An Innovative Integrated Approach to Manage Effectively the Complex Projects, Programs, and Portfolios [1]

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ABSTRACT

In the last ten years, the evident rise of the complexity in both the projects and the programs has been compensated just partially by the increase of the organizations' maturity in project management, and this is reflected in the field data, which confirm very little improvements in projects' performances. This paper explores extensively the domain of complexity in the projects – as well as in their parts, e.g. the sub-projects, the phases, the account controls, the work packages, and as in the programs and the portfolios they are part of – both from a system and a pragmatic perspective, focuses on the foundational importance of the integration as a critical success factor, and proposes both an innovative approach to manage effectively the complex projects, programs, and portfolios, and an innovative model to assess effectively the relevant complexity levels.

THE PROJECT INTEGRATION: A CRITICAL SUCCESS FACTOR AND A CORE COMPETENCE

A system may be defined as "a regularly interacting or interdependent group of items forming a unified whole (Merriam Webster)". In order to face the complexity, we generally break down a system in subsystems that are characterized by lower complexities, and this is typically done in accordance with a hierarchical structure. Each subsystem is characterized by its not only inputs, outputs, and states, but definitively also by its set of relations with the other subsystems and with the system itself, and it is the totality of the subsystems and of their relations that determine the performance of the system as a whole. Therefore, a system's performance do not simply coincide with the sum of the performances of its subsystems, but is determined by the integral sum, i.e. the integration, of the subsystems, which integrates their performances and their relations.

Each project can be considered a nonlinear, open system, in which same inputs may generate, in different states and/or environment, different outputs, and in which diverse levels of complexity characterize the relations among scope, time, cost and quality. In project management, we make efforts to "linearize" projects by breaking them down in subprojects/phases up to work packages, by defining the precedence relations among their work packages/ activities, by making all those estimates that are needed to establish a common baseline, and we take into account the project complexity by properly

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managing – also in terms of modifications and/or corrective actions to be implemented – the deviations from the baseline that arise from adequate Key Performance Indicators, the principal of which is the Earned Value (indeed, Earned Value Management is specifically thought to recognize and to face the non-linear relations among the cost, the time, and the work performed).

In addition, since all projects are made by people for other people (Pirozzi, 2019), and the same principle is of course valid also for all subprojects and work packages, above structured, *rational* approach must be integrated with a structured, *relational* approach that can manage properly the interactions among stakeholders, which occur in the form of communications – therefore, it is not so surprising that the project managers spend almost 90% of their time in communicating! –, the effectiveness of which can be continuously tested via measuring other specific Key Performance Indicators, as e.g. the stakeholder satisfaction and the project perceived value (Pirozzi, 2021) KPIs.

A systemic view (Fig.1) – valid for the elements at the different levels of project breakdown, including the project, the subprojects, the phases, the control accounts, and the work packages – can be applied to the stakeholder perspective (Pirozzi, 2017), in order to highlight – visually too – the importance of the integration.

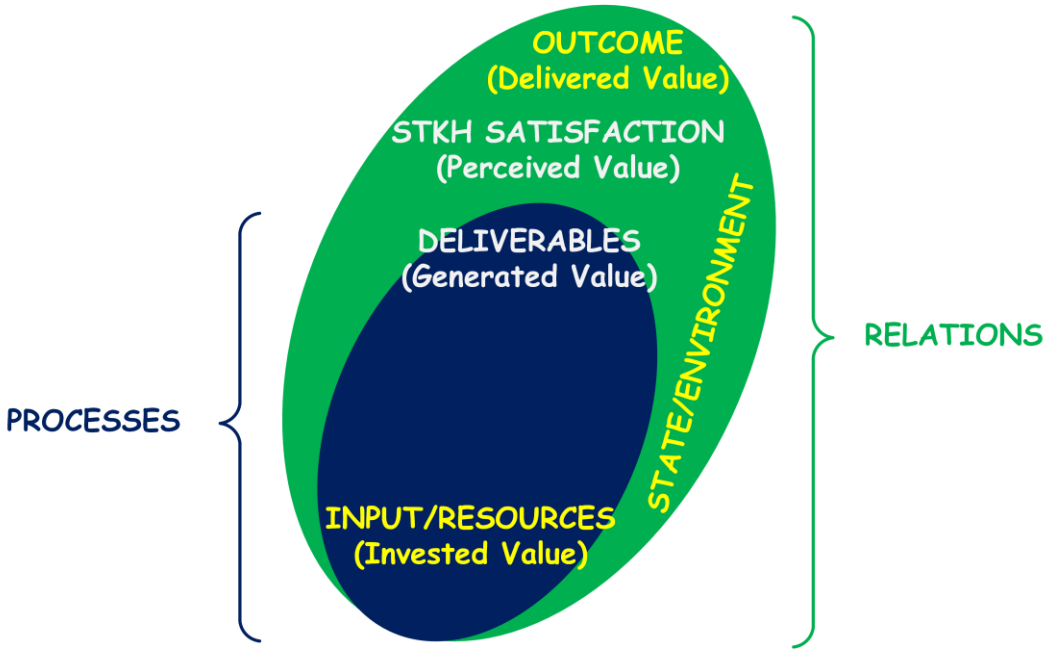

Fig.1 – A Systemic View of a Project

Indeed, for each project element, the outcome is the result of the integration of the processed inputs with the relations, i.e. the integration of the generated value due to the deliverables with the perceived value due to the stakeholder satisfaction. In each project

element, the width of the "green" gap represents the incidence on the results due to the relations with respect to the "blue" incidence due to the processes, and corresponds also both to the level of systemic non linearity and, therefore, to the level of complexity, as we will see in the following. Definitively, the "green" domain corresponds to the integration work, which is a responsibility of the project manager, while the "blue" domain corresponds to a delivery work, the responsibility of which is of the team members/leaders who are entitled to realize the different work packages by respecting the given constraints.

