ONTONIX
COMPLEXITY MANAGEMENT

Business Dimensions

COMPLEXITY MEASUREMENT

A new, comprehensive metric for project management

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A new, comprehensive metric

BACKGROUND

The dynamism and volatility of a project or a portfolio (frequently changing scope, objectives, priorities, resource allocation, etc) imply that the project can no longer be managed and governed with static or predefined metrics, methodologies and best practices.

As the environment in which a project has to be managed becomes uncertain and unpredictable, it becomes necessary, if not mandatory to measure, manage and control the ***complexity*** of a project.

This is particularly true for mega projects that involve multiple stakeholders who may be geographically dispersed and that affect multitudes of beneficiaries. Such projects are too big to fail and may be termed too complex to fail (TCTF). Such highly complex projects, offering, introducing or enabling innovative technologies that must respond to organizational changes or business needs are inherently fragile. **Their fragility is proportional to their level of complexity**. A project with a fragile structure can suddenly, without warning, exhibit behaviors and reactions that could lead to unexpected results not in line with the defined objectives. It is therefore preferable to design and maintain a ***less complex*** project providing the same level of performances and results.

If properly controlled and managed, complexity will become a critical factor of success in the development and implementation of projects.

Therefore, it becomes important to adopt a comprehensive metric to objectively measure the complexity of large, complex and unpredictable projects or program environments.

This paper describes how the complexity of any project can be measured. Below, we shall show, how through its measurement, complexity can provide a significant value add to the management. First, as an early warning indicator that can forecast and forestall possible crises in time-sensitive situations. Second, from a business intelligence point of view, allow identifying the main factors that generate or increase the level of complexity. The goal of managing TCTF projects will essentially be to decrease the level of complexity to the "physiological" limits of a project where complexity is properly balanced between benefits and risks.

Conventional approaches and emphasis

Best practices, for completing a project with a good chance of success have been well established The most popular are the PMI (Project Management Institute) or IPM (International Project Management Association). Derived best practices and methodologies such as Prince2 or GDPM, describe a structured vision for determining how to improve elementary or constituent processes.

The PMBOK (www.pmi.org) provides the following project definition: "A project is a temporary endeavor undertaken to create a unique product, service or result. A project must be planned, controlled and executed by the management who draws its motivation in establishing clear objectives."

Applying a strategy through the implementation of change processes requires the establishment of an organizational structure that:

- Involve technologies, applications, know-how and availability of people and skills;
- Knows how to balance the need for change within the current principle of management.

But this is not enough: You must ensure that the project (processes) will have the ability to co-evolve with the company's organizational structure, involving all other actors in the business environment and its ecosystem. We can then say that a project becomes a key element governing the process of change to achieve the desired results.

Then, we can all agree that managing and governing are multidisciplinary approaches, in terms of knowledge, techniques and practices, which must integrate an effective way to manage the scope of the project (time, cost and quality) with a particular attention to :

- Skills and knowledge;
- The use of human resources;
- Control of the risks;
- Care about the communication;
- The selection of sources of supply.

These necessary preconditions in conventional approaches are not sufficient today. So far, project management best practices have mainly focused on how to manage and govern projects without a strong emphasis on managing complexity. While in reality, projects have a capacity to surprise which is typical of complex systems.

In fact, a project works the same way as an interacting living organism which must adapt and evolve interacting with different internal and external systems (its ecosystem) which are subject, like any living organism, to many uncertainties.

Traditional approaches, therefore, do not give a proper emphasis to the measurement of a project complexity. It becomes very difficult, in quantitative terms, to answer to questions such as:

- What is the project completion?
- What are the most complex projects of a program or portfolio and how do they affect the total complexity of the program or portfolio?
- What are the contributions from individual project tasks or elements to the complexity of projects?
- What are the most unstable or uncertain projects, within a program or portfolio?
- Is a project or portfolio able to sustain and deliver its stated objectives in an increasingly uncertain environment?
- What critical plans and resources will affect a project success or failure?

One of the main reasons for the difficulty in answering these questions is the lack of an objective measure of complexity.

METHODOLOGY

A common definition of complexity

Before defining complexity, it is important to clarify the some basic differences between a complicated process and a complex process. While the two adjectives are used interchangeably, there is, in fact, a substantial difference.

A system can be complicated but with a low or no complexity. A complicated system, such as mechanical wrist watch, is indeed formed of numerous components – in some cases as many as one thousand - which are linked to each other but, at the same time, the system is quite deterministic in nature. It does not behave in an uncertain manner. It is therefore easy to manage. In the case of the wrist-watch – essentially a single degree-of-freedom system – one knob is sufficient. In effect it is very complicated, but with little or zero complexity.

