Exploring scenario development
- A case study of two collaborative research projects

Abstract

Purpose – The paper explores scenario development (SD) as a method for engaging known challenges in collaborative research projects, i.e. SD is the construct under investigation.

Design/methodology/approach – Criticism of the dominant, rational approach to project management (PM) and its underlying hypotheses highlights a considerable PM research gap for research projects (research problem). We undertake a six-step constructive research approach to investigate if SD (the construct) constitutes a fruitful method to support the management of collaborative research projects. A two-part literature review summarizes known challenges in collaborative research projects and introduces the history and application of SD methodology. The work includes participatory action research (PAR) in two case studies, constituting a qualitative research method.

Findings – We found the SD method to be useful for structuring and analysing intuitive project processes. However, using SD in the management of single projects presents some fundamental challenges. SD, like PM, struggles with issues related to myopic decisions, a "predict and provide" attitude with clear aspects of path dependency in the project front-end as well as inconsistent and/or missing identification of success criteria among different stakeholders.

Research limitations/implications – This paper does not provide any comprehensive, normative account of scenario techniques or compare SD with other foresight and future studies methods. Although PAR is in itself a research method that demands systematic description and execution, the focus of this paper is the overall constructive research approach.

Practical implications – The paper offers a broadened repertoire of methods to describe and analyse project stakeholder situations (collaborative aspects) and to structure and balance the need for both rational and intuitive project processes (research aspects). The SD method also supports development of graphical storylines and facilitates the use of influence diagrams, event trees and cost/benefit analysis.

Originality/value – Although PM literature contains several references to SD, the practical application of SD at single-project level has, to our knowledge, never been described in the PM literature.

Keywords – project, collaborative, research, scenario development, constructive research

Paper type Research paper

1. Introduction

Recent decades have seen an increasing preference for collaborative research projects as a form of organization when commissioning research and innovation work, particularly for academia – industry cooperation. Collaborative research projects are typically distributed, virtual or global teams characterized by a multi-disciplinary, inter-organizational and inter-cultural nature (Barnes et al., 2006, Brocke and Lippe, 2015). The management of collaborative research projects is further challenged by ambiguously defined goals and the heterogeneous interests of many partners (Lippe and Brocke, 2016). All these characteristics are known to foster challenges to effective coordination and cooperation (Aarseth et al., 2013, Calamel et al., 2012, Aaltonen and Sivonen, 2009). This paper reports on a constructive research study investigating to what extent scenario development (SD) constitutes a fruitful method for managing known challenges in collaborative research projects. Scenarios are "*a set of possible future events that represent alternative plausible future states of the world under different assumptions"*.

Samples (1976) attributed the following perspective to Albert Einstein: "*The intuitive mind is a sacred gift and the rational mind is a faithful servant. We have created a society that honours the servant and has forgotten the gift*". We believe that such a perspective aligns with criticism of the dominant, rational approach to PM, and its underlying hypothesis (Hodgson and Cicmil, 2006, Nightingale and Brady, 2011). Thus it represents a PM research gap and a key challenge for innovation, research and development projects (Lenfle and Loch, 2010, Lenfle, 2016).

We recognize that the notion of intuitive or non-rational thought processes warrants elaboration. However, such discussions depend on defining the unexpectedly elusive term "rational". Mercier and Sperber (2017) emphasize that rationality has to be defined according to how well you accomplish some goals, i.e. one can't be rational in a vacuum. Thus, what is rational behaviour is relative to the definition of what we want to achieve, e.g. the definition of a project's success. In this paper we distinguish between instrumental rationality, e.g. PMBOK (2017), which helps project managers focus on how to do things, and other rationalities that help them to decide what to do and why (Dane and Pratt, 2007). These other rationalities, such as intuition, holistic and relational thinking, are often labelled non-rational thought processes. Methods and techniques associated with such non-rational thought processes are largely missing from PM bodies of knowledge (Thomas et al., 2012).

The limited PM literature related to use of methods, tools and techniques to implement the appropriate combination of intuitive and rational management processes represents a PM research gap. PM research literature addressing collaborative research projects in a global environment is especially scarce.

With its history as a policy and social forecasting tool for economists and strategists SD is considered a valuable tool for structuring and balancing the need for both rational and intuitive processes. As a tool for disciplined thinking and problem solving, SD can be traced back to the Manhattan Project (Miller and Waller, 2003), where scientists tried to understand the consequences of the nuclear reactions they were creating (Schwarz, 1991). Most authors trace SD as a discipline back to the 1940s and the RAND Corporation's work for the US Air Force, in fact, the same time and place that "modern" PM traces its roots to (Lenfle and Loch, 2010, Schoemaker, 1993, Brady et al., 2012, Morris, 2013). Although PM literature refers to the use of scenarios, there are to our knowledge no accounts of how projects have implemented the use of scenarios in practice (Fossum et al., 2016). Consequently, we formulate our research question as:

To what extent does SD represent a viable method to manage known challenges in collaborative research projects?

The paper is organized as follows: *First*, in the next section we outline the result from our two-part literature review. Part one defines collaborative research projects and addresses known challenges to their management. In part two we outline the historical, theoretical and conceptual basis for SD. *Second,* we present the selected research methodology and approach to the study. *Third,* we present the findings from our case studies. *Fourth*, we discuss our findings, the theoretical connections and known weaknesses of the study, including validity and reliability. *Finally*, we offer some concluding remarks and contemplations on potential contributions to the PM body of knowledge.

2. Literature review

The literature review was performed as two parts, each with its own objective. First, a review of PM literature was done to map the current state of the art regarding management of collaborative research projects. The second part of the literature review focused on current knowledge of scenario methodology and its relevance for PM.

2.1 Collaborative research projects

First, we present definitions and structure the known challenges of collaborative research projects.

2.1.1. Defining collaborative research projects

Katz and Martin (1997) concluded that the notion of research collaboration is very "fuzzy" or ill-defined and exactly what defines collaborative research is a matter of social convention and open to negotiation. We are inclined to argue that this conclusion still has merits 20 years later. Davenport et al. (1998) describe experiences from a technology programme supporting collaborative research and development projects. Projects eligible for the programme needed to satisfy the following criteria: "technological advancement, close working relationship between the business and the research institute, a good business opportunity and a commitment from the business". Based on case studies in the automotive and aerospace industries, Barnes et al. (2006) reported on the development of a management tool designed to provide practical guidance on the effective management of collaborative R&D projects. However, no clear definitions of a collaborative project were proposed. Factors that continue to challenge our understanding of what PM is (Artto et al., 2017, Fowler et al., 2015) include stakeholder interest and policy in funding bodies that maintain a focus on innovation and learning outcomes from collaborative R&D (Autio et al., 2008, Jiménez-Sáez et al., 2011) and new ways of coordinating research, e.g. "crowd science", "citizen science", or "networked science" (Franzoni and Sauermann, 2014). Lippe and Brocke (2016) and Brocke and Lippe (2015) define collaborative research projects as "a temporary organisation for the purpose of building and evaluating novel results under a pre-defined research objective and with constraints on resources, cost and time". Although the project management literature provides a good view into the nature of collaborative research projects, we propose that it fails to highlight the main characteristics that make collaborative research a specific project type, i.e. the combination of collaborative challenges and the unknown dimension, that of the project product, created by the research aspect. In line with work on project classification (Shenhar and Dvir, 1996, Niknazar et al., 2017, Besner and Hobbs, 2012a) and following James March's definitions (March, 1991, Lenfle, 2008), we propose classifying collaborative research projects as a type of exploration project. Thus, we propose defining a collaborative research project as:

"*a project that is jointly financed, planned, and executed by a legally regulated consortium of academic, industry and/or public partners with the intention to generate new knowledge and/or application of such knowledge through collaborative explorative investigation and experimentation efforts".*

2.1.2. Known PM challenges for collaborative research projects

The management of collaborative research projects faces many known challenges (Barnes et al., 2006, Calamel et al., 2012, König et al., 2013, Brocke and Lippe, 2015, Etzioni, 1964). Brocke and Lippe (2015) identify many research papers that address the challenges of managing collaborative research projects. They divide the reviewed research contributions into two main research streams, one that explains the settings and processes of collaborative research projects (first stream) and one that addresses operational knowledge aimed at practical use (second stream). König et al. (2013) address experience gained in inter- and transdisciplinary research and propose a framework for structuring interdisciplinary research management. Known management challenges include facilitation of mutual learning, enabling shared goal definition, creating rules for cooperation and synergy, managing complexity and heterogeneity, planning integration, balancing personal attitudes and careers of involved researchers (König et al., 2013). A hallmark of collaborative research projects, e.g. those funded by the European Union (EU) Framework Programmes (FPs) for Research and Innovation, are the combined challenges of interdisciplinary, international, distributed and virtual projects.

