Global Collaborative Research Projects

Exploring scenario development

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Doctoral thesis

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Thesis for the Degree of Philosophiae Doctor

Trondheim, February 2020

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Preface

Today, it is established knowledge that project management practitioners require not only technical skills, but also leadership, strategic and business management skills to succeed.

The tools and techniques available to the project management discipline are considered adequate to manage most project types. However, this is not always the feeling one is left with when working with collaborative research projects in global environments. Prior to my research for this doctoral thesis I worked for several years as a project manager and as a research manager with project portfolio responsibilities. Having experienced the practical challenges of managing collaborative research projects in a global environment, my efforts with this thesis are motivated by the need for a better understanding of the challenges involved in managing global collaborative research projects.

Successful research projects hinge on the capacity to manage interactions between people, organizations, technology, stakeholder politics and business interest in a holistic manner. Furthermore, as all our knowledge is about the past and all our decisions are about the future, we need to carefully consider how we cast forward our knowledge of the past onto the images we hold of the future.

This dissertation builds on the differentiation of project management and project leadership roles and investigates how foresight and future studies methods for strategic and business decision support (scenario development) can be implemented to support both roles.

This thesis addresses safety and human factors as a specific technical and operational component of the project product with considerable importance for the strategic and business success of the project and used as a frame of reference when investigating and discussing the two case studies.

Parts of the research presented in this thesis were done at NTNU Social Research AS in preparation for my doctoral thesis, including interactions with a wide variety of colleagues in both academia and industry.

For time and the world do not stand still. Change is the law of life.
And those who look only to the past or present are certain to miss the future[1].

- John F. Kennedy –

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[1] "Address in the Assembly Hall at the Paulskirche in Frankfurt (266)," June 25, 1963, *Public Papers of the Presidents: John F. Kennedy, 1963. https://www.jfklibrary.org/learn/about-jfk/life-of-john-f-kennedy/john-f-kennedy-quotations*

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Summary

In hindsight most managers are able to point out the decisions which took a project in the wrong direction as well as the factors that most likely impacted the decisions. Similarly, with hindsight it is easier to identify alternative decisions that could have increased the chances for a successful project. Foresight, often considered the opposite of hindsight, has become a widely used term to describe a set of competencies used to support strategic management, identify new business opportunities and increase innovation capacity.

This dissertation focuses on global collaborative research (GCR) projects, e.g. those funded under the framework programmes implemented by the European Union (EU), and it investigates how scenario development as a foresight methodology can support identification, mitigating and monitoring of known project management (PM) challenges for GCR projects. This dissertation also addresses human factors & safety as a specific technical and operational component of the project product. Structured along a six-step constructive research approach, this dissertation addresses three research questions (RQ).

RQ1: What are the known PM challenges for global collaborative research projects?
RQ2: To what extent are known PM challenges linked to lacking focus on human factor & safety aspects in new technology developments?
RQ3: To what extent can scenario methodology assist project managers in addressing known challenges of global collaborative research projects?

The research questions are addressed through seven individual publications that comprise the core of this dissertation. Page 18 lists the papers in the order they are published. However, the recommended order of reading is as follows: Paper VI, V, III, IV, I, II and VII.

Based on findings in these individual publications and supporting literature reviews, this dissertation clarifies the GCR projects as a project archetype and provides a theoretical framework to describe, analyse and address key challenges in the management of such projects.

RQ1 was addressed in the initial literature review and later supplemented with results from the survey and case studies. As the literature review found very little research addressing GCR projects, a decision to address the literature from three perspectives with significant amounts of relevant PM literature was made. That is, *a global, a collaborative and a research perspective.*

The three most challenging areas identified were i) The project environment, e.g. the global and collaborative aspects. ii) The decision making, e.g. implementing iterative project processes and balancing rational vs. intuitive decision processes. iii) Diffuse success criteria driven by the research aspect and heterogenic stakeholder interests.

RQ2, addressed in four of the seven publications, investigated human factors & safety as a specific technical and operational component highly relevant for strategic and business objectives of new technology development. NASA's Space Shuttle project provides a relevant example, where a super high-tech (array type) project was managed as a high-tech (system type) project, arguably contributing root causes of the Challenger accident.

Findings from the case studies in this dissertation suggest that known PM challenges such as a narrow focus in different project phases and insufficient information coordination contribute to marginalizing the role of human factors in design and development of new technology, consequently generating increased risk towards strategic and business objectives of new technology developments.

RQ3 addressed in the context of RQ1and RQ2 considers a practical and holistic approach to scenario development. That is, considering the key PM challenges for GCR projects (RQ1) and findings indicating that known PM challenges may contribute to lack of attention to human factors and safety aspects in new technology developments (RQ2), a model was developed to investigate to what extent scenario methodology could assist project managers in addressing known challenges of GCR projects.

The sequence of the four sections, or topics, as illustrated in the figure – project environment, decision making, success criteria and scenarios – represent a chronological order relative to the project timeline and the alignment of the four sections of the matrices has key functions that can assist project managers in addressing known challenges of GCR projects.

Sense making with scenarios

S = Illustrate that this is a sense-making model, not a categorization model.
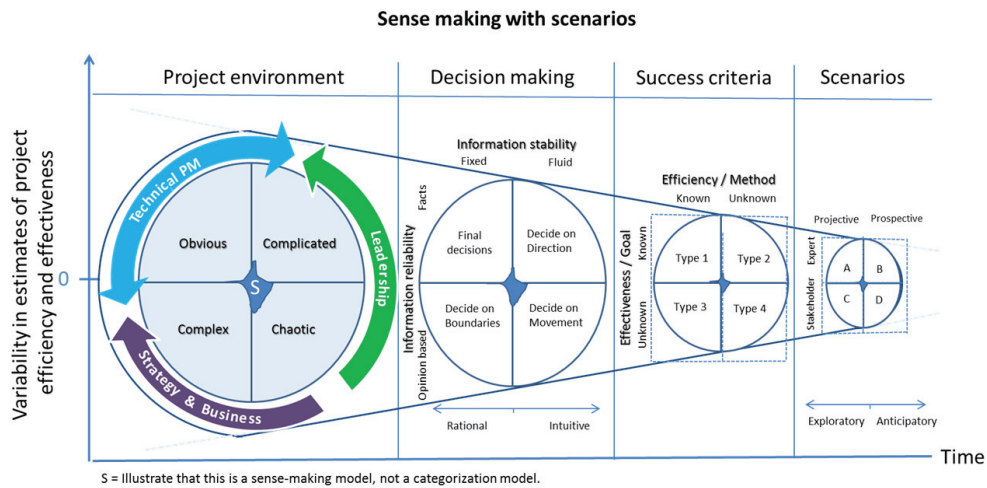
Conventional PM knowledge proposes that estimation improves as a project progresses, i.e. the (missing) arrow on the x-axis should point to the right. However, in scenario methodology the current situation is considered to be known and the future becomes increasingly uncertain, i.e. the (missing) arrow on the x-axis should point towards the left.

Right to left: The initial scenario definition phase should include four types of scenarios (A-D) identifying drivers for change and assumptions relevant to the project goal, variables affecting alignment project concepts (method) and organizational strategy, as well as drivers for cost and time. Comparing and analysing the alternative scenarios will reveal to what degree the different stakeholders and experts share the same images of project efficiency and effectiveness. For example, if the project efficiency criteria are found to be aligned (known) but criteria for project effectiveness are unaligned (unknown), the scenario construction phase should continue to engage stakeholders and further develop projective and exploratory scenarios. By analysing the reliability and stability of the information used to develop the scenarios, one can start to prepare the project decision making process and insert decision points and criteria in the developed scenarios. Analysis of the available information can also help identify the project environment type. For example, if a considerable part of the information used to develop the scenarios is opinion based and fluid, it is likely that one is facing a chaotic project environment. In chaotic project environments it is recommended to emphasize project leadership and strategy & business management skills to make decisions that move the project environment towards "obvious", via "complicated" and "complex" states respectively.

Left to right: In a chaotic project environment, for example, it is recommended to emphasize project leadership and strategic & business management skills to develop intuitive decision processes, i.e. in a chaotic environment there is little use for rational, cause-effect analyses based on historical directions or known boundaries. When one is facing a chaotic project environment, it is important to critically review anything one believes to be known about project efficiency and effectiveness criteria. As the project develops and decisions are made, it is important to update the scenarios and monitor the alignment of the project decisions with the success criteria. A vital factor is the continuous engagement of stakeholders to further develop prospective and anticipatory scenarios to analyse risk and opportunity related to movement in the efficiency and effectiveness criteria among stakeholders. The key objective is also to "move" the project from chaotic (type 4) projects to the more manageable type 2 or 3 (complicated or complex). Type 1 projects should not be eligible to be considered research projects.

The basic idea in both examples is to use scenario development to engage stakeholders and experts with the aim of defining clear, and achievable success criteria and to build support for the implementation of decision points and criteria in the project decision making, suitable for the relevant project environment.

The research contributions in this dissertation bridge three identified research gaps: (i) empirical PM research on GCR projects is limited, (ii) methods for balancing the rational and intuitive project leadership and strategic processes in GCR projects are largely missing from the PM literature, (iii) frameworks addressing the full set of known PM challenges in GCR projects are lacking.

Theoretical contributions made to a field of endeavour typically accept and attempt to extend current paradigms or reject current paradigms and try to replace them. This dissertation builds on existing theories and literature with the aim of identifying and addressing existing research gaps. As such, neither presumptions nor conclusions consider rejection or replacement of existing PM paradigms as appropriate avenues.

The findings in this dissertation suggest that adoption of terms like "technical PM", "project leadership" and "strategy and business management" in the Project Management Institute (PMI) perspective is a result of, or response to, PM research streams that during two decades accentuated the "one size doesn't fit all" and "beyond the hard paradigm" perspectives. As such, this dissertation supports the efforts of an ongoing redefinition of the field suggesting that movements are in a direction appropriate for managing known challenges of GCR projects. Addressing the limited PM literature related to the use of methods, tools and techniques to implement the appropriate combination of intuitive and rational management processes and the notion of combining PM processes and foresight processes constitute novel theoretical contributions.

An important aspect of any research contribution is the distinction concerning "*theory building vs. theory testing*" and "*problem structuring vs. problem solving*". Development of credible contributions to PM theory using existing publications and empirical observations as well as anchoring the research in existing theories is a key objective of this dissertation. As such, this dissertation contributes towards theory building, i.e. extending (instead of reinventing) PM theory. Theory testing is often defined by the use of hypothetico-deductive approaches, i.e. specifying the theory to be tested, deriving a set of conceptual propositions and restating the conceptual propositions as testable hypotheses. Although not mutually exclusive with a constructive research approach the research in this dissertation neither aspire towards nor satisfy the criteria of theory testing.

The typification of GCR projects and their known challenges constitutes a problem structuring approach and is considered one of the key contributions of this dissertation. However, building on this suggested problem structuring, the "sense making with scenarios" model arguably constitutes a construct for problem solving.

The practical contributions of the dissertation reside in the facilitating potential of integrating PM and scenario development processes. The model supports the practical implementation and hold a promise of project processes for identifying, mitigating and monitoring the key challenges of GCR projects: project environment, decision making and diffuse success criteria. Building on six different schools of thought, the practical application and chain of thought behind the "sense making with scenarios" model are as follows: - Governance defines the objectives of the project and success criteria - Success provides the objectives of decision making. - Contingency and behaviour define the project in a "social world" – Modelling supports better decisions and better decisions give more successful projects.

The dissertation further discusses and provides practical examples how the "sense making with scenarios" model could be used in different phases of the project lifecycle, e.g. harmonization with parent company strategy and governance processes and project stakeholder processes.

In conclusion, addressing identified research gaps this dissertation contributes to theory building and problem structuring by typifying GCR projects and practical problem solving by introducing the "sense making with scenarios" model. However, more research is necessary for further testing and enhancing synergies of PM and scenario processes, further documenting the utility of different approaches and remedies it offers for the management of GCR projects.

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Summary in Norwegian

I etterkant kan de fleste prosjektledere påpeke beslutningene som tok et prosjekt i feil retning, samt de faktorene som mest sannsynlig påvirket avgjørelsene. På samme måte er det i ettertid lettere å identifisere alternative beslutninger som kunne ha økt sjansene for et vellykket prosjekt. «Foresight», av mange betraktet det motsatte av etterpåklokskap, er blitt mye brukt begrep for å beskrive et sett av kompetanser som brukes til å støtte strategisk ledelse, identifisere nye forretningsmuligheter og øke innovasjonskapasiteten. Denne avhandlingen tar opp menneskelige faktorer og sikkerhet som en spesifikk teknisk og operativ del av prosjektproduktet.

Denne avhandlingen fokuserer på globale samarbeidsprosjekter, f.eks. de finansierte under rammeprogrammet gjennomført av EU, og undersøker hvordan scenarioutvikling som fremsynsmetodikk kan støtte identifisering, redusering og overvåkning av kjente utfordringer for globale samarbeidsprosjekter. Strukturert langs en seks-trinns (faser) konstruktiv forskningsstrategi, omhandler denne avhandlingen tre forskningsspørsmål.

RQ1: Hva er de kjente PM utfordringene for globale samarbeidsprosjekter?

RQ2: I hvilken grad er det kjent PM-utfordringer knyttet til manglende fokus på menneskelig faktor og sikkerhetsaspekter i ny teknologiutvikling

RQ3: I hvilken grad kan scenario metodikk bistå prosjektledere i å ta opp kjente utfordringer i globale samarbeidsprosjekter?

Forskningsspørsmålene er adressert gjennom syv individuelle publikasjoner som utgjør kjernen i denne avhandlingen. Side 18 lister opp artiklene i den rekkefølgen de er publisert. Imidlertid er den anbefalte rekkefølgen av lesing som følger; artikkel VI, V, III, IV, I, II og VII.

Basert på funn i disse individuelle publikasjonene og støtte litteraturvurderinger, forklarer denne avhandlingen globale samarbeidsprosjekter som en prosjektarketype og gir et teoretisk rammeverk for å beskrive, analysere og håndtere viktige utfordringer.

RQ1 adressert i den første litteraturvurderingen og senere supplert med resultater fra undersøkelsen og casestudier. Ettersom litteraturvurderingen fant svært lite forskning som adresserte GCR-prosjekter, ble det gjort en beslutning om å adressere litteraturen fra tre perspektiver med betydelige mengder relevant PM-litteratur. Det er; et globalt, et samarbeidsprosjekt og et forskningsperspektiv.

De tre mest utfordrende områdene ble identifisert; i) Prosjektmiljøet, f.eks. de globale og samarbeidende aspektene. ii) Beslutningen, f.eks. implementere iterative prosessprosesser og balansere rasjonelle vs intuitive beslutningsprosesser. iii) Diffuse suksesskriterier drevet av forskningsaspektet og heterogene interessentinteresser.

RQ2 adressert i tre av de syv publikasjonene undersøker menneskelige faktorer og sikkerhet som en spesifikk teknisk og operativ komponent som er svært relevant for strategiske og forretningsmessige mål for ny teknologiutvikling. NASAs Space Shuttle-prosjektet er et relevant eksempel der et super-høyteknologisk (array type) prosjekt ble forvaltet som et høyteknologisk (systemtype) prosjekt og uten tvil bidrar som årsak til Challenger-ulykken.

Funn fra casestudier i denne avhandlingen tyder på at kjente PM utfordringer som smalt fokus i ulike prosjektfaser og utilstrekkelig informasjonskoordinering bidrar til å marginalisere rollen som menneskelige faktorer i design og utvikling av ny teknologi og dermed generere økt risiko mot strategisk og forretningsmessige mål for ny teknologiutvikling

RQ3 adressert i sammenheng med RQ1 og RQ2 vurdere en praktisk og helhetlig tilnærming. Det er, med tanke på de sentrale PM-utfordringene for GCR-prosjekter (RQ1) og funn som indikerer at kjente PM-utfordringer kan bidra til manglende oppmerksomhet på menneskelige faktorer og sikkerhetsaspekter i ny teknologiutvikling (RQ2), ble det utviklet en modell for å undersøke i hvilken grad scenario Metodikk kan hjelpe prosjektledere til å møte kjente utfordringer ved GCR-prosjekter.

Den grunnleggende er å bruke scenarioutvikling for å engasjere interessenter med sikte på å definere klare og oppnåelige suksesskriterier og bygge støtte for gjennomføring av beslutningspunkter og kriterier i prosjektbeslutningen, egnet for det relevante prosjektmiljøet.

Forskningsbidragene i denne avhandlingen identifiserte tre forsknings gap; (i) Begrenset empirisk PM-forskning på globale samarbeidsprosjekter, (ii) metoder for å balansere det rasjonelle og intuitive prosjektledelsen og strategiske prosesser i GCR-prosjekter mangler i stor grad fra PM-litteraturen (iii) rammeverk som omhandler hele settet med kjente PM-utfordringer i GCR-prosjekter mangler.

Teoretiske bidrag til et fagfelt aksepterer vanligvis og forsøker å forlenge nåværende paradigmer eller forsøket å avvise nåværende paradigmer og prøve å erstatte dem. Denne avhandlingen bygger videre på eksisterende teorier og litteratur med sikte på å identifisere og bidra til eksisterende forsknings gap. Som sådan vurderer verken forutsetninger eller konklusjoner forkastelse eller erstatning av eksisterende paradigmer som passende veier.

Funnene i denne avhandlingen antyder at vedtak av begreper som "teknisk PM", "prosjektledelse" og "strategi og bedriftsledelse" i PMI-perspektiver er et resultat av eller respons på PM-forskningsstrømmer som i løpet av to tiår fremhevet "en størrelse passer ikke til alle" og "utover det harde paradigmet" perspektiver. Som sådan støtter denne avhandlingen innsatsen til en kontinuerlig redefinering av feltet og antyder at bevegelsene er i riktig retning. Å adressere den begrensede mengden PM-litteratur knyttet til bruk av metoder, verktøy og teknikker for å implementere den rette kombinasjonen av intuitive og rasjonelle styringsprosesser og begrepet kombinering av PM-prosesser og «foresight» prosesser, utgjør nye teoretiske bidrag.

Et viktig aspekt ved ethvert forskningsbidrag er skillet mellom "teori bygging versus teori testing" og "problemstrukturering versus problemløsning".

Utvikling av troverdige bidrag til PM-teori ved bruk av eksisterende publikasjoner, empiriske observasjoner og forankring av forskningen i eksisterende teorier er et sentralt mål for denne avhandlingen. Som sådan bidrar denne avhandlingen til teori bygging, dvs. utvide (i stedet for å gjenoppfinne) PM-teori. Teoritesting defineres ofte ved bruk av hypotetisk deduktive tilnærminger og, selv om det ikke er gjensidig utelukkende med en konstruktiv forskningsstrategi, går forskningen i denne avhandlingen heller ikke mot eller tilfredsstiller kriteriene for teoritesting.

Typegodkjenningen GCR-prosjekter og deres kjente utfordringer utgjør et problemstrukturerings-tilnærming og regnes som et av nøkkelbidragene til denne avhandlingen. Men bygger på dette foreslåtte problemet strukturering av "sense making with scenarios" -modellen utvilsomt en konstruksjon for problemløsning.

De praktiske bidragene til avhandlingen ligger i det tilretteleggende potensialet for å integrere PM og scenarioutviklingsprosesser. Modellen støtter den praktiske implementeringen og holder et løfte om prosjektprosesser for å identifisere, redusere og overvåke de viktigste utfordringene ved GCR-prosjekter; prosjektmiljø, beslutningsprosesser og diffuse suksesskriterier.

På grunnlag av fire tankeskoler er den praktiske applikasjonen og tankegangen bak "sense making with scenarios" -modellen som følger: - Styring definerer målene for prosjektet og suksesskriteriene - Suksess gir målene med beslutningstaking. - Beredskap og oppførsel definerer prosjektet i en "sosial verden" - Modellering støtter bedre beslutninger og bedre beslutninger gir mer vellykkede prosjekter.

Avhandlingen drøfter videre og gir praktiske eksempler på hvordan modellen for "sense making with scenarios" kan brukes i ulike faser av prosjektets livssyklus, f.eks. harmonisering med morselskapsstrategi og styringsprosesser og prosessinteresseprosesser.

Konklusjon; Når det gjelder identifiserte forsknings gap bidrar denne avhandlingen til teori bygging og problemstrukturering ved å typifisere GCR-prosjekter og praktisk problemløsning ved å introdusere "sense making with scenarios" -modellen. Mer forskning er imidlertid nødvendig for ytterligere testing og forbedring av synergier i PM- og scenarioprosesser, og videre dokumentasjon av bruken av ulike tilnærminger og rettsmidler det tilbyr for styring av GCR-prosjekter

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Journal papers

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PAPER VI

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PAPER VII

FOSSUM, K.R, BINDER, J. MADSEN, T. AARSETH. W. & ANDERSEN, B. 2018. Success factors in Global Project Management - A study of practices in organizational support and the effects on cost and schedule. *International Journal of Managing Projects in Business (Pre-Published) https://doi.org/10.1108/IJMPB-09-2018-0182*

PART I: THEORETICAL BACKGROUND AND KEY FINDINGS

1. Introduction

Project management (PM) is predominantly a task-oriented discipline and most projects are managed and delivered with an operational mindset, focusing on scope, time and budget goals. Also, in an increasingly dynamic, global and competitive environment, project managers are under ever increasing pressure to focus on the strategic & business aspects of their projects (Aaltonen et al., 2008, Anantatmula & Thomas, 2010, Orr et al., 2011, Aarseth et al., 2011, Aarseth et al., 2013, Binder, 2007). Skilful management of interdisciplinary and collaborative projects in a global environment depends on a successful balance of day-to-day task and technical management with project leadership and organizational business cooperation (Brocke & Lippe, 2013, Lippe & Brocke, 2016).

As a discipline, PM developed from several fields of application including civil construction, engineering and heavy defence activity (Morris, 2011, Seymour & Hussein, 2014). Today PM theories, tools, and techniques are mainstream in most organizations and industries.

Project-based research has become the prevailing practice for funding and organising research efforts and collaborative research projects have emerged as a particular form of academia–industry interaction (Brocke & Lippe, 2015, König et al., 2013, Fowler et al., 2015). Each year European companies and academic institutions compete for billions of euros in research funding[2]. Most research projects resulting from such funding will have a multi-national, inter-disciplinary, inter-organizational and decentralized structure. The main goal of these programs and projects is to bring European institutions and companies to the frontlines of global innovation and to address the major challenges facing the European and global society (EC, 2019). These global collaborative environments are more often our only rational response to the complexity, ambiguity and uncertainty in the grand challenges for our global society (UN, 2018). As such, these projects represent increased challenges to our PM tools, processes and philosophies.

In the contexts of such global collaborative environments, one observation holds true for many PM practitioners and academics: the human factor[3] creates abundant challenges as well as solutions. Whatever undertakings humans set out to complete, even efforts to create fully autonomous systems, they are imprinted with aptitudes and flaws spawned from the nature of human beings. Within the PM discipline, such a perspective is most familiar to the behavioural school (Bredillet, 2008a), which highlights the importance of the relationships between people on the project, team building, leadership, communication and human resource management (Thamhain, 2004, Turner & Müller, 2005, Müller & Turner, 2007). Knowledge of human nature is also prominent in stakeholder management (SM) literature (Aaltonen et al., 2013, Aaltonen & Sivonen, 2009) and in key ideas put forward by the marketing school (Bredillet, 2008c). The understanding and modelling of organizational, behaviour and political issues affecting projects are also part of the modelling school soft-system methodology and sense making literature (Bredillet, 2007). Thus, the capacity of an organization to provide appropriate support to their managers and employees, e.g. management of the human factor, is a topic of interest within several schools and research streams in the PM discipline.

Drouin & Jugdev (2013) highlight the importance of translating knowledge from more established fields to PM research. PM is still evolving and there are merits in the concept of drawing from solid theoretical foundations, such as those found in organizational theory. However, in terms of understanding and guiding practitioners (Bredillet et al., 2015) the central argument is that organizations must be viewed from different theoretical perspectives, that is, single theories or approaches cannot address the full complexity of organizations (Bolman & Deal, 2017, Morgan, 1986, Ghoshal, 2005, Mintzberg, 2004) (Ghoshal, 2005, Mintzberg, 2004)

This introductory chapter addresses the background, objectives and rationale for the scoping of the thesis and the research presented. This section also introduces presumptions, theoretical positioning and the influence this could have on the selected research approach and structure of this thesis.

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[2] The European Commission (EC) has an estimated research and development budget of approx. EUR 78 billion for the 2014 – 2020 period. Other (pan) European organizations such as the European Space Agency (ESA) have programs and incentives that spawn similar types of projects.

[3] We refer to the human factor as the human abilities, limitations, and other characteristics that are relevant to design of tools, machines, systems, tasks, jobs, and environments for safe, comfortable, and effective use

1.1 Background

Small and Medium Sized Enterprises (SME) are the driving force of the European economy and we need SMEs that are ready to take their ideas to the European and global markets, taking the lead in bringing Europe to the front line of global innovation. To gain such a competitive advantage takes strategic planning and requires a research capacity and capability that few SMEs have in-house. To master such challenges, SMEs depend on good partnership and research collaboration with other SMEs, research institutes and universities, as well as large industries and public institutions. This situation is widely acknowledged and actions have been initiated (EC, 2014). Each year, European companies compete for billions of euros in research and innovation funding. Significant parts of such funding spawn research projects that through inherent needs and through incentives have a multinational, interdisciplinary, inter-organizational and decentralized structure.