The inverse is also true: a system can be composed of very few parts, or agents, but still be highly complex. For example, a family of 4 people that has no more than 6 socially interacting "parts" can certainly generate significant complexity from a social standpoint!

Representing the project operations, lifecycle and possible behaviors using the conventional approaches is difficult if not impossible. In order to get a better picture, we will introduce more stringent controls to prevent and limit the emergence of critical states by measuring the project complexity.

At this stage, it is clear that simply measuring the complexity will not allow predicting how a project will adapt itself to the changes it is subject to.

In such a case, can an intelligent or self-adaptive structure within a project or environment be a solution to those continuous and unpredictable changes? Or does a self-adaptive structure increase the uncertainty within a volatile and interconnected system, impacting the results, quality, schedule and anticipated costs?

To describe the complexity it is not just enough to count the number of links between the elements that determine a project environment. It is also necessary to take into account the uncertainty that exists within these links and determine the rules by which they interact with each other to dynamically create the project lifecycle.

A conceptual approach for project complexity management is shown in figure 1. Using off the shelf complexity management tools, the Gantt chart of a project can be rendered into a "Complexity and Risk map" which not only shows the links between the various tasks but also quantifies the associated uncertainties, obtained by following the conceptual approach. The map and its relation to the Gantt chart is shown in figure 2.

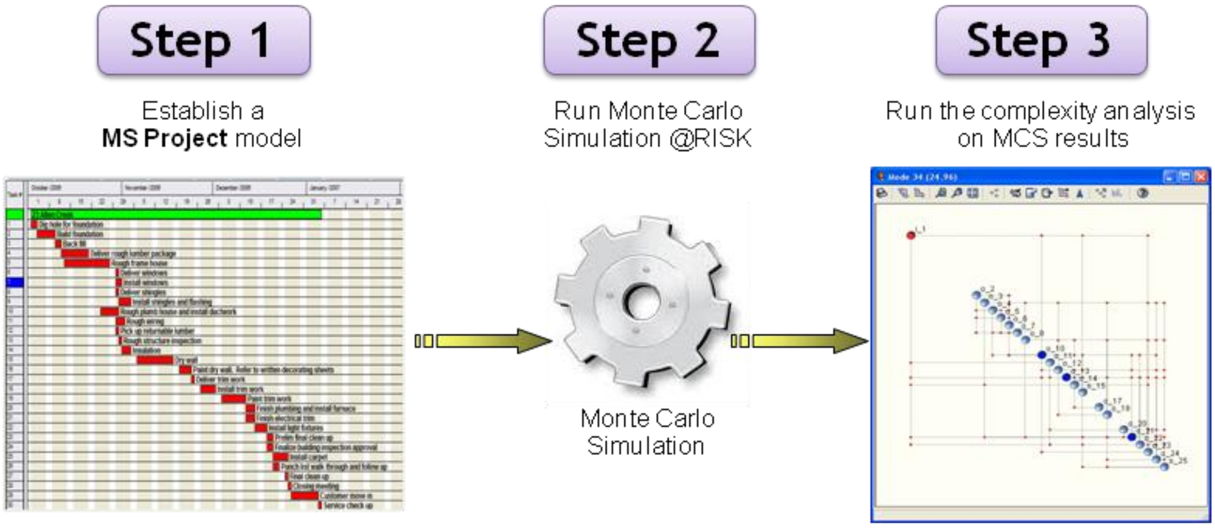

Figure 1. Conceptual approach.

The complexity "C" of a project is a measure of the interdependency and uncertainty of the constituent elements (tasks or sub-tasks), where:

- interdependencies represent the information flow existing between the different tasks or sub-tasks
- entropy quantifies the uncertainty between the relationships and provides useful information about the degree of predictability and possible behaviors of a project.

Using entropy to measure uncertainty will enable project managers to more efficiently handle uncertainty within projects.

