity and change over the next five years. This is a problem that is not going away.

A number of publications have claimed that complexity can be beneficial (for instance, see Stacey 1996). These authors argue that innovation happens in systems with a complexity level "on the edge of chaos." Pascale, Millemann, and Gioja (2000) explain that "the edge of chaos is a condition, not a location. It is a permeable, intermediate state through which order and disorder flow . . . The edge is not the abyss. It's the sweet spot for productive change" (61). While this is an attractive notion, especially in a world where growing complexity seems unavoidable, it is disconnected from reality in two regards. First, complexity cannot be objectively quantified; rather, it is subjectively experienced and handled, or suffered, by managers. As a result, it is not possible to see

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where this mythical point, the edge of chaos, is in practice. Second, our combined 60 years of experience has shown us that the greater the complexity posed by a project, the lower the chance that any successful outcome, let alone an innovative one, will be achieved.

We were motivated by these observations to find a way of understanding and actively managing complexity in projects, both to reduce its risks and to access its potential benefits. If complexity can be better understood, our studies show, then it can be removed or reduced and managed to ensure that the levels and kinds of complexity in play fit with organizational capabilities. To that end, we have developed a complexity assessment tool that allows managers to identify and assess early in the process the kinds of complexity in play in a given project.

What makes *your* project complex to manage?

"What makes *your* project complex to manage?" is a deliberately specific question: it is about your experience. Complexity is a subjective notion, reflecting the lived experience of the people involved. The complexity of projects can be likened to risk in projects—highly dependent on perception and influenced by conscious, subconscious, and affective factors (Murray-Webster and Hillson 2008). Perception influences the judgment of whether something is complex to manage or not and the degree to which a manager believes he or she can influence the situation. Furthermore, project complexity is a dynamic, not a static concept (Geraldi, Maylor, and Williams 2011), and there is no single best way to manage it (MacCormack et al. 2012).

Why then is complexity assessment difficult? We believe that this is in large part because of the subjectivity of assessments of complexity. For any given piece of work, there will be multiple possible assessments of its complexity, depending on the individual rater. One person might view something as complex based on his or her knowledge or lack of knowledge. One manager may recognize how challenging a particular task can be, having done it or seen someone do it before; another manager might not view the work as complex at the outset because of a lack of understanding of what it actually involves. Perceptions and knowledge are intertwined with complexity and the subsequent assessment of risk. A low level of domain knowledge may be acceptable if the work is straightforward, but an accurate assessment of a difficult piece of work requires significant understanding.

Individual assessments of complexity are dependent on whether the manager believes he or she can deal with that particular complexity. This is linked to whether that manager believes he or she is personally responsible for something that may be challenging. Complexity assessments also exhibit association bias, expressed by one manager as, "My project will always be more complex than yours." The complexities identified by managers in our study tied in closely with their roles and responsibilities. Managers on the same project could describe the work quite differently—there was little shared understanding of its complexity. For example, when three managers involved in the development of a new financial system were independently asked the same questions about the complexity of that project, their responses differed considerably. The project manager focused on the problems of the system's architecture. The project management office manager focused on the particular internal process challenges. The program manager characterized the complexities in yet another way: "Everybody sees it as a technical system . . . but in actual fact it's much more of a change project because it is going to significantly change the way people work." While this kind of divergence is not itself surprising, it does significantly affect the reporting of complexity.

At the same time, any project rating is unstable, based on what is perceived at the time of the rating. The complexity of a project might be expected to decline over the course of the project's life, as unknowns become known and the period to which any uncertainty refers shrinks. We found, however, that events such as major changes in requirements, abandonment of work by delivery partners, and technical difficulties arising in integration emerged within the cases we studied, increasing complexity as the projects developed. We conclude that assessments of complexity must be explicitly time bracketed, with the project considered in its entirety or for the next phase only, with the understanding that the assessment will need to be revisited.

Complexity is a subjective notion, reflecting the lived experience of the people involved.

Not complexity, but complexities . . .