An example of the visual representation of a project obtained that may be obtained by integrating its subprojects and its work packages is given in Fig.2, while in Fig.3 there is the correspondent traditional representation of the same project's Work Breakdown Structure. It is evident that the importance of the integration work, which is clear and colored in green in Fig.2, it is not immediately perceivable in Fig.3. Moreover, the same representation and the above concepts are fully applicable to both programs and portfolios, which both are generally a combination of projects and operations (that can be considered as *simple* projects, to be managed via a "management by projects" approach).

Fig.2 – A Systemic View of a Project Breakdown (example)

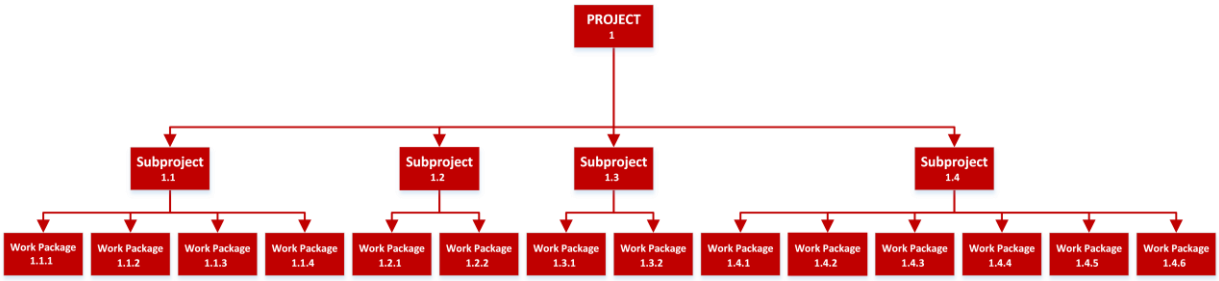

Fig.3 – The correspondent Work Breakdown Structure (example)

Definitively, the integration of project processes and relations, supported by effective coordination and communication, represents a primary task for each project/program/portfolio manager, who, therefore, must have the correspondent core competence to manage it: in fact, if the problem of performing the project results would just be that of making the sum of the work packages' results, probably, with all due respect, the project managers could be replaced by accountants… on the contrary, an effective integrated project management approach can arise to be the a key to project success, especially in those projects that are characterized by high levels of complexity.

Ultimately, the integration is a pillar of project/program/portfolio management: integrating work packages, phases, control accounts, subprojects, projects, operations, programs in terms of both their processes and their relations, as well as integrating rational and relational approaches, integrating objective and subjective measures, integrating predictive and agile/adaptive approaches, integrating processes-based and competences-based approaches, integrating hard and soft skills in a high level of competence are, in fact, all necessary issues, and, at the same time, may become critical success factors.

On the other side, since there are at least ten years that 30% or more of projects don't meet their original goals and business intents, and almost 40% or more of projects are not completed on time and/or within the original budget (Project Management Institute, 2018 and 2021), a main cause of this persistent failure of performances can be explained exactly with the structural poorness and/or inadequateness of the integration between processes and relations, especially in the cases of complex projects.

THE DIFFERENT LEVELS OF COMPLEXITY IN THE PROJECTS

In general, every project is characterized by an inherent degree of multilevel complexity, and this is valid a fortiori for the programs and the portfolios. That is mainly because, on one side, all projects are unique and unrepeatable, while, on the other, all their relations are intrinsically non-linear, and this attributes are valid not only for the projects themselves as a whole, but also for their results, deliverables, scope, time, cost, quality, value, constraints, assumptions, risks, and, of course, stakeholders. However, in order

to optimize the project management efforts, distinguishing the various levels of project complexity may be useful (Pirozzi, 2019).

A model which can be very helpful to face complexity, by supporting effectively decision-making processes, is the well-known Cynefin® Framework, which have been created, and developed, starting from early 2000s (Snowden, 2020). Cynefin® Framework is properly a Sense-Making Model based on observation, in which "data precede model", rather than a theoretical Categorization Model, in which "model precedes data": it individuates four domains, which are characterized by different levels of complexity, i.e. *simple, complicated, complex, and chaotic*. If we apply the Cynefin® Framework to the projects, we observe that, while the operations – that can be anyway considered as "simple" projects – are generally part of simple domain and, respectively, the crisis of chaotic domain, the projects may be part either of the complicated or of the complex domain. In a systemic perspective, the operations/simple projects are linear systems, the complicated projects are nonlinear systems having performances that are quite similar and/or may be approximated to those of the correspondent "linearized" systems, while complex projects are nonlinear systems in all respects.

In the simple projects and/or in the operations, the value generation is a consequence of achieving the target of operation objectives: a normal operations management is generally sufficient, although project management can be useful. Procedures are essential, and following procedures is the critical success factor; there is just one lesson–to-be–learned, which is the unique best practice to follow. The outputs are the results of a linear process of the inputs, the most appropriate action path is *sense* – *categorize* – *respond*, and, therefore, the approaches that take into account the organizations' procedures are generally the most convenient.

In the complicated projects, the support of the experts is needed, and that is why the project managers start to become necessary. In this domain, the value generation is a consequence of achieving the target of project objectives, the discipline of project management is very important and/or essential, and fulfilling the project requirements is the critical success factor; lessons learned about good practices are very useful. The outputs are substantially the result of processes, the most appropriate action path is *sense* – *analyze* – *respond*, and, therefore, the predictive project management approaches are the most convenient.