The European Commission (EC) alone has an estimated research and development budget of approx. EUR 78 billion (EC, 2015) for the 2014 – 2020 period. Other (pan) European organizations such as the European Space Agency (ESA) also have programmes and incentives that result in similar types of projects. The main goal of these programmes and projects is to bring European companies to the front line of global innovation and to address the major challenges facing European and global society. However, these interdisciplinary and collaborative projects are themselves known to have inherent challenges (Davenport et al., 1998, König et al., 2013, vom Brocke & Lippe, 2015).

Building on extensive review of scientific literature Lippe & Brocke (2016) account for known challenges in the management of collaborative research projects. Using projects originating within the EU Framework program as examples Brocke & Lippe (2015) propose a conceptualization of collaborative research projects. Investigating interdisciplinary research management König et al. (2013) adapted the Competing Values Framework as a map and sense making device for locating functions, demands and potential conflicts in research project management These contributions account for research that has resulted in general rules, recommendations and contributions that explain the settings and processes inherent for the management of collaborative research projects. As such, there is considerable amount of relevant research literature addressing the research and collaborative aspects of EU Framework projects. However, this body of literature, arguably, lack full and relevant comprehension and conceptualization of the global environment in which these project operate

Recent years have seen an increased scepticism and criticism towards the last 70 years of increasing globalism and a preference for multinational agreements. However, the work presented in this dissertation builds on a worldview where solutions to global challenges, national and commercial competitiveness need global strategies and collaboration. The efforts behind this thesis are motivated by the need for a better understanding, and management, of collaborative research projects in global environments, i.e. global collaborative research (GCR) projects.

1.2 Research objectives

The objective of this thesis is to develop a better understanding of GCR projects as a specific type of project with the aim of gaining and presenting novel knowledge contributing to better management of such projects. This overall goal was broken into four research objectives (ROs).

RO1 - Collect empirical data on PM of global collaborative research projects

RO2 - Identify and describe the key determinants of their success

RO3 - Contribute new PM knowledge on global research collaboration

RO4 - Develop new knowledge useful to those undertaking global collaborative research projects

Based on these objectives, three research questions (RQs) were formulated. The research questions and the rationales behind their formulation are presented in Section 2.5.

1.3 Research scope

This thesis focuses on global collaborative research (GCR) projects, e.g. those funded under the framework programmes implemented by the EU, and investigates how foresight methodology – more specifically, scenario development – can support identification, mitigation and monitoring of known challenges for GCR projects. This thesis addresses aspects of human factors and safety as a specific technical and operational component of the project product and used as a frame of reference when investigating and discussing PM in GCR projects.

1.4 Structure of the dissertation

This PhD dissertation consists of two parts: Part I - Theoretical background and key findings and Part II - Individual publications. Part I consists of six chapters which present the theoretical background, the research approach, the key findings and a discussion of the contributions in dissertation (see Figure 1).

Chapter 1 is an introduction to the dissertation presenting the background, research objectives, scope, research process and introduction to the individual publications and the structure of the dissertation. Chapter 2 provides a literature review on the key theoretical perspectives relevant to this study. Chapter 3 describes the research approach and provides a methodological review in order to demonstrate why the research questions were formulated and how they have been answered through this dissertation. Chapter 4 provides a summary of the main results of the individual publications. Chapter 5 discusses the key theoretical and practical contributions of the research, as well as the limitations. Chapter 6 includes the main concluding remarks and suggestions for future research.

Part II includes a collection of the individual publications, three journal articles and four conference articles that represent the core work and contributions of the PhD research
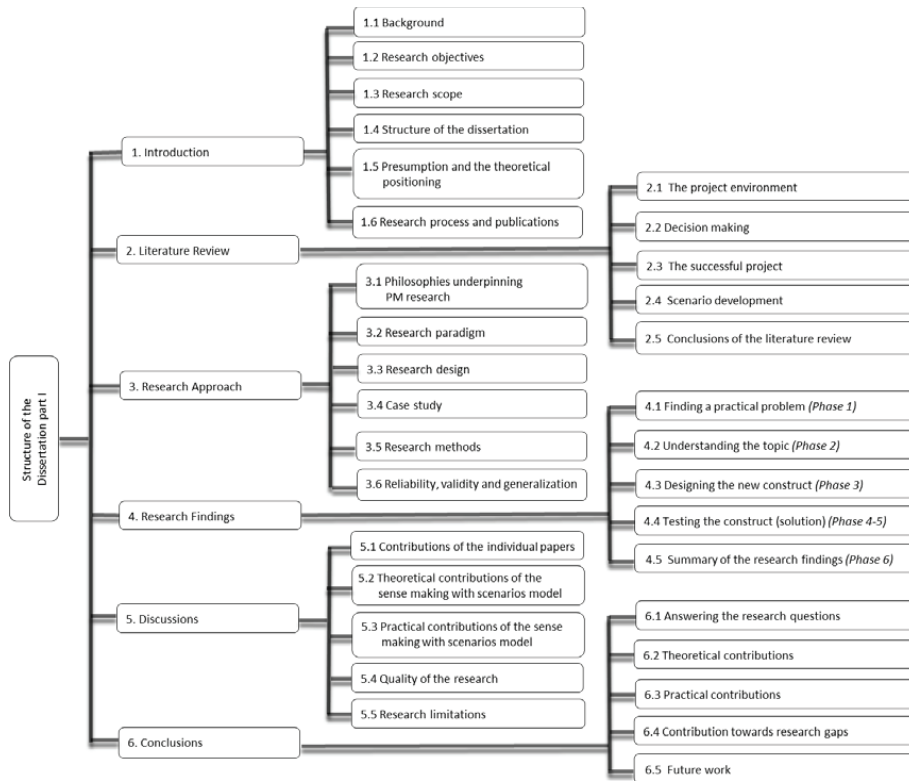
Figure 1 Structure of part I of the dissertation

1.5 Presumptions and the theoretical positioning

Presumptions are views about the world and how it works that we carry with us, impacting assumptions that we make every day, often without being aware of them. Such assumptions, tacit or implicit, are based on personal life experiences and usually not consciously apparent in our daily lives.

The logical and scientific ideals encourage us to leave all assumptions out of any decision making environment; however, as humans we know that this rarely is the case. Thus, it is important to be aware of how our experiences shape what assumptions we make and influence our interpretation of reality, both hindering and enabling us to see the "truth".

The **background,** objectives, scope and structure of this dissertation are described in the above sections and a detailed discussion of the "what", how" and "why" is covered in Chapter 5. These are descriptions and discussions of this dissertation as a final product. However, a PhD project is not just about the final product. It is just as much about the process. It should be a learning process with room to evolve the research process as new data is synthesized with existing information and knowledge, and hopefully, resulting in some wisdom.

In contemporary PM literature, there seems to be a general consensus that successful projects depend on more than rational and technical PM. Shenhar & Dvir (2007) were among the first to formulate this notion using three different theoretical perspectives: the strategic/business view, the team leadership view, and the operational/process view. Following Aarseth (2014), these can be considered as different mindsets that are essential for successful project managers: a rational PM, a leadership and a business mindset.

The three-part theoretical perspectives of Shenhar & Dvir (2007), the notion of different mindsets advocated by Aarseth (2014) and the introduction to foresight methodology by Mahmoud et al. (2009) form key theoretical boundaries for the research focus of this PhD project.

1.6 Research process and publications

The overall process for the PhD project started with the selection of the subject matter, i.e. a research focus, and objectives to be achieved through the research. Literature reviews were performed to identify relevant PM discourse and research gaps. Based on this the research questions were formulated. The topics of the individual publications have to some degree been opportunity based but have been developed according to the research objectives outlined in the previous section. The key and final step of the process is the dissertation, providing a synthesis of the research process and discussing how the research contributes to PM theory and practice (Figure 2).

Figure 2 Overall process for the research presented in this dissertation

It is important to acknowledge and account for the fact that the research focus, objectives and questions were modified during the PhD project, especially following the literature reviews and as the work with the case studies progressed. The chief intention of this section and Figure 3 is to provide such an account.

One of the early challenges experienced with the research process illustrated in Figure 2 was implementing the advice of Eisenhardt (1989) (and my supervisors) to quickly establish a research focus, the selection of the subject matter, to avoid becoming overwhelmed by the volume of data available. However, the overarching focus was always clear: this was to be a PM thesis. This provided some clear guidance on establishing a research focus, but also presented some challenges. This is exemplified by the three major changes that were made to the title of this PhD project.

Anno 2015 the initial title, under which the PhD project was approved, was *"A study of collaboration and success factors in international research alliances".* This focus was based on personal experience from projects in two different but related environments: the International Space Station (ISS) Programme and EU research programmes. The key objective was a better understanding of factors relevant for successful projects in such international and collaborative environments.

Anno 2016, during the mandatory year-one update of the PhD project description, it seemed right to update the title to *"A study of collaborative research projects".* This was done to make it clear that the unit of study is "the project" and the relevant project context is "collaborative research". This update was based on the initial literature search.

Anno 2017 the research focus, or research scope, had matured and the title on the first page reads, "A Study of Global Collaborative Research Projects" with the sub-heading "Exploring Scenario development". The topic of foresight methodology and scenario development originated in opportunities identified in two of the case studies and the decision to adapt this focus in the study was supported by a thorough researcher triangulation. In early 2019 the "A study of" was removed from the title.
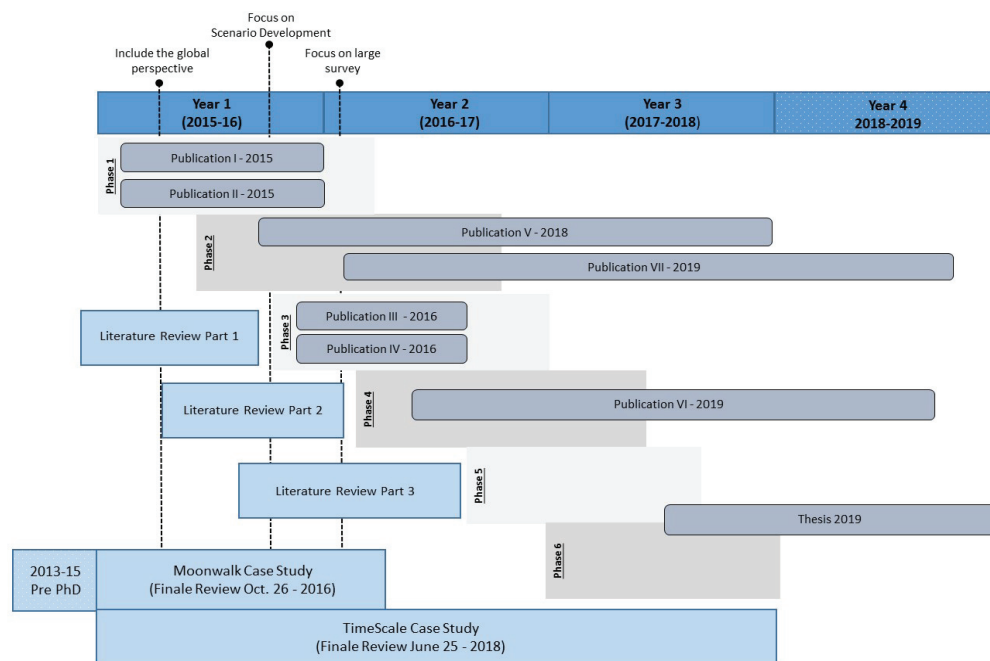
Figure 3 Research chronology with key changes to the planned research process on top. The six phases refer to the six step constructive research approach (see section 3.3). Different lengths of the publication bars indicate the time from initiation to publication.

Although the research questions (RQs) and research methods did undergo some modifications during the process, the initial intention of the research was maintained. These modifications provide an account of the learning process, and familiarization with the diverse and voluminous knowledge area that the PM discipline represents, which is essential for the final focus area of this research.

Explanation of the six phases of the constructive research approach are found in section 3.3, the case studies are described in section 3.4 and literature reviews are described in section 3.5.1 – Collaborative research projects (part 1), 3.5.2 – Organizational support in global projects (part 2) and 3.5.3 – Scenario development (part 3).

The choice to focus on foresight methodology and scenario development was supported by a thorough researcher triangulation / evaluation and the results constitute key contributions of this dissertation. However, with only two relevant case studies identified it represent a limitations to the research quality. These limitations introduced by such changes during the research process are discussed in section 5.5.2.

The following Chapter account for the result of the literature reviews.

(Intentionally blank)

2. Literature

This chapter presents the theoretical background and context that underpin this dissertation. This dissertation taps into different streams of literature and Figure 4 illustrates the literature structure in this chapter. Section 2.1 – 2.3 draw upon PM theory from six different "schools of thought" providing the PM theory used to discuss global collaborative research (GCR) projects in this dissertation (see Figure 5). Section 2.4 introduces scenario development and Section 2.5 provide the conclusions of the literature review and present the research questions» (see Figure 5).

Section 2.1 accesses the "contingency school" and PM theory on project characteristics to typify and generalize GCR projects and the environment to which most of them are exposed. This section also introduces aspects of the "behaviour school", addressing the need to include project teams in PM models, focusing on team building and leadership, communication, the role of human resource management and organizational support. Section 2.1.6 addresses relevant PM models and frameworks used to describe or explore complex project environments.

Section 2.2 draws upon two additional schools of thought to support the discussion on the applicability of scenario development (SD) and its contribution to PM knowledge. The "decision school" and PM lifecycle theory frame discussions on decision making. Theory on the "soft-systems modelling school" methodology and sense making is included, addressing the organizational, behavioural, political issues affecting projects and the complex environments within which they operate.
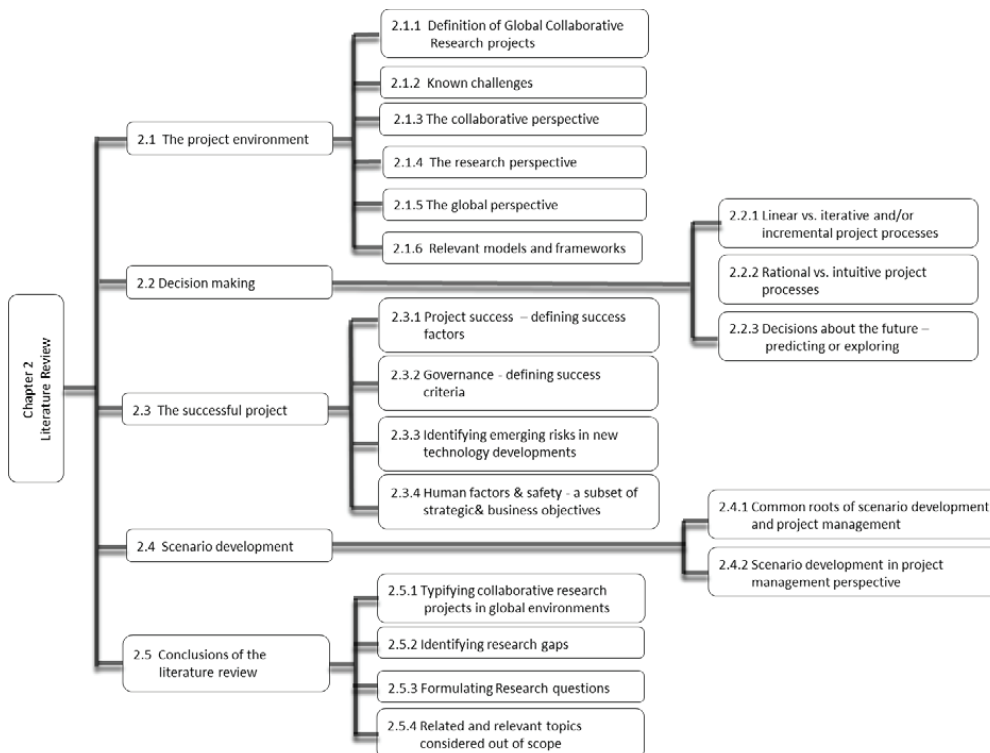
Figure 4 Chapter structure

Section 2.3 addresses literature from the PM "success school" to build a taxonomy and theoretical framework for discussing the success of the proposed construct, i.e. scenario development (SD), as a support to the successful management of GCR projects.

The constructive approach is, at its core, about identifying a problem, constructing a solution and testing how successful the proposed construct is. In this context, the ambiguity in the meaning of success also need to be addressed, e.g. project success vs. project management success

The definition of PM strategies and objectives and as such of success criteria is here introduced as an integral part of the "governance school". This section also introduces human factors & safety as a subset of strategic and business success criteria in new technology developments.

In short, the chain of thought behind this approach is as follows: - Governance defines the objectives of the project and success criteria. - Success provides the objectives of decision making. - Modelling helps us to make better decisions. - Better decisions support the success of the project.
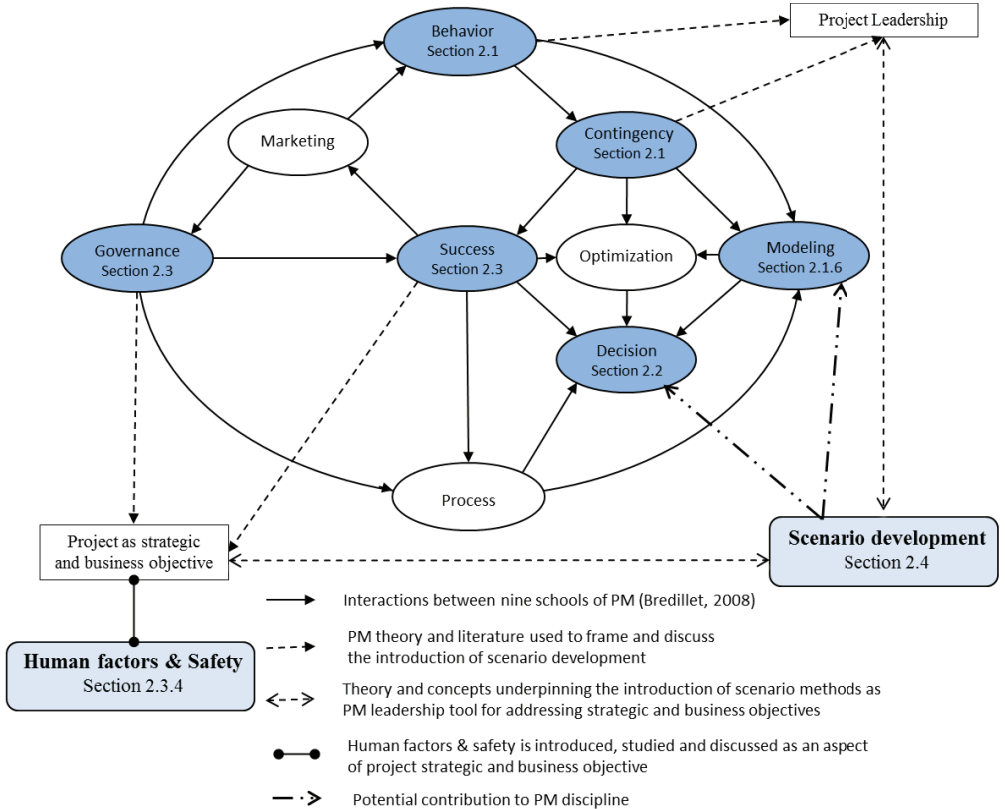
Figure 5 Building on the mapping of interactions between the nine different PM schools by Bredillet (2008c) this figure illustrates the structure of the different streams of literature included in Chapter 2.

Section 2.4 introduces the history, theory and literature relevant to scenario development and Section 2.5 draws conclusions from the literature, identifies research gaps and formulates the research questions addressed in this dissertation.

This chapter is not a comprehensive account of the topics but rather an introduction with the aim of minimizing any semantic confusion and lack of uniformity about the definitions, and theoretical implications, that underpin this dissertation.

2.1 The project environment

The introduction to Chapter 2 and Figure 5 clarifies which literature this dissertation draws upon. However, regardless of the theoretical schools of thought/perspectives applied, it is argued that PM researchers must be explicit about the project type they are theorizing about (Söderlund, 2011), i.e. no project can be studied comprehensively without considering its context (Hanisch & Wald, 2012). Thus, the objective of this chapter is to provide the theoretical foundations needed to generalize and typify GCR projects and the environment to which most of them are exposed.

The chapter starts with an introduction to a stream of PM literature addressing the role of ordering and classification schemes in the PM discipline. Aspects of the "contingency" and "behaviour" schools of thought are introduced. The next five sub-sections (Section 2.1.1 – 2.1.5) reflect results from two of the literature reviews (see Section 3.5.1 – 3.5.3) and introduce the definition of GCR projects as well as the known PM challenges, then explore the nature of these projects from three viewpoints: *the global, the collaborative and the research perspective*. The last section (Section 2.1.6) addresses relevant PM models and frameworks used to describe or explore complex project environments.

The contingency school recognizes the difference between various types of projects and project organizations and considers variation of management approaches and leadership styles most suitable for various project settings (Bredillet, 2008b). Prominent PM research within this school includes Shenhar & Dvir (1996), Turner & Cochrane (1993), Crawford et al. (2005), Crawford et al. (2006) and Müller & Turner (2007). Hanisch & Wald (2012) presented a comprehensive account of how contingency theory has been used in PM research and Turner (2018) provided a personal reflection on key contributions to the field of contingency and categorization. Of special relevance to the research presented in this dissertation is the topic of complex projects and the position that perspectives from all nine schools of thought apply to every project, i.e. they are not mutually exclusive. Contingency theory is thus an organizational theory that claims that there is no single best way of managing and organizing, and no single best way to organize and lead a company or a project or to make decisions (Hanisch & Wald, 2012).

Niknazar & Bourgault (2017) address the semantic confusion and lack of uniformity in the definitions and theoretical implications of the terms *classification, typology and taxonomy*. They state that typologies are conceptually derived interrelated sets of ideal types that explain a dependent variable, while classification systems are more about sorting entities into mutually exclusive, exhaustive groups. Furthermore, taxonomy is often used interchangeably with classification but taxonomy is only one kind of classification for which objects are classified based on statistical generalizations (Niknazar & Bourgault, 2017). Niknazar & Bourgault (2017) interpret "project type" as a homogeneous category of projects which share a certain degree of similarity in terms of specific features.

The behaviour school is closely associated with the governance school and takes as its premise that project organizations are social systems (Bredillet, 2008a). The behaviour school has a long and rich history with much relevant research. This dissertation draws upon research that is relevant for the leadership role in view of the growing diversity of project teams and globalization of project work. Key contributions considered in this dissertation include Thamhain (2004)'s studies of project teams and the research by Turner & Müller (2005) and Müller & Turner (2007) into the relationship between leadership style and project success.

2.1.1 Definition of Global Collaborative Research (GCR) projects

Since the PM literature includes very limited research addressing GCR projects, the definition of GCR projects builds on literature from two research streams with significant amounts of relevant PM literature That is: *a global PM literature* and *collaborative research literature.*

Katz & Martin (1997) concluded that the notion of research collaboration is very "fuzzy" or ill-defined; exactly what defines collaborative research is a matter of social convention and open to negotiation. 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 research project were proposed.

Changing stakeholder interest and policy in funding bodies that maintain a focus on innovation and learning outcomes from collaborative research projects (Autio et al., 2008, Jiménez-Sáez et al., 2011) and new ways of coordinating research[4] (Franzoni & Sauermann, 2014) continue to challenge our understanding of PM in research projects (Artto et al., 2017, Fowler et al., 2015). Brocke & Lippe (2015) identified 10 articles that directly address collaborative research projects and another 20 articles that provide related knowledge. They found that many authors do not directly analyse project data, but draw from secondary sources, such as interviews. Ahlemann et al. (2013) found that much relevant literature is conceptual research and argue a lack of empirical research. Also, increasing globalization has changed the way most organizations design and develop their products, creating a need for additional research addressing factors of specific interest for projects in such settings (MacDonald et al., 2012, Orr et al., 2011, Binder et al., 2010, Aarseth et al., 2011, Aarseth et al., 2013).

Brocke & Lippe (2015) and Lippe and Brocke (2016) 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"*. The PM literature provides a good insight into the nature of both global projects (GPs) and collaborative research projects. However, attention to combined effects of the main characteristics is lacking: the combination of collaborative challenges in a global environment and the unknown dimension of the project product created by the research aspect.

Verburg et al. (2013) analysed several critical success factors in current literature on global projects and concluded that organizational support (OS) is one of the most important practices for the success of global projects. The notion that traditional success factors focused on internal project issues, while more recently global success factors have been focused on the role of global management, global leadership and the human side of management is supported by several authors (Aaltonen et al., 2008, Anantatmula & Thomas, 2010, Orr et al., 2011). Aarseth et al. (2013) address different definitions of global projects and propose that global projects are *"temporary collaboration between organizations across nations and cultures with the intention to jointly deliver a unique product or service in a complex external context requiring relationship management"*.

In line with work on project classification (Shenhar & Dvir, 1996, Niknazar et al., 2017, Besner & Hobbs, 2012a) and following James March's definitions (March, 1991, Lenfle, 2008), one could argue that GCR projects are a type of exploration project. Thus, we propose defining a global collaborative research (GCR) project as:

"A jointly financed, planned and legally regulated consortium of academic, industry and/or public partners executed in a global context with the intention to generate new knowledge and/or application of such knowledge through collaborative explorative investigation and experimentation efforts".