As our initial studies progressed, we identified another factor making it difficult to assess complexity: it became clear that there is more than one dimension to complexity. Our original empirical study identified the items that made projects complex to manage (see "Methodology," p. 47). Combining this information with the findings of a systematic literature review and further field research, we moved from a binary understanding of complexity in projects (the work is complex, or it is not) to thinking about three dimensions of complexity:

- Structural complexity
- Sociopolitical complexity
- Emergent complexity

Structural complexity is associated with size, variety, breadth of scope, the level of interdependence of people or tasks, or the pace of the work. It is the most easily recognized of the complexities by both practitioners and researchers and is also described as complicatedness or the level of interconnectedness. For instance, one of our cases described the development of a new product for a large firm, where the

Methodology

We began by grounding our understanding of complexity in a thorough review of the literature. An initial review revealed little empirical evidence for the definitions presented by many authors (see, for instance, Jafaari 2003; Shenhar and Dvir 2007). As a result, we broadened our search, starting from a deliberately naïve question: "What makes a project complex to manage?" We set out to answer this question through interviews, workshops, and focus groups that solicited the views of over 120 managers from multiple sectors, producing more than 1,000 individual statements. These were coded as 160 separate concepts that provided the basis of our initial framework, which has been published separately (Maylor, Vidgen, and Carver 2008). This work was elaborated through a systematic literature review of previous studies of complexity using the process described by Tranfield, Denyer, and Smart (2003). The results of the literature review have also been published separately (Geraldi, Maylor, and Williams 2011). This preliminary work informed our subsequent fieldwork.

In parallel with the development activities, we undertook case study research to explore the perceptions of, and responses to, complexity in development projects. Eight technical project cases from diverse settings (three from the finance sector, two from telecoms, two from government services, and one from healthcare) were prepared. Assessments involved interviewing three to five managers individually for each case and gathering extensive organizational data. As a result of this work, together with further development and testing through workshops, interviews, and observed trials with a range of major organizations from several sectors, we produced the final classification of complexities, a tool for identifying and assessing sources of complexity—the Complexity Assessment Tool (CAT)—and an approach to actively managing complexity.

program manager commented, "We're talking about 450,000 end users, which doesn't necessarily make it complex, but when all of those 450,000 have different requirements, then that does make it quite complex." The complexity associated with pace can be particularly challenging as the faster the pace, the greater the resource intensity and therefore the more complex the project is to manage, albeit for a limited time. This may be the case, for instance, in a project developing a new piece of consumer electronics.

Sociopolitical complexity is associated with the project's importance, its people, power, and politics, both within the project team and in the wider stakeholder communities. In one of the cases, the program manager noted, "You've got multiple relationships within the bank. They've all got their own agendas, they never look at the thing as a whole." The number of stakeholders represents a structural complexity, but their different agendas cause sociopolitical complexity.

Emergent complexity comprises uncertainty and change. Uncertainty is typically the result of novelty of technology or process (Wouters, Roorda, and Gal 2011), a lack of experience, a lack of availability of information, or some combination of these. Change, on the other hand, appears to be inherent in R&D projects—including changes in requirements, in technology, in stakeholders, and in the organization itself. We identify emergent complexity as a challenge caused by a potential or actual change in either a structural or sociopolitical element. As an example, one of our cases had considerable uncertainty. The project manager reflected, "We've got a balanced scorecard which we fill in and [the clients] fill in, and we said, 'In terms of technical direction we haven't got a clue which way you're going.' And they said, 'No, you're right, because we really don't know either.'" One complexity of managing this project came from the certainty that requirements were going to change, yet without predictable timing or direction. In this third dimension, we identified the overlap between emergent complexity and risk; that is, uncertainties that would affect project objectives should the uncertain situation or event become a reality.

With this fuller understanding of complexity in mind, we aimed to develop a practical way for managers to integrate active diagnosis and management of all of these complexities. The three complexities provide a useful high-level classification, but greater granularity was needed to guide discussions about specific complexities and their management. Our objective was to capture the results of the fieldwork and literature analysis in a list of potential complexities sufficiently large to be comprehensive, yet not so large as to become a barrier to use. Over a period of several years of testing and revision, we combined and reduced elements from an original list of 160 items, gleaned from literature and our own work. The result was the Complexity Assessment Tool (CAT), an assessment tool designed to identify the elements of complexity in a project and guide discussion of those elements.