Project managers of collaborative research projects face specific challenges because they need to balance and build trust between different organization cultures and working practices (Katz and Martin, 1997, Davenport et al., 1998, Elias et al., 2002, Wingate, 2015). Lack of a strong project owner, the research aspect (unknown product) and contract types (consortiums) further combine and amplify challenges of stakeholder management created by the collaborative nature of the projects. However, we argue that each of the relevant individual challenges is addressed at some level in the PM literature and propose that it is the combination of known challenges that makes collaborative research projects a specific project type, not any single unique characteristic or challenge. We found it useful to structure these challenges in two groups: challenges that are related to the collaborative nature, and challenges related to the research processes, e.g. unknown dimensions of the product.

In the following, we address these two groups of challenges from *a collaborative perspective* and *a research perspective.*

2.1.3 The collaborative perspective

Not surprisingly, the collaborative aspect is a key concern in much of the literature on collaborative research projects (Barnes et al., 2006, Brocke and Lippe, 2015, Davenport et al., 1998, Siedlok et al., 2015, Tripsas et al., 1995). We build our collaborative perspective by outlining collaborative challenges related to five variables (Binder, 2009, Binder, 2007), i.e. languages, locations, organizations, cultures and time zones.

Languages; most collaborative research projects, e.g. those financed by EU FPs, include project participants with several different languages. It is usual to agree on one common language in which communication takes place, e.g. English. However most non-English speakers will be limited by their knowledge of English expressions, which may create challenges, e.g. failing to use and understand jokes. *Locations;* collaborative research projects typically have team members located in two or more countries. This may have some direct challenges, e.g. limitations on face to face meetings, but most challenges come from secondary sources such as the need to implement some form of technology-mediated communication. Further challenges may arise in cases where key team members need to relocate to new locations. *Organizations;* collaborative research projects often combine the challenges of global, international and virtual projects, meaning the project manager would have to deal with different organizational and occupational cultures. This may be cooperation between university-industry and/or between small businesses and large companies generating challenges due to differences in corporate governance, work processes and tools. *Cultures*; beyond the organizational and occupational cultures, the customs and traditions of different country cultures can bring diversity to a project. The strength of collaborative research projects is the integration of different research perceptions, ideas and views that are needed to solve complex tasks. Nevertheless, cultural diversity can be a source of conflict and misunderstandings. *Time zones*; this challenge may not be relevant for all collaborative research projects, e.g. most projects financed by EU FPs have their project team on the European continent. For many other collaborative research projects, e.g. those in The World Climate Research Programme (Allison et al., 2001, Barry, 2003), the presence of project partners in multiple time zones leads to projects that score very high on all five challenge variables.

With increasing numbers and larger distances in collaborative research projects, exemplified by the five challenge variables the stronger challenges related to individual diversity become (Shore and Cross, 2005, Adler et al., 2009, Calamel et al., 2012). Consequences of such diversity are often manifested at organizational levels when divergent motivations for joining a project result in contradictory expectations (Elias, 2015, Ruuska and Teigland, 2009).

2.1.4. The research perspective

The central role of experimentation in collaborative research projects establishes an unknown dimension of the project product. As such, a predictive project life cycle, also known as “fully plan-driven” (PMBOK, 2017) is usually not recommended (Samset and Volden, 2016). Turner and Cochrane (1993) reasoned that in projects where goals, methods or both are poorly defined, it is not possible to plan projects in the conventional way, in terms of the activities to be undertaken. Based on the degree of awareness of project goals and methods one can classify research projects into three groups (Kuchta and Skowron, 2016, Khedhaouria et al., 2017):

- Well-defined goals but insufficiently defined methods; insufficiently defined goals and well-defined methods; insufficiently defined goals and insufficiently defined methods.

Adaptive project life cycles, also known as change-driven or agile methods (PMBOK, 2017), are often used when addressing insufficiently defined goals and methods. However, unknowns addressed by change-driven or agile methods usually originate from the project customer or other external factors, e.g. in software / IT development. Many collaborative research projects, e.g. those funded by the EC, do not have such customer-driven changes to requirements.

Loch et al. (2006) and Lenfle (2016) describe an iterative PDCA (plan-do-check-act) cycle as a basic building block in experimentation. Loch et al. (2006) argued that PM where all task and requirements must be defined before the project can start fails to implement PDCA cycles, consequently failing to be experimental and explorative. Thus, from a PMBOK (2017) perspective an iterative and incremental life cycle would be the most appropriate for project-based research work, e.g. collaborative research projects, where the unknowns are driven by missing knowledge about the product and other project internal factors. We find that the limited PM research addressing iterative and incremental project life cycles represents a significant research gap for research projects in particular (Lenfle, 2008, Fowler et al., 2015), and what Lenfle (2016) refers to as exploratory projects in general (Brady et al., 2012, Loch et al., 2006, Brady and Davies, 2004, Brady and Davies, 2014).

2.2. Scenario development

Scenarios are a set of possible future events that represent alternative plausible future states of the world under different assumptions (Mahmoud et al., 2009). From the storytelling transferring our history and facilitating learning around Stone Age bonfires to the music of the Renaissance and the operas of the 1800s, scenarios have had a role in human societies. The fact that scenarios can be many things to many people makes it a non-trivial task to summarize its relevance, history and application. Although scenarios, and methods for their development and utilization, have a rich history as tools used by individuals, businesses and governments there still exists a lack of common standardized development practices (Urwin et al., 2011, Schwarz, 2008, Durak et al., 2014).

Any unified classification and standardization are further challenged by the evolving use of scenario methods in new areas; e.g. within environmental studies the application of scenarios is emerging as tools to guide and control policies and strategic planning for impacts by alternative futures (Mahmoud et al., 2009, Schlüter and Rüger, 2007, Dong and Giesen, 2011). When used in context of planning processes the use of scenario methodology is often referred to as scenario planning. This is also the term used by US Air Force planners when using scenarios to foresee their opponents actions during World War II (Schwarz, 1991). Scenario analysis is the process of evaluating possible future events through the consideration of alternative plausible, though not equally likely, states of the world (Mahmoud et al., 2009). Our rationale to focus on SD, i.e. the construct/concept under investigation in this study, rest on the fact that both scenario planning and scenario analyse include or rely on the initial process of developing scenarios.

As such, this review of SD is not an attempt to provide the full story scenario methodology but intended to provide PM professional with a relevant vantage point to further explore the world of scenarios. We will focus on two aspects: the historical application of the SD method as a process and its relevance for the PM discipline and discourse.