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[4] Crowd science, citizen science and/or networked science

2.1.2 Known challenges

The management of collaborative research projects faces many known challenges (Barnes et al., 2006, Calamel et al., 2012, König et al., 2013, Brocke & Lippe, 2015, Etzioni, 1964). Brocke & 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). Collaborative research projects, e.g. those funded by the EU Framework Programmes (FPs) for Research and Innovation, are typified by the combined challenges of interdisciplinary, international, distributed and virtual project environments. 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 & 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 (e.g. consortiums) further combine and amplify challenges of stakeholder management created by the collaborative nature of the projects. However, each of the relevant individual challenges is addressed at some level in the PM literature, suggesting that it is the combination of known challenges that makes collaborative research projects a specific project type, not any single unique characteristic or challenge. The following two sections address these challenges from *a collaborative perspective* and *a research perspective.* Most collaborative research projects fulfil the criteria used to define global projects and furthermore have all characteristics of organizations with clear efficiency goals that require more than just effective project management. Aarseth et al. (2013) and Binder (2009) suggest that the number of organizations and locations involved in the project implementation can help separate the intertwined terms of international, virtual and global projects. Section 2.1.5 addresses this *global perspective* of collaborative research projects with a multinational, interdisciplinary, inter-organizational and decentralized structure.

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 & Lippe, 2015, Davenport et al., 1998, Siedlok et al., 2015, Tripsas et al., 1995, Lippe & Brocke, 2016). To view the world with a collaborative perspective may seem intuitive. Humans cooperate for all sorts of reasons to a myriad of effects: immediate benefit, genetic connections, and mutual benefit, indirect reciprocity, group selection, etc. However, from an academic perspective it quickly become a very challenging undertaking. The term collaboration has been used throughout a variety of research disciplines to describe multiple types of interaction; yet, a unified, comprehensive definition of the construct remains elusive (Bedwell et al., 2012). Even when the scope is limited to the PM discipline there are numerous papers within several research streams that remain relevant. A collaborative perspective is perhaps most familiar to the behavioural school, which highlights the importance of the relationships between people on the project, team building, leadership, communication and human resource management (Bredillet, 2008a). In the stakeholder management literature, the collaborative aspects are prominent in both models and methods (Bredillet, 2008c). The role of collaboration is also important for understanding and modelling of organizational, behaviour and political issues affecting projects, e.g. as part of the modelling school soft-system methodology and sense making literature (Bredillet, 2007).

Successful collaboration requires good leadership and with the increasing focus on the role of project leadership (Aarseth, 2014, Drouin et al., 2018, Packendorff et al., 2017, Dias et al., 2017, Walker & Lloyd-Walker, 2016, Suprapto et al., 2015), the collaborative perspective may have come into its own within an acknowledged PM research stream. This includes research with a focus on the role of human resources management (HRM) and HR issues in project based organizations (Keegan et al., 2012, Drouin et al., 2010, Huemann, 2010, Calamel et al., 2012).

Calamel et al. (2012) introduce their paper with a quote from the leader of a Belgian innovation cluster: "It is easy to find hundreds of project management books. But the collaborative project management manual is still to be written". They continue to report from two different collaborative projects within a global innovation cluster, bringing a qualitative understanding on the complex and dynamic process of collaboration.

The seminal contribution of Walker & Lloyd-Walker (2015) provides a thorough introduction to collaborative project procurement arrangements, or relationship-based procurement (RBP), emphasizing not only the characteristics of these forms of project procurement but also the knowledge, skills, attributes, and experience (KSAE) required of project managers delivering these projects. The book introduces relevant literature and describes an array of frameworks, models and methods relevant to aspects of human behaviour such as trust and commitment and emerging forms of collaboration terms.

There is a body of literature that describes experience and results from collaborative research projects, specifically those funded by EU framework programmes (Derntl et al., 2015, Colombo et al., 2016, Contreras & Conejo, 2002, Pinheiro et al., 2016, Stanoevska-Slabeva & Fricke, 2015). Although they contribute to a relevant and interesting perspective on collaborative research in global environments, most papers fall short of contributing to PM theory. As for PM research on collaborative research projects, Lippe & Brocke (2016) in particular describe research that has resulted in general rules, recommendations and contributions that explain the settings and processes inherent in such projects. They further argue that, "if it is applied in the right situation, collaborative research projects can use existing PM knowledge, reduce the time required to learn-by-doing, and draw from the various benefits of a professional and targeted project manager".

Aarseth (2014) emphasizes the importance of a collaborative mentality when facing the challenges of managing global projects (Aarseth et al., 2013, Aarseth et al., 2012). Section 2.1.5 addresses these aspects of global projects that multiply and amplify collaborative challenges that, at some level, exist in most projects. The next section addresses the research perspective of GCR projects.

2.1.4 The research perspective

The central role of experimentation in GCR projects establishes an unknown dimension of the project product. In endeavours 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 (Turner & Cochrane, 1993). Loch et al. (2006) and Lenfle (2016) describe an iterative PDCA (plan-do-check-act) cycle as a basic building block in experimentation and argue 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.

The contingency school emphasizes the necessity of linking a management approach with a given project type. The typification or classification of projects is thus a key step towards matching the appropriate PM approach to a given project. This applies to projects in general, not only to research projects.

The majority of relevant literature suggests the use of four groups of information to classify R&D projects into different types (Kuchta & Skowron, 2016, Khedhaouria et al., 2017).

1) project magnitude, i.e. personnel, budget, schedule
2) project deliverables, i.e. product breakdown structure (PBS)
3) tasks and methods required to achieve given products, i.e. work breakdown structure (WBS)
4) resources or abilities required for any given stage implementation, i.e. organization breakdown structure (OBS)

Kuchta & Skowron (2016) also found that the variety of R&D PM methods and their taxonomies pose difficulties in the selection of a PM concept suitable for a particular type of R&D project (Table 1). They found that "with reference to the research project typology, the relevant literature does not provide much information" and that "most of the R&D project classifications do not carry unequivocal implications concerning management".

Table 1 R&D projects and recommended management approaches from Kuchta & Skowron (2016).

R&D project type	Recommended management concept	Number of cycles / iterations	Plan specified for next cycle	Plan for all cycles
Alpha	TPM	Known		PBS, WBS, OBS
Beta	APM (1)	Known	WBS, OBS	PBS, partially OBS
Chi	APM (2)	Known	PBS, WBS, OBS	partially WBS & OBS
Delta	xPM	Unknown	PBS , WBS, OBS	

TPM = traditional PM, APM (1-2) = Variations of agile PM and xPM = extreme PM.

Agile project management (APM), also known as adaptive project life cycles, change-driven or agile methods (PMBOK, 2017), is often recommended for addressing insufficiently defined goals and methods (Conforto et al., 2014, Indelicato, 2012). Similar, predictive project life cycles, also known as "fully plan-driven" (PMBOK, 2017) are usually not recommended for research projects (Samset & Volden, 2016).

To understand to what extent, and to what result, APM has been adopted by industries other than IT and software development, Conforto et al. (2014) investigated new product development in 19 companies that do not yet formally recognize the use of APM methods. They found that these companies are struggling to use their current management practices (not APM) in the face of different project challenges and that the presence of some APM enablers indicates opportunities to adapt the APM theory for companies other than those in IT / software development.

The incomplete PM research addressing iterative and incremental project life cycles represents a significant research gap for R&D projects (Lenfle, 2008, Fowler et al., 2015) and in particular for projects that Lenfle (2016) refers to as exploratory projects (Brady et al., 2012, Loch et al., 2006, Brady & Davies, 2004, Brady & Davies, 2014).

2.1.5 The global perspective

Globalization changed how organizations designed and developed their products and created a need for additional research addressing factors of specific interest for such projects (McDonough et al., 2001). These changes constitute the basic rationales for global project management (GPM) as a self-standing research stream within the management literature. After three–four decades with increasing globalization, it is interesting to observe that GP management continues to be an area with limited research knowledge (Binder, 2007, Aarseth et al., 2013, Ainamo et al., 2010, Orr et al., 2011).

Orr et al. (2011), Binder (2007), Aarseth et al. (2011), Aaltonen et al. (2008) and Scott et al. (2011) provide good reviews of the GPM challenges and literature, proposing widely accepted frameworks and definitions. According to Binder et al. (2009) the term "global projects" was first coined by Zeitoun (1998) to specify a subset of virtual projects that involved people and locations in more than one nation, dealing with a variety of cultural differences, political systems, languages and time zones. Global projects thus combine the challenges of international and virtual projects (Binder, 2007, Binder et al., 2009) and are typically carried out in institutionally demanding environments (Aaltonen et al., 2008).

Orr & Scott (2008) provide specific examples of challenges from 23 global projects. The study builds on institutional theory and presents a generic narrative model of how challenges in global projects arise and how they are resolved, typically involving three general phases: ignorance, sense making , and response. They suggest that cross-cultural sense making operates between two extremes: open-minded and close-minded. Aaltonen & Sivonen (2009) discuss external institutional pressure and response strategies in the highly uncertain and turbulent environments facing most global projects and Aarseth (2014) further explores the role of cultural aspects and benefits of different mindsets in global project management.

According to Binder (2007), global projects are defined by their extent in the "five challenge" dimensions *languages, locations, organizations, cultures* and *time zones*. Binder (2007) thus builds on the dimensions described by Hofstede (Hofstede, 1984, Hofstede, 1993) and some of those used by Trompenaars (1998). Although this gives a comprehensive view on the role of culture, it has been claimed to ignore some aspects such as variation in ideas, ideologies and identities (Orr et al., 2011).

Languages: most GCR 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:* GCR 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:* GCR 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 GCR 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 GCR 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 proximity dimensions.

The larger these challenge dimensions are in GCR projects, the stronger challenges related to individual diversity become (Shore & 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 & Teigland, 2009).

Following Lyytinen & Newman (2008), Binder (2009) and Binder et al. (2010) current knowledge related to the management of global projects can be structured in four areas, i.e. teams, communication, organization, collaborative tools and techniques. These areas are consistent with the four organizational variables used by Leavitt (Leavitt, 1964, Leavitt, 1965), i.e. people, tasks, structure, technologies.

This chapter has so far described GCR projects as complex collaborative endeavours with a considerable amount of uncertainty regarding the project goals, methods and organizational resources. The next section introduces some relevant frameworks and models used to describe and manage uncertainty and complexity in project environments.

2.1.6 Relevant models and frameworks for project complexity

The literature presented in this section has been accessed from the extensive literature reviews by Geraldi et al. (2011) and Bakhshi et al. (2016) but also draws upon other concepts, such as the "cone of uncertainty" (McConnell, 1996).

The concept of *uncertainty* and its intrinsic relationship with risks has been present in the management literature for almost 100 years. Following Geraldi et al. (2011), uncertainty constitutes one dimension (out of five) of complexity that, through risk and opportunity management, have well adopted approaches that could be extended to project complexity management. This notion is revisited in Section 2.2.3 related to decision making and in Section 2.3.3 in the context of risk & safety as a component of project strategic and business objectives. However, as there still is a lack of common understanding of what constitutes project complexity in PM literature (Bakhshi et al., 2016), this section focuses on project complexity.

Complexity has become an inseparable aspect of contemporary systems and one of the important factors in the failure of projects. In the effort to typify and generalize GCR projects, the above sections draw a picture of GCR projects as complex endeavours with inherent uncertainty. In line with this, the section has two objectives.

1) Use definitions of complex projects to support typifying and generalizing GCR projects
2) Introduce relevant models and frameworks addressing project complexity.

PM literature has several generally accepted definitions of project complexity but it is challenging to present a truly accurate and comprehensive definition. Geraldi et al. (2011) identified five dimensions of complexity: structural complexity, uncertainty, dynamic, pace and socio-political complexity.

Bakhshi et al. (2016) suggest defining project complexity as an intricate arrangement of the varied interrelated parts in which the elements can change and evolve constantly with an effect on the project objectives. They also included an analysis of different definitions of complex projects from the literature and suggested 10 attributes that define complex projects. Table 2 uses these attributes as a topology of complex projects and compares them with the literature from the previous five sections (2.1.1 – 2.1.5). Bakhshi et al. (2016) suggests that more attention should be paid to the system thinking approach and the relationship between complexity factors.

Table 2 Project complexity definitions (Bakhshi et al., 2016) as a topology for complex projects compared with identified topology from the three perspectives on GCR projects, i.e. research, collaborative and global.

	Project complexity topology	Global Collaborative Research Projects
a	Interdependence of tasks, teams and inputs	Yes, it is a characteristic of the collaborative nature
b	Causality is networked	Yes, resulting from the global and collaborative nature
c	Dynamics emergence exists	Partly, depending on research type and stakeholder map
d	Predictability and control are reduced	Yes, as part of the research / exploratory nature
e	Scope and boundaries are unclear	Often, part of the research and collaborative nature
f	Project governance is decentralized, and autonomy of teams is high	Yes, it is a characteristic of the global and collaborative nature
g	Number of plausible references is high	Often, depending on the type of research
h	Project is self-organizing	Often a result of the global and research aspects
i	Low transparency, including objectives, process and methods	Often, due to the use of consortiums and high-level agreements
j	Diversity of resources is heterogeneous	Yes, as a characteristic of the global perspective

Bakhshi et al. (2016) examined more than 420 published research papers and proposed three distinctive models of project complexity: the Project Management Institute (PMI) view, the System of Systems (SoS) view and the Complexity Theories view. In the following this section addresses three frameworks/models with a similar three-part structuring: PMI Talent Triangle®, The Cynefin framework and the Cone of Uncertainty.

The PMI talent triangle was introduced to the 2017 update of the PMBOK (2017). However, already in 2015, as part of its effort to ensure that its certifications are relevant to the needs of industry and organization, PMI developed and announced its talent triangle as part of changes that one can expect to come.

Geraldi et al. (2011) found that most researchers leaning towards the PMI perspective tend to emphasize structural complexity, uncertainty and socio-political elements rather than other complexity dimensions. This seems to be mirrored in the terms "Technical PM", "Project leadership" and "Strategy & Business management" defined in the PMI talent triangle as the ideal skill set for project managers. The academic PM literature is lacking in specific references to the PMI talent triangle (per 2018); however one could argue that the talent triangle is a result of, or response to, PM research that over the last two decades has accentuated the "one size don't fit all" and "beyond the hard paradigm" perspectives.

The talent triangle can be decoded as following (Heldman, 2018): *Technical PM:* Technical reference to PM methodologies that complemented with real world experiences and solutions are deployed to overcome project technical/structural challenges.

Leadership: Refers to skills that support project managers in delivering on all project objectives and stakeholder expectations by displaying situationally appropriate behaviour, including negotiation skills, conflict management abilities, team development, emotional intelligence and resources motivation.
Strategic & business management: To improve on project implementation and deliver the best possible organization results, project managers need to execute their projects in a manner that aligns with the strategies and vision of company leaders. This includes entrepreneurial, contract management and strategic planning skills.

These expectations for project manager skill sets reflected in the talent triangle should arguably support the efforts to decode and simplify both complex projects and complexity in projects, thus forming the rationale to include the PMI talent triangle as one of the frameworks underpinning this thesis.

The Cynefin framework developed by D. Snowden and colleagues (Snowden, 2000, Snowden, 2002) is known for its approach to complexity (Snowden & Boone, 2007) supporting the Systems of Systems (SoS) view. The Cynefin is a sense making framework, as opposed to a categorization framework, and define four types of (project) environments: "obvious, complicated, complex and chaotic". The simple/obvious domain represents the "known knowns", the complicated domain is considered to consist of the "known unknowns", the complex domain represents aspects of the "unknown unknowns of project management and the chaotic domain is reserved for environments where cause and effect are unclear, e.g. in the case of some catastrophic or emergency events.

The concept of sense making is defined as "the ongoing retrospective development of plausible images that rationalize what people are doing" (Weick et al., 2005). Weick (1979) is one of the early proponents of the focus on "organizing", rather than organizations. Aubry & Lavoie-Tremblay (2018) adopted sense making as the basis for a social view on organizational design, suggesting that sense making, as a theoretical approach, aligns well with the conceptualization of new forms of organizing where networks, knowledge and power systems are to be taken into consideration.

Jamshidi (2008) describes Systems of Systems (SoS) as large-scale integrated systems that are heterogeneous and independently operable on their own but are networked together for a common goal. A key aspect that distinguishes the SoS view (from the PMI view) is the inclusion of autonomous and independent systems and the lack of control in managing autonomous and independent systems. The SoS view on complexity is employed in many large defence and health projects in the western world and represents a very different view of complexity than the PMI. This is why Bakhshi et al. (2016) introduce complexity as one of the most important and controversial topics in PM discourse.

This competing, or complementing, view on project complexity is the rationale for including the Cynefin as one of the key frameworks underpinning this dissertation.

The "cone of uncertainty" is a concept popularized by McConnell (1996) and often associated with software development projects where the technical and business environments change very rapidly. However, the original conceptual basis of the cone of uncertainty was developed for engineering and construction in the chemical industry and can be traced back to 1958. The most famous use of the cone of uncertainty is perhaps its graphic usage in hurricane forecasting, i.e. predictions on where a hurricane may move.

The idea that uncertainty decreases significantly as one obtains new knowledge seems intuitive and conventional PM knowledge proposes that estimation gets better as a project progresses. However, one can argue that the only reason uncertainty decreases as the project progress is because decisions made in the project reduce the opportunity space, e.g. after selecting a concept for the project product only the uncertainty relevant for this concept remains. Before such decisions, the uncertainty for *x* number of considered (and ignored) concepts is relevant (Samset et al., 2014, Samset & Volden, 2016). If the concept is questioned or changed during the project, the cone of uncertainty become wider, not narrower. In many disciplines, including scenario methodology, the use of the cone of uncertainty is essentially the opposite of the usage in PM. In scenario development (SD) the current situation is considered to be known and the future becomes increasingly uncertain, e.g. the location of a hurricane.

Such dual views on uncertainty and its potential consequences for PM make up the rationale for including the cone of uncertainty as one of the key models underpinning this dissertation.

At the close of this section on projects and complexity it is important to recollect the findings of Shenhar et al. (2016) that "no generally accepted framework has emerged thus far to support the analysis of highly complex and innovative projects" and, furthermore, to emphasize the distinction between "complexity in projects" and "complexity of projects" (Geraldi et al., 2011). The first stream studies projects through the lenses of various complexity theories while the second stream is practitioner driven and aims to identify the characteristics of complex projects and how individuals and organizations respond to this complexity.

The next section introduces two additional schools of thought to support the discussion on applicability of SD and its contribution to supporting decision making in complex projects.

2.2 Decision making

A key purpose of SD is to support decision making by engaging stakeholders, facilitating continuous learning and ensuring transparency by exploring the impact of rationales and positions of both opposing and aligned stakeholders. Decision making is a demanding topic where discourse quickly becomes too academic and generic or too context specific. This section provides a general introduction to the notion of decision making and a brief introduction to decision making in PM literature.

When investigating decision making methods for sustainable design in commercial buildings Arroyo (2014) found that decision making is rarely documented, lacking rationale, transparency and formal decision making methods. Thus, it often fails to build consensus or continuous learning among stakeholders with different perspectives and conflicts of interests. The term decision making means slightly different things depending on the discipline and context. In psychology and behavioural decision making the focus is on mental processes (Stingl & Geraldi, 2017). In computer science and analytical modelling, e.g. in project control systems, the focus is on computerized processes (Hazır, 2015). Decision making literature is both prescriptive, i.e. with a focus on how optimal decisions could/should be made, and descriptive, i.e. concerned with how decisions are actually made (regardless of decision quality). It is useful to differentiate between decision making and decision analysis. Decision analysis, representing an extensive discipline in its own right, is usually associated with the process of collecting and processing data for quantitative analyses of uncertainties, often including creation of decision making algorithms.

Multiple-criteria decision analysis (MCDA) or multiple-criteria decision making (MCDM) is considered a sub-discipline of operations research used to evaluate multiple conflicting criteria in decision making (Arroyo, 2014, Rolstadås et al., 2015). Depending on whether the solutions are explicitly or implicitly defined, a major distinction is made between "evaluation problems" and "design problems". Multiple-criteria evaluation problems consist of a finite number of alternatives, explicitly known in the beginning of the decision-analysis process, while for multiple-criteria design problems the alternatives are not explicitly known (Triantaphyllou, 2000). Some MCDM methods with relevance for PM are addressed by Rolstadås et al. (2015) and include: Analytical Hierarchy Process (AHP), Choosing By Advantages (CBA), GRAI method and Earned Value Analysis (EVA).

The AHP draws upon the judgment of the decision maker to decompose the decision problem into a hierarchy of sub-problems, then quantify and assign relative priorities for a given set of alternatives. The AHP method stresses the importance of the intuitive judgments of a decision maker as well as the consistency of the comparison of alternatives in the decision making process (Saaty, 1990, Arroyo et al., 2014). The choosing by advantages (CBA) system differs from most MCDMs by postponing "value" judgment about alternatives as long as possible and focusing on advantages of one alternative over another, i.e. it does not focus on disadvantages (Arroyo et al., 2014, Suhr, 1999).

Project control techniques such as S-curves, milestone analysis, Gantt charts and checklists are also familiar tools that most project managers use to facilitate decision making in the project execution phase.

This thesis addresses decision making as an integral part of PM and one of the core activities undertaken by project managers (Stingl & Geraldi, 2017, Hazır, 2015, Rolstadås et al., 2015) and draws upon two schools of thought to support the discussion on applicability of scenario development (SD). The "decision school" and "process school" theory frame discussions on project decision making, emphasizing organizational, behavioural, political issues affecting GCR projects and the complex environments within which they operate. Bredillet (2008b) attributes the decision school with two focuses: decision making in the early stages of projects and information processing in projects. Williams & Samset (2010) and Samset & Volden (2016) address the front-end of projects and present ten paradoxes relevant for decision making. Rolstadås et al. (2015) suggest sorting the PM literature relevant for decision making into four groups, according to the focus of the papers: *decision environment, decision making tools, decision making process, and applications.*

Emphasizing that successful decision making in projects is about more than selecting from a list of alternatives, a decision making process is briefly explained in Figure 6.

Rolstadås et al. (2015) describe some early decision making models of Dewey (1978), Simon (1960) and Drucker (1955). Key steps in these models included: define the problem, analyse the problem, develop alternative solutions, decide on the best solution, convert decisions into effective actions and follow up on actions taken. Figure 6 builds on these models and emphasizes three different types of decisions in a project: selection decisions, authorization decisions and plan decisions.
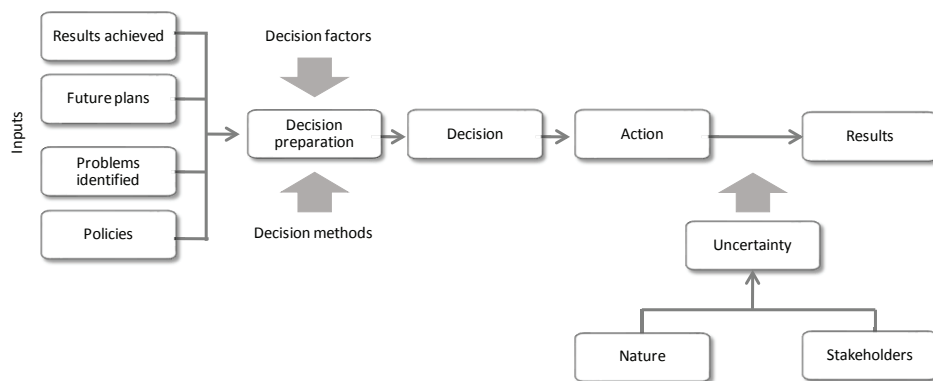
Figure 6 Decision making process (Rolstadås, 2014, Rolstadås et al., 2015)

Kirytopoulos et al. (2010) address the large difference between making a decision alone and making a group decision. One inherent challenge with making decisions in groups is deciding who will make the final decision. There are several alternatives to consider and Kirytopoulos et al. (2010) describe four types of group decision styles: command, consultative, consensus and majority vote.

Williams & Samset (2010) address several important aspects of decision making, including the differentiation between strategic "do the right project" to tactical "do the project right" type of decisions. They also emphasize the ambiguity implicit in major decision making processes, e.g. psychological and political biases, consideration of social geography and politics within stakeholder groups. Humans are not supremely rational beings and at best display "bounded rationality" (Simon, 1972); our rationality is limited by the tractability of the decision problem, the cognitive limitations of our minds and the time available to make the decision.

There seems to be an agreement that the selection of optimal decision processes, methods and tools is highly dependent on the project environment and application. The previous section characterized the type of project environment relevant for this thesis, i.e. GCR projects. In the following three aspects of decision making processes considered of key importance for GCR projects are addressed.

The two first sub-sections (acknowledge the research aspect of GCR projects and address implications related to decision making in linear vs. iterative project processes and rational vs. intuitive decision making. The last section addresses decision making as an approach to the future and describes some implications related to predicting vs. exploring the future.

2.2.1 Linear vs. iterative and/or incremental project processes

Fowler et al. (2015) argued that university research should "call for PM tools that acknowledge the processual nature of venturing into the unknowns", addressing the explorative process towards uncovering the unknown dimension of the project product (Lenfle, 2016). However, most GCR projects, e.g. EU projects, also include industry and public partners that have different traditions in R&D project processes.

Adaptive project life cycles, also known as change-driven or agile methods, have emerged as the most notable of non-linear PM processes. For decades, experienced software designers abandoned top-down methods in favour of agile approaches (Guindon, 1990) and today many projects use agile methods. However, agile is still used to best effect in settings with substantial use of software and IT, such as high technology, healthcare and professional services (Serrador & Pinto, 2015). Agile PM has some

limitations in addressing key challenges of GCR projects. The change-driven or agile methods usually require key stakeholders such as the project customer or end-product consumer representatives to "play ball with". That is, the informal and organic evolutionary-delivery model requires rapid feedback from stakeholders with the power and influence to define the project success. Many GCR projects, e.g. those funded by the EC, do not have such customer-driven dialogue regarding requirements. Stakeholder power-influence maps of GCR projects usually fail to identify any one key stakeholder that can define the project success.