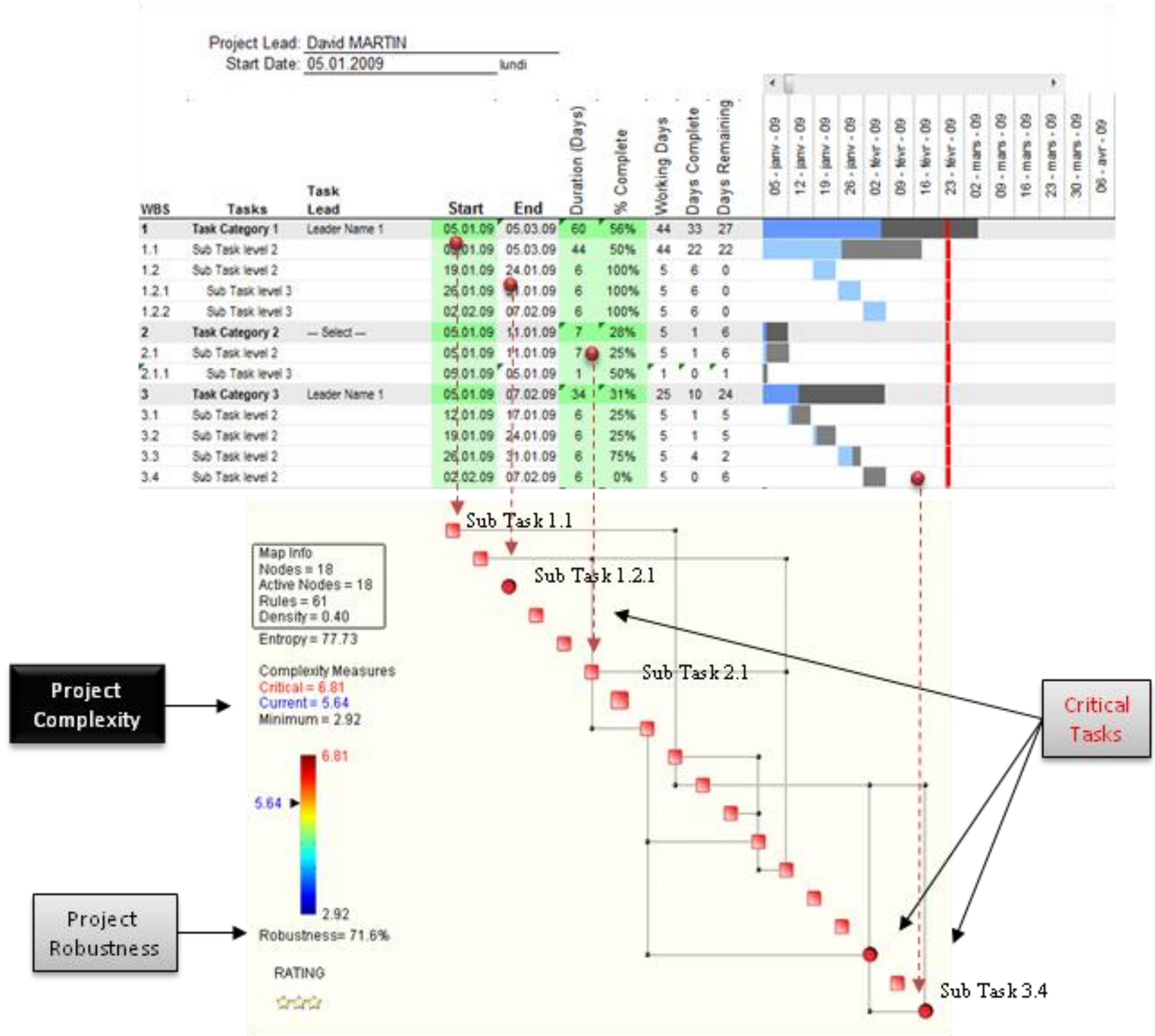

Figure 2. Gantt chart relations.

How complex is a project or program?

The variables describing the project structure (functionalities, time, human and technological resources used, internal and external costs, number of changes, etc) are represented as nodes along the diagonal. The points on the variables side are the existing links between parameters and relationship between variables within the project. Every off-diagonal link is an interdependency. It is now obvious why complexity would increase with more links. What is not obvious however is that two maps with the same number and topology of links, may have entirely different complexities depending upon the uncertainty (entropy) within the links.

The application of the Complexity and Risk Map is further extended in figure 4 to represent a *portfolio* of projects or a program. The red and blue nodes along the diagonal represent individual tasks or sub-tasks within a project. An entire sequence of reds or blues represents a complete project. The entire map is a collection of different projects, thus representing the complete portfolio. Clearly there may be links not only between the nodes of a given project (for example between reds or blues in a block) but also between the tasks of different projects (for example between the reds and the blues from different sets).

The complexity of such a portfolio may be monitored over several time periods as well. The following figure 3 reflects the typical "desired" program lifecycle, consisting in a set of technological and organizational projects. The complexity and risk maps show the structure of relations between the parameters / variables of different projects with their impact over time. The maps address all individual projects and globally, those related to a program.