2.2.1. History and application

Most authors trace SD as a discipline back to the 1940s and the work RAND Corporation did for the US Air Force. The RAND Corporation was a non-profit organization originally created as a “think tank” for the US Air Force (Brady et al., 2012). Herman Kahn, regarded in many quarters as the father of SD, came to prominence while working at the RAND Corporation as a military strategist and systems theorist. Kahn later adapted and expanded the scenario approach to include public policy and social forecasting, and he developed it as a tool for economists and strategists (Schwarz, 1991). Pierre Wack is also frequently cited as the father of scenario development. In the 1970s Wack elevated the use of scenarios to a new level by creating ‘‘alternative futures’’ for Royal Dutch Shell’s oil enterprise (Schoemaker and van der Heijden, 1992). This enabled Shell to respond quickly to the oil embargo of 1973–74 and secured the company’s position in the industry, and the position of SD as a tool for business and strategies (Van der Heijden, 2011).

By 1982 over 50 percent of Fortune 500 industrial companies had at some point turned to scenario planning as a tool (Linneman and Klein, 1983). A decade later Bunn and Salo (1993) presented an analysis that supported a re-evaluation of how SD was converging with contemporary forecasting practice. We will however lean towards Schoemaker (2002), stating that SD is not really about planning, and Mahmoud's (Mahmoud et al., 2009) consideration that projections in traditional forecasting applications are typically limited to the most likely futures, attempting to simulate the future with a high degree of accuracy. Such probabilistic predictions explicitly weight the likelihood of different outcomes. Also, according to the definition of the Intergovernmental Panel on Climate Change (IPCC), scenarios are not forecasts or predictions. Instead, they provide a dynamic view of the future by exploring various trajectories of change that lead to a broadening range of plausible alternative futures. Schoemaker (1993) writes that SD is about exploring the future in order to develop new instincts that allow faster learning and smarter decisions. Scenario planning was examined by academics and described by practitioners early on, but Schoemaker (1995) was the first who sought to bridge theory and practice. The success of the Global Business Network (GBN) matrix approach at Royal Dutch Shell (Schwarz, 1991) made it the "gold standard of corporate scenario generation". It became so popular that many SD practitioners do not even know that it is only one of more than two dozen techniques for developing scenarios (Bishop et al., 2007). Bishop et al. (2007) analyse the use of SD in the futures studies discipline and describe eight categories of techniques that include a total of 23 variations used to develop scenarios. van Vliet et al. (2010) describe a number of scenario studies that in the last decade have worked with a combination of models and storylines, such as the Global Environment Outlook, the Millennium Ecosystem Assessment and the IPCC on the global scale and, among others, MedAction, PRELUDE, and VISIONS on the European scale. Most of these studies involved stakeholders in the SD process. SD also have a history in context of social-technical dimensions of human-machine interactions and complex systems development (Funabashi et al., 2005, Woods et al., 2006, Yomo et al., 2015), especially with application in the military (Prasolova-Førland et al., 2013, Urwin et al., 2011, Xinye et al., 2012, Yuan Kwei et al., 2009) and spaceflight (Bolton et al., 2013, Fragola et al., 1994, Kordon et al., 2005) domain.

We will use the IPCC definition of a scenario as *"a structured, coherent, internally consistent and plausible description of a possible future state of the world. It is not a forecast; rather, each scenario is one alternative image of how the future can unfold*" (IPCC, 2008)

2.2.2 SD conceptions

Given that our introduction of SD is rather novel to the PM discipline and, the analysed literature use the terms scenario "development, analyse, planning, method, methodology and technique with varying applications and/or week definitions we want to address some possible confusions. Following Bishop et al. (2007) we make the following clarifications.

1). SD is often equated with scenario planning, but scenario planning is a more comprehensive process, of which SD is one aspect. SD is usually concerned with creating actual stories about the future.
2). The term scenario is often associated with ''alternative future''. A common misconception is that all descriptions of alternative futures are scenarios.
3). Methods and techniques are terms often used interchangeably in the literature and in practice. We emphasize a subtle difference in the terms, with method being focused more on the steps for carrying out the process and technique focusing more on the particular way in which the steps are carried out.
4). A "tool" is a term often confused with method or technique. We define a tool as a device that provides a mechanical or mental advantage in accomplishing a task. As such, scenarios may not constitute a tool. However, we argue that the process of developing scenarios constitutes a tool in the same way that PM processes are regarded as part of the "PM toolkit".

2.2.3 Scenario development in the PM discourse

Morris (2013) identifies some challenges that our society is facing in the future and implications this may have for the PM discipline. He foresees that management could become more instinctive and mentions scenario planning as something that will become more common. Although PM literature refers to the use of scenarios in projects (Smith, 1994) as best practice (Kwak and Dixon, 2008) or as advanced PM software, e.g. Besner and Hobbs (2012b), we found no accounts of how the projects had implemented the use of scenarios in practice, e.g. what topology and process steps were used (Fossum et al., 2016, Bishop et al., 2007). Mahmoud et al. (2009) outline a framework for SD in support of environmental decision-making. Although they do not address single projects per se, environmental decision-making happens more often in conjunction with larger civil and industrial development projects, either in the project front-end (Samset and Volden, 2016) or during the project execution (Sanderson, 2012). Table 3 summarizes PM papers that mention scenario-related methods in four topic areas: Strategy and Business, Risk and Uncertainty, Planning, and Project Health and Evaluations.

Table 1. Key project management papers that address or mention scenario-related methods classified into four themes: strategy and business, risk and uncertainty, planning, and project health and evaluations.

Topic area	Description	Key papers
Strategy and business		
	Scenarios are mentioned or addressed in the context of business and strategy development. The literature mainly addresses alignment of parent organization strategy and project management, but single-project perspectives are also found.	Grundy (2000), Bredillet (2008), Williams and Samset (2010), Besner and Hobbs (2012b), Dick et al. (2015), McKenna and Baume (2015)
Risk and Uncertainty		
	Application of scenario methodology to address complexity, risk and uncertainty. This research more often focuses on scenario methodology in conjunction with quantitative methods such as Monte Carlo simulation and Bayesian networks.	Chapman and Ward (1997), Zeng et al. (2007), Kwak and Dixon (2008), Sanderson (2012), Hanaoka and Palapus (2012), Khodakarami and Abdi (2014), Taroun (2014)
Planning		
	Scenario planning is proposed to support the project plan's versioning system. Enriching the planning process vs. the end product (the plan) with information beyond traditional Gantt charts and project plans.	(Ahlemann, 2009), van der Hoorn and Whitty (2015)
Project Health & Evaluations		
	Scenario methods have been included in the analytical techniques for project monitoring and control. In this way, they contribute to the theory and application of diagnostic concepts to assess the health of projects or programmes.	Smith (1994), Jaafari (2007), PMBOK (2017)

Although PM literature refers to scenario methodology as useful in single projects and individual topic areas, we consider the real forte of SD as a management method when implemented to support the entire life cycle of projects, including alignment of programme and portfolio objectives.

2.2.4 The intuitive SD process

Scenarios are not particularly intended to be probabilistic; they are rather meant to portray a set of alternative futures that could occur no matter how improbable the occurrence is (Mahmoud et al., 2009). The strength of scenarios is to identify and include elements that were not or cannot be properly modelled in predictive and rational PM processes, e.g. changing world views, value shifts, disruptive regulations or innovations. As such, scenarios go beyond objective analyses to include subjective and intuitive interpretations (Schoemaker, 1995).

SD comprises both exploratory and anticipatory scenarios (figure 1). Exploratory scenarios describe the future according to known processes of change and extrapolations from the past while anticipatory scenarios are based on different desired or feared visions of the future that may be achievable or avoidable if certain events or actions take place.