Further characteristics of GCR projects that challenge the efficient use of agile PM include constraints in assigning full-time dedicated project teams; challenges in co-locating all project team members; difficulty in creating effective distributed or virtual multidisciplinary teams, and the challenge of involving customers (project external stakeholders) with a high degree of influence in project development.

The iterative or incremental processes characteristics of research processes are better characterized by what Lenfle (2016) refers to as exploratory projects. However, there is limited PM research addressing such explorative project processes (Brady et al., 2012, Loch et al., 2006, Brady & Davies, 2004, Brady & Davies, 2014, Lenfle, 2016, Lenfle, 2008, Lenfle & Loch, 2010) in collaborative settings (Lenfle, 2008, Fowler et al., 2015, Brocke & Lippe, 2015, Brocke & Lippe, 2013, Lippe & Brocke, 2016). This represents a significant research gap for GCR projects (Fossum et al., 2019a).

Loch et al. (2006) described an iterative PDCA (plan-do-check-act) cycle as a basic building block in experimentation and argued that projects where all task and requirements must be defined before the project can start fail to implement PDCA cycles, consequently failing to be experimental and explorative. This is supported from a PMBOK (2017) perspective, suggesting that settings where unknowns are driven by missing knowledge about the product and other project internal factors an iterative and incremental life cycle would be the most appropriate.

2.2.2 Rational vs. intuitive project processes

Decision making as part of a problem-solving activity with the objective of yielding an optimal or at least satisfactory solution usually depends on both explicit and/or tacit knowledge and beliefs and, as such, can be a more or less rational process. Thomas et al. (2012) suggest that "while instrumental rationality helps project managers focus on how to do things, other rationalities, particularly those labelled non-rational, help them to decide what to do and why to do it". Suggesting that by understanding how expert project managers navigate between prescribed project management doctrine and their own praxis opens a space to rethink how PM is researched, taught and talked about. 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". Such a perspective aligns with criticism of the dominant, rational approach to PM, and its underlying hypothesis (Hodgson & Cicmil, 2006, Nightingale & Brady, 2011) and represents a key challenge for innovation, research and development projects (Lenfle & Loch, 2010, Lenfle, 2016).

The notion of intuitive or non-rational thought processes warrants elaboration but any such discussions depend on defining the unexpectedly elusive term "rational". Mercier & Sperber (2017) emphasize that rationality must be defined according to how well you accomplish some goals, i.e. one cannot be rational in a vacuum. Thus, what is rational behaviour is relative to the definition of what one wants to achieve, e.g. the definition of a project's success. 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'.

Project management as a discipline devotes significant attention to techniques and models designed to identify, assess and ultimately manage the risks and uncertainties associated with the project. Besner & Hobbs (2012b) conclude that the current PM paradigm is oriented towards reducing uncertainty and that PM in highly uncertain contexts may need new flexible approaches. In an increasingly fluid, networked and agile world, PM could become more instinctive, including the enterprise level where institutional project and programme management support such improved instinctiveness (Morris, 2013).

This thesis distinguishes 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 & Pratt, 2007). These other rationalities, such as intuition, holistic and relational thinking, are often labelled non-rational thought processes. However, methods and techniques associated with such non-rational thought processes are largely missing from PM bodies of knowledge (Thomas et al., 2012).

2.2.3 Decisions about the future – anticipatory or exploratory

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, it is deemed useful to address some implications of different assumptions that decision makers may have on the future. Sanderson (2012) list four views on the future that decision makers could take:

- *a priori probability:* Believe they are able to assign objective probabilities to a known range of future events based on mathematically "known chances".
- *Statistical probability:* Believe they are able to assign objective probabilities to a known range of future events based on empirical/statistical data about similar events in the past.
- *Subjective probability:* Believe they face a known range of possible future events but lack the data necessary to assign objective probabilities to each.
- *Socialized uncertainty:* Believe they face a situation in which the nature and range of future events is unknown, not simply hard to understand because of a lack of relevant data.

The introduction of "bounded rationality", and the resulting "intended rationality" of decision makers, by Simon (1947), emphasizes the need to understand the impact of cognitive and resource limitation (time, money, knowledge) on decision making processes. Although the considerable limitations of human cognitive capabilities are well known (Schoemaker, 1993, Kahneman & Tversky, 1996), many economic and decision theories build on the assumption that human behaviour can be approximately described by the theory of full rationality (Sanderson, 2012, Schoemaker, 1993). Bayesian decision theory, as an example, is supported by the core idea of utility theory and assumptions of approximate validity (Schoemaker, 1982).

Besner & Hobbs (2012b) present the somewhat counter-intuitive result that the use of risk management practices and tools is negatively related to the degree of project uncertainty. That is, there is a tendency that better defined contexts (lower uncertainty) increase the use of all project management tools and techniques. Acknowledgment of such trends has led to emphasis on the need to distinguish different situations and, accordingly, different ways of managing projects (Lenfle, 2008) but improper use of the project format to manage research and exploratory activities is still found (Fowler et al., 2015). In their extensive discussion of alternative explanations for the failure of megaprojects, Sanderson (2012) conclude that the projects-as-practice approach, with its "organizing rather than organization" and "becoming rather than being" focus, has obvious potential because it gives proper attention to the view that the future unfolds in unknowable ways through myriad decisions and interactions between autonomous actors.

Various PM research streams and schools of thought may differ in argument, suggested solutions and underlying theories. However, most research share one significant feature — *an acceptance of the notion of actor foresight, that is, accepting that actors can and should prepare for the future before it has happened* (Sanderson, 2012). Rolstadås et al. (2015) emphasize the important aspect of project success when addressing the topic of decision making. Any notion or discussion of successful decision making in projects needs to include distinctions such as those made between project success and PM success.

Building on the "triple test performance framework" (Zwikael & Smyrk, 2012), the following section emphasizes that any notion of 'success' and 'failure' of projects depends on the context and perspective of those who are measuring it (Jha & Iyer, 2006).

2.3 The successful project

This section draws upon theory from the PM "success school" and "governance school" to build a taxonomy and theoretical framework for discussing how the proposed construct, i.e. scenario development, could contribute to successful GCR projects. The section starts with a short account of the success and governance schools and definitions used for the terms "success" and "governance" in a PM context.

The first section (section 2.3.1) focuses on PM literature addressing success factors. The next section (section 2.3.2) emphasizes the definition of PM strategies and objectives, and as such success criteria, as an integral part of the "governance school". Section 2.3.3 takes a narrower look at the concept of "emergent risks" in the context of the "complexity – uncertainty – risk" complex" and implications this may have for delivering successful new technology development projects. The section rounds off with the introduction to human factors & safety as a subset of the criteria for strategic and business success in new technology developments (section 2.3.4).

The PM success school focuses on the success and failures of the project (Bredillet, 2008a). However, the notion of 'success' and 'failure' of projects may be open to debate depending on the context, i.e. success as a subjective term is dependent on the perspective of those who are measuring it (Jha & Iyer, 2006). One of the key contributions to the "success school" is Cooke-Davies (2002) introduction of the labels "PM success" and "project success". It was an elegant expression of a perspective that for some years had been discussed in the PM literature (Turner, 1993) and aligns with the introduction of "project efficiency" and "project effectiveness" (Jugdev et al., 2001).

Project success is discussed and defined in multiple fashions, e.g. ul Musawir et al. (2017), Müller & Jugdev (2012) and Shenhar et al. (2002). The theorizing presented in this dissertation builds on the "triple test performance framework" proposed by Zwikael & Smyrk (2012). i) *Project management success* relates to the "iron triangle" criteria and a measure of the project manager's performance in achieving the project plan, ii) *Project ownership success* is represented by the project owner's ability to realize the business case, and iii) *Project investment success* refers to the actual value generated by the project investment.

The governance school, like most other PM schools of thought (Bredillet, 2008a), had its beginning as a form of "overflow" from the general management literature, i.e. it was natural for PM researchers to start asking whether it also was relevant to the PM discipline. Turner (2018) provides a personal reflection on how project governance research came into prominence and Müller et al. (2014) and Ahola et al. (2014) provide extensive literature reviews on project governance, demonstrating the diversity of both application and history of project governance.

Project governance and general governance literature was analysed by Ahola et al. (2014) and 15 prominent PM articles describing and/or defining governance were identified. However, this dissertation draws upon the definition of Pinto (2014) as "*the use of systems, structures of authority and processes to allocate resources and coordinate or control activity in a project*". Project governance refers to the management of individual projects, while governance of projects refers to the management of a group of projects and collectively they refer to management of portfolios, programmes and individual projects, all which coexist within a corporate (or any organizational) management framework (Müller et al., 2014). The concept of *governmentality* refers to the way the governance task is designed and implemented in an organization, e.g. through strict rules or through soft "cultural" values (Clegg et al., 2002).

It is important to recognize that an in-depth and practical understanding of relationships between a) the use of systems, structures of authority, b) processes to allocate resources to coordinate and control activity in a project and c) project success still represent a gap in the PM literature (Joslin & Müller, 2016, Pinto, 2014, Keegan et al., 2017).

2.3.1 Project success – defining success factors

Research addressing success factors represents one of the large research streams in PM literature, e.g. a dedicated search on "success factors" identified 735 papers in three journals (Table 6). Early landmark

publications on project success such as Pinto & Slevin (1987), Pinto & Slevin (1988), Pinto & Prescott (1988), Shenhar et al. (2001) and Shenhar et al. (2002) provided a solid foundation for subsequent research on project success and related success factors. Müller & Jugdev (2012) discuss these classic contributions and the evolution of project success as a PM research topic.

Decades of research have brought up a variety of new success factors and extended the number of success criteria (Joslin & Müller, 2015, Hobbs & Besner, 2016). Zwikael & Globerson (2006) and Fortune & White (2006) presented broad reviews of the success factors found in the literature and reported several limitations, e.g. unclear factor definitions, limited agreement on what factors influence project success and the proportion of success explained by success factors. Hobbs & Besner (2016) argued that "the considerable opinion-based literature that presents lists of overall success factors only contributes marginally to an understanding of which PM practices contribute significantly to project success". Hobbs & Besner (2016) emphasize a distinction between "success factors" and "best PM practices".

Thus, when addressing success factors there are some key aspects to consider: Success factors must always be considered in the context of success criteria (who defines success), when and where in the project lifecycle they are to be applied, i.e. factors vary by project types, life cycle phases, industries, nationalities, individuals, and organizations (Müller & Jugdev, 2012). Furthermore, success factors should have a measurable relationship to project performance that acknowledges the complex networked nature of project success.

2.3.2 Governance - definition of success criteria

The process of defining project strategies and objectives and thus the project success criteria is an integral part of the project governance and governance of projects. The majority of published research on project governance is conceptual with little quantitative evidence on the relationship between project governance and project success (Joslin & Müller, 2016). However, for the purpose of establishing a framework to describe and discuss the research presented in this dissertation, governance is considered the school of thought that is most closely associated with the definition of success criteria.

Hussein et al. (2015) address problems associated with defining project success criteria and highlight four related problems related to poor or missing assessment of expectations and constraints at the project initiation phase. - Failure to assign the degree of importance to a set of success criteria, - Including success criteria that are competing or conflicting, - Defining too optimistic or pessimistic targets and - Having ambiguous success criteria.

Turner & Müller (2005) and Müller & Turner (2010) showed that leadership is a critical success factor of projects. Van Asselt & Renn (2011) highlight that some authors differentiate between horizontal and vertical (risk) governance and Muller et al. (2016) address the subject of balancing vertical and horizontal leadership. Thus, the notion that failed alignment of "the horizontal governance layers" and missing "vertical governance" are common denominators for challenges associated with defining project success criteria underpin this dissertation.

In new technology development, the safe and reliable application of the product is a criterion of high importance for the strategic and business success of the project. This thesis thus addresses risks to safe and reliable application as a specific technical and operational component of the project product.

2.3.3 Identifying emerging risks in new technology developments

Both practitioners and risk governance scholars stress the need to pay attention to the legal, economic, social and institutional contexts in which risks are managed (Hermans et al., 2012). There is also an increased emphasis on research addressing risk-related decision making in settings where many stakeholders are involved and where these different stakeholders hold diverse meanings on the concept of risk (Renn & Graham, 2005, Aven, 2011). Besner & Hobbs (2012b) investigate the interplay between risk management, uncertainty and the contextual variability of risk management practice.

It is difficult for any organization to foresee the future and to evaluate the consequences of existing trends and drivers of change. This can lead to risks going unnoticed or being ignored or neglected. In this context the concept of emergence is useful to explore from a project risk management perspective. Some threats or risk events are predictable with precision because they are associated with known, recurring or likely patterns. Other risks, such as demographic evolution, can only be predicted with a margin of error. However, those risks associated with new technologies, changing patterns, complex systems or new contextual conditions are generally unanticipated and are not widely understood, and they have no convincing plan of action for mitigation. These are often called "emerging risks" (IRGC, 2015).

Three groups of emergent risks relevant to new technology development are: i) Scientific unknowns/technological advances, i.e. the development and introduction of new technology, e.g., automatization and robotics, may have unknown vulnerabilities. Risks may emerge when technological change is not based on prior investigation or surveillance of results. Risks can also be exacerbated when policy or regulatory frameworks, for example, in the front-end definitions phase, are insufficient. ii) Loss of (safety) margins/increased connectivity and new interactions, i.e. management of integrated technology developments may pose a substantial challenge due to poor understanding of consequences such as couplings (Hokstad et al., 2012). Tight couplings may lead to loss of buffering or margins and emergent problems have been seen when automated systems resolve too many issues before the human enters the control loop, that is, 'human in the loop' challenges. This is also a challenge that may be related to scientific unknowns. iii) Conflicts about interests, values and science/social dynamics, i.e. public debates about emerging risks seldom show a clear distinction between science, values and interests. Thus, there is a need to support open information sharing and trust between stakeholders when developing new technology and concepts, in particular those that constitute or are integrated into complex sociotechnical systems (Johnsen et al., 2017).

2.3.4 Human factors & safety - a subset of strategic & business success criteria

The constructive research approach is, at its core, about identifying a problem, constructing a solution and testing how successful the proposed construct is. It is in this context that the topic of human factors & safety is introduced to this dissertation, i.e. as a "unit of analysis". That is, when theorizing about GCR projects, their known challenges and how to address such known challenges, the topic of human factors & safety in new technology developments and how this is affected by the known PM challenges is explored.

The human factors discipline is traditionally divided into three areas: physical ergonomics, cognitive ergonomics and organizational ergonomics. Physical ergonomics is mainly concerned with human anatomical, physiological and biomechanical characteristics as they relate to physical activity. Cognitive ergonomics focuses on perception, memory, information processing and reasoning relevant to, for example, task analysis, human-machine interactions (HMI), workload, and alarm philosophies. Organizational ergonomics addresses issues relevant to organizational structures, policies, processes and operational philosophies. Leva et al. (2015) provide a good overview of current industrial practices and standards promoting inclusion of human factors knowledge in structured system design processes.

Investigations of serious accidents in the petroleum sector such as Piper Alpha and Macondo (Cullen, 1993, USCS, 2016) have shown that triggering causes include the little understood interaction of factors at various system levels, such as technical, human, social, organizational, managerial and environmental. Pinto (2014) examines the critical role of project governance in minimizing problems of normalization of deviance in project-based work. Normalized deviance or gradualism occurs in scope adjustment, safety standards modification, or incremental changes to plans and other control documentation. Increased project cost and schedules are known effects of gradualism.

Key examples from the space industry include the investigation reports from the two fatal space shuttle accidents that point towards human, organizational and political aspects as root causes (Godwin, 2003, Vaughan, 2009, Vaughan, 1996), clearly stating that the accidents were a product of long-term organizational problems.

In the context of NASA's Challenger project, Shenhar and Dvir argue that discrepancy in the project's management style (difference between second-order construct of real project and ideal type) was the reason for the project's failure (Sauser et al., 2009, Shenhar et al., 2005, Shenhar, 1992).

Thus, there is a basis to link missing attention to human factors & safety to project success criteria. Furthermore, existing research and theory underpin the notion of investigating cause – effect relations between project management and a lack of attention to human factors & safety.

The next section introduces the history, theory and literature relevant to scenario development and its adaptation in this dissertation.

2.4 Scenario Development (SD)

This section aims to introduce and demonstrate what scenarios can be to the PM discipline and its discourse. Section 2.4.1 recaps the common historical roots of SD and PM. Section 2.4.2 describes references to SD in the PM literature. SD is also presented in both Fossum et al. (2016) and Fossum et al. (2019a).

The term "foresight and future studies" has become widely used to describe a set of competencies used to support strategic management, identify new business opportunities and increase innovation capacity. Although many regard scenarios as a foundational method in future studies the futures studies literature lack scholarly consensus with regard to the application of theory to support scenario methodology. The essence of scenarios is that they seem to be many things: art and science, deduction and induction, rational and political, and this have caused it to be fuzzy and elusive by academic standards (Schoemaker, 1993, Spaniol & Rowland, 2018b). Bunn and Salo (1993) describe varying definitions used for a scenario and discourse relevant to scenario methodologies.

Spaniol & Rowland (2018a) found that, despite many varying definitions and claims of missing unifying theory, the academic community of futures and foresight science does not seem to suffer from so-called confusion over the definition of scenario. Spaniol & Rowland (2018a) proposed a process for classifying scenarios and differentiating them from non-scenarios (Figure 7).
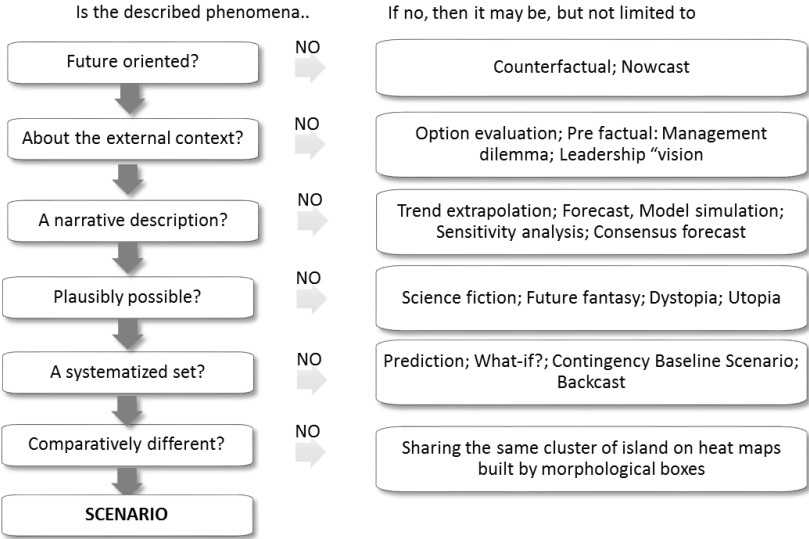
Figure 7 Checklist supporting the classification of a scenario in the context of foresight and future studies from Spaniol & Rowland (2018a).

For the purpose of this dissertation definition of a scenario by the Intergovernmental Panel on Climate Change is used (IPCC, 2008).

"A scenario is a 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."

Bishop et al. (2007) and Wright et al. (2013) introduce a broad and inclusive overview of scenario techniques and methods, ranging from quantitative modelling approaches to qualitative narrative methods and mixed methods that encapsulate both. Scenario analysis is considered as a subset of scenario planning while scenario construction, description, discovery and orientation are some of the terms used in relation to work with scenarios.

Scenario development is often considered a subset or equivalent of scenario planning; however, neither is really about planning (Schoemaker, 2002). It is about exploring the future in order to develop new instincts that allow faster learning and smarter decisions as one moves forward and chaos becomes ambiguity and uncertainty before manifesting itself as risks and finally as certainty. Thus, acknowledging the diversity and discourse relevant to scenario methodologies, understanding scenario planning is a more comprehensive process, of which SD is one aspect. This dissertation uses the framework for SD (Figure 16) as described by Mahmoud et al. (2009). Figure 8 illustrate the four types of scenarios addressed by Mahmoud et al. (2009). 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.
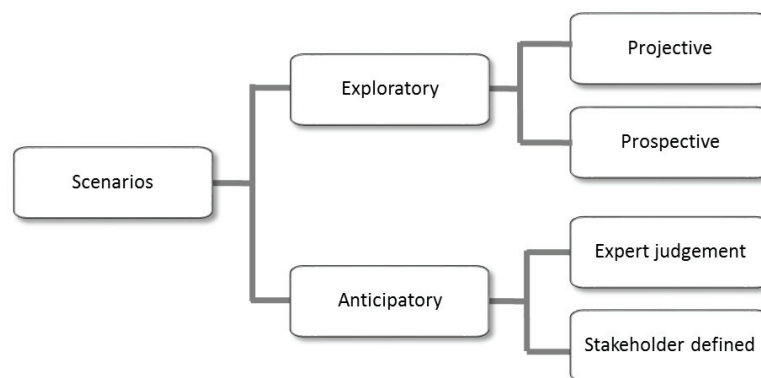
Figure 8 Four different scenario types addressed by Mahmoud et al. (2009).

Schoemaker et al. (2013) discuss how an organizational strategic radar can be used to integrate outside networks, weak signals, sense making, strategic dialogue and scenario planning. They describe organizational strategic radar as a five-stage (set up, research, monitor, analyse, publish) integrated framework that uses scenario planning, business analytics and dashboard technologies to monitor and scan for important signals from the external environment and to trigger strategic and operational adjustments in response to these changes as needed.

Chapter 3 and 4 describe the implementation, testing and results of these SD process in the two case studies. The next sections describe the common history of SD and PM and the role of SD in the PM literature.

2.4.1 Common roots of scenario development and project management (PM)

As a tool for disciplined thinking and problem solving, SD can be traced back to the Manhattan project (Miller & Waller, 2003) where scientists tried to understand the consequences of the nuclear reactions they were creating (Schwarz, 1991), e.g. they were concerned that the entire atmosphere would ignite and that the lack of computational power did not allow the desired calculations of mathematical models.

Most scholarly authors trace SD as a discipline back to the 1940s and the work RAND Corporation did for the US Air Force (Schoemaker, 1993, Schwarz, 1991, Lindgren & Bandhold, 2003). The RAND Corporation is a non-profit organization originally created in 1948 as a "think tank" for the US Air Force called Project RAND, short for research and development. The organization was based within the Douglas Aircraft Company in Santa Monica, California and part of the cluster of aerospace companies that had grown up during the Second World War (Brady et al., 2012).

This is in fact the same time and place to which "modern" project management also traces its roots (Lenfle & Loch, 2010, Brady et al., 2012, Morris, 2013). Although the PM discipline as we came to know it first took shape in the 1960s during the McNamara administration (Brady et al., 2012) both PM and SD disciplines could be considered as young siblings that co-developed in the post-war era and the US efforts to foresee their opponents' actions and to manage their cold war portfolio of huge projects.

It is likely that the users and usage were different from the start but it may seem that during the 1960s the PM discipline and SD developed in different directions. Under the impetus of the McNamara administration, PM became a tool for controllers and engineers (Lenfle & Loch, 2010, Morris, 2011) while Herman Kahn, by many recognized as the father of SD, adapted and expanded the scenario approach to include public policy and social forecasting and developed it as a tool for economists and the strategists (Schwarz, 1991).

2.4.2 Scenario development in project management perspective

The PM literature contains several references to scenarios but the use of a scenario development process at single project level has never been addressed. PM literature that does mention SD is mainly related to project governance and/or focus on strategy, risk, uncertainty, complexity and decision making. Several papers also focus on methodology and tools for evaluation of project management quality. However, SD is most commonly used at enterprise top management (portfolio) or project office (programme) levels and often used to address challenges at regional, national or international level. Table 3 provides a summary of SD related references in the PM literature.

Table 3 SD related references in the PM literature

Author, year	How are scenarios described/defined/ understood in the paper?	Key contribution from a GCR project viewpoint
Articles discussing scenarios in a strategy and business context		
Grundy (2000)	Provides an example of how strategic behaviour influenced a scenario development process at a retail company, making an interesting case for the importance of addressing the strategic behaviour of stakeholders.	Argues the close affinities between strategy implementation and PM. Describes the merits and methods of including techniques for surfacing behavioural issues in PM, e.g. scenario development.
Bredillet (2008d)	Scenario analysis is mentioned as a method / tool for identifying the mutually impacting variables from dangerous stakeholders and other stakeholders	Introduces the underlying principles and the general features of a meta-method (MAP method) with practical applications ranging from development of case studies, scenario analysis, corporate strategy evaluation, and tools for strategic control by the students and faculty
Williams & Samset (2010)	Scenario planning is mentioned together with strategy identification, project alignment and project estimating as issues rooted in the same set of organizational issues which need to be considered as an integrative whole	Describes the importance of front-end decision making phase in projects and the need for alignment of organizational strategy and project concepts beyond the front-end into the implementation stage.