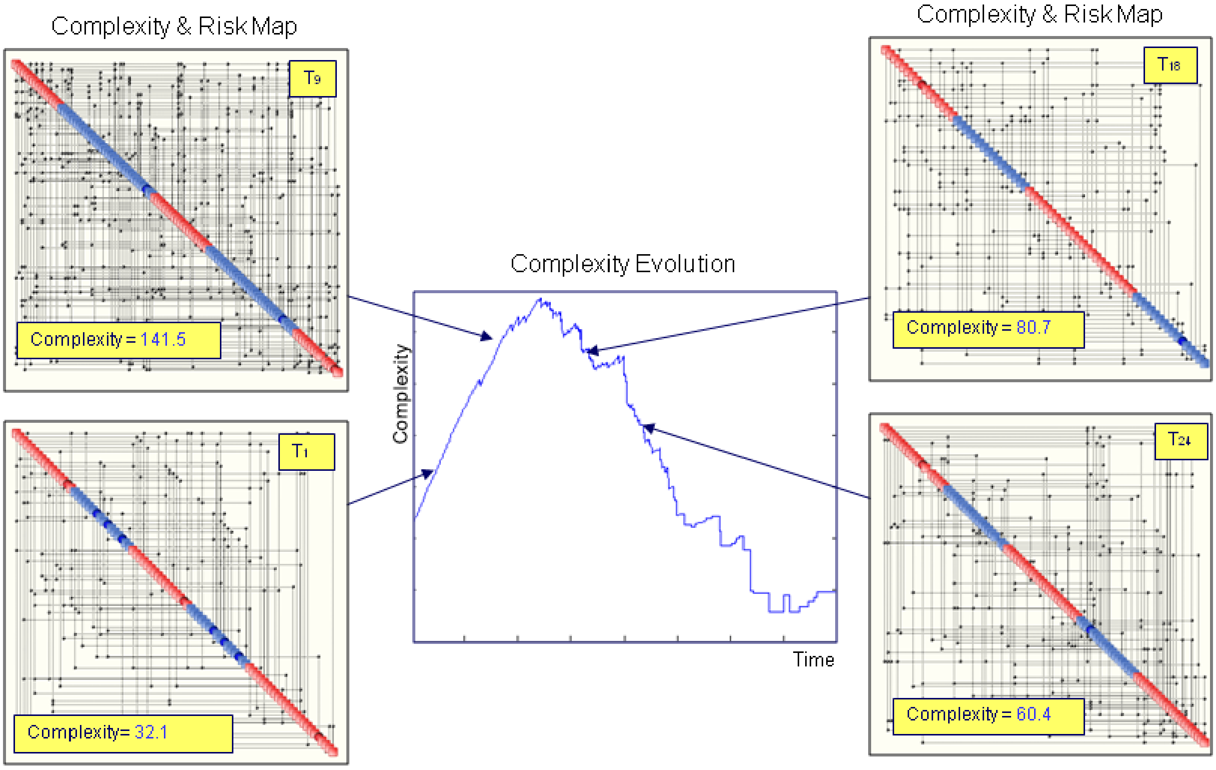

Figure 3. "Normal" complexity evolution of a program. Complexity and risk maps over time.

The process map or Complexity & Risk map is the synthetic representation of a project state at a given moment containing all basic information allowing a first and rapid diagnosis.