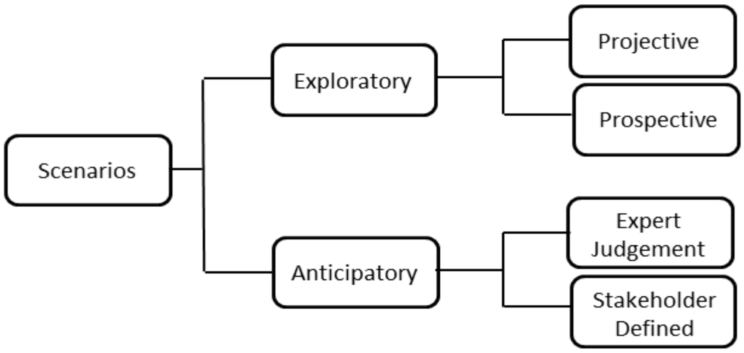

Figure 1. Four different scenario types: projective, prospective, expert judgment and stakeholder defined (Mahmoud et al., 2009).

Expert interpretations, judgment and practice are often supported by intuitive, holistic and relational thinking and most project managers make informed intuitive actions every day (Thomas et al., 2012). Without such intuitive thinking, experts are not equipped to interpret, and act on, the moment-by-moment impressions that play a key role in any skilled practice (Dreyfus and Dreyfus, 2005). As such, expert judgment-driven scenarios (figure 1) are suited to model future conditions based on the intuitive thinking of experts. Prospective scenarios are used to address such futures that significantly vary from the past, e.g. where experts or key stakeholders intuitively anticipate change that have not been, or cannot be, modelled according to known processes or extrapolations from the past.

2.2.5 The collaborative SD process

One of the great values of scenarios lies in the articulation of a common future view to enable more coordinated decision-making and action. However, the inclination of project partners to invest in plausibility studies, such as SD, often depends on how potential risk and rewards are perceived. If a failure to predict the future has a high cost, or correctly anticipating a future condition has high rewards, the incentive to expend available resources usually increases. Although SD as a consensus-building approach can work even with starkly different viewpoints among participants, most people show reluctance towards negative and/or extreme scenarios (Schoemaker and van der Heijden, 1992, Schoemaker, 1993). Mahmoud et al. (2009) emphasize that for the SD process to be a working success, trust must be built between participants, e.g. stakeholders, researchers, and end-users. Thus, one faces a paradoxical situation: a commonly developed future view provides a fertile basis for collaboration but to develop such a scenario one needs trust, also a key factor for collaboration (Davenport et al., 1998, Henderson et al., 2016, Rezvani et al., 2016). However, the strength of collaborative SD processes, and the key to their success, is to use them to build trust via explicitness, transparency and clarity. Moreover, those advocating the use of SD processes should be convinced of its application by first successfully employing it for their own purpose.

3. Research approach

The ontological position of this research is based on critical realism with the epistemological stance that observable phenomena explained within a context can provide credible and useful data (Wahyuni, 2012). The work presented in this paper constitutes a constructive research approach (Oyegoke, 2011, Lahdenperä, 2016) with PAR in two case studies. Constructive research approach is a problem-solving method associated with both interpretive and positivist epistemology and empiricism (Oyegoke, 2011) and as such embrace both quantitative and qualitative research methods (Wahyuni, 2012).

Although constructive research approach are characterized by heuristic innovations and demonstration of the practical usability of the proposed solutions, i.e. it produces new knowledge primarily through the "method of reasoning" (Kasanen et al., 1993), constructive research as a methodology begins with strong grounding in identifying a practical problem from practice complemented by related literature. To guide the process of collecting, analysing and interpreting the data as well as to avoid situations where the evidence does not address the initial research questions, we endeavoured to achieve a six-step constructive research process (Oyegoke, 2011). *Step one*: identify a practical relevant problem that has research potential, i.e. the known challenges of collaborative research projects. *Step two*: perform a literature review to obtain a general, comprehensive understanding of the topic, i.e. SD methods. *Step three*: design the new construct, i.e. the SD process to be tested. *Step four*: demonstrate how the new construct works, i.e. implementing the SD process in the case studies. *Step five*: discuss the theoretical connections and the research contribution of the proposed concept. *Step six*: examine the scope of applicability of the solution to overall PM research.

Acknowledging that both constructive research approach and (PAR) are methods with fairly limited use in PM research we make efforts to further detail and clarify aspects related to the reliability and validity of the research.

3.1 Literature review - Collaborative research projects (Step 1)

We followed a three-step approach used for literature review. First, we clarified the scope by selecting key search words. "Collaborative" and "research project" were derived from our research question. Since a hallmark of research projects is their "exploratory" nature (Lenfle, 2008, Lenfle, 2016) we also included this as a key search word (Table 2). Second, we demarcated the search for evidence by targeting journals that are widely recognized as the leading sources in the PM field and one journal devoted to analysing, understanding and effectively responding to the economic, policy, management and organizational challenges posed by innovation, technology, R&D and science. The selected journals included *International Journal of Project Management (IJPM), Project Management Journal (PMJ) and International Journal of Managing Projects in Business (IJMPB) and Research Policy (RP).* Third, due to the large number of matches in the initial search, we limited the selection by targeting papers with the key search words included in the title and/or abstract. The papers were then individually reviewed by the first author and PM papers addressing key challenges of collaborative research projects were identified.

Table 2. Summary from the literature search.

Initial full text search

Journals	collaborative	exploratory	"research project"
IJPM	326	312	293
PMJ	141	171	121
IJMPB	180	295	92
RP	824	472	804

Key words in title or abstract

	Collaborative	exploratory	"research project"
IJPM	12	6	0
PMJ	12	11	0
IJMPB	27	14	0
RP	13	3	0

Many non-PM papers also provide rich accounts from engineers, researchers and managers working in collaborative research projects. As example a search in the IEEE Transactions on Engineering

Management journal using the key words, collaborative, exploratory and "research project" resulted in numerous papers and books. Narrowing the search to "collaborative research projects" gave 27 papers and when combined with “project management” the search gave 4 hits. Although such accounts are of relevance it was deemed appropriate with a relative narrow scope for the literature search (PM discipline), reducing risk of becoming too ambiguous without a clear identification of the research problem.

3.2. Literature review - scenario development (Step 2)

Before starting the literature search we tried to conceptualize the topic for our SD literature review (Brocke et al., 2009) and establish clear definitions of the main terms to support the identification of search phrases (Zorn and Campbell, 2006). Scenarios are the key concept in SD; they are what we develop. Thus, we decided that any methodology related to the development of scenarios would be of interest. However, we did not have the means to perform a full systematic literature search on scenario methodology. Thus, the literature search for scenario methodologies started with two main sources: 1) The 2013 special issue of Technological Forecasting & Social Change on scenario methodology (Wright et al., 2013) and 2) The top five hits on “scenario development” using Google Scholar (Schoemaker, 1993, Bishop et al., 2007, Mahmoud et al., 2009, Westhoek et al., 2006, Van Notten et al., 2005). The Google Scholar settings included all academic articles, i.e. no timeframe limitation, sorted by relevance. Patents and quotes were excluded. Based on the literature search for different scenario methodologies we selected four frequently referred terms: “scenario development”, “scenario planning”, scenario analysis/analyse” and “scenario methodology”. For the next step we selected three top-ranking project management journals and reviewed them for the selected search words (Table 3). The selected PM journals were IJPM, JPM and IJMPB.

Table 3. Key search words were “scenario development”, “scenario planning”, scenario analysis/analyse” and “scenario methodology”. Search results are grouped in three top-ranking project management journals: *International Journal of Project Management* (IJPM), *Project Management Journal* (JPM) and *International Journal of Managing Projects in Business* (IJMPB). The search included key words, titles and main text of the papers.