The Complexity Assessment Tool (CAT)

The result of this work is the Complexity Assessment Tool (CAT). The purpose of the CAT is to enable the early identification of complexities so that they can be managed to minimize their negative impact on the project and the team. The tool comprises a set of 32 statements that encompass all 160 of the themes identified in our foundational work (see "The Complexity Assessment Tool," p. 48). The 32 statements are complete and generically applicable to a broad range of projects, although the statements may be tailored to fit specific scenarios better.

For the purposes of a practical tool, the original 160 concepts were too unwieldy. Questions as to the presence of each particular element of complexity could be covered in a facilitated discussion of about 40 minutes, but there was considerable overlap between the elements, and the effectiveness of the process was highly dependent on the facilitator. Through a series of trials within Hewlett Packard Enterprise Services and with senior management teams from a range of public entities (including the U.K. Government, National Health Service, and Police Service) and private-sector

The Complexity Assessment Tool

Areas of complexity • Structural Complexity (1–21) • Sociopolitical Complexity (22–32) • Emergent Complexity (defined by expectations for stability)		Do you agree with this statement? (Y/N)	Do you expect this situation to remain stable (i.e., NOT to change)? (Y/N)
Structural Complexity			
1	The vision and benefits for the work can be clearly articulated.		
2	Success measures for the work can be defined in agreement with the client.		
3	The technology is familiar to us.		
4	The commercial arrangements are familiar to us.		
5	The scope can be well defined.		
6	Acceptance criteria for quality and regulatory requirements can be well defined.		
7	A schedule and resource plan can be well defined.		
8	The supply chain is in place.		
9	Lines of responsibility for tasks and deliverables can be defined.		
10	Accurate, timely, and comprehensive data reporting is possible.		
11	Existing management tools can support the work.		
12	Sufficient people with the right skills are available.		
13	Managers have adequate control of human resources (i.e., direct reporting).		
14	Key people are wholly allocated to the work.		
15	Integration across multiple technical disciplines is not required.		
16	The budget is sufficient for the task.		
17	The budget can be used flexibly.		
18	The work will be carried out in a single country/time zone/language/currency.		
19	The work is independent of other projects and business-as-usual operations.		
20	The pace is achievable.		
21	Resources (e.g., test facilities, equipment) will be available when needed.		
Sociopolitical Complexity			
22	The work has clear sponsorship consistent with its importance.		
23	The business case for the work is clear.		
24	The goals for the work align with the organization's strategy.		
25	Your own senior management supports the work.		
26	Team members are motivated and function well as a team.		
27	Managers are experienced in this kind of work.		
28	The work involves no significant organizational/cultural change.		
29	The work will be unaffected by significant organizational/cultural change.		
30	The external stakeholders (i.e., not immediate team members) are aligned, supportive, and committed to the project and have sufficient time for the work.		
31	The external stakeholders (i.e., not immediate team members) have a realistic, shared understanding of the implications of the work.		
32	The core team has the authority to make decisions.		

organizations (a major national infrastructure provider, a defense contractor, a financial institution), we sought to streamline and simplify the tool. Examination of responses to early versions showed where different complexities had the same effect on the management task and so could be combined. Various versions also provided the opportunity to trial multiple versions of items and different presentation formats (as questions or statements). Over time, the feedback from practitioners participating in trials gradually evolved from suggestions for improving the tool to thoughts about how they could use it in their work. The final version was tested with live projects, initially administered by facilitators, and generated positive feedback from participating project teams. Participants noted that the tool allowed them to reflect upon their projects and identify the most important areas to focus their time on, as well as allowing teams to discuss issues openly. As one senior manager told us after using the CAT with his team, "One comment I got back was that it's nice to have somebody to appreciate that there are problems out there, and not just try and paper over them."