Author, year	How are scenarios described/defined/ understood in the paper?	Key contribution from a GCR project viewpoint
Besner & Hobbs (2012b)	Investigates the interplay between risk management and uncertainty and the contextual variability of risk management practices. Scenario analyse software tools are listed as known advanced PM software.	Paper concludes that the current PM paradigm is oriented towards reducing uncertainty and that project management in highly uncertain contexts may need new flexible approaches.
Dick et al. (2015)	Describes how scenario planning was used to define possible futures. This included four scenario-based workshops with managers from industry partners within the Australian sector for care of elderly people and community care.	Proposes that project managers seeking to implement agile methods may find action research strategies relevant.
McKenna & Baume (2015)	Comments how idea mapping used to categorize stakeholder statements can emerge creatively and be analysed scientifically using e.g. scenario planning.	Explains how idea mapping could be used to categorize stakeholder statements and how underlying linguistic concepts that help project managers understand projects with complex, powerful and conflicting stakeholder communities.

Articles discussing scenarios in a risk and uncertainty context

Chapman & Ward (1997)	Addresses the social effect of influencing stakeholders and stakeholder motives and suggests using incremental scenario planning to determine both likelihood and impact of risk.	Project risk management positively influences project performance by instrumental effects: through creation of a contingency plan or by influencing project time, budget, or design plan.
Zeng et al. (2007)	Addresses risk assessment techniques currently used in the UK construction industry that are comparatively mature, such as Fault Tree Analysis, Event Tree Analysis, Monte Carlo Analysis, Scenario Planning, Sensitivity Analysis, Failure Mode and Effects Analysis, Programme Evaluation and Review Technique.	Presents methodology for project risk analysis associated with construction projects in complicated situations
Kwak & Dixon (2008)	The paper identifies strategic scenario planning as one of 13 best practices/processes to manage strategic risk on project level in high-tech industries.	Identifies best practices from high-technology industries that face many of the same challenges around uncertainty, complexity, and risk facing the pharmaceutical industry.
Padhy & Sahu (2011)	The paper contributes to managerial practices by identifying a new way of valuing Six Sigma projects through Real Option Analysis. The paper mentions the accuracy of scenario planning and costing exercises as a limitation of the study.	Illustrate managerial practices by identifying a new way of valuing Six Sigma projects.
Sanderson (2012)	Discusses different explanations for the performance problems exhibited by many megaprojects and examines the proposed governance solutions. The paper compares scenario planning with "using expectations grounded in historical practice to estimate the subjective probability of future events".	The core argument being made is that future research should focus equally on (spontaneous) project governing, i.e. "project-as-practice" and project governance.

Author, year	How are scenarios described/defined/ understood in the paper?	Key contribution from a GCR project viewpoint
Hanaoka & Palapus (2012)	Uses Monte Carlo simulation and bargaining game theory to determine the reasonable concession period for build-operate-transfer of road projects. An extension of sensitivity and scenario analysis as it simultaneously takes into account the different ranges of possible values and different probability distributions.	Illustrates how Monte Carlo simulations can support quantification of effects of risk and uncertainty in project schedules and budgets.
Petit (2012)	Scenario analysis techniques were found to be used to plan and identify options when changes were requested to already overloaded projects"	Investigates how uncertainty affects project portfolios managed in dynamic environments.
Khodakarami & Abdi (2014)	Integrating the inference process of Bayesian networks (BN) to the traditional probabilistic risk analysis can yield powerful analyses including predicting the marginal probability distribution of the total project cost, various scenario analysis, and updating our beliefs about common causes in light of new observations in cost items (i.e. learning).	Illustrates how assessment framework integrating the inference process of Bayesian networks to the traditional probabilistic risk analysis.
Taroun (2014)	A literature review of construction risk modelling and assessment. It was found that the Expected Monetary Value (EMV), break-even analysis, scenario analysis and sensitivity analysis were the most widely used.	Obtaining a realistic project risk level demands an effective mechanism for aggregating individual risk assessments.

Articles discussing scenarios in a planning context

Author, year	How are scenarios described/defined/ understood in the paper?	Key contribution from a GCR project viewpoint
Ahlemann (2009),	The paper refers to scenarios several times and mention that the project plans versioning system can be used to create baselines at certain points in time and can be used as a starting point for scenario planning.	Project management information systems have become comprehensive systems challenged with the support to the entire life cycle of projects, project programs, and project portfolios.
van der Hoorn & Whitty (2015)	The paper mentions scenario planning when addressing the importance of the planning process vs. the end product (the plan). The paper concludes that PM artefacts such as the term 'project', Gantt charts, plans and the iron triangle veil or distort the individual's experience of the phenomena of project work.	The Heideggerian paradigm challenges the dominant paradigm that underpins much project literature.

Articles discussing scenarios in a project health and evaluation context

Author, year	How are scenarios described/defined/ understood in the paper?	Key contribution from a GCR project viewpoint
Smith (1994),	Scenario planning is mentioned as a tool which was used to good effect in which various credible but unlikely possibilities were examined to gain an understanding of the threats that they might pose and to examine options for action to retrieve any problems.	Understanding of threats – action of unlikely possibilities in project evaluation context.

Author, year	How are scenarios described/defined/ understood in the paper?	Key contribution from a GCR project viewpoint
Jaafari (2007)	Scenario analysis is mentioned as part of an Integrated Facility Engineering (IFE) system.	Makes a case for a shift to strategy-based PM, a component of which is real-time management of risks, uncertainties and opportunities using a life cycle project management approach.
PMBOK (2017)	Chapter 4.4.2.2 – Analytical Techniques mentions scenario building as an example of forecasting methods.	Applicability of Project Management Institute (PMI) standards and guidelines.
Articles discussing scenarios in miscellaneous contexts		
Morris (2013)	Morris foresees that project management could become more instinctive and mentions scenario planning as something that will become more common.	Describes the history of PM challenges that our society is facing and implications this has for the project management discipline.
Contreras & Conejo (2002)	Scenario generation was a dedicated task in the OMEGA project. The paper includes accounts of project internal disagreements associated with the scope of the scenario tree generation and how models and tools for uncertainty handling and scenario development were considered critical for the systems under development.	The paper gives an account of the OMEGA Project, an EU 5th Framework programme.

The PMBOK (2013) mentions scenario building when addressing the use of forecasting methods as a part of analytical techniques for project monitoring and control. In their investigation of the interplay between risk management and uncertainty and the contextual variability of risk management practices Besner & Hobbs (2012b) conclude that the current PM paradigm is oriented towards reducing uncertainty and that PM in highly uncertain contexts may need flexible new approaches. In Williams et al. (2009), Kees van der Heijden provides interesting insights about how scenarios can be undertaken and used at the front-end projects. Lenfle & Loch (2010) in their paper on the how project management came to emphasize control over flexibility and novelty propose that "the discipline should overcome its self-imposed constraints and go back to its roots from the 1940s of 'making the impossible happen'."

Lenfle & Loch (2010) further maintain that PM has a critical role to play in organizational challenges and the community should pick up the challenge and formulate how PM can contribute to strategy formulation and start improving its record on push-the-envelope initiatives.

Most literature refers to scenario methodology in the context of company or program strategic objectives. However, 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 approach to addressing project context.

The next section provide the conclusions from the literature review and identify research gaps and research questions.

2.5 Conclusions of the literature review

The published research on collaborative research projects in global environments is relatively limited and empirical research is almost non-existent. However, there is a great deal of relevant PM literature that addresses the collaborative aspect of projects. Also, both research projects and global projects are areas with considerable research focus, often with an emphasis on collaboration related challenges. This body of research in turn draws upon a large body of general management and organizational research literature.

2.5.1 Typifying collaborative research projects in global environments

An initial conclusion from the considerable contextual variation in the compiled literature, that is, the diversity of business/sector, project type, project processes and products, etc., made it challenging to judge what knowledge was relevant for collaborative research project in global environments. Also, one of the first realizations during the literature reviews was the necessity to be explicit about the project type this dissertation addresses and what body of literature to draw upon.

Another early conclusion from the literature review was to compile a list of known PM challenges seen from these three perspectives - *collaborative, research and global*. Moreover, it was concluded that a search for new unique challenges would not be the most fruitful endeavour. Rather, it was decided to study how these known challenges are addressed, in both theory and practice.

A key result from this was the decision to adopt the term global collaborative research (GCR) projects and the conclusion that these projects represent a distinctive project archetype.

2.5.2 Identifying research gaps

Based on the initial conclusions it was decided to focus on three distinctive knowledge gaps identified and formulated during the literature reviews.

(i)   Limited empirical PM research on global collaborative research projects

(ii)   Methods for balancing the rational and intuitive project leadership and strategic processes in GCR projects are lacking in PM literature

(iii)   Frameworks addressing the full set of known PM challenges in GCR projects are lacking

2.5.3 Formulating research questions

The literature is rich with theory and knowledge describing the challenges of coordination and cooperation in multidisciplinary, international, inter-organizational and/or distributed teams, as well as for global projects and collaborative research. Any reductionist attempts to formulate a handful of questions that represent this research in terms of their individual, constituent contributions and their interactions was deemed a less fruitful approach. Thus, the key drivers behind the selected research questions are the author's presumptions and the availability of the empirical information.

RQ1: What are the known PM challenges for global collaborative research projects?

RQ2: To what extent are known PM challenges linked to a lack of focus on human factor & safety aspects in new technology developments?

RQ3: To what extent can scenario methodology assist project managers in addressing known challenges of global collaborative research projects?

The rationale for these questions is founded on a strong motivation to contribute to new knowledge that can create awareness of success factors for GCR projects. There is also a clear benefit from knowledge that fosters mindfulness in the selection of project tools and processes to mitigate challenges to collaborative research processes.

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3. Research approach

This chapter introduces the key philosophies that historically underpin PM research and describes the research paradigm and research design of the work presented in this dissertation. The case studies are introduced, and the research methods applied are described, before the reliability, validity and generalization of the research are discussed. Figure 9 shows the structure of this chapter.
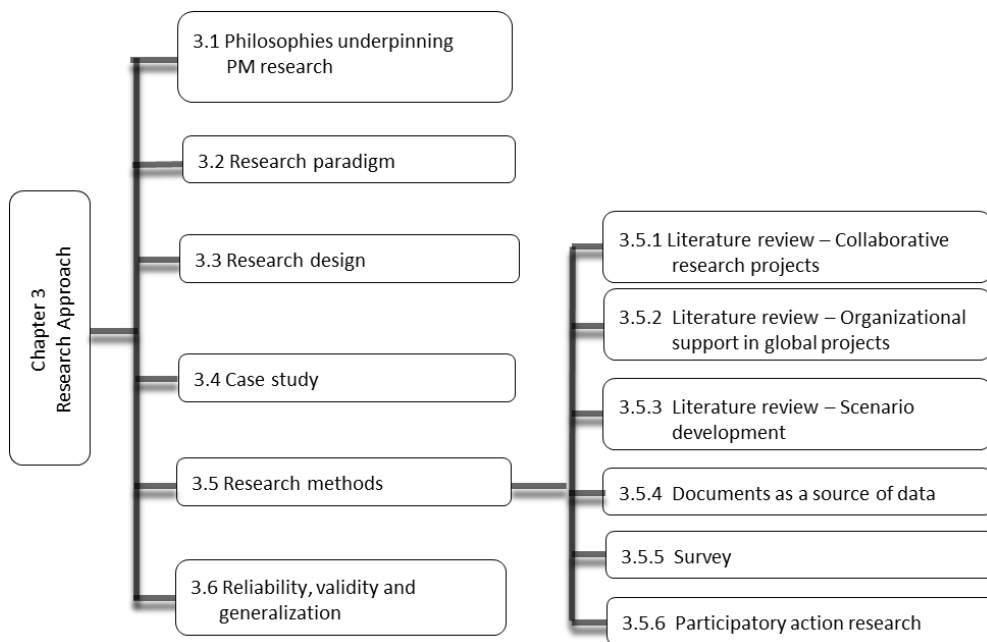
Figure 9 Chapter structure

Research generally starts with the researcher being interested in solving a particular problem through being better acquainted with the facts surrounding the problem (Walker, 1997). Such interest and ideas on how to approach the subject are usually shaped by personal experiences and knowledge. Although the fundamental aim of research is to answer a question or address a problem, the first important step is to formulate questions that allow a structured methodical approach. Identifying the research questions thus requires a methodology in itself or, as a minimum, a research strategy should be developed.

As illustrated in Figure 2 and elaborated in Figure 10, the overall research strategy for this dissertation was to first identify research objectives, then identify and describe research gaps and the appropriate research questions. As illustrated in Figure 3, the literature reviews were initiated in parallel with the case study work. Scanning the environment and the state of the art to get an early appreciation on what practical restrictions and opportunities the particular case studies offer is a standard research approach.
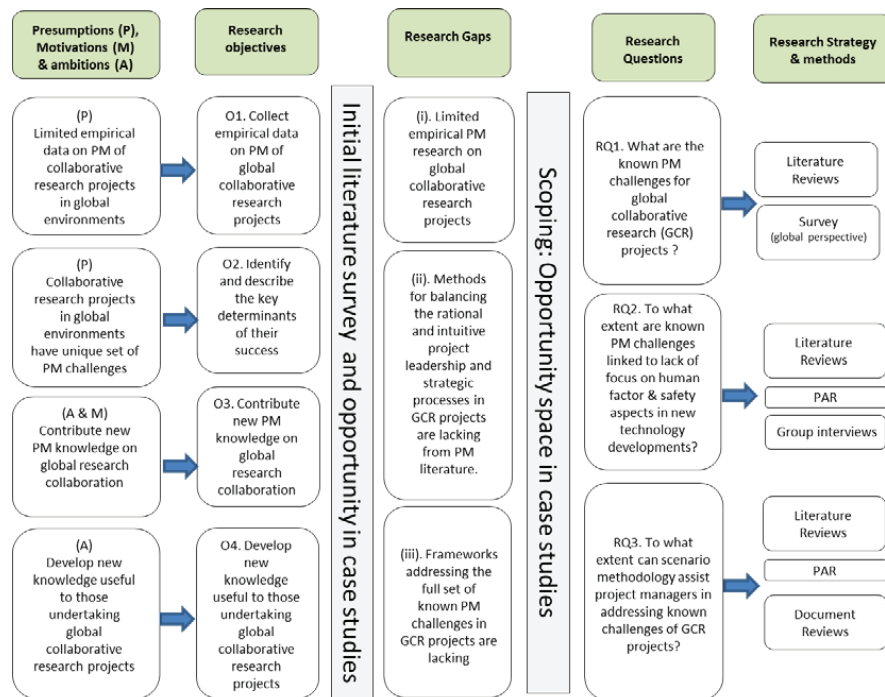
Figure 10 The overall research approach for this dissertation

The purpose of this research is to improve our ability to identify GCR projects as a project archetype (RO1), as well as to compare and contrast these projects with other project types (RO3). This new ability, building on practical experience and existing theories, contributes to a better understanding of the knowledge, skills, attributes, and experience (KSAE) essential for the successful management of such projects (RO2). With this new understanding, the aim is to introduce new methods and develop a new model useful to those undertaking the management of GCR projects (RO4).

3.1 Philosophies underpinning PM research

In a guest editorial in the Project Management Journal, Konstantinou & Müller (2016) introduce a special issue that provides for a large variety of philosophical perspectives on projects and their management, including perspectives of both classical thinkers and contemporary writers, such as Aristotle, Schopenhauer, Heidegger, Rorty, Popper, and Wittgenstein.

Historically there are strong relations between the hard paradigm and PM, e.g. it underpins the PMBOK Guide®, but recent decades have seen a growing acceptance of the soft paradigm in PM research. The hard paradigm is commonly associated with a positivist epistemology while the soft paradigm is commonly associated with an interpretive epistemology (Pollack, 2007). Smyth & Morris (2007) postulated that key epistemological aspects of dominant methodologies used in PM research include positivism and empiricism, critical realism as well as some other methodologies.

Positivism holds that society, like the physical world, operates according to general laws. Antipositivism or interpretivism often associates positivism with the term "scientism". Scientism is used by historians, philosophers and cultural critics to highlight the possible dangers of excessive reductionism in fields of human knowledge. Smyth & Morris (2007) maintained that positivist methodology is unsuitable for addressing many project issues, exceptions being when simple closed systems are studied.

Empiricism is closely aligned with positivism but acknowledges that insufficient is known about something to conceptualize or generalize, hence the facts are investigated to find the story, making case studies one approach to empiricism. As such, empiricism has application within any of the paradigms but, as with positivism, there is a strong instrumentalist current endeavouring to identify practices and tools that may prove useful (Smyth & Morris, 2007).

Critical realism has features in common with both positivism and antipositivism but recognizes that multiple causes usually influence events and situations in open systems. Critical realism philosophically places the research endeavour in the context of both theory and practice and the general and particular, hence encouraging critical evaluation and reflection (Smyth & Morris, 2007).

Smyth & Morris (2007) remind us that a primary weakness of critical realism is the way in which researchers interpret its emphasis in application, i.e. a "realist" who tends towards structuralism may critique others for being too "empiricist" and vice versa. Pollack (2007) emphasized that at a practical level, PM tends to adopt a problem-solving rather than a problem-structuring approach to projects.

Accounting for their research approach Walker & Lloyd-Walker (2015) draw upon Mingers (2003) to define a paradigm. Mingers (2003) compares the main philosophical assumptions underpinning management science methods and takes the position that the basic mechanism they all have in common is that of modelling, while underlining that "they differ in terms what they model (ontology), how they model (epistemology), and why they model (axiology)", i.e. their paradigms differ.

Coming back to Konstantinou & Müller (2016) it is clear that the growing acceptance of the soft paradigm that Pollack (2007) recognized has indeed matured. Konstantinou & Müller (2016) highlight project governance as a subject that has virtually exploded since 2005. This seems to be underpinned by a growing acknowledgment that projects are no longer inward-looking standalone entities that deliver standalone products or services but rather are parts of a larger whole or system, i.e. the macroscopic global changes are reflected in the microscopic world of PM. Moreover, for humans to make sense of their world, their projects, roles and tasks therein a multiplicity of philosophies is required (Konstantinou & Müller, 2016).

It seems that PM discourse has converged on the concept of projects as temporary organizations, acknowledging that scholars can, and should, hold different views about the concept of organizations, e.g. whether they consist of artefacts or processes (Van de Ven & Poole, 2005, Aubry & Lavoie-Tremblay, 2018). The shortcomings of organizational and management models and theories, in terms of understanding and guiding practitioners, form a basis for the argument that organizations must be viewed from different theoretical perspectives, that no single theory or approach can address the full complexity of organizations.

3.2 Research paradigm

According to Guba (1990) paradigms can be characterized through three aspects: ontology (what is assumed to exist), epistemology (the nature of valid knowledge), and methodology. Mingers (2003) explains the term paradigm as "… a construct that specifies a general set of philosophical assumptions covering, for example, ontology, epistemology, methodology and ethics or axiology (what is valued or considered right)", i.e. paradigm is a "particular combination of assumptions". Figure 11 summarizes a framework supporting the notion of the "hard" and "soft" paradigms that underpin the majority of PM research.

The central aspect of the paradigm of this dissertation is that PM, both in practice and research, cannot be about "either/or"; it needs to be about both, i.e. mature PM needs to embrace both the hard and soft paradigm, assuming that the key to success is knowledge about when and where to apply which.

Although "slicing and dicing" of the term paradigm into its components of ontology, epistemology, methodology and axiology is needed to add precision, it can also add confusion. Precision is needed to elaborate on the presumptions and theoretical positioning underpinning this research and to clarify what aspects of GCR projects this research can and cannot claim to address with reliability and validity.

The aim of this section is to clarify the research paradigm behind the research work presented in this dissertation.
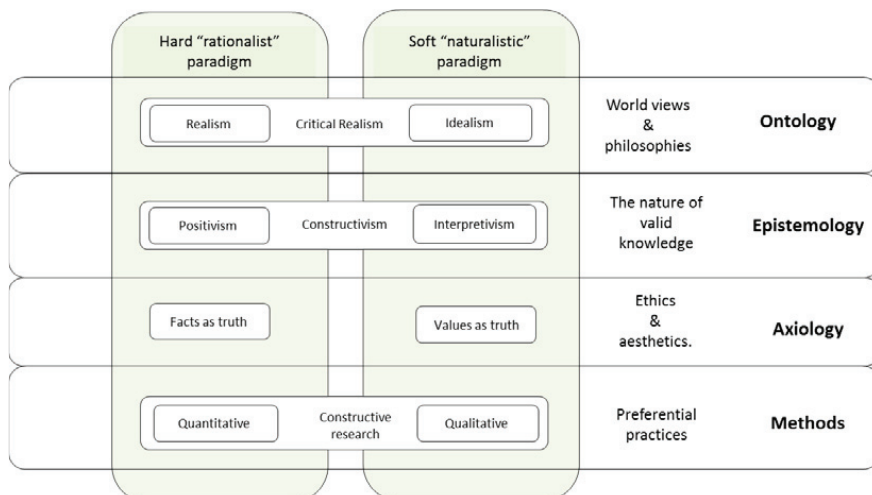
Figure 11 Some key research paradigms underpinning PM research

The ontological position of this dissertation, i.e. the perspective of what can be assumed to exist, is based on critical realism. However, adopting the thinking of Stephen Hawking and Leonard Mlodinow (Mlodinow & Hawking, 2010) a more accurate term is *model-dependent realism*, i.e. the reality of the natural world is only accessible through our models, e.g. atoms, immunology or solar systems and the universe. As an ontological stance, model-dependent realism implies that one can only know an approximation of what happens in projects and that PM models represent negotiable constructs rather than knowledge that aims to "represent" social realities more or less accurately, consequently considering technical PM a discipline that aims to construct and implement the best possible models of project reality.

Allowing a dual view on the world, critical realism permits the acknowledgment that the social world cannot be modelled in the same way as the natural world while also opening for a problem structuring of challenges related to the engagement and management of the human and social construction of (new) knowledge critical to the project strategic and business decision making process. In the view of model-dependent realism, the only meaningful criteria are the usefulness of a model.

The constructivist epistemological stance of this dissertation is based on two assumptions. 1) most projects interact with the natural world at some level, e.g. building a hydroelectric dam, travel to the moon or curing cancer. 2) project organizations and project organizing are social constructions in a social world where the natural world has a small or non-existent role in the construction of new knowledge. Constructivism recognizes that the natural world is independent of human minds but insists that any knowledge of the world always is a human and social construction. Constructivists maintain that representations of physical and biological reality such as atoms and immunology are socially constructed models.

Following these assumptions, a need for a dual epistemological stance emerges. 1) Valid knowledge on how the natural world may impact a project is best obtained via the hard paradigm 2) Valid knowledge about the social world may impact the project is best obtained via the soft paradigm.

The axiological position, i.e. what evidence is most valued, follows that of the model-dependant realism. Knowledge is valuable regardless of paradigms if obtained with methodological rigour, e.g. triangulation, required to demonstrate conformity and completeness to ensure acceptability across paradigms. The only relevant value of knowledge is its usefulness in theoretical frameworks or practical application.

From a method perspective this research constitutes a constructive approach. The constructive research approach means problem solving through the construction of models, diagrams, plans, organizations, etc. This mode of research is widely used in technical sciences, mathematics, operations analysis, and clinical medicine, but is scarcely used in management research (Kasanen et al., 1993, Oyegoke, 2011). The next two sections address the research design and methods in detail.

3.3 Research design

The research work presented in this dissertation constitutes a constructive research approach. The research design presented is based on the work of Kasanen et al. (1993) and Oyegoke (2011). Examples where the constructive approach is used in PM research can be found in Oyegoke (2007), Oyegoke & Kiiras (2009), Lahdenperä (2016). Lahdenperä (2016) also addresses the similarities between the constructive and design science approach. Constructive research as a methodology begins with a solid foundation for identifying a practical problem that can be supplemented with relevant theoretical and empirical research literature. The research problems are used to suggest research questions that help solve and/or get better acquainted with facts surrounding the problem. The questions are addressed through the development or construction of a solution or approach that will be put into operation to determine the usability and suitability (Oyegoke, 2011). The constructive research approach is thus related to both rationalist (quantitative) and naturalistic (qualitative) paradigms. It assumes that reason and experience (rationalism and empiricism) rather than the non-rational (anti-rational) are the fundamental criteria in the solution of problems. However, in the naturalistic context, constructive research assumes that there are multiple interpretations of reality and the need to understand how individuals construct their own reality within their social context. Furthermore, constructivism as an epistemology requires researchers to reflect upon the paradigms that underpin their research and urges them to consider alternative ways of interpreting results of their research. The research design is presented in Figure 12 and Figure 13 builds on six phases, or steps, that impart the methodological rigour underpinning robust PM research.

Phase one: Finding and defining a practical relevant problem that has a research potential. The justifications for the focus on GCR projects have three parts. First, the interests are rooted in personal experience as a PM practitioner from this type of project environment. Second, discussions and anecdotal evidence have been obtained via discussions with other project managers. Third, there is sufficient PM literature on both collaborative research projects and global projects to suggest that a combination of these two project types constitutes highly demanding project environments.

Phase two: Obtaining a general and comprehensive understanding of the topic through theoretical understanding of what has been done to date. This was done via several literature reviews.

Phase three: The constructive approach requires that the design of a construct should be based on an in-depth interpretation and synthesis of the contextual literature review and the practicalities of the problems.

Phase four: In constructive research, both the hard and soft paradigms can be used to demonstrate the workability of the new construct because the constructive approach closely links theory and practice together.

Phase five: Showing the theoretical connections and the research contribution of the solution concept. Based on the combined theoretical and empirical bases the construct are validated along the principle of triangulation

Phase six: Examining the scope of applicability of the solution - The constructive approach requires that the study's contribution to the body of cumulative knowledge should be specified and areas for further studies should be highlighted.