	“Scenario Development”	“Scenario Planning”	“Scenario Analysis” / “Scenario Analyse”	“Scenario Methodology”
IJPM	2	13	13 / 1	0
PMJ	0	3	11 / 0	0
IJMPB	0	3	1 / 0	0

To exemplify role of SD in context of non-PM journals a search in the IEEE Transactions on Engineering Management journal was performed. “Scenario development" as search criteria resulted in 75 papers but when combined with "project management" the search gave only 3 hits. After sorting the 75 papers according to relevance the top 25 papers were reviewed. Of the 25 papers a total of 11 papers were included as references due to their; - account of SD as a method /process, - relevance towards space industry and/or - relevance for socio-technical aspects of new technology development. The two last criteria were implemented due to their relevance towards the two case studies.

3.3 Designing and testing the SD process (Step 3)

PM as a discipline devotes significant attention to techniques and models that are designed to identify, assess and ultimately manage the risks and uncertainties associated with the project (Miller et al., 2001, Williams et al., 2009, Loch et al., 2011). In his investigation into different explanations for known project performance problems, Sanderson (2012) examines different assumptions about decision makers’ cognition and views on the future (risky or uncertain). He revisits the work of Simon (1947) and highlights the proposition that “decision-makers are intendedly rational, but only limitedly so”.

The key idea behind the proposed SD process is to combine the normative strength of PM processes (PMBOK, 2017) with the explorative strength of the SD method, i.e. providing a dynamic view of the future by exploring various trajectories of change that lead to a broadening range of plausible alternative futures, and their associated risks and opportunities. The SD process implemented for this study was a five/step method inspired by Mahmoud et al. (2009). The five steps included scenario definition, scenario construction, scenario analysis, scenario assessment, and risk management (Figure 2).

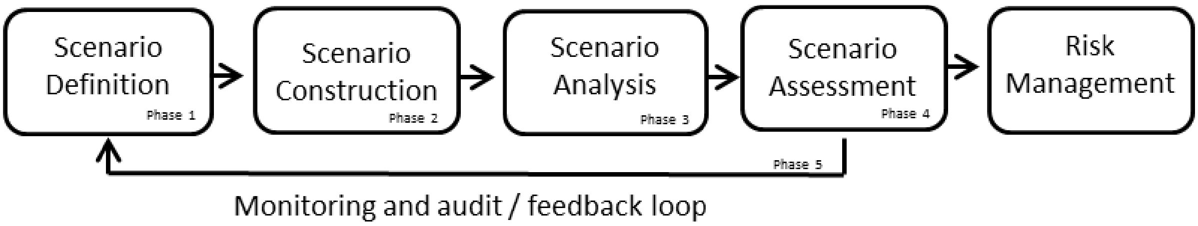

Figure 2. The five phases of the implemented SD process proposed by Mahmoud et al. (2009). Scenario assessment is the step of SD process where one crosses back into the realm of PM risk assessment and where the SD process has a natural convergence point with PM risk management processes.

In the following we account for the implementation and testing of these SD process in the two case studies.

3.4 Case studies

The two case studies are projects funded by the EU FPs, one under the 7th FP and one under Horizon 2020 (8th FP). Both projects were funded under the FP Space Calls[1] to develop innovative space technologies and operational concepts. The projects are anonymized in this paper. Table 4 identify the key attributes of the projects.

We will refer to them as "Robo-Coop" (Case 1) and "Greenspace" (Case 2). The Robo-Coop project consortium had seven beneficiaries from seven countries and was tasked with the development of collaborative human-robot technologies, i.e. robots and astronauts cooperating in exploration of the Moon and Mars. Greenspace had eight beneficiaries from six countries addressing emerging technology and concepts for photosynthesis-based regenerative life support systems, i.e. cultivating plants and algae in automated systems to produce food for astronauts on deep space exploration missions.

Both projects included verification testing of prototype system as part of the formal project deliverables. For simplicity we will refer to the project beneficiaries as project partners. Collaborative R&D projects funded by the EU under the FPs for Research and Technological Development are key research and innovation policy instruments used by the European Commission to foster knowledge exchange and recombination between partners located in different EU countries and to overcome the innovation gap between Europe and its key competitors (Colombo et al., 2016). Success of the funded projects is therefore considered a high priority at top political levels.

Table 4. Key attributes of the "Robo-Coop" and "Greenspace" projects.

	"Robo-Coop"	"Greenspace"
Goal	Development and testing of collaborative human-robot technologies for exploration of the Moon and Mars	Development and testing of technology and concepts for cultivating plants and algae in automated systems to produce food for astronauts on deep space exploration missions
Duration	36 months	36 months
Person-months	205	337

1 https://ec.europa.eu/programmes/horizon2020/en/h2020-section/space

No. of project partners	7	8
No. of countries involved	7	6
Person-months planned for PM	8	21
Person-months reserved for SD	14	15.5

During the project proposal preparation, it was suggested to the project teams that SD could be a way to improve collaboration in the projects. Work took place in the timeframe 2013-2017 and the two case studies allowed exploration of differences both within and between cases, thus making the study more robust and reliable than single-case studies (Yin, 2003).

Both projects had a dedicated work package (WP2) named “Scenario Development”. One of the authors was a WP manager in both projects. Steps three and four of our constructive research approach thus constituted a form of participatory action research (PAR), seeking to understand the world by trying to change it, collaboratively and following reflection (Reason and Bradbury, 2001, Lewin, 1946).

The use of PAR in PM research literature is actually fairly limited, but seminal works like Stephens (2013), Aubry et al. (2014), Walker et al. (2014) and Dick et al. (2015) establish PAR as a promising approach, especially as part of constructivist research. Stephens (2013) explores applied case studies utilizing PAR and presents us with a poorly researched perspective in PM, thus extending boundaries in PM theory as well as access to alternative research approaches that have been successfully applied to PM-related topics (Walker, 2013). Although PAR is in itself a research method that demands systematic description and execution, the focus of this paper is the overall constructive research approach, so we do not address PAR as a research method in further detail.

The findings presented in this paper are qualitative of nature with the aim of providing a rich account of how SD, as a method for engaging known challenges in collaborative research projects, was implemented and to what results. However, the authors’ account of the scenario process is supported by data triangulation, using minutes from project progress meetings and project e-mail correspondence as well as review of project proposals, formal project deliveries, progress reports and the periodical review reports from the commission and reviewers to the projects.

3.5 Reliability and validity

As accounted for by Wahyuni (2012) traditional concepts of reliability and validity do not fit perfectly into the qualitative research landscape and Bryman (2012) explain that reliability and validity per se cannot be practically used as criteria to assess qualitative research. In qualitative research dependability is often used similar to reliability in quantitative research while credibility, transferability and confirmability is often used in the same way as internal validity, external validity and construct validity in quantitative research (Bryman, 2012, Lincoln and Guba, 1985, Guba and Lincoln, 1989). The reliability and validity are further addressed in the discussion chapter.

4. Results and reflections (Step 4)

In the following section we discuss the role, scope and results of the SD processes in the two case studies. The main sources of information used here are project proposals, formal project deliveries, progress reports and the technical review reports from the commission and reviewers to the projects. Figure 3 and 4 illustrate the distances related to the five challenge variables and composition of types of organizations in the case studies, indicating the presence of a challenging collaboration setting. Four of the partners in Robo-Coop project had already worked together in similar EC projects.

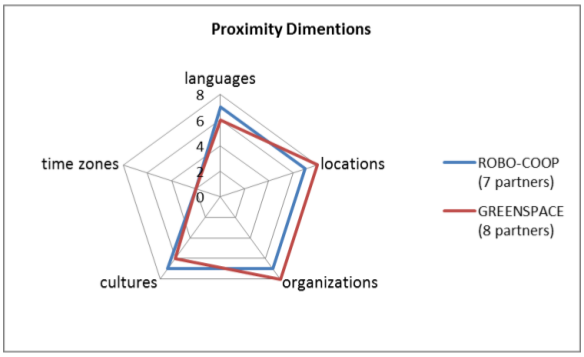

Figure 3. Using the five challenge variables to illustrate aspects of the case studies impacting the collaborative setting.