In use, the benefits of the CAT arise not directly from the questionnaire but from the subsequent conversations between managers involved in the project. In our trials, managers responded positively to the tool, as it offered a structured approach to thinking about a project, highlighting issues they may not have considered previously. This is the major benefit of the approach—as a tool to bring to light individuals' conceptions of the project, allowing them to be shared to promote a broader, more holistic, and common understanding among the team. The CAT is, in other words, a tool for sensemaking. Participants admitted that before using the CAT they might have been making decisions at cross-purposes to their colleagues, due to dissimilar perceptions of the work. In addition, participants in the trial suggested that external facilitation would be helpful, not only in providing guidance and structure, but also to alleviate power or status differences between participants. Managers reported this to be a powerful technique; even those who had worked together closely for years valued the insight the process gave.

The framing of the elements as statements facilitates the discussion with colleagues. All of the items are phrased as particular challenges, designed to identify real, significant sources of complexity. For instance, a negative response to an early framing of a question as "the scope *is* well defined" had the effect of prompting the team to go back and define it better, a relatively trivial solution that may or may not diminish complexity. We asked, instead, if the scope *can* be well defined. A "no" in response to this item represents a nontrivial challenge. Each of the statements regarding structural (21) and sociopolitical complexities (11) is traceable back to the systematic literature review and to particular elements in our original thematic list.

Emergent complexity is a result of potential or actual changes in the state of one or more of the 32 items captured by the CAT's list of statements. As a result, the tool measures emergent complexity differently, capturing it as the number of expected or possible changes in structural or sociopolitical sources of complexity. For example, managers might agree with the statement that "the budget is sufficient for the task" at the beginning of the project but express uncertainty over potential funding changes that may cause the budget to be insufficient for the task at a later stage. That uncertainty represents a potential emergent complexity, tracked in the right-hand column of the tool by an indication that the element may be unstable and therefore subject to change.

Having identified the complexities and their potential instability from the list, we now look for some overall assessment of the project. For each of the dimensions, a qualitative assessment of "high," "medium," or "low" may be assigned based on aggregate responses and subsequent discussion. A "high" rating is given where many of the items in one dimension have evoked negative responses or a few specific items (or just one) are seen as particularly challenging. The result of such rating may be a complexity summary diagram illustrating the dimensional nature of the complexities for a given project (Figure 1). This diagram provides an indicator for discussions with, for instance, clients or senior managers, about

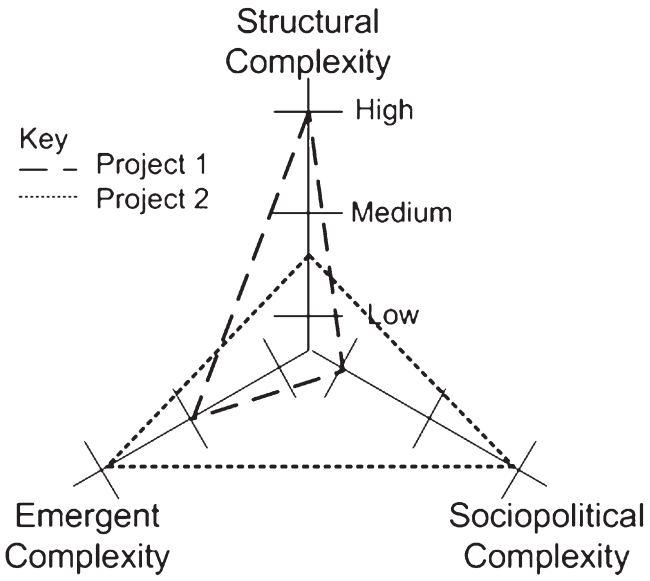

FIGURE 1. A complexity summary diagram

the nature of the complexities being faced in the project. For instance, in the example, Project 1 has very high structural complexity—as we would expect from a big technology project. On the other hand, Project 2 is lower in structural complexity but high in both sociopolitical and emergent complexities. This would be typical in a major organizational change, such as restructuring.

So what? And what now?

Our work has three main implications for organizations. The first, following from the assessment of complexities via the CAT, is that complexity can be actively managed; the project team can work to remove, reduce, or proactively address sources of complexity. The second is that projects can be selected based on their complexity. Third, project personnel and processes must be fitted to the particular residual complexities a project faces (Figure 2).

Actively managing complexity

Our approach recognizes the subjective nature of complexity and encourages conversations around complexities. This is necessary but not sufficient to benefit from taking a complexity-based view of projects. Having identified and agreed on the complexities within a piece of work, managers must next identify what can be done about each.