In general, in the complicated projects, there is a small gap between meeting the requirements and meeting the expectations of stakeholders and/or between the value generated by projects and the delivered value (Fig. 4). This happens when e.g. the project is part of the customer's core business ("supplier perspective", as in internal or in outsourcing projects), and, then, for the customer, the project is the business goal, and/or the project results are product-oriented and/or tangible (e.g. in some infrastructure projects) and/or, in any case, the stakeholder requirements are either well-defined (as in traditional contexts) or are evolutionary, but, in both cases, all stakeholders cooperate effectively, and/or projects are essentially plan-driven, and/or the triple constraints Time-

Cost-Quality are dominant; and/or the relations with stakeholders are important and periodic (Pirozzi, 2019).

Since, in complicated projects, the domains of the stakeholder expectations and of the stakeholder requirements substantially overlap, we can assume that the success is based on the fulfillment of stakeholder requirements, and that, therefore, managing properly the generated value, whose measures consist, as in classic project management, in cost and in consistency/progression of the deliverables, is generally necessary and sufficient.

The generated value management requires "technical" metrics in order to assess and/or to estimate the deviations from the project baseline: the use of project management KPIs (e.g. the Earned Value, the percentages of completed work packages compared to those planned, the turnover indices, the numbers and percentages related to the modifications) and of economic KPIs (e.g. Return Of Investments, margins) is, then, appropriate.

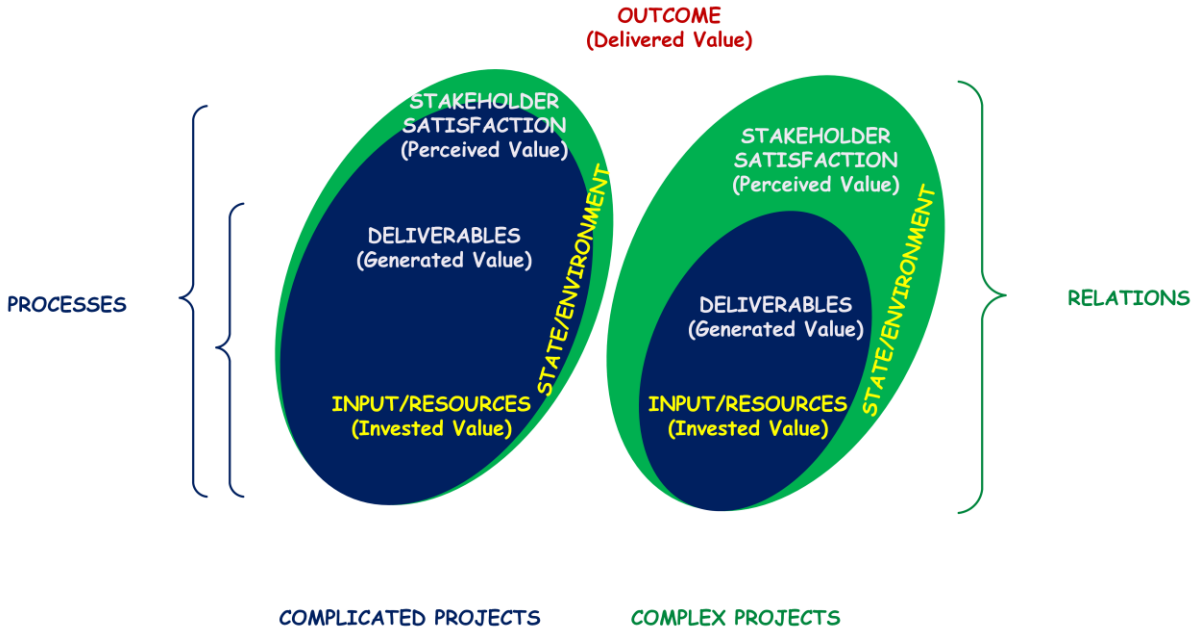

Fig.4 – A Systemic View of the Complicated and the Complex Projects

In general, the project management KPIs are especially useful to enhance project control, and to maintain and/or modify the proper route towards deliveries that fulfill stakeholder requirements, and are very helpful both in complicated and in complex projects. In addition, the economic KPIs are especially useful to improve relations with top management and funders, and to maintain and/or modify the proper route towards the satisfaction of their economic and financial expectations: their use can be very helpful in complicated projects, and it is basic in complex projects. .

Indeed, in the complex projects, but also in a part of the "manageable" emergencies, which include those events that are substantially unpredictable, but where it is possible to plan previously adequate responses and/or to manage properly the relevant risks, the value generation is a consequence of achieving the target of project goals, the discipline of project management is essential, and satisfying the stakeholder expectations is the critical success factor; lessons learned are in these cases essential to find out a proper *emergent* practice. The outputs are the results of the processes integrated with the relations, the most appropriate action path is *probe – sense – respond*, and, therefore, the adaptive/agile project management approaches are the most convenient.

In the complex projects, there is a significant gap between meeting the stakeholder requirements and meeting the stakeholder expectations, and/or, because of the importance of the perceived value due to the incidence of the relations, between the value generated by the processes and the delivered value (Fig.4). This happens when e.g. the project is a support of the customer's core business ("customer perspective", as in most external projects), and, then, for the customer, the project is a mean to achieve his business goals (while the same project "is" the business goal for the project management and the team!), and/or the project results are service-oriented and/or intangible (e.g. in software projects), and/or stakeholder requirements are not well-defined, or are evolutionary, but not all stakeholders cooperate effectively, and/or the projects are essentially value-driven, and/or the importance of the perceived value and the reputation is superior to that of the triple constraints time/cost/quality, and/or the relationships with stakeholders are primary and can be continuous, fast, interactive evolutive (Pirozzi, 2019).