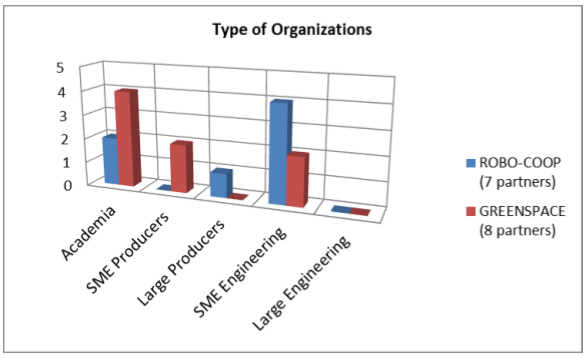

Figure 4. Illustration of type of organizations participating in the cases. Large > 250, small <250 employees.

We refer to the project proposals as they were granted after a negotiation phase with the EC, also referred to as description of work (DOW) under the 7th FP and description of action (DOA) under Horizon 2020. Both case studies had a dedicated work package (WP2) titled "Scenario Development" proposed with approx. 15 person-months of effort and scheduled for the four first months of the 36-month project durations. Robo-Coop was planned with a total of 205 person-months and Greenspace with 337 person-months. As such, 7.3% and 4.6%, respectively, of the human resources person-months) was reserved for the SD processes. As a reference, the dedicated PM work packages constitute a respective 3.9% and 6.2% of the manpower in the projects. Although the significant resource allocation indicates a key role of the SD process in the projects, neither of the final project proposals provided a clear definition of SD nor a description of an SD process. The term "scenario" is mainly referred to as a possible future state of the context in which the project products will be used. In the Robo-Coop DOW (94 pages) the term "scenario" was mentioned 43 times and "scenario development" was only mentioned five times all referring to the WP2 title. In the Greenspace DOA (57 pages) this was respectively five and two times, indicating less prominence than the resource allocation alone indicates.

In Robo-Coop the WP2 objective focused on developing three different scenarios for the use of the project product. In Greenspace the goal of WP2 was to elaborate and describe one scenario for the project. In Robo-Coop, the WP2 has three formal deliveries while Greenspace has only one, but with a similar three-part structure. All deliveries were limited to documents. In both cases it is emphasized that the SD is based on constraints and opportunities known from the state of the art (SoA).

In the following we describe the results/products of the SD process along the five SD phases: definition, construction, analysis, assessment and risk management/monitoring (Figure 2). We focus on how the SD process was addressed and the result utilized by the project teams.

4.1 Scenario definition

The intentions of the scenario definition phase are to identify the specific characteristics of scenarios that are of interest to project stakeholders, such as the spatial and temporal scales and key variables affecting the system of study. The key output from the definition phase should include drafts of preliminary narratives or mental images, e.g. by using a storyline process, scenario narratives provide qualitative descriptions of the end state of the desired scenario or the propagations of change necessary to achieve the desired end state (Schoemaker, 1993, Bishop et al., 2007, Mahmoud et al., 2009).

In both cases the main effort during the scenario definition focused on the identification and description of constraint and opportunities known from the relevant SoA. Participation in the SD process was limited to the project consortium partners, i.e. no external stakeholders were included.

In Robo-Coop the work under WP2 produced numerous scenarios for human-robot cooperation. The scenarios took the form of cartoon/comic strips, i.e. a sequence of drawings arranged in interrelated panels to display/form a narrative; however, text in balloons and captions was not used. Most of the identified scenarios were also serialized, i.e., indicating that one scenario would, or should, precede or follow another. The lack of "methodological scaffolding" used to derive these scenarios resembled what Bishop et al. (2007) called judgmental technique using visualization. Judgmental techniques are considered the most common in SD. They are easy to use and usually the origin for how most people, even professionals, assert what they believe the future will or could be.

With the development of only one main scenario in Greenspace, the project team chose an approach resembling what Bishop et al. (2007) define as baseline/expected technique. Such scenario is named baseline because it is the foundation of all the alternative scenarios considered.

The differences between the two cases show that sometimes one or few scenarios are considered sufficient to bind the zone of possibilities, while at other times numerous scenarios are considered necessary.

Although manifested in different ways, it seems that the project team in both case studies struggled with deciding if the scenarios should be developed for the management of the project, the product or both. Such balancing and trade-off discussions have similarities to known PM challenges of balancing project efficiency (PM success) vs. effectiveness (project success).

4.2 Scenario construction

Once the key scenarios have been defined, the next step is to complement the scenarios with details that reflect the scenario characteristics. The efforts of the construction phase depend on the scope and resources of the process. As initial input to project planning, an elaboration of the scenario narratives may be sufficient. For larger strategy processes one may use larger data sets and computational model-based approaches to construct scenarios (Mahmoud et al., 2009).

In both case studies there was little or no emphasis on formally separating the definition and construction phase, but both projects made efforts to add further information to the defined scenarios. Review of the selected scenarios may suggest that both project teams worked under a "predict and provide" approach (Samset and Volden, 2016) with clear aspects of path dependency. In practice, path dependency means we act as we did before, making the same choices, even if these narrow our focus, conflict with rational choices and ignore new opportunities (Samset et al., 2014, Dosi, 1997).

This observation is supported by the absence of extreme scenarios, i.e. creating one scenario with only positive outcomes and one with only negative outcomes. The use of extreme scenarios is a recommended scenario technique used to eliminate combinations that are not credible or not possible, thus developing the internal consistency and plausibility of scenarios. However, there is no trace of any negative scenarios in the project documents reviewed. It may seem that both project teams had difficulties in envisioning and accepting negative scenarios, ignoring such extreme scenarios due to lack of believability. Such effects are consistent with findings by Schoemaker (1993).

4.3 Scenario analysis

Scenario analysis focuses on identifying the consequences of interactions among the identified boundary conditions, driving forces and system components of the constructed scenarios. Most SD techniques describe the use of statistical and analytical techniques to analyse scenarios. The main intent of such analyses is to identify notable system conditions or behaviours, including trends, regimes, thresholds and triggers, discontinuities and cascading effects (Bishop et al., 2007, Mahmoud et al., 2009). No trace of such analyses can be found in the project documentation in either of the case studies. We present a twofold observation as an explanation for this: First, the selection of concepts and technologies was strongly driven by the interests of the participating organizations, i.e. the development of certain technology and/or knowledge was the main motivation, not the fundamental needs and long-term viability of the end result from the project. Second, it may seem that both mind-set and project resources are already fixed to a high degree at the start of the project, i.e., the opportunity space for various trajectories of change to take place within the project timeline is considered to be limited. We find support for this in the following cases and quotes:

1) The following comment was made by the reviewer in the first technical review report of the Robo-Coop project: *"- a realistic scenario should drive the employed technology! Here often the impression arises that it was handled the other way around: that technology available in the team drives the selected scenario".*

2) Already at the project kick-off meeting, the Greenspace project team was asked by key stakeholders about the possibility to develop a scenario where the project would *"work towards the manufacturing of ISS[2] flight hardware"*. That is, as an alternative to the proposed breadboard system for ground-based testing. No detailed technical analysis for such a scenario was performed, but such a scenario was deemed not feasible by the project team. Main rationales were related to the project resource envelope and need for redistribution of funds between project partners. Quote from the WP2 formal delivery in Greenspace: (This scenario is) *"Not a part of the formal GA[3] but an invitation from stakeholder X and Y[4] (and) Will require major reprioritizing of project objectives and resources and still with large risk for not qualifying for an ISS flight".*

The observation from Robo-Coop aligns with results of Sætren et al. (2016), who found that homogeneous groups of engineers tend to have a strong focus on technology and what technical problems are the important ones to solve. We also suggest that known challenges from PM related to the measurement of success and myopic decisions (Samset et al., 2014) can contribute to explain the reluctance to consider alternative technologies. As such, it seems the key stakeholder for each project partner, and the key driver for their definition of project success, is the top management of their parent organization.