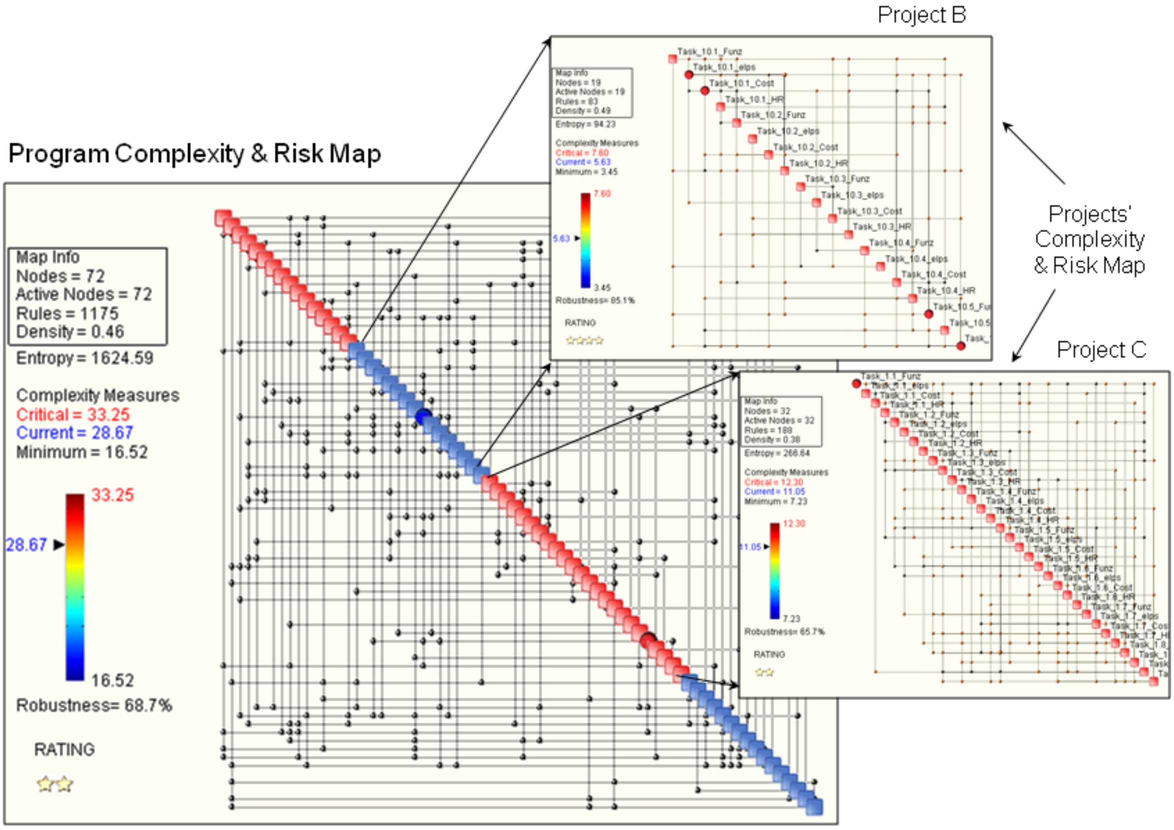

Figure 4. A program and two projects complexity & risk maps.

The map shown in Figure 4 provides an immediate overview of a program criticality level. When the program complexity (currently around 28) approaches the critical complexity level (currently around 33), management is likely to become harder. The complexity rating indicates that immediate precautions are needed to manage this program. Any actions increasing the program complexity may lead to more management difficulties and increase the program fragility.

The critical complexity of a project / program is not related to its complexity but rather to its ability to withstand perturbations. Being highly complex and close to its critical complexity (maximum) is a risk factor indicating that a slight change in the environment (external or internal) could result in a significant loss of map structure and hence project robustness.

Sudden changes, in complexity levels are the classic symptoms of possible "trauma", regardless of whether these changes are endogenous or exogenous in nature. They are clear signs of potential problems. Abrupt changes impacting the complexity level are typical warning bells indicating unstable and high-risk situations.

Therefore, to successfully manage a project, the distance between its current and maximum complexity needs to be measured and improved as an ongoing process. Measuring the complexity allows one to anticipate critical situations and adjust them to restore natural areas within a manageable complexity level. Knowing the state of a project is a competitive advantage as it allows preventing unexpected outcomes.

Other information can be derived from the maps, such as:

- The density of links. A map with a high density of relationship means that the structure of the project is rigid or that the impact of conscious changes are negligible and therefore any options for improvement are minimal;

- Hubs are tasks (or elements) that naturally control the outcomes of many other elements – for example in a building project, digging the foundation may be a natural "hub" because of its strategic role in the project execution, any delay here is likely to propagate downstream. Hubs are also the major contributors in the generation of the complexity within a project. It is "generally" preferable having a multi-hub structure than a single hub structure which will be more vulnerable. In fact, any event or action on a hub has an immediate propagation impact throughout its network.

Hubs in the map are the nodes identified with an intensity circles color greater than the other variables described by squares, both set on the diagonal.

Programs and projects can be composed by tens or even hundreds of variables correlated with each other within a very large network. The information flows coming from and going to all possible directions are "noisy", which means not deterministic (see Figure 5). Noise is inherited by the presence of uncertainty in complex projects. Noise is an open door to unexpected behaviors.

The figure below illustrates the relationship between two types of variables that contribute to a program complexity. The first case (strong relationship) is more deterministic than the second case (weak relationship). In such case, a program or project is more complex and less predictable. The intensity of the information exchanged between variables also helps to differentiate, characterize and better quantify the existence of a relationship.