Since, in complex projects, the expected project goals can be far away from the required project objectives, the project success is based on the satisfaction of both the stakeholder requirements and the stakeholder expectations, and, therefore, managing properly the perceived business/social value, in addition to managing properly the generated value, becomes mandatory.

Indeed, the perceived value management requires "business/social" metrics in order to assess and/or to estimate the deviations from the project baseline that are due to relations: the use of business/social KPIs (e.g. measures and percentages of stakeholder satisfaction, measures and percentages of stakeholder positive engagement, measures of perceived value/ quality/ reputation/ climate/ innovation/ sustainability, functional and/or quantitative measures, and the relevant percentages of completion/deviation from budget/schedule, which are specific of each sector of activity) is, then, appropriate. The business/social KPIs are especially useful to improve relations with customers and users, and to maintain and/or modify the proper route towards the satisfaction of their business expectations; their use is foundational in complex projects (Pirozzi, 2018).

All the above project-related issues may be fully applied both in the case of the project breakdowns in subprojects, phases, control accounts and work packages and in the case of project assembles in programs and portfolios. In general, in each assemble, the level

of complexity coincides with the highest level of complexity that is relevant to the assembled items: however, a proper integrated approached that can be tailored on the different levels of complexity may be an effective and an efficient way to manage projects, programs, and portfolios that are characterized by inherent diverse levels of complexity.

AN INNOVATIVE INTEGRATED APPROACH TO MANAGE EFFECTIVELY THE COMPLEX PROJECTS, PROGRAMS, AND PORTFOLIOS

Therefore, in order to propose an approach that may effectively address the complex project, program and portfolio diverse scenarios, the following basic issues may be considered as starting points:

- a systemic view of the project highlights that the effect of the relationships among the diverse project parts (sub-projects, phases, control accounts, deliverables, work packages, etc.) corresponds to the gap between the value generated by the project (output) and the delivered value that is actually released and perceived by the stakeholders (outcome). This gap can be bridged – or, at least, reduced – through an effective integration and coordination work.

- Any initiative that is aimed at achieving specific objectives in a defined time (e.g. a project, but also a program or a portfolio) is a complex adaptive system (CAS), which is intrinsically non-linear. Indeed, small or negligible causes may generate macroscopic effects. In general, the non-linearity may determine a substantial invalidity of the cause-effect relationships and jeopardizes the possibility of predicting the occurring of the events. However, if the context allows it, we can consider some specific areas or aspects of the project as if they are linear, and, then, we may apply breakdown techniques (e.g. with respect to the scope, the project organizational model, risks, requirements, etc.) to try to bring back the behaviors of the systems and/or the subsystems to those of the parts that compose them.

- The Cynefin® framework, which focuses on domains of increasing complexity (e.g. simple, complicated, complex), may usefully represent the reference scenario for projects, programs and portfolios complexity.

In general, as the level of complexity increases:

- the importance of the coordination and integration work, both within each project area (scope-schedule-cost, risk, communications, etc.) and/or between different areas, grows;

- the effectiveness of the linearization and the application of the breakdown techniques (WBS, OBS, RBS, etc.) decreases;

- the gap between the generated value (output) and the delivered value (outcome) rises;

- there is a shift from the dimension of the repetition to that of the uniqueness;

- the procedural and the predictive management approaches become less effective and, then, must give way to the adaptive / agile approaches.

The scheme that summarizes the general criteria for choosing the most effective management approach in the context of a project, program or portfolio, can be seen as a matrix with two main dimensions (Fig.5):