Phase 1 | Phase 2 | Phase 3 | Phase 4 | Phase 5 | Phase 6

Phase 1
Identify practical problem that has a research potential
Theoretical review
Theory Connection

Phase 2
Practical experience
Understanding the topic
Theory based

Phase 3
Designing a Construct
or
Construction of a Solution

Phase 4
Theoretical & empirical
Testing of construct / solution
Theoretical contributions

Phase 5
Demonstrate that solutions works
Triangulation and validation
Research contribution

Phase 6
Applicability of solutions & constraints
Identify further studies

Publication I
Publication II
Publication V
Publication VII
Publication III
Publication IV
Publication VI
Thesis

Figure 12 Six phases (steps) of the constructive research approach (Oyegoke, 2011) linking publications to the different stages of the research process. The results in Chapter 4 are presented relative to the six phases of the research approach, i.e. results from work performed in phase 1 are presented before results from work performed in phase 2

.

The research builds on literature reviews, the study of two case studies and results from a large survey. The case studies are global collaborative research (GCR) projects funded by the EU Framework Programmes (FP). Both projects were funded to develop and deliver innovative space technology and concepts. The survey addresses success factors success in global projects.

Case studies are considered the preferred strategy when the investigator has little control over events, and when the focus is on contemporary phenomena in a real-life context (Yin, 2003). Participatory observations represent a methodology where the researcher is immersed in a setting for an extended period and observes behaviour related to the research question in hand. The methodology usually includes the study of documentation and dialogue / interviews with key informants (Bryman, 2012).
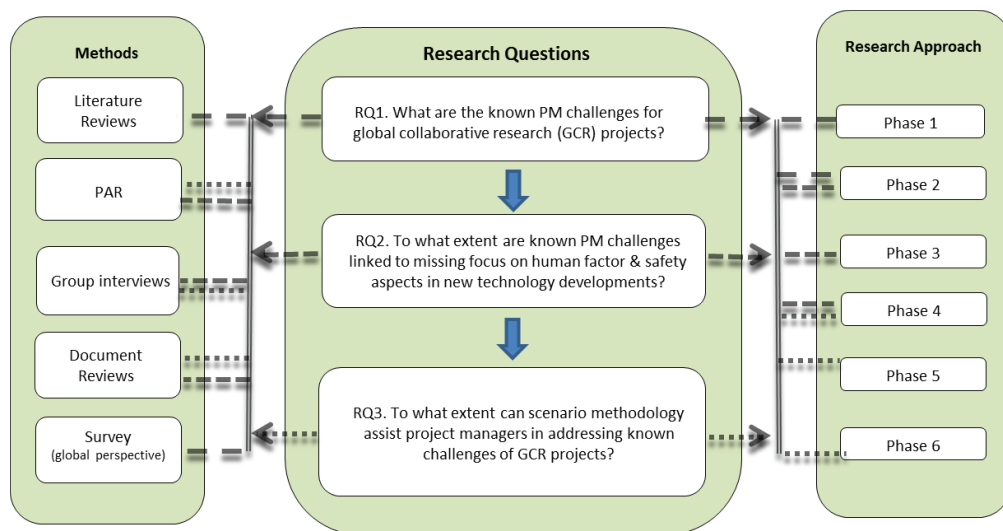
Figure 13 Illustrates how RQs are linked to the use of methods and the six phases (steps) of the research approach.

An important aspect of any research design is to clarify the ambitions for theory building, theory testing or both (Colquitt & Zapata-Phelan, 2007) and consider how the research design will produce results that constitute a valuable contribution to the field of research (Whetten, 1989, Müller & Klein, 2018). Theory testing is often defined by the use of hypothetico-deductive approaches, i.e. specifying the theory to be tested, deriving a set of conceptual propositions and restating the conceptual propositions as testable hypotheses. This dissertation neither aspires to nor fully satisfies the criteria for theory testing. These aspects are further discussed in Chapter 5.

The six phases (steps) of the constructive research approach represent the structural components of this dissertation, e.g., Chapter 4 present the results relative to the six phases of the constructive research approach and the applied methods (Figure 14).

3.4 Case study

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[5] to develop innovative space technologies and operational concepts. Table 4 identifies the key attributes of the projects.

The case studies are referred to as "Moonwalk" (Case 1) and "Time Scale" (Case 2). The Moonwalk 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.

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[5] https://ec.europa.eu/programmes/horizon2020/en/h2020-section/space

Time Scale 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 systems as part of the formal project deliverables. For simplicity the project beneficiaries are referred to 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 EU 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.

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).

Table 4 Key attributes of the "Moonwalk" and "Time Scale" projects.

	Moonwalk	Time Scale
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
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

Both projects had a dedicated work package (WP2) named "Scenario Development". The PhD candidate was WP2 manager in both projects.

3.5 Research methods

The core research design builds on case studies and participatory observations with mixed methods approach and use of triangulation.

3.5.1 Literature review – Collaborative research projects

The literature review followed a three-step approach. First, the scope was clarified by selecting key search words. "Collaborative" and "research project" were derived from the research objectives. Since a hallmark of research projects is their "exploratory" nature (Lenfle, 2008, Lenfle, 2016) this was also included as a key search word (Table 5). Second, the search for evidence was demarcated 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, the selection was limited by targeting papers with the key search words included in the title and/or abstract. The papers were then individually reviewed and PM papers addressing key challenges of collaborative research projects were identified.

Table 5 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

3.5.2 Literature review – Organizational support in global projects

A structured literature review was selected (SLR) because of its transparency and reproducibility, i.e. other researchers can more easily verify the findings of the study by replicating the research setup. A three-step approach for the SLR was adopted according to recent examples in project research literature (Aarseth et al., 2016, Ahola et al., 2014, Müller et al., 2014).

1) *Clarify the scope*: The key search words, "organizational support" and "global project" were derived from the research objectives. Approaching the global projects with the viewpoint of the success school, the term "success factors" was also added to the search criteria. The scope was further limited by only addressing one organizational variable (Leavitt, 1964) according to the framework used for classifying and comparing organizational support in global projects, i.e. emphasis on research addressing practices and factors classified within the organizational variable structure and GPM knowledge area organization.

2) *Search for evidence*: The selected journals included *Project Management Journal (PMJ), International Journal of Project Management (IJPM), and International Journal of Managing Projects in Business (IJMPB).* A keyword-based search was performed for each selected journal. Such a search provides a good representation of the comprehensive volume of related research. In particular, it identifies recent papers with low citation rates.

3) *Application of selection criteria*: To decide the relevance of the articles identified for the study, the following criteria were applied. Each criterion was awarded one relevance point, forming a 1-5 relevance scale.
   - Addressing global, international, virtual or multicultural projects
   - Addressing organizational support in the context of project management
   - Addressing success factors in the context of project management
   - Addressing aspects of *structure* as an organizational variable
   - Addressing practices in the context of project management

Initial search in the selected journals identified a high number of articles (Table 6). To limit the number of hits and increase the relevance the selected key words were combined in the search criteria. After applying the selection criteria, further articles were excluded

Table 6 Large numbers of articles were identified using the key words as search criteria.

Keywords in search	PMJ	IJPM	IJMPB	Total
"Global Project"	47	59	13	119
"Success factor"	197	451	87	735
"Organizational support"	25	45	16	86
Keywords in search	**PMJ**	**IJPM**	**IJMPB**	**Total**
"Global projects" + "success factors"	25	23	4	52
"Organizational support" + "success factor"	15	22	3	40
"Organizational support" + "Global project"	2	3	1	6

3.5.3 Literature review – Scenario development

Before starting the literature search, the topic for the SD literature review was conceptualized (Brocke et al., 2009) and clear definitions of the main terms were established to support the identification of search phrases (Zorn & Campbell, 2006). Scenarios are the key concept in SD; they are what is developed. Thus, it was decided that any methodology related to the development of scenarios would be of interest. 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 four frequently referred terms: "scenario development", "scenario planning", scenario analysis/analyse" and "scenario methodology" were selected. Three top-ranking project management journals were selected and reviewed for the selected search words (Table 7).

Table 7 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

3.5.4 Documents as a source of data

The results from the case studies include review of project proposals, formal project deliveries, progress reports and the periodical review reports from the commission and reviewers to the projects. The authors' account of the scenario process is supported by analysis of minutes from project progress meetings and project e-mail correspondence. However, academic research project documents may be unreliable, which is due to the fact that the reports are frequently prepared only in order to meet formal criteria which with respect to the specificity of customers in research projects are not always equivalent to a reliable reflection of the project course and its results (Kuchta & Skowron, 2016).

3.5.5 Survey

The survey-based research was selected for its ability to collect experience data from a large sample group, thus allowing generalization to a broader population. The survey questions were designed according to the principles established by Bryman (2012) and Oppenheim (2000).

A Likert scale was selected to allow participants to assess the extent to which a particular practice is important to the success of their projects (managerial success) and the extent to which the practice is implemented in their project organization. This approach is in line with similar PM studies (see for example (Hobbs & Besner, 2016)) and rests on the assumption that respondents, as expert PM practitioners, adopt the perspective of practitioners' bodies of knowledge to project success, which is

that success criteria vary for each project and are defined at early stages in the project charter (PMBOK, 2017). To confirm such premises, the level of expertise of the survey respondents and their awareness about PM bodies of knowledge was assessed by the demographic questions (Fossum et al., 2019b).

3.5.6 Participatory action research

Phase 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 & 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 seldom 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).

3.6 Reliability, validity and generalization

Yin (2012) use the terms *reliability and validity* and include several recommendations for enhancing these quality criteria, including triangulation. However, the terms *reliability and validity* are by some considered unsuitable for qualitative research (Wahyuni, 2012, Bryman, 2012).

The ideas of trustworthiness and credibility were introduced by Lincoln & Guba (1985) and Guba & Lincoln (1989) and included four criteria for research trustworthiness, i.e. *dependability, credibility, transferability and confirmability*, which have been widely used among social science researchers to sensitize reliability and validity to the specific nature of qualitative research.

In qualitative research *dependability* is often used similarly to reliability in quantitative research while *credibility, transferability and confirmability* are often used in the same way as internal validity, external validity and construct validity in quantitative research (Wahyuni, 2012). Thus, to ensure the quality of the research the *dependability* (reliability), *credibility* (internal validity), *transferability* (external validity), and *confirmability* (construct validity) are considered in the research design and data collection. Transferability is addressed as similar to generalization, i.e. the extent to which the findings can be analytically generalized to other situations and project types.

Table 8 Four criteria applied to the research quality in this dissertation

Criteria and tactics to improve reliability in case studies		
Criteria	Goal	Tactics / Implementation
Dependability	Consistency and repeatability of the research procedures	Use multiple sources of evidence Establish chain of evidence Have key informant review draft case study report
Credibility	Establish causal links and conclusions recording the effects of the construct under investigation	Do pattern matching Do explanation building Address rival explanations Use logic models
Transferability	Clarify the analytical generalization of findings	Use theory in single-case studies Use replication logic in multiple case studies
Confirmability	Obtain accurate and objective measure of the concept under study	Use case study protocol Develop case study data base

A triangulation strategy was implemented to improve the credibility and dependability of the case study research. Bryman (2012) defines triangulation as "The use of more than one method or source of data in the study of a social phenomenon so that findings may be cross-checked."

The triangulation approaches included in the research approach include data triangulation (both data type and source), method triangulation, triangulation by theory and researcher/evaluator triangulation (Table 12). Researcher triangulation supported identification of the study perspective and construct identification as well as the data analyses. The quality of the research is further discussed in Section 5.4.

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4. Research Findings

This chapter provides an overview of the individual publications and describes their place in the narrative motif (thread) of this dissertation. Consequently, the research findings are not presented in the order that the papers were published. Rather, the research findings of each paper are presented in the context of the phases of the constructive research approach to which they belong (Figure 12 and Figure 13).

Figure 14 shows how the structure of this chapter follows the different phases of the constructive research approach and how the different publications align with these phases. Table 9 presents key findings from each publication, links them to the relevant research objectives and research questions, and emphasizes how findings are represented in the overall summary of research findings. A summary of the key research findings is presented at the end of this chapter. The summary section also examines the scope of applicability of the scenario development for GCR projects.
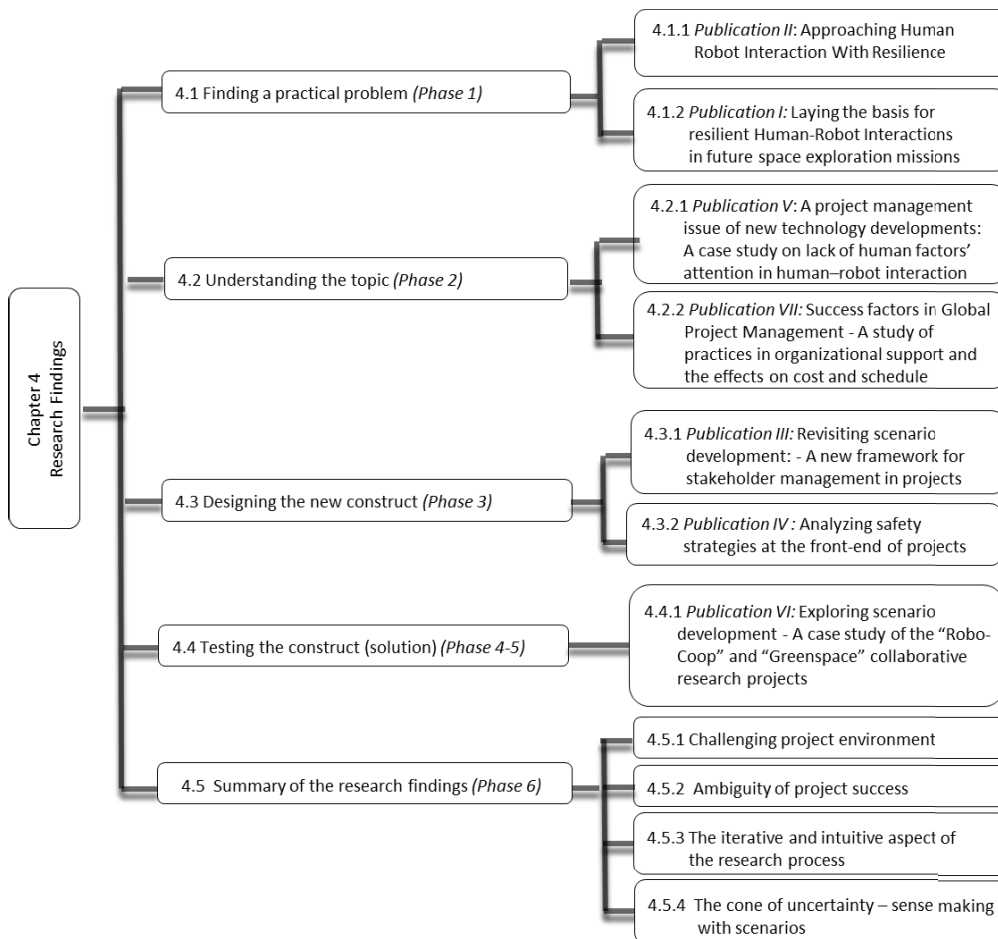
Figure 14 The chapter is structured according to the six phases of the constructive research approach

Due to practical aspects of any research process and the maturation and education as part of the PhD process the chronological order of publications does not fully reflect the chronological order of the research work. Thus, in this chapter the chronological nature of the six-step constructive research approach is used to structure the account of individual contributions of each publication.

Table 9 Linking key findings of each publication to the relevant research objectives, research questions and their role in the overall summary of research findings. See Figure 10 for details on research objectives and questions.

Publ. No	Relevant objective	Key issues / findings	Relevant RQ	Consequence for summary of research findings
I	O1, O2	Scenario analysis identified misunderstandings, mistakes and errors in the development of new technology for human–robot cooperation.	RQ2, RQ3	Myopic safety/design philosophy can limit the performance of the complex sociotechnical systems they are imposed upon.
II	O1, O2	The scenario analysis part is an important aid in identifying and assessing impacts of different requirements and trade-offs in new technology developments.	RQ2, RQ3	Together with Paper I, these findings gave rise to the notion that lack of focus on human factors was not a design (process) oversight but a project management issue.
III	O2, O4	A framework for scenario development as a method for stakeholder engagement was developed. By analysing different scenarios one can identify criteria and factors of key importance for the project success.	RQ3	SD processes can be harmonized with project SM processes, contribute to assessment of stakeholder strategies, identify relevant uncertainty/ risk and introduce results to the project risk management processes.
IV	O2, O4	Nine checkpoints for project front-end definition to guide development of safety strategies supporting the alignment of different "layers" of (risk) governance in project based organizations was developed.	RQ2	Introduces the notion that failed alignment of "the layers of horizontal governance" and missing "vertical governance" are common denominators for why "projects fail" and "accidents happen".
V	O1, O3	Narrow focus in different project phases and insufficient information coordination was found to contribute to marginalizing the role of human factors in design and development of new technology.	RQ 2	Projects developing new technology should address emergent risks as a part of the criteria for the project's long-term strategic and business success.
VI	O1, O3	SD method was found useful to support the description and analysis of project stakeholder situations (collaborative aspects) and to structure and balance the need for both rational and intuitive project processes (research aspects).	RQ1, RQ3	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.
VII	O2, O3	Findings show positive correlation between some types of OS and the completion of GPs within cost and schedule – specifically, that effective processes and practices for selection and training of team members are a primary factor for successful management of GPs.	RQ1	Organizations relying on GPs need "better best practices" for selection and training processes that prepare project personnel to identify and manage uncertainty originating from the social worlds with the same excellence that they prepare them to use natural and engineering science to understand and manage the natural world.

The constructive approach is a rigorous research approach which spans construction, application and operationalization that require innovation, creativity and transparency (Oyegoke, 2011). The following sections address these phases and describe the context and contribution of individual publications. However, it is important to note that the process is not as linear as presented in Figure 12 but a dynamic and interactive process between the six different phases.

4.1. Finding a practical problem (Phase 1) - *Publication II and I*

The constructive research approach begins with identification of relevant practical problems that have research potential, e.g. finding a practical PM problem related to new technology development in GCR projects.

Identifying a PM problem in the context of new technology development was mainly driven by the presumptions and opportunities that opened up in the selected case studies. As such, the first two publications originated in the context of initial PAR work with the Moonwalk project (case study I) initiated in parallel with the initial literature reviews.

The Moonwalk project key objective was to explore and develop new methods for approaching teamwork between humans and robots for future planetary exploration where robots are foreseen to help astronauts to carry material, assist in the installation of equipment and scout sites that are too dangerous for humans, or assist in search and rescue activities. The goal of the project was to develop new concepts and technologies for astronaut-robot cooperation. The concepts and technologies were tested in Earth-analogue environments, i.e. in environments representing key features of the Moon and Mars environments.

Paper I and II contribute to identifying the relationship between safety design philosophies in the early phase of new technology development and the long-term performance when imposed on complex sociotechnical systems, representing an increased risk regarding long-term strategic and business objectives of new technology developments.

4.1.1 Publication II: Approaching Human–Robot Interaction with Resilience

The paper describes how the Moonwalk project implemented the Crisis Intervention and Operability analysis (CRIOP) method to analyse the new concepts and technologies in context of the scenarios developed at the beginning of the project (WP2), i.e. the rationale for selection of CRIOP methodology and the initial checklist development.

A generic challenge of robot designers is one of uncertainty of the specific task that the robot will be required to execute. For the design and development of space robotic systems working side by side with humans this will be the main challenge, and it is not addressed by current standards and practices of safety in a comprehensive way. At best we can find the answers fragmented over several research disciplines and their related standards.

The question that arises is how to design intrinsically safe systems that also capitalize on the superior human capacity to anticipate and solve problems in complex space exploration settings.

The continuous trade-off between safety and performance, a complex balance between safety design of hardware, software and control systems, the degree of automation and training and certification needed for operators, is at the core of all risk management. It is in support of this continuous trade-off and balance that scenario methodology can be a valuable supplement.

Of special interest in the Moonwalk project is the resilience of Human–Robot Interaction (HRI) - how to design new technology / systems to ensure that deviations are discovered as early as possible and unwanted incidents and surprises are handled in a manner that reduces consequences and enables recovery to a normal state. Resilience is described as "A system or organization's capacity to anticipate disruptions, adapt to events and create lasting value through safe and efficient operation".

CRIOP has been successfully applied to prevent accidents in Norwegian oil industry for more than 20 years and is recommended as the preferred methodology for "validation of the design, manning and procedures, and the ability to control process disturbances and emergencies" of a control centre in all modes of operation. CRIOP analysis consists of two main components, a general checklist covering relevant areas of the control system and scenario analysis of key scenarios. The scenario analysis component comprises a detailed, multidisciplinary assessment of operator activities and responses to different situations or scenarios where the new technology and/or systems are applied. The results from the SD itself are addressed in Paper VI and the specific results from the workshop, i.e. scenario analysis, are presented in Paper I (Fossum et al., 2015).

4.1.2 Publication I: Laying the basis for resilient Human–Robot Interactions in future space exploration missions

This paper summarizes the preparation and presents the execution and results from a workshop performed as a part of the Moonwalk project. The initial preparations, e.g. checklist development, for the study and rationale for selection of CRIOP methodology are covered by Paper II. The workshop took place about halfway in the 36-month project.

A key objective of the workshop was to analyse the scenarios developed in the beginning of the project. Human factors & safety was addressed as a specific technical and operational component highly relevant for strategic and business objectives of the project products.

Day one of the workshop started with an introduction to the CRIOP method. Printouts of the checklist were handed out to the participants. The facilitator read the questions one by one, and participants discussed the answers. The comments and answers provided in response to the checklists were summarized on posters/flip-overs posted on the meeting room walls.

After completing the checklist, the participants were asked to prioritize the identified issues by importance. Each participant was handed five post-it notes, each with a number from 1 to 5. They were asked to select and rank the top five issues documented on posters/flip-overs according to individual opinion, 5 being the most important and 1 the least important issue.

Day two started with a short introduction to the scenario methodology before two of the developed scenarios were analysed. The scenarios were described and analysed using the STEP method— Sequentially Timed Events Plotting. The STEP method focuses on identifying all actors, the events, sequence and interaction of events and issues regarding roles and responsibilities during the planned activity. The STEP documentation is a basis for further Human Factors analysis and can be used to explore how the human actor observes, interprets, plans and performs actions.

The workshop did reveal crucial vulnerabilities that, if left unaddressed, could threaten the core mission objectives of the Moonwalk project: Vulnerabilities arising from intertwined organizational, human and technical issues that otherwise may not have been addressed in a consistent and coordinated manner. The application of CRIOP methodology also provided a good foundation for the project management to develop tailored preventive measures in cooperation with the project staff.

The results from the workshop debrief show that the project team found the results from the methodology and process useful for the project.

4.2. Understanding the topic (Phase 2) - *Publication V and VII*

After the problem is defined (phase 1), a general understanding of the topic is obtained through the theoretical understanding of what has been done to date (literature review). In order to have a comprehensive understanding of the topic the line of enquiry should be further extended to related disciplines and practices where comparison and synthesis should be carried out (Oyegoke, 2011).

Paper V further explores the notion that a lack of attention to human factors in new technology developments may be linked to known PM challenges.

Paper VII addresses the global perspective on PM and explores the effects of practices within organizational support on PM success.

4.2.1 Publication V: A project management issue of new technology developments: A case study on lack of human factors' attention in human–robot interaction

This article investigates how known PM challenges can contribute to the lack of attention to human factors and safety issues in the design and development of new technology. The paper reports on findings in the Moonwalk project (case study I).

During the last 40 years, projects have become a dominant way to organize research, development and construction efforts. The main focus of the PM research has been on challenges, failures and success of

projects. PM is strongly rooted in scientific disciplines such as engineering and economics, and traditional methodology is dominated by technical risk analyses calculating expected benefits and monetary costs as part of engineering planning and design.

In the same time frame, system safety engineering and safety research have offered strong evidence of the crucial role of human factors knowledge in the design and construction of new systems. As such, research efforts have focused on advancing human factors methodology and its application in engineering projects. The human factors discipline includes a vast set of methods and processes, and there is clear merit to the recommendations of most human factors standards that technological developments could benefit from including human factors experts from the outset of the project. However, the literature is rich in examples and explanations of why relevant human factors analyses were excluded or inadequately performed.

Findings indicate that lack of attention to the role of human factors in the development of new technology and concepts can be linked to insufficient information coordination in project front-end phase, often seeding erroneous logic of causalities and probabilities or predict and provide approaches, or neglecting opportunity space. Moreover, findings suggest that early project deliveries with no or little requirement or accountability for the operational phase increase the risk that short-term project goals take priority, often leaving the long-term viability and efficient operation of the project product to suffer.

Findings indicate that evaluating the merits of alternative technologies, the causalities between their strengths and weaknesses and the probabilities of realization within the project envelope take precedence over assessments of end-user needs, limitations as well as the performance in relevant social and operational environments.

The paper concludes that a narrow focus on early project phases and insufficient information coordination contribute to marginalizing the role of human factors in the early design and development of new technology.

4.2.2 Publication VII: Success factors in Global Project Management - A study of practices in organizational support and the effects on cost and schedule

This paper describes and analyses organizational support (OS) practices in global projects (GPs) and investigate their importance for managerial success and correlation with efficiency.

PM literature addressing GP focuses to a large extent on contextual and relational factors and how global organizations should adapt their practices to the global context of their projects. However, there is a lack of research investigating correlation of such global practices with managerial success and project efficiency using a large sample of expert practitioners across countries. The paper reports from a large survey among GP practitioners (1170 respondents) across 74 countries, emphasizing a subset of the survey that addresses OS practices.