The observation from Greenspace finds parallels in the PM literature addressing challenges related to project front-end management, i.e. analyses and decisions made before a project actually starts, and the process that defines the key characteristics of a project such as budget, timeframe, objectives and core concepts (Samset and Volden, 2016). It seems that decisions taken in the front-end management of collaborative research projects, such as budget, timeframe, objectives and core concepts, reduce the prospect for change of key requirements to take place within the project timeline. Furthermore, it reduces the believability among the project teams evaluating merits of alternative scenarios, and technologies, which require changes to the key characteristics of the project budget and schedule. Such effects are consistent with findings by Schoemaker (1993). More specifically, attempts to discuss scenarios that implied a redistribution of budget between project partners were experienced as extra provoking by most partners.

4.4 Scenario assessment - risk management, monitoring and post-audits

Scenario assessment includes identifying risks, rewards, mitigation opportunities and trade-offs. The assessments include dialogue with stakeholders, presenting results and collecting feedback needed to (re)formulate plans, to monitor and audit scenarios and resulting management strategies. Recommended techniques include influence diagrams, event trees, contingency planning, cost/benefit analysis and Delphi techniques (Bishop et al., 2007, Mahmoud et al., 2009).

As one of the ten PM knowledge areas, project risk management is usually performed as part of the PM planning process group but also considered a key activity in the PM monitoring and controlling process group (PMBOK, 2017). Scenario assessment is the phase of SD process where one crosses back into the realm of risk assessment and where the SD process has a natural convergence point with PM processes.

Although risk management was a recurring topic in both case studies there is no basis for claiming that this was done as part of the SD process. For Robo-Coop we quote from the year one technical review report: *"a cost / benefit (with respect to innovation and advancement in testing) analysis should help to set priorities for different scenarios".* This could be understood as a request for the type of activities recommended as part of the scenario assessments phase. However, a general quote from

2 ISS = International Space Station

3 Grant Agreement

4 X and Y are used to anonymize two major project stakeholders

the final technical review report of Robo-Coop is: *"Most of the suggested improvements from review 1 and 2 are still not addressed in a satisfactory way".* As there is no trace of such analysis in the project documentation, it appears that few or no assessments of the scenarios were done.

In Greenspace the project proposal included a comprehensive risk matrix identifying and defining the level of risk by considering the category of probability or likelihood against the category of consequence severity. This matrix is referred to in minutes from project meetings, indicating that it was used to support management decision-making. However, the project documentation shows no trace of an assessment and update of the baseline/expected scenario, i.e. no or limited monitoring and feedback loop was implemented for the SD process.

In the following we discuss to what degree the SD method represents a viable management processes for collaborative research projects. We also discuss the theoretical connections and applicability of SD to PM knowledge.

5. Discussions (Step 5)

Collaborative research is perceived in many quarters as somewhat fuzzy, involving high uncertainty, with an unclear rate of return, and troublesome to manage, e.g. (Fowler et al., 2015, Katz and Martin, 1997, Wingate, 2015). Given the prominent role of collaborative research projects in today's competitive environment, it is of key interest to understand to what degree existing PM models apply to the known challenges of such projects.

Selecting a constructive research approach, we investigated the extent to which SD constitutes a viable method to manage known challenges in collaborative research projects.

We identified several challenges using SD in the context of single-project management. Similar to PM processes, there are some fundamental challenges in using SD in the management of single projects (Samset and Volden, 2016). We found that SD processes struggle with issues related to decision-making in the project front-end, the definition and measurement of success, myopic decisions and a "predict and provide" attitude with clear aspects of path dependency. Furthermore, debating if scenarios should be developed for the management of the project, the project product or both has similarities to known PM challenges of defining and balancing PM success vs. project success.

In our literature review we did not identify any single PM challenge that is unique to collaborative research projects. Rather, we found the challenging combination and severity of known PM challenges to be a hallmark, making collaborative research projects a unique project type. Our findings thus align with those of Barnes et al. (2006) and Lippe and Brocke (2016), suggesting that any re-invention of PM approaches for this specific type of project is not an appropriate approach. However, findings in our study support the impression that missing or misunderstood application of intuitive, incremental and iterative PM processes represents a key challenge for innovation, research and development projects (Fowler et al., 2015, Lenfle, 2016). Although such processes are reflected in the PM body of knowledge, e.g. PMBOK (2017), we found limited knowledge (literature review) and missing practice (case studies) regarding how to apply such processes. This represents a significant PM research gap

Artto et al. (2008) addressed innovation projects and different context-specific strategies of single projects and found that project strategy is more often a mere image of its parent organization's or a sponsor organization's strategy. This is supported by our findings indicating that senior management of parent organizations are the key stakeholders of each project partner. We find this to be a natural consequence, i.e. it is reasonable to expect that new knowledge from a research project should align with the strategies of parent organization to advance dedicated knowledge areas. However, implementing multiple strategies of different partners' parent or sponsoring organization in collaborative research projects represents a murky landscape.

Lippe and Brocke (2016) identify 16 factors and present a situation-specific approach enabling managers to apply established PM knowledge according to changing, possibly contradictory, project needs. However, given the core of known challenges for collaborative research projects, each project partner most likely has a very different understanding and description of the project situation, a situation that most likely would change over time. We would rather solicit PM knowledge and processes that address the known core challenges of collaborative research projects, i.e. insufficiently defined goals and/or (research) methods, challenging stakeholder environment and the need for intuitive and iterative project processes.

In both Robo-Coop and Greenspace projects, the SD process resulted in scenarios that were used to shape the collective mind-set of the project teams as well as the project products. Although the processes (both PM and SD) in our case studies failed to be iterative both projects incorporated innovative features in their products that were initiated as part of intuitive thought processes.

We propose that viable management of collaborative research projects needs to address two key perspectives: - A *collaborative perspective*, i.e. the heterogeneous nature and the “challenge variables” mean that collaborative research projects “tick the boxes” for almost all known PM collaboration challenges. - A *research perspective*, i.e. the central role of experimentation (methods) in research projects establishes a need for iterative and intuitive project processes. In the following we discuss these two perspectives further.

The collaborative perspective - SD process as stakeholder management

Our literature review revealed that SD and PM are “siblings” originating from the same roots. With the long history of SD in engaging stakeholders in political and business strategies and decision-making and the introduction of stakeholder management in the PM discipline during the last decade, it seems that the two disciplines have rediscovered each other. We proposed that the reintroduction of SD and PM would have a great potential for the management of known challenges of collaborative research projects, e.g. by building scenarios as alternatives to single issue “snap-shots” it is expected that the dialogue and the information from stakeholders would be much richer. Also, to analyse the scenarios that stakeholders develop is expected to be far more valuable than current methods for project stakeholder analysis. In specific it is expected that the type of “what if” information extracted from scenarios will be valuable in understanding stakeholder dynamics.

However, in our case studies we found little evidence that the SD processes mitigated known challenges related to the collaborative perspective. Successful SD rests on the ability to enable more coordinated decision-making and action by articulating a common view towards the future and the key influencing factors. This, we would argue, is also key to successful PM and as such raises some fundamental questions about the usefulness of SD in the management of single projects collaborative challenges.