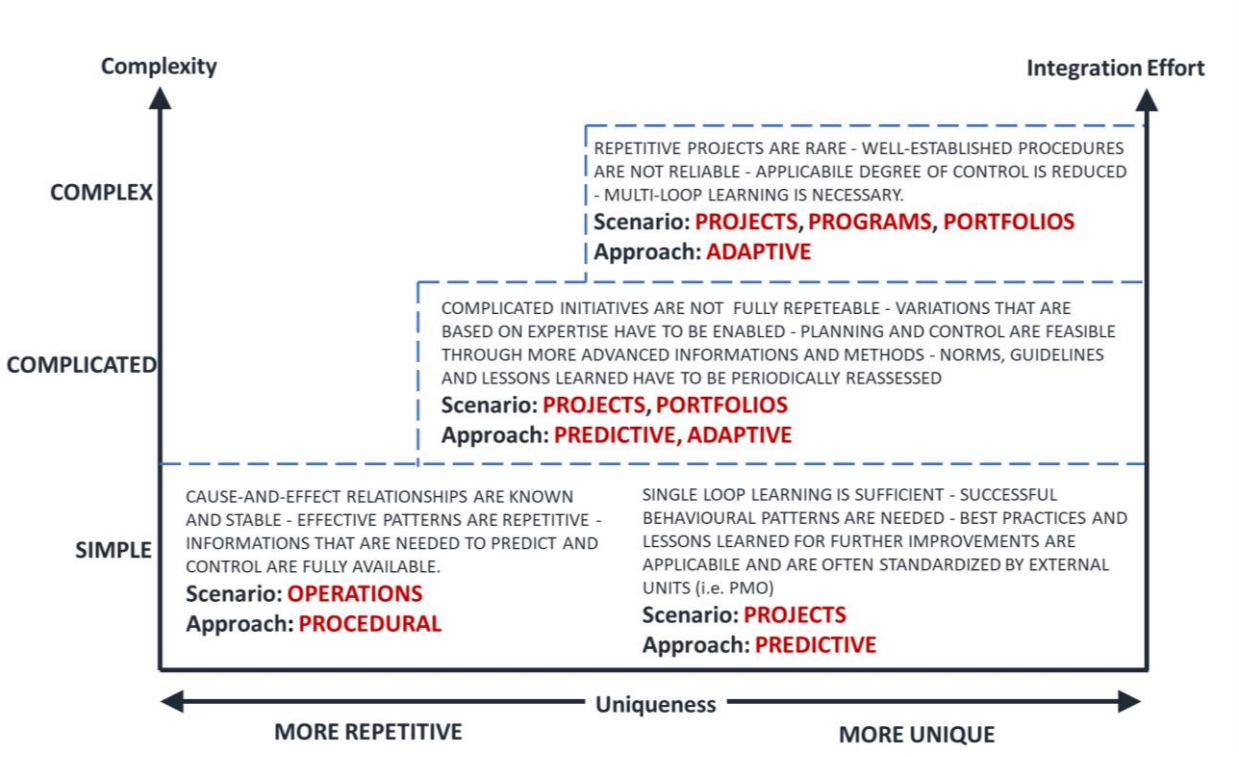

Fig.5 – Management approach for PPM scenarios referring Cynefin domains

- the level of complexity of the scenario of interest – referred to Cynefin®'s domains, i.e. simple, complicated, and complex – and the consequent integration effort, which increases as the level of complexity increases.

- the degree of uniqueness of the output (product / service / capacity to provide a service) to be achieved.

In the "simple" domain, the repetitive initiatives correspond to the *operations*, which are characterized by well-known and stable cause-and-effect relationships, and in which repeatable patterns are used. In this scenario, where all information that are needed to predict and to control processes are fully available and/or organizational models are

siloed, bureaucratic and/or inspired to Tayloristic "scientific management", the best approach will be *procedural* and the processes will be oriented to respect formal rules and/or procedures and controls. Quoting Kurtz and Snowden (2003) "[…] structured techniques are mandatory in this space. […] single point forecasting, field manuals and operational procedures are legitimate and effective practices…"

There are also some projects that can be repeatable to a certain extent, although, in any case, at a lower degree than the operations. Some examples could be the standard birthday/wedding parties that are organized by event planning agencies or professionals, some simple IT projects that are carried on within the organizations, the responses to those tenders that are part of a specific domain in which both the evaluation criteria and the offer structure are recurring, etc. This type of projects, or some parts of them (subprojects, phases/stages, control accounts, work packages), are approached in a *predictive* way, with a "single loop learning" logic. All the needed information are available, the context is stable and the planning effort is concentrated at the beginning of the project to derive plans and baselines as soon as possible through successful behavioral patterns and/or by applying some best practices and/or lesson learned for further improvements, which, on turn, are often standardized by other organizational units (e.g. a PMO).

However, even the simple projects that are managed predictively could be challenging. In fact, the failure rates of these projects cannot be explained solely by the incompetence of the project manager and/or of the team, and may be due to diverse reasons. Indeed, even if in this scenario the integration work is limited, the tools, the techniques and the standard procedures and/or guidelines cannot – and do not – replace the competencies and the satisfaction of the relevant and legitimate stakeholders. Furthermore, even in a "single loop predictive approach", several performing organizations fail to collect the lessons learned in a structured and effective way, and this may nullify the potential reuse of standardized behaviors.

In the "simple" Cynefin domain, programs and portfolios are evidently not considered, due to the degree of articulation and complexity that intrinsically characterizes them.

Unlike in the simple domain, in the complicated one the initiatives are not fully repeatable, as shown in Fig. 5. The complicated domain may concern *projects* and *portfolios*, but does not include programs, because a program, by definition, relates the specific objectives of the individual projects and/or operations that compose it, so bringing out more emergent and systemic goals. In other words, a program is complex in its very nature. On other hand, a portfolio is normally made up of programs, projects and operations with a lower degree of reciprocal relationship, with specific objectives that are often completely independent, and which compete in terms of priority to obtain adequate resources for their performances.

The optimal management approach for the complicated domain resembles that of simple one, but it takes place in a more extended form. While sticking to formal bureaucracy and

procedures, standard and guidelines are treated as "good practices" that may enable variations that are based on expertise. Both the planning and the controlling are still feasible predictively, but through more advanced information and methods, requiring subject matter experts, teams with excellent technical skills and experienced project managers.

As the degree of uniqueness of the project/portfolio increases, the breakdown/ linearization techniques are still effective but require more experience and awareness, so that the management approach can be still *predictive*, but has to be accompanied by a “multiple loop learning” logic. Therefore, it becomes increasingly important to interpret properly the rules, the guidelines and the good practices in order to have the possibility and/or the opportunity of a periodic reassessment of the norms and of the lessons learned. In these cases, the predictive approach has to be enriched by a more active engagement of stakeholders, and the processes / practices are carried out iteratively to generate learning and change in behavior and management models.

However, in order to apply “flexibly” the guidelines and procedures, a specific training and/or experience that may enable to simulate diverse situations in different real environments is preferred, or in some cases required. Therefore, the projects and the portfolios with a high degree of uniqueness require a specific knowledge that is based on both the experience and the continuous learning, in order to determining a shift towards an *adaptive* approach, in which the planning and controlling effort is distributed over the entire life cycle of the initiative – and not concentrated only in the early stages.

In the complex domain, the initiatives are not predictable, and the cause-effect relationships can be interpreted only in retrospective. This does not mean that project behavior in a complex context will be necessarily random or chaotic, but that “expert opinions based on historically stable patterns of meaning will insufficiently prepare us to recognize and act upon unexpected patterns” (Kurtz, Snowden, 2003).

Indeed, the complex domain concerns all the types of initiatives (*projects, programs and portfolios*) that are rarely repetitive. In some cases, the complex projects may contain some simple and standard elements that can be repeated, which seem to require to be managed with a breakdown approach, and which suggest continuing to apply “standard” project, program and portfolio management techniques. However, in the complex domain, the breakdown techniques may cause a general and systematic loss of view and, therefore, they must be applied with caution.