Aarseth et al. (2011) defined OS in GP as "… an area of PM that pertains to how the global organization can support its projects and project staff to enable their best performance in GPs". In their research into effects of OS on components of virtual project teams, Drouin et al. (2010) outlined a conceptual framework where OS is divided into seven categories of support systems and 18 different mechanisms associated with the different support systems. Berssaneti & Carvalho (2015) found relations between high maturity of PM practices and project completion on time and at cost, thus supporting findings by Gelbard & Carmeli (2009) reporting that interaction between team dynamics and OS was significantly related to budgetary, functionality and time performance. Based on such studies, OS can be defined as "the use of governance systems, structures of authority and processes, aiming at coordinating, controlling and supporting the efficient and successful delivery of projects".

Building on mature organizational models and theories, a framework for GPM knowledge areas was elaborated, using OS practices as the unit of analysis to investigate correlations between OS and project scope, cost and schedule.

Findings show positive correlation between some types of OS and the completion of GPs within cost and schedule – specifically, that effective processes and practices for selection and training of team

members are a primary factor for successful management of GPs. The statistically significant correlations found were weaker than expected, indicating that correlation between OS practices (as success factors) and project efficiency (as success criteria) is more complex to study than expected. The paper discusses the possibility that the OS practices explored are poor success factors for project efficiency (as success criteria), as well as the suitability of opinion-based research for investigation of success factors.

The paper concludes that organizations relying on successful GPs need "better best practices" for selection and training processes. That is, organizations need to prepare project personnel to identify and manage uncertainty originating from the social worlds with the same excellence that one prepares engineers to use natural and engineering science to understand and manage the natural world.

4.3. Designing the new construct (Phase 3) - *Publication III and IV*

The constructive approach requires that the design of a construct should be based on an in-depth interpretation and synthesis of the contextual literature review and the practicalities of the problems (Oyegoke, 2011).

Paper III is a conceptual research paper exploring the common roots of scenario development (SD) and project management (PM) disciplines and discusses how an introduction of SD to current PM practices can support project stakeholder management (SM).

Paper IV is a conceptual paper addressing common challenges in project and risk governance and discuss how safety strategies in project-based organizations should be analysed in recognition of these challenges.

4.3.1 Publication III: Revisiting scenario development: - A new framework for stakeholder management in projects

This paper presents the initial work to establish a framework for the development of scenarios to support the PM process. The framework could be useful for all types of projects but its full potential is aimed at projects with long time horizons or short-term decisions with long-term consequences, i.e. projects with high levels of uncertainty.

The paper describes and proposes how to add SD to the PM toolbox with PM professionals subscribing to PMBOK® processes considered as the main audience. However, the paper also discusses how SD and the proposed framework contribute to the project SM body of knowledge in particular and the PM discourse in general. Based on the components and processes identified in Figure 15 the paper outlines a proposed process framework. Emphasis is placed on illustrating how the SD process can be used as an "overlay" on the PMBOK (2013) SM process. The proposed SD process uses the same project inputs, tool & techniques and outputs as the project SM process.

The paper demonstrates how the framework for SD can support the identification of and trade-off between project efficiency and effectiveness goals and contribute to the analysis and assessment of options for initial investment in flexibility that reduces the cost of altering its strategy late in the project. The paper also discusses SD as a contribution to strategy-based project management, e.g. the evaluation of risks must be based not only on delivering projects on time and within budget but also on crafting, developing and operating a long-term business entity which can deliver the business objectives needed for projects to succeed in today's global environment and to manage the inherent uncertainty of the future. With the recognition that no amount of sophistication is going to allay the fact that all our knowledge is about the past and all our decisions are about the future the paper concludes with the slogan:

> "*The future must be created and recreated every day. There are no final solutions.*"
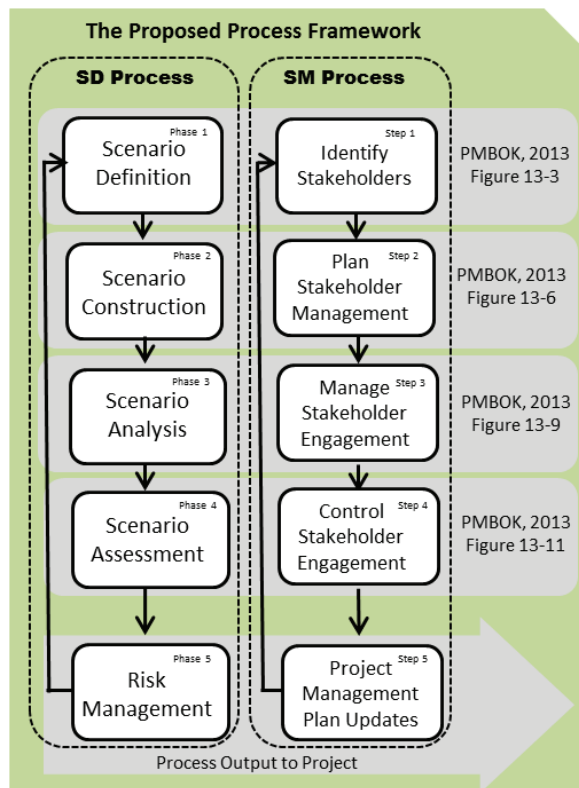
Figure 15 The five phases of the proposed SD process and five steps in the PMBOK SM process they relate to. The horizontal areas refer to the more detailed data flow diagrams of the PMBOK (2013) with their dedicated output to other project management processes. The black arrows going back to the top indicate the feedback loop of the iterative process.

4.3.2 Publication IV: Analyzing safety strategies at the front-end of projects

This conceptual paper addresses common challenges in project and risk governance and argues how methodology used for project front-end definition can be applied to these challenges. The paper further discusses how safety strategies in project-based organizations should be analysed in recognition of these challenges.

Both practitioners and risk governance scholars stress the need to pay attention to the legal, economic, social and institutional contexts in which risks are managed. There is also an increased emphasis on research addressing risk-related decision making in settings where many stakeholders are involved and where these different stakeholders hold diverse meanings on the concept of risk. Similarly, the PM literature supports the notion that legal, economic, social and institutional contexts of project based organizations provide complex challenges that cannot be sufficiently addressed by traditional technical PM alone, one also needs leadership, strategy and business management skills.

With this background, the paper identified nine common challenges in project and risk governance and proposed nine initiatives to address these challenges. Both project and risk managers in PBOs could use this as a "checklist" to make sure that the strategies they are implementing do not build on inadequate assumptions, with the risk of compromising long-term strategic and business objectives.

4.4. Testing the construct (solution) (Phase 4-5) - *Publication VI*

Within a framework of the constructive research approach, it is required to demonstrate that the proposed construct (solution) works in practice (Phase 4), shows relevant theoretical connections and shows the research contribution of the construct (Phase 5). The most appropriate method to test and improve a construct is via pilot case studies (Oyegoke, 2011).

Paper VI explores SD as a method for engaging known challenges in GCR projects, building on the two case studies Moonwalk and Time Scale projects, aka the Robo-Coop and Greenspace projects.

4.4.1 Publication VI: Exploring scenario development - A case study of two collaborative research projects

This paper addresses collaborative research projects as a widespread approach to implement complex research work. The paper accounts for the 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 in global environments and introduces the history and application of SD methodology. The work includes participatory action research (PAR) in two (pilot) case studies

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. Figure 16 illustrates the five-phase/-step SD process implemented for this study.
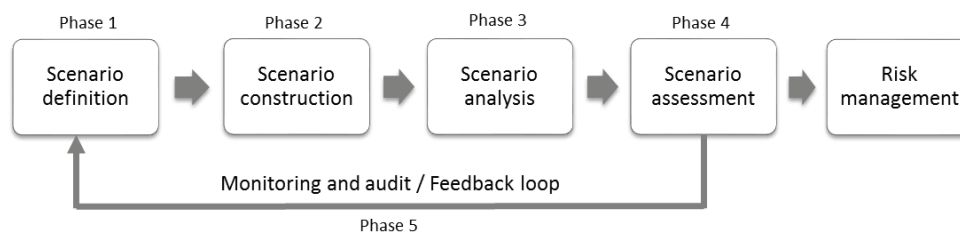
Figure 16 The five phases of the implemented SD process proposed by Mahmoud et al. (2009).

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 to develop innovative space technologies and operational concepts. During the project proposal preparation, it was suggested to the project teams that SD could be a way to improve collaboration in the projects. Both projects had a dedicated work package (WP2) named "Scenario Development". Both projects included verification testing of prototype systems as part of the formal project deliverables. The projects are anonymized in the paper.

The results from the case studies include review of project proposals, formal project deliveries, progress reports and the periodical review reports from the commission and reviewers to the projects as well as reviews of minutes from project progress meetings and project e-mail correspondence.

Work took place in the timeframe 2013-2018 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).

Findings indicate that SD can 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.

The paper concludes that future studies of collaborative research projects need to look beyond the single project perspective. Furthermore, that there is 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 with the intuitive and exploratory 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.

The practical contribution of this research is knowledge about alternative tools and processes for organizations to address key obstacles to improved 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.

4.5. Summary of the research findings (Phase 6)

It is important to recognize that each publication represents "snapshots" from the different phases of the research process. In the following the findings are summarized along three dimensions of challenges known to GCR projects: Challenging project environment, ambiguities of project success and implementation of iterative and intuitive project processes.

Phase six of the constructive research approach emphasizes the requirement to examine the scope of applicability of the construct (solution), i.e. the contribution to the body of knowledge should be specified and areas for further studies should be highlighted (Oyegoke, 2011). Although most of this is covered in Chapter 5 this section introduces the "sense making with scenarios" model and aims to clarify how the findings from each individual paper have shaped the development for this model, i.e. how the model represents a part of the research findings.

4.5.1 Challenging project environment

A key aspect of contingency theory is the notion that there is no one single best way to organize and lead a company or a project or to make decisions (Hanisch & Wald, 2012). That is, project managers need to sense which context they are in so that they can make better decisions and avoid problems that arise when their preferred management style causes them to make mistakes.

Findings in the two case studies indicate that the global aspects and the combination of collaborative challenges and the unknown dimension of the project product created by the research aspect results in challenging project environments. Table 10 and Table 11 use the project type and scope level variables of Shenhar & Dvir (1996) to describe characteristics of the two case studies. Figure 17 uses distances in five challenge dimensions and types of organizations involved in the case studies to characterize key aspects of the project environment.

Table 10 Project characteristics of the case studies according to technical uncertainty (Shenhar & Dvir, 1996)

Variables	Project characteristics according to technological uncertainty, i.e. project type variable. (Low tech, medium tech, high tech, super high tech)	
	MOONWALK Project	**TIME SCALE Project**
Technology	**Super high tech** Novel integration of existing technology and key technologies that do not exist at project initiation.	**Super high tech** Integration of existing concepts but key technologies do not exist at project initiation.
Typical industries	**High tech** See Figure 17	**High tech** See Figure 17

Type of products	**High tech** Known technologies but key deliveries include implementation of beyond the state-of-the-art concepts and application	**High tech** Known but non-proven concepts. Need key technologies beyond state of the art
Development and testing	**High tech** Considerable development and testing. Prototyping used for testing and verification during field (outdoor) test campaigns.	**High tech** Considerable development and testing. Sub-system development and prototyping used for laboratory testing during development process and final verification test.
Design cycles and design freeze	**Medium tech** One to two cycles. Overall design and key concepts are defined in the project proposal and the negotiated description of work (DOW)	**Medium tech** One to two cycles. Key concepts and technologies to be developed are to a large degree defined in the project proposal and description of action (DOA)
Communication and interaction	**Low tech** Mostly formal communication at predetermined, low-frequency meetings. More intense communication in preparation and execution of field tests	**Medium tech** Mostly formal communication at predetermined, low-frequency meetings. Some partners have more intense tri- or bi-lateral communication
Project manager and type of workers	**High tech** Good technical skills of manager. Many professionals and academicians in the project team	**High tech** Good technical skills of manager. Many professionals and academicians in the project team
Management style and attitude	**Medium tech** Moderately firm style. Ready to accept some changes	**High tech** Moderately flexible style. Expecting many changes
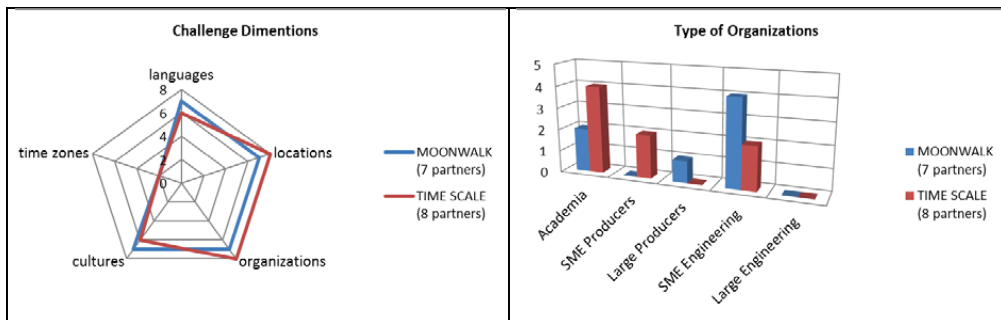
Figure 17 Five challenge dimensions (left), number and typed or involved organizations (right) illustrate aspects of the project environment that may impact the collaborative setting.

Table 11 Project characteristics of the case studies according to system scope (Shenhar & Dvir, 1996)

Variables	Project characteristics according to system scope, i.e. scope level variable (assembly, system or array)	
	MOONWALK Project	**TIME SCALE Project**
Description and function	**Array** Development and demonstration of training astronaut suit, including stress/health monitoring system, a small scout rover, voice- and gesture-based communication systems.	**System** Development and demonstration of technology and concepts for photosynthesis-based regenerative life support systems, i.e. cultivating plants and algae in automated systems to produce food
Operational aspects	**Array** Solutions should serve a wide-range mission that is achieved by the assembly of the various systems involving the interaction of many people in its operation	**System** Technology and concept should serve a well-defined need for future long duration and deep space exploration missions.
Customers	**Array** Public organizations / government (EU / ESA)	**Array** Public organizations / government (EU / ESA)
Form of purchase, payment and delivery	**System** Consortium type contract with payments by milestones (deliveries) and (final) delivery at project completion incl. support items / systems.	**System** Consortium type contract with payments by milestones (deliveries) and (final) delivery at project completion incl. support items / systems.
Project organization	**Assembly** Performed within one consortium type organization under a single PM team. No staff in project organization	**Assembly** Performed within one consortium type organization under a single PM team. No staff in project organization
Planning	**Assembly** Simple manual tools with fewer than 100 activities in network	**Assembly** Simple manual tools with fewer than 100 activities in network
Control and reports	**System** Formal scientific and technical reviews with EU. Tight and formal control on financial and schedule matters.	**System** Formal scientific and technical reviews with EU. Tight and formal control on financial and schedule matters.
Documents	**System** Many formal document deliveries – technical and managerial	**System** Many formal document deliveries – technical and managerial
Management style, attitude and concern	**Assembly** Mostly informal style. Some political, inter-organizational aspects	**System** Mostly informal style. Action item lists and minutes of meeting (MoM) implemented. Some political, inter-organizational aspects
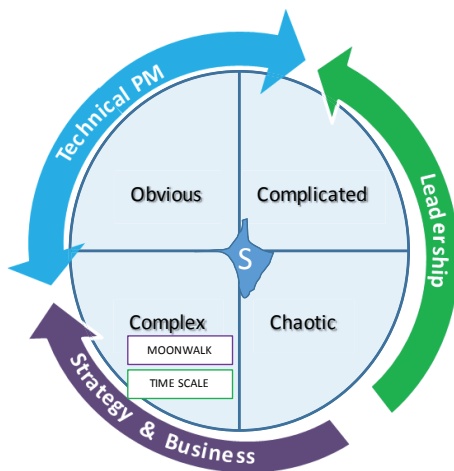
Figure 18 Combining components of the Cynefin framework and the PMI talent triangle to support the identification and description of the project environment of the case studies. The S in the centre Illustrates that this is a sense making model, not a categorization model.

Figure 18 is inspired by the Cynefin framework (Snowden, 2002, Snowden & Boone, 2007) and divides the project environment into four types: "obvious, complicated, complex and chaotic". By integrating the PMI talent triangle into this framework, the figure suggested which skills are most appropriate for the four environment types. It is proposed that technical PM is best suited in "obvious" project environments. In a "chaotic" environment it is suggested to use project leadership and strategy & business management skills to make decisions that move the project environment towards "obvious", via "complicated" and "complex" states respectively. Based on the above findings both case studies can be characterized as complex or complicated project environments.

The combination of the array (scope level) variable for description and function and operational aspect (see Table 11) and the low tech (project type) variable for implementation of communication and interaction (see Table 10) represent the key difference, making the Moonwalk project a somewhat more complex project than the Time Scale project.

4.5.2 Ambiguity of project success

Findings in this dissertation indicate that lack of attention to human factors and safety aspects is rationalized by referring to existing work package objectives, scope and agreed plans for the project (Fossum et al., 2018). From a human factors perspective, the results from the case studies thus identified a lack of attention to the operation phase, and unclear understanding of the responsibility and authority of the operation organization (in which responsibility for utilization of the new systems and technology would reside) was identified as a main concern.

Although the need to (de)scope new technology development projects has clear merits, there are clear and known risks generated by limiting any realistic involvement of end users and their organizations. Thus, findings support the notion of aspects related to human factors and safety as a subset of strategic and business objectives in new technology developments that are of key importance to long-term project success criteria.

To summarize findings from the case studies related to the ambiguity of project success, Figure 19 builds on the 2 x 2 goals-and-methods matrix introduced by Turner & Cochrane (1993). Available information on project success criteria (efficiency and effectiveness) is used to place the case studies in the goal-and-method matrix of Turner and Cochrane (1993). The original matrix uses the maturity of product breakdown structures (PBS) and work breakdown structures (WBS), i.e. how well defined they are, to suggest four different types of projects:

- Type 1 – Project where the goals and methods of achieving the project are well defined
- Type 2 – Project where the goals are well defined but the methods are not
- Type 3 – Project where the goals are not well defined but the methods are
- Type 4 – Project where neither the goals nor the methods are well defined

Project efficiency relates to the project management success criteria and a measure of the project manager's performance in achieving the project plan. The type of contracts and financing used for EU projects like Moonwalk and Time Scale, i.e. fixed firm price contracts with limited scope for extending project duration, results in a relative clear image of the expected efficiency (cost and schedule). As such, the success criteria related to efficiency were well known at project initiation.

Efficiency / Method

Known   Unknown
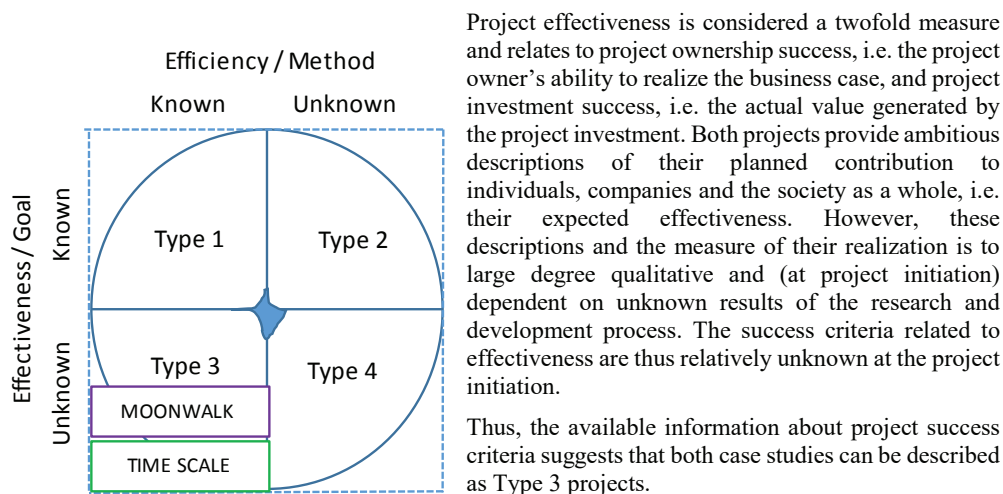
Figure 19 Available information at project initiation about WBS and PBS and on project success criteria (efficiency and effectiveness) is used to place the case studies in the goal-and-method matrix of Turner & Cochrane (1993). The area in the centre Illustrates that this is a sense making model, not a categorization model

Project effectiveness is considered a twofold measure and relates to project ownership success, i.e. the project owner's ability to realize the business case, and project investment success, i.e. the actual value generated by the project investment. Both projects provide ambitious descriptions of their planned contribution to individuals, companies and the society as a whole, i.e. their expected effectiveness. However, these descriptions and the measure of their realization is to large degree qualitative and (at project initiation) dependent on unknown results of the research and development process. The success criteria related to effectiveness are thus relatively unknown at the project initiation.

Thus, the available information about project success criteria suggests that both case studies can be described as Type 3 projects.

According to Turner & Cochrane (1993) research projects, and thus the case studies in this dissertation, are typical Type 4 projects. However, both project proposals included high level milestone WPSs and a budget breakdown for both materials and manpower as part of their proposals and management plans.

Both project proposals also had a high-level description and plan for the development of sub-systems and concept components. However, neither projects used the term PBS.

The Moonwalk project planned for the delivery of detailed development plans at Month 9 (of 36). This delivery aimed for the detailed identification of all essential system components, extraction of hardware developments and development dependencies, estimation of development times for each component, definition of the detailed hardware development plan and summarizing the potential risk and issues.

The Time Scale project had a similar deliverable at Month 7 (of 36) titled requirement implementation. The efforts with design and manufacture, assembly, integration and test (MAIT) were planned to start at project month 16. As such, both projects fit the description of Type 3 projects, i.e. typical engineering projects where the PBS is ill-defined (at the project initiation) but the WBS is partially defined. That is, the typical sequences of tasks required to achieve the deliverables are well known, but the precise form of those deliverables, and hence the precise balance or sequence of tasks, is not (Turner & Cochrane, 1993).

4.5.3 The iterative and intuitive aspect of the research process

Findings from the case studies indicate missing or misunderstood application of intuitive, incremental and iterative PM processes (Fossum et al., 2019a), thus supporting the impression that implementation of such processes represents a key challenge for innovation, research and development projects (Fowler et al., 2015, Lenfle, 2016). Examples from the case studies are the use of linear, milestone-driven Gantt charts as the main planning tool and the absence of iterative, incremental or exploratory planning models in the project management documentation.

Findings indicate that SD processes are useful to structure, describe and analyse intuitive project processes. However, some fundamental challenges in using SD in the management of single projects were found. Similar to PM processes, they struggle with known PM challenges 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.

Figure 20 aims to illustrate how the two case studies approached uncertainty, which is inherent to a research and development process, by analysing the key output from the SD definition phase.
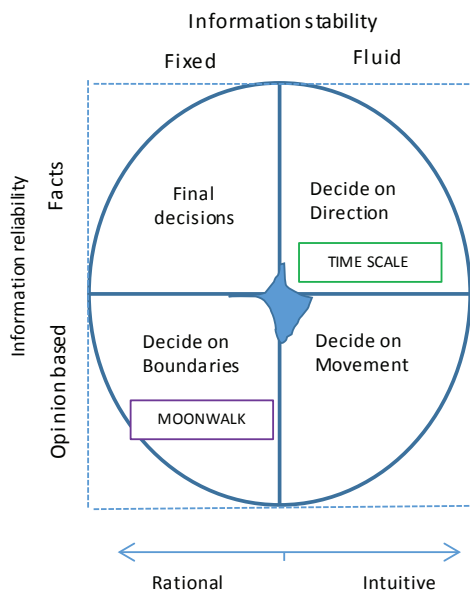
Figure 20 Type of scenarios developed in the case studies positioned in different quadrants of the framework. The area in the centre Illustrates that this is a sense making model, not a categorization model. By analysing the available information one can decide on the most appropriate type of decision making for the project.

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

In Moonwalk, the SD process 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. 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 are usually the basis for how most people, even professionals, assert what they believe the future will or could be. The approach is useful when one is seeking to establish boundaries for what the project should focus on.

With the development of only one main scenario in the Time Scale project the team chose an approach resembling what Bishop et al. (2007) define as baseline/expected technique. Such a scenario is named baseline because it is the foundation of all the alternative scenarios considered and is useful when one is deciding on what direction one should take the project. Although it was manifested in different ways, it seems that the project team in both case studies struggled with deciding if the scenario development was intended to support the project management processes, the product design process or both. Such balancing and trade-off discussions have similarities to known PM challenges of balancing project efficiency (PM success) vs. effectiveness (project success).

4.5.4 The cone of uncertainty – sense making with scenarios

Projective scenarios project forward in time using trends experienced over some past period while prospective scenarios anticipate upcoming change that significantly varies from the past. Expert judgment-driven scenarios model future conditions by means of knowledge derived from decisions, rules, objectives and criteria established by senior managers, advisors and field experts while stakeholder-defined scenarios involve stakeholders in defining the assumptions about the future that are to be incorporated into scenarios.

More generally, one can divide the different type of scenarios into two categories: exploratory scenarios which describe the future according to known processes of change and extrapolations from the past and anticipatory scenarios which 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 21 identify the type of scenarios developed in the two case studies. In both case studies the main effort during the scenario definition focused on the identification and description of constraint and opportunities known from the relevant SoA, i.e. "fact finding". Participation in the SD process was limited to the project consortium partners, i.e. no external stakeholders were included. As such, findings from the case studies suggest that the developed scenarios were driven by projective expert judgment.