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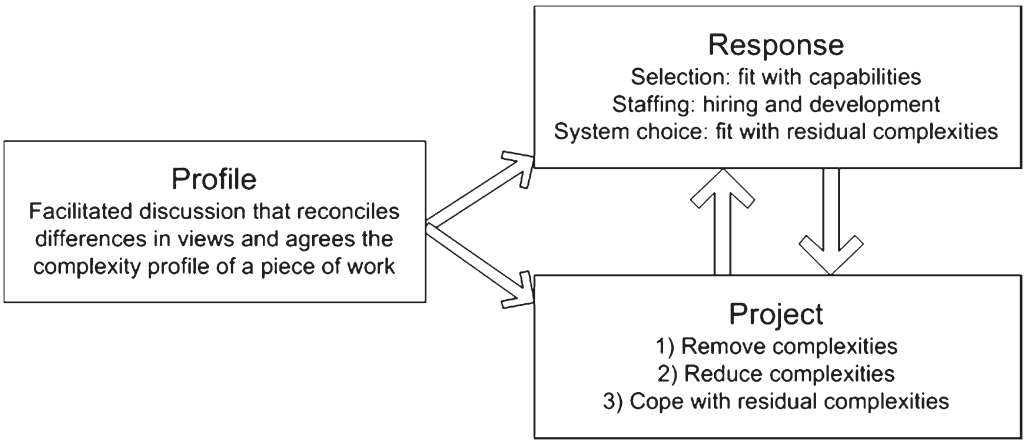

FIGURE 2. Active complexity management

One of our cases, a large multiyear government project, illustrates the benefit of the dialogue that the CAT promotes and demonstrates how the complexities identified in the CAT process can be managed. The challenges included multiple agendas for the project within the client organization (high sociopolitical complexity) and a contract that assumed certainty for the duration of the work. In reality, right from its inception, the project changed considerably (high emergent complexity). Additionally, the supplier's assumption that the primary objective was low cost was at odds with the client's requirement for on-time delivery and a specified minimum level of performance, with some flexibility in the available budget (high sociopolitical complexity). The senior managers on both sides were constrained by their organizational procedures and had limited (formal) flexibility to accommodate the other's difficulties (additional sociopolitical complexity).

Recognizing that the complexities were benefitting neither party, the two most senior managers involved met off site (neutral territory) to identify and acknowledge the high sociopolitical and emergent complexities of the project. They removed some elements of complexity through negotiation, and reduced others through acknowledgement of their existence and a joint effort to resolve them (at least partially). The remaining elements had to be lived with but at least with a shared understanding of the difficulty. There was an agreement that any changes could be discussed further with explicit give and take. This openness, which was counter to the culture of both organizations, had the effect of reducing the sociopolitical and emergent complexities, as assessed by both sides, to a lower level.

Even when complexities can be managed, either by removing sources of complexity or reducing their impact, some residual complexities almost always remain, requiring response.

Project selection, staffing, and systems

Even when complexities can be managed, either by removing sources of complexity or reducing their impact, some residual complexities almost always remain, requiring response. The first response is active selection of projects. For instance, a firm with advanced capability in the delivery of projects with high structural complexity may be wary of taking on a project that has very high sociopolitical complexity. The CAT assessment provides input to guide such a choice.

The second response is in project staffing, specifically in the selection and development of the project management team. Understanding the dominant complexities within a piece of work allows the allocation of a manager with the appropriate experience and skills. For example, if the complexities are primarily structural, a more planning and control-oriented "managerial" approach may be warranted; to address sociopolitical complexities, a skilled relationship builder who takes more of a "leadership" approach may be preferable. And where emergent complexity is anticipated, flexibility in management is key, and the manager must have an ability to work with uncertainty and change; a more "entrepreneurial" style is called for.