In fact, the predictive approaches can be applied up to a certain level of structural complexity (e.g. in the cases of medium-sized infrastructure and construction projects) but are quite ineffective in dealing with scenarios that are characterized by a dynamic complexity, in which both the context and the relationships between parts can vary frequently over time. In this case, the approach must be *adaptive (agile)*, the integration and communication effort is high, and the result is built in an iterative and incremental

way by shortening the feedback loop and by engaging the stakeholders as much as possible in controlled experiments.

Ultimately, it is important to highlight that the above described criteria, which allow to applying the different management approaches according to the diverse levels of complexity and degrees of uniqueness, are "fractal", i.e. are valid for the projects as well as for both the entities that compose them (sub-projects, phases, control accounts, work packages) and those entities that eventually contain them (programs, portfolios).

AN INNOVATIVE MODEL TO ASSESS EFFECTIVELY THE COMPLEXITY LEVEL IN PROJECTS, PROGRAMS AND PORTFOLIOS

However, the levels of complexity that correspond to the Cynefin® domains, and which have been represented as discrete, actually constitute a continuous spectrum. Therefore, while the applicability of the procedural approach is limited to scenarios that are characterized by a low level of complexity and a high level of repetitiveness, the predictive approach can be applied to a large variety of situations, both from the point of view of the level of complexity (low-medium) and from that of the uniqueness of the initiatives. Consequently, since any project, program or portfolio scenario is actually “complex” by definition, also because it involves social networks of stakeholders, when should the predictive approach give way to the adaptive one? When the use of breakdown techniques, with consequent local linearization, will start to become ineffective, and, then, to no longer be used?

For instance, in the logical network that usually represents the path for building a house, two different parallel branches are usually considered for the masonry works and for the hydraulic /electrical systems installations, also because the skills that are involved in the diverse cases are very different. Applying a breakdown logic and representing the scope with a WBS, the relevant activities will be part of two work packages that apparently do not relate directly, but only indirectly through the executive design (which precedes them) and, for example, the realization of the finishing touches (that follows). However, this lack of relation is only apparent, because the two work packages interact continuously during the project, and this relationship is resolved through the integration activity carried out by the site manager. If the importance and the impact of this integration work are not properly taken into account, the relationship between the two parts of the system (work packages) is not taken into due consideration, and this is the case in which a complex system is – not appropriately – reduced to two complicated or even simple subsystems, i.e. an oversimplification is made. However, an oversimplification, in terms of the Cynefin® framework, risks causing a “complexity creep” and, then, a shift towards the “chaotic” quadrant, resulting in the unmanageability of the project.

Another example of linearization through the application of breakdown logic is the use of an OBS (Organizational Breakdown Structure) to treat the project stakeholder network or part of it, as it is just a complicated system, while, in fact, what is usually represented

as a tree structure is actually a graph (Fig. 6). Indeed, the representation of the project organization as a stakeholder network enables to identify actual and relevant sub-networks that may better highlight the effective relationships among the stakeholders. This may facilitate the integration effort and may allow to:

- designing more effective and efficient communication flows;
- bridging the gap, in terms of perceived value, between the generated value (output) and the delivered value (outcome) of the project.

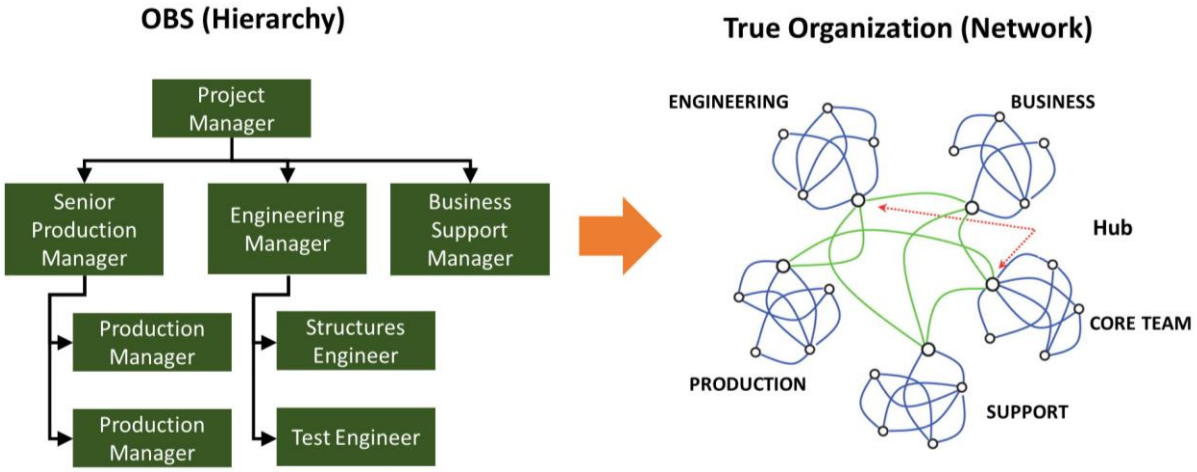

Fig.6 – Representation of the project organizational model

The previous example can be extended to the possible representations of the generated value (output). In the simple / complicated domain, or more generally where it is possible to linearize the project with breakdown techniques, the elements of the WBS (work packages and/or Control Accounts, specific points of aggregation for the budget and/or the actual costs) are typically matched with those of the OBS (stakeholders) to determine the responsibility matrix (RAM) (Fig. 7), which allows to optimize the local capacity to generate value (output).