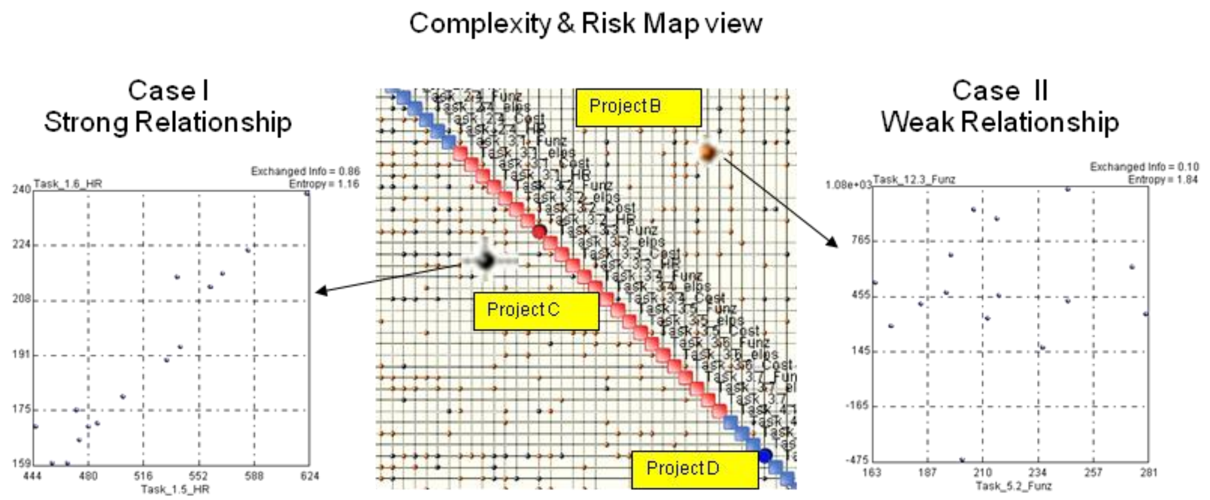

Figure 5. Examples of relationships between two variables.

Variability implies an increasing complexity, but it's also a precious source of information. If it's not pathologic or abnormal, it becomes a healthy signal that a project can react properly to internal and external changes.

Doing the appropriate distinction between complex scenarios allow us to distinguish the "associated physical state" of a project or program. A healthy project, with low entropy, strong relationships and a complexity not close to its critical complexity level will be able to better withstand sudden environmental changes much better.

CASE STUDY

We present a case study in which a portfolio consists of four projects: A, B, C and D. (see Figure 6). The complexity of the program's (see central chart) shows a manageable growth (+16% over the time) except for a small jump (12%) at a single point in its evolution (period 5).

Project "C" shows a significant growth, more than the double (+154%) within the same timeframe compared to the other projects within the program. A significant increase (+94%) should have been detected early on (see the gray area).

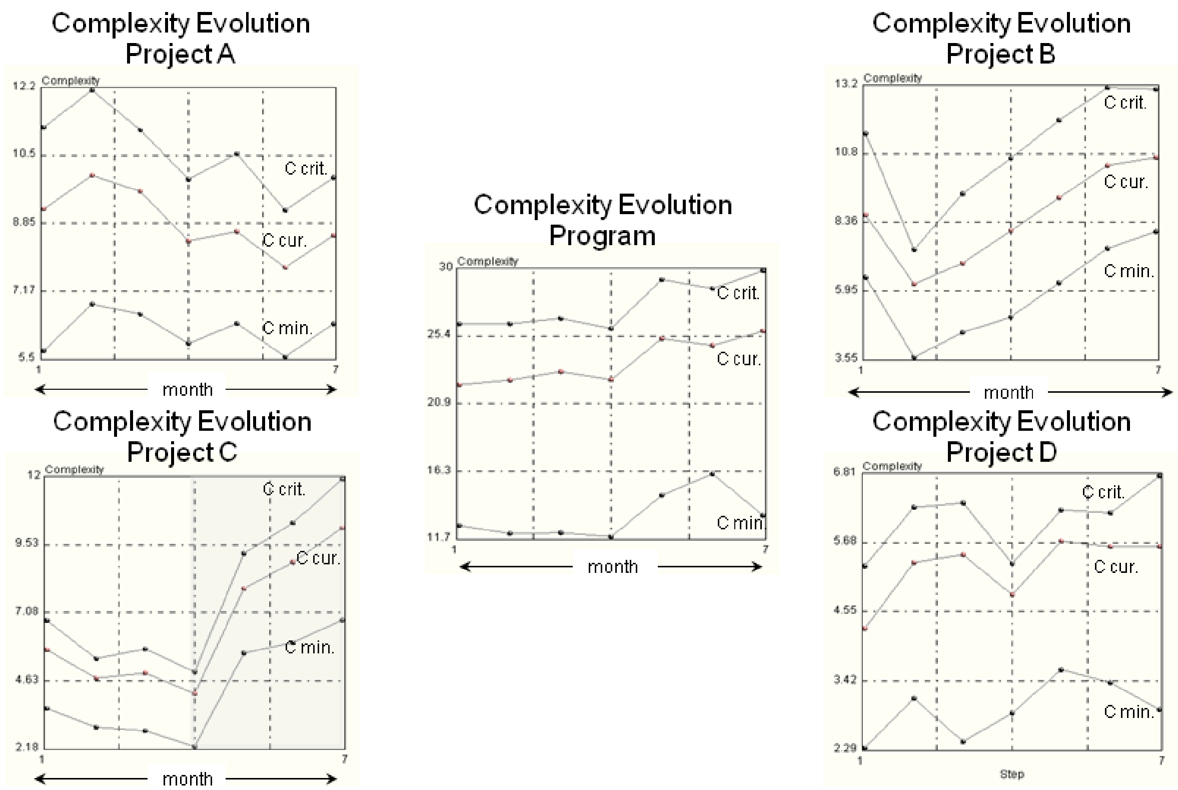

Figure 6. Evolution of complexity of the program and individual projects.