The research perspective - SD as intuitive and iterative project processes

Scenarios are intended to portray a set of alternative futures that could occur no matter how improbable the occurrence is (Mahmoud et al., 2009). The strength of scenarios lies in identifying and including elements that was not, or cannot, be properly modelled in predictive and rational PM processes, e.g. changing world views, value shifts, disruptive regulations or innovations. Scenarios go beyond objective analyses to include subjective and intuitive interpretations usually missing from rational project processes. SD could thus represent powerful processes supporting such “non-rational” decisions, helping project managers to decide what to do and why to do it (Thomas et al., 2012). However, we found some fundamental challenges in using SD in single-project management.

The implementation of the scenario process as a work package limited in timeframe, scope and deliveries was not suited. After the initial effort there was little or no interest in the scenario development process in the project teams. As such we failed to implement the whole process in our case studies and the iterative nature that is a cornerstone of scenario development was virtually non-existent. However, we did find the SD process was helpful for structuring the intuitive project processes in the initial project phases (1-6 months). This resulted in useful scenarios that were implemented in the further project process.

5.1. Theoretical connections and applicability of SD to PM knowledge (Step 6)

We argue that the iterative nature of SD aligns to the normative description of iterative and incremental life cycles provided by PMBOK (2017) and, as such, the iterative aspect of SD processes provides little new theoretical contribution to PM knowledge. However, in both our case studies the projects failed to implement iterative project cycles, indicating that the iterative research process suffers while the project manager struggles to harmonize it with the dominant rational PM approach to the project needs. Our findings thus support those of Fowler et al. (2015) and suggest a considerable research gap in the PM literature.

Lenfle (2008) wrote that projects which deal with exploratory tasks are more about “a way to construct the future and to break with past routines” than a standardized set of management tools. The term “project” stems from the Latin “pro” and “iacio”, meaning to cast forth or throw ahead, supporting the notion that SD and PM are “siblings” that complement each other with a power not very different than the unparalleled power of a “intuitive and rational mind” working together (Samples, 1976).

Not unlike the stakeholder concept, the concept of SD was initially developed for use on corporate level with focus on business and strategy development (Eskerod et al., 2015, Schoemaker and van der Heijden, 1992). We believe there is a strong theoretical connection between SD and stakeholder management processes to build on (Fossum et al., 2016) and that the proposal to (re)introduce SD to the PM discipline have theoretical merits with practical applications.

5.2 Weaknesses

The paper addresses SD methodology but does not provide any comprehensive, normative account of scenario methods or techniques. Nor does this paper compare SD against other foresight and future studies methods.

Our research approach and results also have some limitations: *First;* the empirical data are qualitative and derived from only two case studies funded under the EC FPs. This may limit their transferability to projects funded under other schemes, e.g. national agencies. *Secondly*, the use of PAR for testing the SD construct and chosen approach for reporting the results make this paper especially qualitative, with most of the weaknesses inherent to many qualitative studies.

Third, our approach has some weakness when it comes to distinguishing between cause and effect. An example is the role of trust. Many PM authors highlight trust as an important factor for successful projects. Also, most SD authors emphasize that for SD processes to develop a common future view that provides a fertile basis for collaboration, one need to develop trust among the participants. Thus, in applying SD to a project with a goal of improving collaboration one faces a paradoxical situation when trying to determine cause and effect. For example, in the case of a successful project using SD, was trust already established in the project team at the start of SD process, or – if SD processes develop trust in the team – was it the scenarios, the trust or a combination that contributed the most to the successful project? The research presented here was not designed to identify such cause and effect relations.

Also, a fact that should not be lost on anyone is our choice of a research approach (constructive) that is characterized by heuristic innovations to investigate processes to manage intuitive, holistic and relational thinking in a discipline, i.e. PM, which are strongly anchored in qualitative and engineering disciplines. However, to what extent this represents a weakness strongly depends on the reader’s view on roles and relations between the rational and intuitive mind.

5.3 Reliability and validity

To evaluate the quality of our research we shortly discuss the *dependability* (reliability), *credibility* (internal validity), *transferability* (external validity), and *confirmability* (objectivity) (Wahyuni, 2012).

Dependability corresponds to the notion of reliability which promotes replicability or repeatability. We argue that the detailed explanation of the research design and process, enabling other researchers to follow a similar research framework, ensure that reasonable dependability have been achieved. However, the lack of common standardized practices for SD constitutes a challenge towards any exact replicability of the SD process.

Credibility deals with the accuracy of data reflecting the observed social phenomena. We argue that the selection and documentation of the case studies provide credibility to the claim that the study addresses collaborative research projects and the use of data and researcher triangulation provide credible rich account of both observed social phenomena and the project processes. However, limitations in the data coding could challenge any identification of other perspectives which may have been overlooked by the authors.

Transferability refers to the level of applicability into other settings or situations. We hope that the rich and thick account of case studies and their characteristics provided sufficient transferability. However, we acknowledge that the study and its result have limited transferability beyond the collaborative research projects (project type), EU projects (political and legal frames) and the space sector (application area).

Confirmability refers to the extent to which others can confirm the findings. Given the use of a qualitative research method, that any social setting is unique and hardly reproducible we acknowledge that the study have some limitations. However, our account of the research problem, case studies, research approach and SD as the construct under investigation constitute a research trail that should enable other researchers with access to the project documentation (from the case studies) to confirm our findings.

6. Concluding remarks

We addressed collaborative research projects as a widespread approach to implement complex research work. Using a six step constructive research approach we examined to what extent SD could be a useful method to support the management of collaborative research projects. To our knowledge this is the first study to report on the practical implementation of SD in single project management.

We conclude that SD processes are useful to structure, describe and analyse intuitive project processes. However, we found some fundamental challenges in using SD in the management of single projects. Similar to PM processes they struggle with known paradoxes regarding PM and project governance (Samset and Volden, 2016). SD processes struggle with issues related to decision-making in the project front-end, the definition and measurement of success, myopic decisions and a “predict and provide” attitude with clear aspects of path dependency.

Given the role of innovation in today’s competitive environment, it is important to formalize and circulate relevant PM models for research and innovation projects. Our literature review indicates no single unique challenge existing for collaborative research. It is, however, the combination and degree of known challenges that make them unique as a project type. We conclude that future studies of collaborative research projects need to look beyond the single project perspective. Further, we conclude there is a solid basis for proposing *a collaborative perspective* and *a research perspective* as the main theoretical basis when studying collaborative research projects and seeking an increased understanding of key factors for their successful management.

The main theoretical contribution of this research is the proposed combination of the rational and normative strength of PM processes (PMBOK, 2017) with the intuitive and exploratory (Lenfle, 2016) strength of SD processes, i.e. a tool to align the rational and intuitive mind of project stakeholders and decision makers. As such this research provides novel reflections and contributions to the PM academic discourse and practice. We are optimistic that this study contributes to the structured discourse of a growing community with a focus on research and development within the frame of projects.

The practical contribution of this research is knowledge about alternative tools and processes for organizations to address key obstacles to improve innovation and learning outcomes from collaborative research projects. Such improvement is of key interest and at the core of the policy in funding bodies as well as of importance for organizations to succeed in today's competitive environment.

With the long history of SD in engaging stakeholders in political and business strategies and decision-making and the contemporary role of stakeholder management as a key research stream in the PM discipline we believe there is great potential to further develop SD processes as a tool to support PM processes.

Recognizing that no management processes are going to alleviate the fact that all our knowledge is about the past and all our decisions are about the future, we conclude that SD is a promising tool if one believes that *"the intuitive mind is a sacred gift and the rational mind a faithful servant"*.

Future work

As an larger effort to (re)introduce SD to the PM body of knowledge, future work should provide a more comprehensive normative account of how scenario methods and techniques could be aligned with existing PM process groups (PMBOK, 2017).

Our study indicates some fundamental challenges of using SD in the management of single projects. Given that most known use of SD is on corporate strategic levels it would be interesting to investigate how such strategic use of SD can be extended and integrated into the programme or project portfolio level with the intention to support the front-end definition phases of research projects.

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