In the complex domain, a shift from the "*divide et impera*" mindset, which is based on hierarchies, towards a systemic mindset, which is based on networks of elements, is highly recommended, and, actually, necessary. In fact, each network of stakeholders operates through an activity network, in which all the resources flow and the project/program/portfolio objectives are not those to optimize the single local flows, but those to optimize the overall throughput of the generated value (output).

Consequently, we can extensively apply the network analysis techniques, which are widely used to plan and control the schedule of a project – especially through the CPM, the CCM, and the PERT methods – also in order to assess the overall complexity level of a project/program/portfolio, which, on turn, together with the uniqueness degree of the

product/service to be realized (Fig. 5), can suggest the most effective management approach.

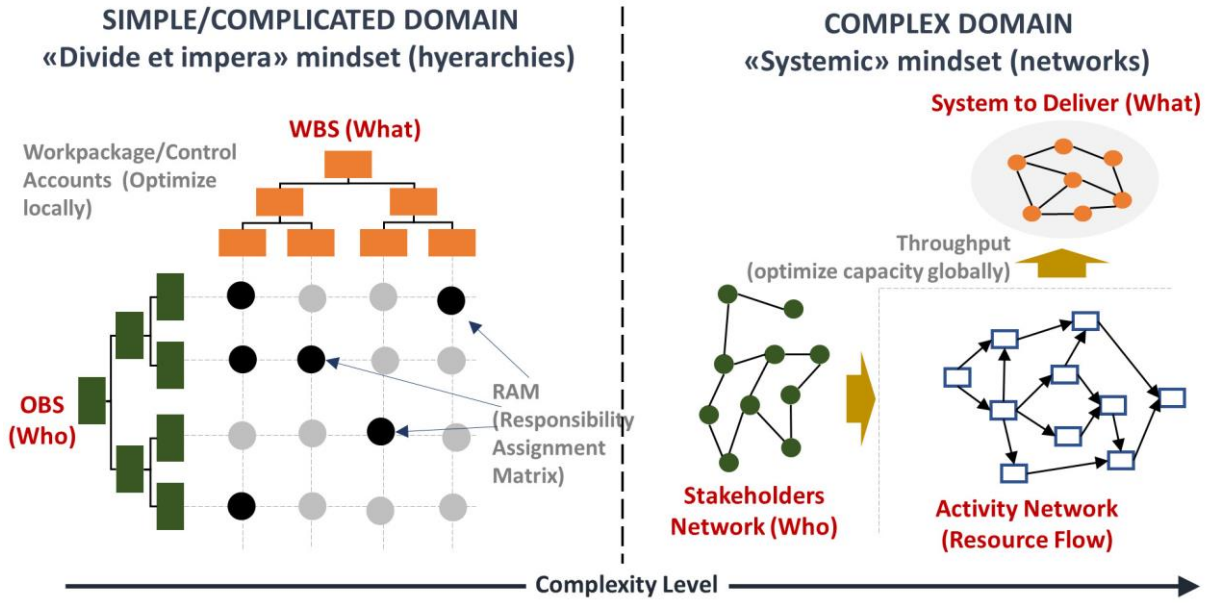

Fig.7 – Mindset shift from simple/complicated to complex domain

In general, the density of a graph in terms of nodes and links can give a simplified measure of the complexity level of the system that is represented. If we limit the observation to a scenario of undirected relationships, the maximum number of relationships *Rmax* among *N* components of a system is given by:

$$Rmax = N * (N-1) / 2$$

If *Nrel* is the actual number of relationships that exist inside the system, the graph density *D* is given by:

$$D = Nrel / Rmax$$

The density is then one in the case of a "complete graph", where each node is directly linked to all the others, while the minimum value of the density is zero, which corresponds to a system whose components (either simple or complicated) are independent. In general, the complexity can potentially increase with the square of the number of components of the system, and *Rmax* could be, then, and index of complexity. However, in a real case – fortunately – not all the components of a system are related to all the others. In fact, e.g., each project activity is actually related only to some other activity that precedes and/or follows it, each stakeholder is not actually in direct relationship with all the other stakeholders of the project network, and so on.

Therefore, we propose a three-step assessment model that conveniently evaluates the graph density for some specific project areas, in order to help determine the overall complexity of a project. In addition, this model can be easily adapted both to the entities that are contained in a project (e.g. sub-projects, phases, control accounts, work packages…) and to those entities that eventually contain a project (programs and portfolios).

The first step is to identify the most representative networks for the project, which include at least the following:

- the network of the *stakeholders*, on which depend both the communication flows and the organizational model;
- the network of the *activities*, which is the same that is generally used for the definition of the project scheduling model (CPM/CCM/PERT);
- the network of the *requirements*, which can be actually considered as mutually independent quite rarely;
- the network of *risks*, which have mutual dependencies that often are not taken into consideration, both in the identification and in the subsequent qualitative and quantitative analysis;
- the network of *deliverables* (or sub-deliverables), which is relevant to the products and/or the services and/or the capabilities to be realized.

Some of these networks are scalable, e.g. the network of the stakeholders is of fundamental importance also at the program and / or the portfolio level. In this case, there may be a bigger view that, however, is characterized by a lower resolution. For example, the stakeholder network of a program includes, in addition to the specific stakeholders that affect – or are affected by – the overall program objectives, the stakeholder networks that are relevant to all the projects that are part of the program itself. These networks, however, can remain on a more general level of description: in other words, there are stakeholders that it makes sense to consider managing a specific project but whose impact is negligible at the program level. In addition, similar considerations are valid also in the case of portfolios, even if the networks of stakeholders could be partially disjointed, reflecting the fact that the project and program initiatives within the portfolio could be independent.