Such typical warning signs indicate a critical situation where actions are needed. The root causes for complexity growth need to be studied and understood. The aim is to verify if the growth is due to events under control or due to some unexpected exogenous changes.

A sudden change in complexity results in a shorter time window for corrective actions. A more linear growth, like in project B (+73 %) occurring gradually over six months and tending to stabilize during the last months provides a longer period to analyze the situation and simulate the possible actions that will impact the complexity of both : the project and the program.

At the reverse, the conclusion of a rapid reduction in complexity, if not due to the project efficiency or to its natural end of life, means that the map is losing its structure (interdependencies) and thus decreasing its ability to provide results and achieve its objectives. The effects of unexpected changes may also be responsible of a complexity reduction. In our example, the complexity reduction of the project A towards the final steps does not indicate a particularly critical situation, as the project is nearing its final stage.

Each project or program (see Figure 4 and 6), as we have previously pointed out, has a maximum complexity which cannot be crossed without clear structural changes. Being in a stressful (positive) situation is a competitive advantage because it allows one to extract the best from the resources allocated to the project. But, at the same time, stressful situation can be also a potential disadvantage because the project is more fragile and more vulnerable. Additionally the project or the program is overexposed to the effects of possible errors and unexpected events which could have a serious impact on the success of the project. In such situation even a minor perturbation is enough to generate unpredictable reactions and unexpected behaviors which can lead to loss of control of the project or the program.

In order to avoid such scenarios, the project must be adapted and reorganized within a new environment by acquiring new resources or by implementing structural changes to eliminate or reduce the links (features and capabilities) or drain entropy (uncertainty and unreliability) reducing the variability (competitiveness and vivacity). All these actions will impact the project balance and avoid a fast or slow inexorable decline.

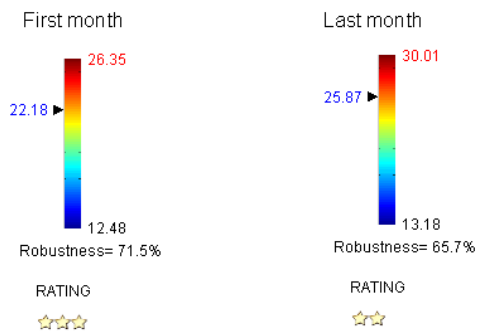

Figure 7. Complexity rating at the beginning and end of observation period.

The current complexity of the program (see Figure 7) at the end of the observation period is a logical situation where you can less efficiently impact the structure or use new resources. It's the area where it is important to raise a higher level of attention to monitor the risks and impacts of unexpected behaviors. Such critical situation may lead to inconsistent results and performances expectations.

The initial situation, opposed to the final, provide a better balance to impact the structure and get better results from all available resources with lower risks and a greater ability to handle changes.

To summarize, operating on the proximity of the maximum sustainable complexity in a manageable stressful situation will allow the project to obtain the best results from the available resources. Operating near critical complexity requires being aware and being prepared for higher risk exposures potentially leading, in extreme cases, to a project collapse.

Complexity distribution and impact

Reducing the program complexity requires information about relevant variables and action plans. Projects B and C have a higher impact on the complexity of the program (see Figure 8) Projects balance and incidence remains unchanged during the considered observation period. However, the critical impact of the project C is in relation to the significant growth of the total complexity (see Figure 6) endangering the whole program.

Analyzing the distributed percentage of impact per task (see Figure 8), allows one to identify immediately where to intervene and in particular in which project, variable and within which specific task or process.