Understanding complexities can also lead to better targeted learning and development activities for managers. In a teaching session on complexity, we asked 246 project managers, "In your work, which of the three complexities are the most difficult to manage?" We then asked the same group, "In your own formal training and development, which of the three complexities has received the most attention?" The contrast between the complexities they faced and the organizational response through learning and development was clear—the area most project managers (68 percent) found most difficult to deal with was sociopolitical (Figure 3A), yet a great majority (87 percent) said their training and development had focused on structural issues (Figure 3B). Having this language for discussion enabled the identification of a significant area for development by the firm. The capability to manage sociopolitical complexity can be enhanced by development activities that focus on stakeholder engagement, project leadership, and change and communications management. Many elements of this complexity can be turned to benefit through focusing on relational rather than procedural aspects of management.

The third response is a process choice. More robust formal processes may be a suitable response to high structural complexity, but may limit the possibilities for responding to

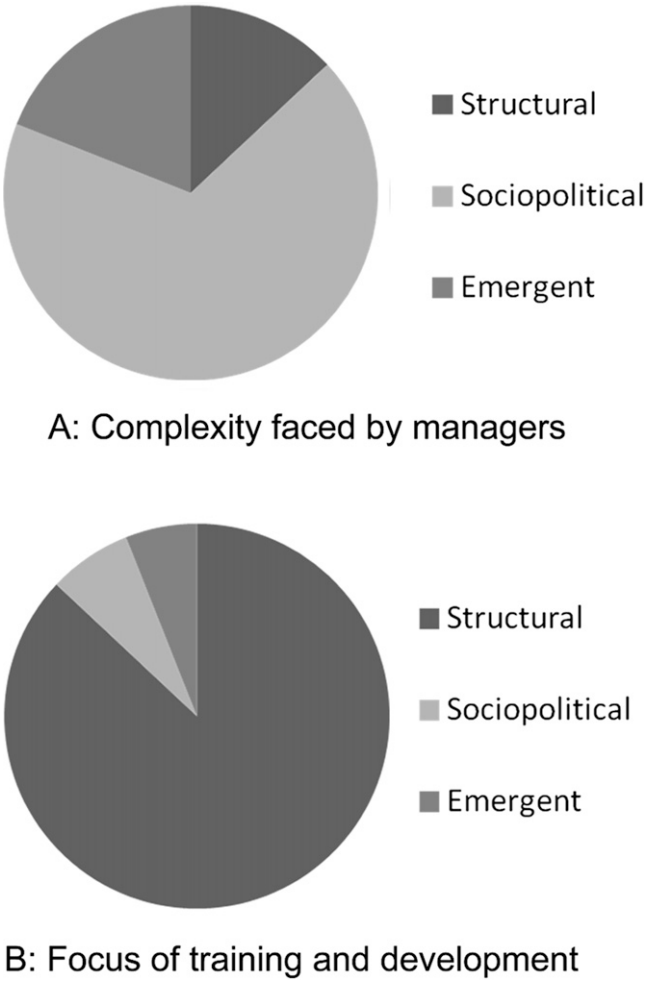

FIGURE 3. Complexity faced by managers vs. focus of training

sociopolitical and emergent complexities. Indeed, many organizations inadvertently increase project complexity as a result of their reliance on formal processes, which can act as a constraint on appropriate, flexible managerial responses. Better understanding the nature of the work, and the complexities that come with it, can allow processes to be tailored to suit the project.

Conclusion

Although complexity comes in different forms—structural, sociopolitical, and emergent—managers are frequently prepared to deal with only one type of complexity—structural. The CAT can help by structuring the approach to complexity, helping project teams to identify sources of complexity by asking a set of pertinent questions. This systematic approach to facilitating discussions can surface difficult issues and develop consensus regarding challenges and the best way to approach them. Once the team agrees on what the specific complexities may be, complexity may be removed or reduced, or it may remain as residual complexities that must be managed. Whatever the approach to managing complexity, the CAT provides a language and a system for articulating and dealing with the practical difficulties inherent in new-product development projects.

"Structural complexity is hard. The rest of it, now that's *proper* hard."

Our initial question was, "How hard can it be?" In the words of one chief executive involved in this study, "Structural complexity is hard. The rest of it [sociopolitical and emergent complexities], now that's *proper* hard." The complexity-based view provides an organization's leaders and project teams with a way of describing how hard their projects are to manage, and most importantly, how they can be supported better and hindered less by the organization.

How hard can it be? A simple notion or just too complex?

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