The network of risks and the network of deliverables are also scalable at both program and portfolio levels. Risk management is a pillar of all managerial disciplines and the diverse outputs that are achieved by the various initiatives have often dependencies that can create additional value; the risks that are related to the different initiatives can also be intertwined in a portfolio (e.g. an external risk deriving from economic or environmental causes can change the priorities – and therefore the start-up schedule – of specific projects or programs). In a program, on the other hand, there is an intrinsic dependency

link between the deliverables of the different projects that compose it (e.g. in a space program, the availability of a specific version of a rocket with certain characteristics enables further missions based on its use).

The networks of activities and of requirements do not need to scale. In fact, inside a program or a portfolio, both the activities and the requirements will be managed in the context of each single initiative.

In addition to the previous ones, there might be further networks according to the diverse type of entities that are considered. For instance, in the case of a program, there is the network of the relevant projects, as well as there may be a network of initiatives (projects and/or programs) in the case of a portfolio. In general, depending on the scenario, further networks can also be taken into consideration to represent other aspects of interest.

The second step is to evaluate, for each of the project networks that have been identified, the densities of the relevant graphs, and, then, to match the calculated values to three conventional ranges, as in the example below:

- *Low Complexity*: when the graph density is between 0 and 0.2
- *Medium Complexity*: when the graph density is between 0.2 and 0.4
- *High Complexity*: when the graph density is greater than 0.4

The choice to concentrate the representative intervals in the first half of the domain of the possible density values 0÷1 responds to heuristic criteria. Indeed, in the literature there is not a strict distinction between the sparse graphs and the dense graphs, and, therefore, it is not possible to establish a precise threshold of the density value. Typically, a sparse (connected) graph has about as many links as nodes, and a dense graph has nearly the maximum number of links. However, the graphs that represent real networks of project elements are generally sparse.

The third step is to plot results on a Kiviat chart, and, then, to assess the overall complexity. Clusters of values that are located close to the center of the chart indicate a low complexity level, while results that are located outside of the center indicate higher complexity levels.

In the plotted example (Fig. 8), the “Project 1” is of medium-high complexity (especially with regard to the stakeholders), while “Project 2” is of low complexity.

Definitively, the resulting complexity assessment may become an integral part of the Project Management Plan, and, then, additional specific considerations can be made. For example, in a project area (e.g. deliverables) that is characterized by a network with a low-medium graph density, we could use more effectively breakdown techniques (e.g. WBS) to linearize and simplify planning and control activities.

In general, adapting and applying the model to the specific project context means integrating the results of the various planning outputs, at different stage of details. For example, the information that are needed to build a preliminary version of some networks could be already available from the Project Charter (e.g. stakeholder network, deliverables network), while the networks of the activities or of the risks derive from the subsequent planning activities.

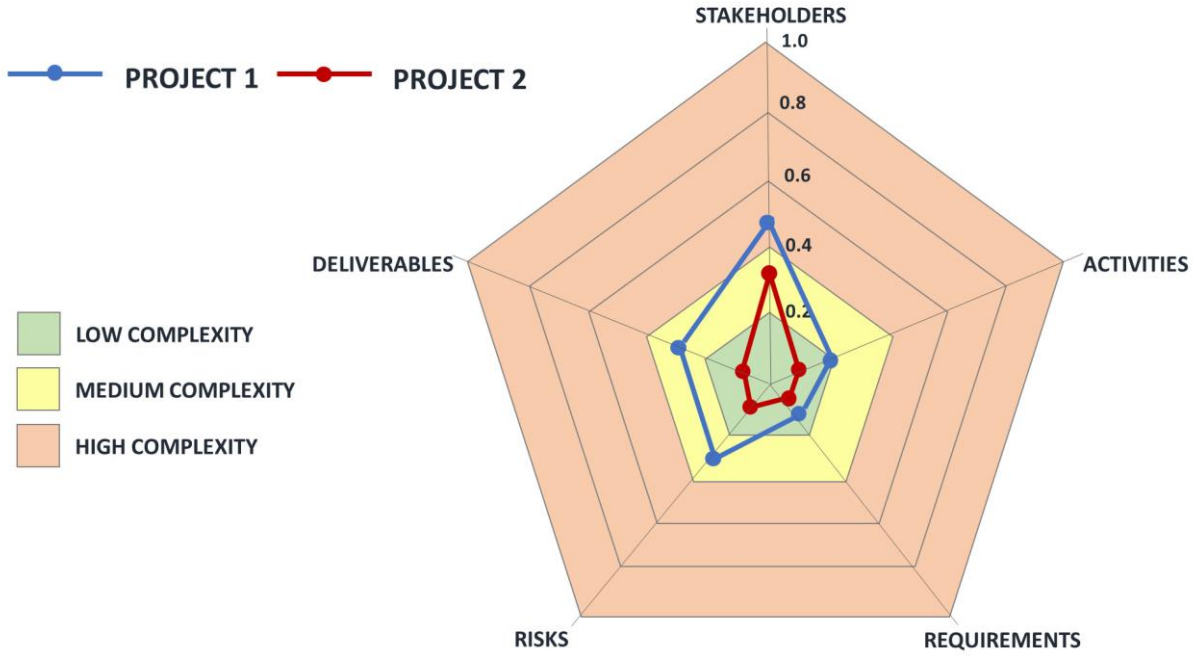

Fig.8 – Complexity assessment evaluating graph density of the project networks

Ultimately, the complexity assessment can be carried out at different times and with different reliability, depending on the effective representativeness of the networks that are analyzed. In all the cases, we can derive from the results of this evaluation, an approximate measure of the integration effort that is necessary to align the generated value (output) and the perceived value (outcome), and this can be a very good guide in the selection of the optimal specific project management approach.

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