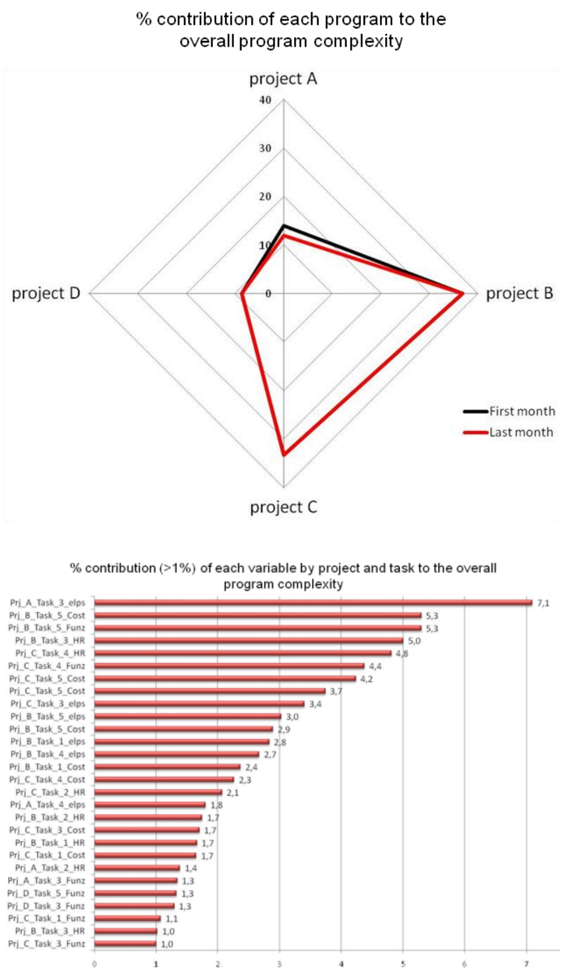

Figure 8. Distribution of drivers that mostly contribute to the program complexity.

The variables impacting the complexity are the ones which:

- Show a greater instability or those with a significant variation;
- Are hubs or have the highest number of links with other elements exchanging a greater volume of information with other network components.

All these variables can affect the program complexity allowing maximizing the use of the allocated resources in each project or within the program.

Identifying such variables allows one to better plan and forecast actions to be taken, apply individual scenarios in order to bring a project or program complexity level to its natural limit. Since the project is not an isolated set of events, its impact on a program or portfolio can be better understood. Thanks to the "butterfly effect", a project improvement could have a direct (program) or indirect (portfolio) impact to other projects.

The strong interdependencies and interconnections that exist between projects, programs and portfolios imply that a comprehensive view better serves the objectives of project management. This is because, locally optimizing one project or program may shift the complexity and entropy to another vast network enclosed in the portfolio of initiatives which share time and resources. Complexity metric is a comprehensive decision-aiding factor in selecting solutions to reduce program risk and failure.

Beyond best-practices, management and governance

Project, program and portfolio manager responsible for business change initiatives can no longer ignore complexity as part of their success or failures.

Complexity is an implicit characteristic, a key variable allowing to handle and manage initiatives at all levels in order achieve the objectives in time, within the defined budget without quality depreciation.

Complexity is a significant benefit within environments dominated by uncertainty, highly interconnected and interdependent with a strong presence of contingency and discontinuity in priorities that could break the communication flux in a structured environment.

Projects, programs or portfolio initiatives can no longer be managed through existing metrics without considering complexity.

About the authors

Giuseppe Graci, Director of Finance & Banking, has more than thirty years in advising and supporting Business Managers to reach their business objectives through the right deployment of technologies and management of complexity of their business and respective environments. Giuseppe has worked for leading research companies such as Gartner, where he held a VP position, and for management consulting firms Nolan & Norton and KMPG. He has broad international experience, having operated at board level of major financial institutions in Italy, Spain and Portugal and in other global corporations. Giuseppe is a thought leader and innovator with strong emphasis on result-oriented decision-making. He has the ability to quickly notice upcoming changes and to create an open flow of information. His background is economics with strong Information Technologies-related know-how in Financial Services. He has recently published a book on managing and governing complexity.

Dr. Deshpande has 15 years of experience in the biomedical, automotive and consulting areas. He holds an MS in Mechanical Engineering (University of Utah), an MBA (University of Michigan) and a Ph.D. in Bioengineering (Carnegie Mellon University). Before joining Ontonix, he was involved in engineering consulting at EASi and automotive product development at Ford Motor Company.

David MARTIN, Charmain of the World Complexity Forum, having operated at the executive level in various companies, including software development, business development, department and company management with the operational experience required to develop the activities within different business models.

With over fifteen years of experience in the Banking and Services sector, in aligning Information Technology with business requirements and demands by creating solutions through the establishment of proper IT projects.

About Ontonix – www.ontonix.com

Ontonix is a privately held software and services firm. The international management team collectively holds over sixty man-years of experience in unconventional risk and complexity management. Established originally in 2005 in the USA, Ontonix is headquartered in Como, Italy, and develops OntoSpace™, the World's first system which allows one to **measure and manage the complexity of a business**. Through our exclusive services we help our clients view business strategy and risk management from a radically innovative and holistic perspective. Based on the fact that excessive complexity is *the* source of exposure, we have devised a **new theory of risk** which is particularly suited for a turbulent global economy.

About the World Complexity Forum – www.wcforum.org

The World Complexity Forum is incorporated as a Swiss not-for-profit foundation.

Its mission is to provide quantitative tools and methodologies, to effectively manage the rapid rise of complexity and decrease its impact on the economy and on society.

Its aim is **to create complexity management standards and practices** which will allow governments and corporations to better manage the increasing uncertainty, fragility and vulnerability of the global society which are consequences of excessive complexity.

To carry out its mission, the World Complexity Forum will bring together members and partners providing them with a unique platform enabling them to interact through ambitious projects and initiatives.