Figure 21 Building on Mahmoud et al. (2009) characteristics of different scenario types (Figure 8), four forms of scenarios can be identified (A-D). Scenarios developed in the case studies represent Type A scenarios.

The sequence of the four sections, or topics of Figure 22 (next page): project environment, decision making, success criteria and scenarios represent a chronological order relative to the project lifecycle and the alignment of the four sections of the circles has key functions. Conventional PM knowledge proposes that estimation gets better as a project progresses, i.e. the (missing) arrow on x-axis should point to the right. However, with scenario methodology the current situation is known and the future becomes increasingly uncertain, i.e. the (missing) arrow on the x-axis should point towards the left. The findings and the dual use of the cone of uncertainty (Figure 22) are discussed in the next chapter – Discussion.

The essence of Figure 22 suggest that Type C scenarios, that is prospective stakeholder defined scenarios, may have served the projects may better. Also, per the model, Time Scale project may have been better served by considering a different decision making process. However, an analysis of what constitute fixed and fluid facts (Figure 20) is not straight forward. The information stability regarding scientific and technical aspects may be high (fixed) but information stability regarding the use cases and mission context may at best be low (fluid).

Sense making with scenarios

Project environment   Decision making   Success criteria   Scenarios

Time

Variability in estimates of project efficiency and effectiveness

0

Project environment

Leadership

Technical PM

Strategy & Business

Obvious | Complicated
Complex | Chaotic
S

MOONWALK

TIME SCALE

Decision making

Information stability
Fixed   Fluid

Final decisions | Decide on Direction
TIME SCALE
Decide on Boundaries | Decide on Movement
MOONWALK

Rational   Intuitive

Information reliability
Facts   Opinion based

Success criteria

Efficiency / Method
Known   Unknown

Type 1 | Type 2
Type 3 | Type 4
MOONWALK
TIME SCALE

Effectiveness / Goal
Known   Unknown

Scenarios

Projective   Prospective

A | B
TIMESCALE
MOONWALK
C | D

Expert   Stakeholder

Exploratory   Anticipatory

S = Illustrate that this is a sense-making model, not a categorization model.

Figure 22 The Sense making with scenarios model build on Figure 18, Figure 19 and Figure 20 and Figure 21

5. Discussion

In retrospect, most managers are able to point out the decisions that took a project in an unfavourable direction as well as the factors that most likely influenced the decisions. Similarly, in hindsight it is easier to identify alternative decisions that could have increased the chances for a more successful project. This dissertation explores whether methodology from foresight and future studies disciplines, i.e. scenario development, provides useful support for decision making processes.

The research presented addresses Global Collaborative Research (GCR) projects (the project type under study) and investigates how scenario development (the construct under investigation) can support identification, mitigating and monitoring of known challenges for GCR projects, i.e. the research problem. Section 5.1 discusses how the individual papers contribute to identifying known challenges of GCR projects (RQ1), to what extent the known challenges are linked to lacking focus on human factors and safety in new technology developments (RQ2) and to what extent scenario methodology can assist project managers in addressing known challenges of GCR projects (RQ3).

Section 5.2 and 5.3 discuss the theoretical and practical contributions of the "sense making with scenarios" model (Figure 22). Section 5.4 discusses the quality of the research, focusing on the validity, reliability and the generalization of the research results. The chapter closes with section 5.5 and a discussion of key limitations of the dissertation.

5.1 Contributions of the individual papers

This section discuss the contributions of the individual papers towards the research questions.

RQ1: What are the known PM challenges for global collaborative research (GCR) projects?

This question was first addressed in the initial literature reviews and later supplemented with results from a survey and the case studies. EU Framework projects constitute instances of GCR projects in the research. As the literature search on GCR projects specifically found little to no relevant research it was decided to synthetize literature from three perspectives with significant amounts of relevant PM literature. That is; describe known challenges of EU Framework projects from a *global, a collaborative and a research* perspective. The main contribution towards RQ1 are found in Publications VI and VII.

Each year European companies and academic institutions compete for billions of euros in research funding with the goal to bring European institutions and companies to the forefront of global innovation and to address the major challenges facing the European and global society (EC, 2019). These global collaborative research (GCR) efforts are often our only rational response to the complexity, ambiguity and uncertainty in the grand challenges for our global society (UN, 2018). As such, these projects test the resilience and robustness of our PM tools, processes and philosophies. There is a substantial body of literature that recounts the experience and results from collaborative research projects in global environments, specifically those funded by EU Framework programs (Derntl et al., 2015, Colombo et al., 2016, Contreras & Conejo, 2002, Pinheiro et al., 2016, Stanoevska-Slabeva & Fricke, 2015). Although, these accounts contribute to a relevant and interesting perspective on collaborative research in global environments, most papers fall short of making contributions towards PM theory.

Publication VII (Fossum et al., 2019b) address the global perspective and publication VI (Fossum et al., 2019a) addresses the collaborative and research perspectives. Paper VI further reports from the overall constructive research approach but this part is addressed under RQ3.

Publication VII investigates organizational support (OS) practices in global projects (GP) to identify their importance for managerial success (from the perspective of the respondents) and correlation with efficiency (based on project costs and schedule variances). This study concluded that organizations relying on GPs need "better best practices" for selection and training processes. Organisations need to prepare project personnel to identify and manage uncertainty originating from the social world with the same excellence that they prepare them to use natural and engineering science to understand and manage the natural world.

Publication VI reports on the known challenges for collaborative research projects and interpretation of the collaborative and research perspectives. Findings from paper VI illustrate how missing or misunderstood application of intuitive, incremental and/or iterative PM processes represents a key challenge for research and development projects. Furthermore, findings indicate that contracts types used for GCR projects such as Moonwalk and Time Scale, with heterogeneous stakeholders and il-defined goals and/or methods create ambiguities for project success criteria. The combined findings from paper VI and VII emphasize how the combination of the global aspects and collaborative challenges with the unknown dimension of the project product created by the research aspect results in increasingly challenging project environments (complicated or complex projects). As such, the key problematic areas identified were; i) The project environment, e.g. the global and collaborative aspects. ii) The decision making, e.g. implementing iterative project processes and balancing rational vs. intuitive decision processes. iii) Diffuse success criteria driven by the research aspect and heterogenic stakeholder interests.

König et al. (2013) and Brocke & Lippe (2015) discuss the need for altering managerial and organizational practices during the project life-cycle, and advocate a situation-specific, contextual PM approach towards collaborative research projects. Brocke & Lippe (2015) identified a stream of research based on the understanding that collaborative research projects require extensions of and adaptations to existing PM knowledge and provide specific guidelines, tools, and techniques that were adapted for the special needs of this type of project. Lippe & Brocke (2016) conclude that, if applied to the right situation, collaborative research projects can use existing project management knowledge.

Findings in this dissertation suggest that the combined effect of the known challenges epitomize the key PM challenge for GCR projects and propose that key challenges of GCR projects can be grouped in two main groups; 1) Challenges related to complexity of contextual factors and 2) Challenges related to the missing or misunderstood application of intuitive, incremental and iterative PM processes.

The lack of attention towards these combinations of challenges represent research gaps within current PM knowledge. This dissertation contributes towards closing this gap by; 1) collecting empirical data and suggesting how knowledge on the contextual factors should help typify GCR projects. 2) Theorizing about how lacking understanding of GRC projects as a project type, e.g. type 2 or 3, may result in suboptimal management approach, e.g. an rational, stage-gate approach.

RQ2: To what extent are the known PM challenges linked to lacking focus on human factor & safety aspects in new technology developments?

This question is addressed in four of the seven publications in this dissertation. Human factors & safety are investigated as a specific technical and operational component highly relevant for strategic and business objectives of the new technology development. The main contribution towards RQ2 are found in Publication I, II and IV and V.

Literature investigating serious accidents in the petroleum sector such as Piper Alpha and Macondo (USCS, 2016, Johnsen et al., 2017, Cullen, 1993) show that triggering causes include the little understood interaction of factors at various system levels, such as technical, human, social, organizational, managerial and environmental. In context of PM literature it has been argued that discrepancy in the PM style was a contributing cause for the NASA's Challenger accident. That is, it was a super high-tech (array type) project that was managed as a high tech (system type) project (Sauser et al., 2009, Shenhar et al., 2005, Shenhar, 1992).

Both the Piper Alpha, Macondo and Challenger accidents happened in (business) operational or (mission) implementation setting. As such the impact on strategic and business objectives (project effectiveness) from lacking focus on safety and human factors issues are obvious. However, the relevance of such accidents for the management of new technology development project are often overlooked. After all the system development phase are completed and successfully delivered to the operating organizations.

Most large system developments are divided into a myriad of contracts under different phases and for different sub-systems are often awarded as projects to different companies or consortiums. Furthermore,

knowing that risk analysis often fail to include human and organizational factors (Skogdalen & Vinnem, 2011) increases the risk for expensive re-designs and minor human errors that breed inefficiency in operations increase, and most likely, result in some form of dormant, aggregated risk in the organization. It is clear that relationships between missing human factor & safety aspects in new technology developments, project success and large accidents are a complex one. However, this is not the focus of the research in this dissertation. Nor is it within the scope of this dissertation to investigate to what degree focus on human factor & safety aspects are lacking in new technology developments.

This dissertation address the notion that lacking focus in human factor & safety aspects in new technology developments are linked to known PM challenges.

Paper V reports on findings from the Moonwalk case study – a research and innovation project developing technology and concepts for human–robot collaboration – and conclude that narrow focus in different project phases and insufficient information coordination contribute to marginalizing the role of human factors in design and development of new technology. As such, indicating that evaluating the merits of alternative technologies, the causalities between their strengths and weaknesses and the probabilities of realization within the project envelope take precedence over assessments of end-user needs, limitations as well as the performance in relevant social and operational environment.

Publication I and II address the preparation, presents the execution and results from an analysis of the scenarios developed in the beginning of the Moonwalk project. The CRIOP methodology was used to analyse the developed scenarios and the results provided a good foundation for the project management team to develop tailored preventive measures in cooperation with the project staff. The scenario analysis revealed crucial vulnerabilities that, if left unaddressed could threaten the core objectives of the project. Indicating that lacking attention to human factors and safety aspect represent as risk towards the strategic and business objectives in new technology developments.

These findings originated the notion that lack of focus on human factors was not a design (process) oversight but a project management issue, thus inspiring the topic of paper IV and V. Findings from paper IV and V align with those of Sætren et al. (2016) and Johnsen & Liu (2015) suggesting that narrow focus in different project phases and insufficient information coordination contributes to marginalizing the role of human factors in design and development of new technology.

Paper IV discuss common challenges in project and risk governance and address how PM methodology used for project front-end definition can be applied toward these challenges. The paper further discusses how safety strategies in project based organizations should be analysed in recognition of these challenges. As such the findings in this dissertation align with those of Pinto (2014) suggesting that normalised deviance (Vaughan, 1996) or gradualism can occur in scope adjustment, safety standards modification, or incremental changes to plans and other control documentation. The research presented in this dissertation encourage further studies into the nature of projects and how their organizational context impact the role of the safety and human factors discipline in the development of new technology and novel concepts.

Acknowledging limitations of the empirical research data this dissertation still constitutes a novel research approach and interesting findings that warrants further investigations into how project processes can be tailored to address a lack of attention to safety and human factors. In specific in early (project) phases where decisions are just as much about 'doing the right project', as it is about 'doing the project right' (Williams & Samset, 2010). Thus, lack of attention to safety and human factors primarily involves project management issues that need to be addressed on organization / corporate management level.

RQ3: To what extent can scenario methodology assist project managers in addressing known challenges of GCR projects?

This question and the efforts to provide answers constitute the core contribution of this dissertation. The main contribution towards RQ3 are found in Publication III and VI. However, paper I and II include relevant reports from the scenario analysis and assessment.

The PM literature contains several references to scenario methodology but no research on theoretical or practical application at single project level were found in the PM literature. Thus, the notion of scenario development as a method to support management of known challenges in GCR projects is a novel one (Fossum etal. 2019b).

The sense making with scenarios model (Figure 22) have similarities with the design and implementation of a corporate system described by Schoemaker et al. (2013) where scenario planning serve as input in terms of sense making. Aubry & Lavoie-Tremblay (2018) recommend to develop in-depth understanding of an organization's specific context by means of sense making activities and König et al. (2013) account for the development of a framework as a mapping and sense making device for locating functions, demands and potential conflicts in interdisciplinary research project management. As such, there is a both practical and theoretical basis to argue the merits of scenario development and sense making as an avenue to support decision making in challenging project environments.

The challenging areas identified (RQ1) were related to the project environment, e.g. the global and collaborative aspects, the decision making, e.g. implementing iterative project processes and balancing rational vs. intuitive decision processes and diffuse success criteria driven by the research aspect and heterogenic stakeholder interests.

Publication III presents the initial work to establish a framework for the development of scenarios to support the PM process. The proposed framework focus on stakeholder management in projects with long time horizons or short term decisions with long term consequences, i.e. projects with high levels of uncertainty. However, a case is made for how scenario development in similar way could be useful for all types of projects and other project knowledge areas, e.g. project risk management.

Publication VI account for the six-step constructive research approach to investigate if scenario development constitutes a fruitful method to support the management of collaborative research projects. The paper also report from a two-part literature review on known challenges in collaborative research projects and the history and application of SD as a method. The PM discourse, and many other disciplines, have recognized that rising complexity and dynamics in organization's environment calls for better tools, skills and more holistic knowledge to support decision making in such environments.

Scenario development can be useful for structuring and analysing intuitive project processes. However, scenario development, like PM, struggles with issues related to myopic decisions, predict and provide attitudes, path dependency and inconsistent and/or missing identification of success criteria among different stakeholders. However, by periodically updating developed scenarios with newly spotted information serves a valuable integration function and, over time, enhance an organization's sense making and adaptive capability, especially when facing increased uncertainty. Sense making, as addressed by Orr & Scott (2008), Schoemaker et al. (2013), Aubry & Lavoie-Tremblay (2018) and in this thesis brings an important insight to understanding organizational design as an ongoing process (Weick et al., 2005). As such scenario development constitute a contribution to strategy-based project management, i.e. the crafting, developing and operating of a long term business entity which deliver the business objectives needed to manage the inherent uncertainty of the future and succeed in today global environment.

The following sections of this chapter discuss to what extent the findings of this dissertation, in specific the sense making with scenarios model, constitute valuable contributions to the PM field of knowledge.

5.2 Theoretical contributions of the sense making with scenarios model

This dissertation, like much PM research, culminates with a model that aims to capture the description and explanation of the phenomenon under study. For such models to constitute a contribution to theory they must describe the characteristics of the "*what*, *how* and *why*" (Müller & Klein, 2018).

Following the considerations of Whetten (1989), there are three essential building blocks of theories: a) variables, constructs and concepts (the what), b) the variable relationships (the how) and c) the reasons behind the relationships (the why).

In the following three sections the contribution to theory building is discussed by addressing the *what, how and why* of this dissertation. In section 5.2.4 the added value of these theoretical contributions is discussed.

5.2.1 The what - variables, constructs and concepts

The variables, construct and concepts of this dissertation originated with the presumptions, motivations and ambitions of the candidate (Figure 10) and matured with changes and choices during the research process, made as a result of literature reviews, opportunities in the case studies and related researcher evaluation/triangulation.

The *variables* of the project environments under study accounted for in section 4.5.1 and captured by means of the Cynefin framework aim to balance the merits of comprehensiveness and parsimony, i.e. including all variables relevant for the phenomena under study vs. exclusion of variables because they add little additional value to understanding the phenomena under study (Whetten, 1989).

As illustrated in Figure 5 and addressed in section 2.1 this dissertation presumes that perspectives from all nine schools of thought, and associated variables, apply to every project. Although highly comprehensive, such a stance lacks appropriate parsimony to design a study with sufficient sensitivity.

Figure 23 provides an alternative structure to identify the variables addressed in this dissertation. These variables were identified through their association with the key (known) challenges of GCR projects.

- Challenging project environments (section 4.5.1)
- Ambiguities of project success criteria (section 4.5.2)
- Lacking application of intuitive and iterative PM processes (section 4.5.3).
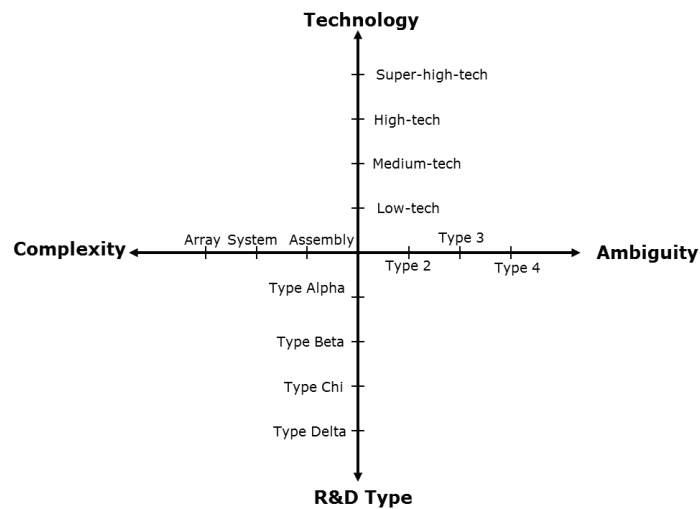
Figure 23 Variables considered in this dissertation. See Table 1 for variable characterizing the R&D types, Table 10 for variables characterizing the technology types, Table 11 variables of the complexity and Figure 19 for clarification of the ambiguity variable.

The construct under investigation, i.e. scenario development, was identified and selected during the research process. Maturing from the initial work with the two case studies, literature reviews and related researcher evaluation/triangulation, it was identified as a phenomenon with considerable research interest (Fossum et al., 2019a). The scenario methodology literature (Section 2.4) commonly considers scenario development and scenario analyses as a subset of the scenario planning process but also recognizes them as key scenario methods in themselves. Scenario methodology, which many foresight and future studies researchers consider a foundational method, has become widely used to support

strategic management, identify new business opportunities and increase innovation capacity. It is thus considered relevant to the development of new knowledge useful for practitioners undertaking GCR projects.

There are two concepts under investigation in this dissertation - the concept of GCR as a project archetype and the concept of scenario development as a useful construct to support the successful management of GCR projects. Concepts are here defined as mental representations, abstract objects or abilities that make up the fundamental building blocks of thoughts and beliefs

5.2.2 The how - relationships of the variables

Together, the *what* and *how* elements constitute the domain or subject of the theory (Müller & Klein, 2018). The *how* is the part that adds order to the conceptualization and, typically, introduces causality to the model. Theoretical dissertations have no strict requirement to produce models with boxes and arrows illustrating causal relationships. Moreover, the lack of opportunity to adequately test suggested links due to restrictions in methods do not immediately invalidate the inherent causal nature of theory (Whetten, 1989). However, the visual representation of models clarifies the candidate's thinking, increases the reader's comprehension and constitutes powerful tools that illustrate the balance of completeness and parsimony, i.e. degree of conceptualization, in the proposed model. Thus, visual representations are arguably a prerequisite for a meaningful discourse regarding causality between variables in any proposed model (Kernbach et al., 2015).

The proposed "sense making with scenarios" model (Figure 22) constitutes such conceptual representation that addresses causal relationships between different variables. The model builds on theory from the six different schools of thought: Contingency, Behaviour, Success and Governance (Figure 5), with the objective of practical contributions to the Modelling and Decision schools of thought.

The chain of thought behind this approach is as follows: - Governance defines the objectives of the project and success criteria. - Success provides the objectives of decision making. - Contingency and Behaviour define the project in a "social world". - Modelling helps us to make better decisions. - Better decisions support the success of the project.

The key premise of the model (Figure 22) is that a "misalignment" of the four quadrants (project characteristics) of the different circles increases the risks related to project performance. Similarly, a misalignment of project management skill sets with the nature of the project environment increases risks to successful PM.

Practical examples of the causal relationships suggested between different variables are:

i)   Complex project environments require good strategy and business skill sets
ii)   Complicated project environments require good leadership skill sets
iii)   Low information stability and reliability are representative of chaotic project environments
iv)   Known efficiency and unknown effectiveness criteria characterize Type 3 projects
v)   Type 2 projects are best managed by deciding on directions
vi)   Type 4 projects are usually characterized by chaotic project environments
vii)   Expert / projective scenario types are most suited for Type 1 projects

Thus, by suggesting that Type A scenarios are best suited for Type 1 projects with obvious project environments where information stability and reliability are suitable for final decision making, i.e. rational, stage-gate, non-iterative decision making, the model could explain why the scenario process in the case studies failed to be iterative. Further, the model suggests that Type C scenarios would be better suited to support the complex nature of the Moonwalk and Time Scale projects.

5.2.3 The why - reasons behind the relationships

According to Müller & Klein (2018) the explanation of "*Why*" is a challenge that much empirical research work fails to address adequately, i.e. by failing to go beyond a form of descriptive explanations in the analysis of data one fails to provide a theoretical contribution of their findings.

The causal relationships between different project characteristics and the associated variables, included in the model (Figure 22), build on mature PM theory from several schools of thought. The suggested relationship between complicated / complex project environments and good leadership, strategy and business management skill sets is arguably such a case. Consequently, the PM literature (Chapter 2) is rich in research that addresses the reasons behind the suggested causal relationships between different variables. Most of these reasons for the suggested causality originate from research efforts to explain and avoid fallacious reasoning or incomplete or faulty analysis. Samset & Volden (2016) summarize a list of ten "paradoxes" to describe situations where such fallacies result in counter-intuitive decisions.

Examples of fallacies supporting the need to "align" the different variables addressed in the model (Figure 22) include:

- Ludic fallacy: A failure to take into account unknown unknowns in determining the probability of events taking place
- Argument from fallacy: Assuming that if an argument for a conclusion is fallacious, then the conclusion is false
- Appeal to probability fallacy: Takes something for granted because it would probably be the case
- Base rate fallacy: Making a probability judgment based on conditional probabilities, without taking into account the effect of prior probabilities

To summarize: The *what* and *how* describe relationships but only the *why* provides reasons for the causality. As such, the *why* is also a suitable point of departure for a discussion on the practical contributions of the research. But first, the added value of the theoretical contributions is addressed.

5.2.4 The added value of theoretical contributions

This dissertation, like much contemporary organizational research, does not generate new theory from scratch. Rather, it constitutes an effort towards improving what already exists. In that context, it is often difficult to judge what constitutes enough to claim a noteworthy contribution to theory (building).

Whetten (1989) and Müller & Klein (2018) argue that any new applications should improve theory, not just confirm its utility; suggested improvements should address more than a single element of existing theory, and theoretical critique should include suggested remedies, not just pointing out limitations of current theory. Whetten (1989) uses quote from Poincare (1903) to make the following analogy. "Science is facts, just as houses are made of stone.... But a pile of stones is not a house, and a collection of facts is not necessarily science."

Using such an analogy, the GCR project represents the type of house one wants to design. The variables are the stones, existing theory is the mortar binding them together and groups of variables reflect different characteristics of the house. The scenarios represent use cases for the house and the "sense making with scenarios" model constitutes a (design) tool supporting the organization of different characteristics to optimize the functionality of the house. As such, this dissertation does not criticize current theory (theory building); it (re)introduces scenario development (the construct) as a new remedy for addressing several known challenging variables and characteristics (the research problem) and suggests the sense making with scenarios model (Figure 24) as a tool to support the appropriate implementation of the suggested construct (problem structuring).

5.3 Practical contributions of the sense making with scenarios model

The following sub-sections discuss the practical contributions of the sense making with scenarios model associated with three key areas: Understanding and structuring the known challenges of GCR projects – The management of known challenges in GCR projects, and – The balancing of rational vs. intuitive project processes.

5.3.1 Understanding and structuring the known challenges of GCR projects

The proposed "sense making with scenarios" model (Figure 24) and the framework it builds on constitute a practical contribution to PM decision making in challenging (complex, complicated or chaotic) project environments, i.e. GCR projects.

The concepts of strategic management and futures studies both recognize the rising complexity and dynamics in an organization's environment and the need for managers to make decisions in such an environment. Building on the differentiation of project management and project leadership roles and emphasizing the strategic & business aspects of successful projects, work under this dissertation tested the practical application of scenario development as a method to support both leadership and strategic & business management in GCR projects. The practical contribution of the resulting model (Figure 24) includes the following:

- Analysis and characterization of the project environment, e.g. complex or complicated
- Identification and analysis of constraints and opportunities to support decision making
- Translation of project goals into measurable success criteria
- Development of scenarios suitable for the knowledge available about the above points a - c
- Operationalization of the developed scenarios by (managing) constraints and (engaging) opportunities

5.3.2. Managing the known challenges of GCR projects

Building on existing theories, this dissertation emphasizes the need to "align" variables related to project environment, decision making and success criteria. Introduction of the sense making with scenarios model (Figure 24) provide a theoretical foundation and practical approach to understand how scenario development can positively influence the overall performance of GCR projects and support managers towards proactive management of projects.

The model shape is based on a concept popularized by S. McConnell in 1996 and termed "the cone of uncertainty". The idea that uncertainty decreases significantly as one obtains new knowledge seems intuitive and conventional PM knowledge proposes that estimation gets better as a project progresses over time. However, it can be argued that the only reason uncertainty decreases is because decisions made in the project reduce the opportunity space, e.g. after selecting a concept only the uncertainty relevant for this concept remains. Before such decisions, the uncertainty for x number of considered (and ignored) concepts is relevant. Thus, following conventional PM knowledge proposes that estimation gets better as a project progresses, i.e. the (missing) arrow on the x-axis should point to from the left towards the right (Figure 24).
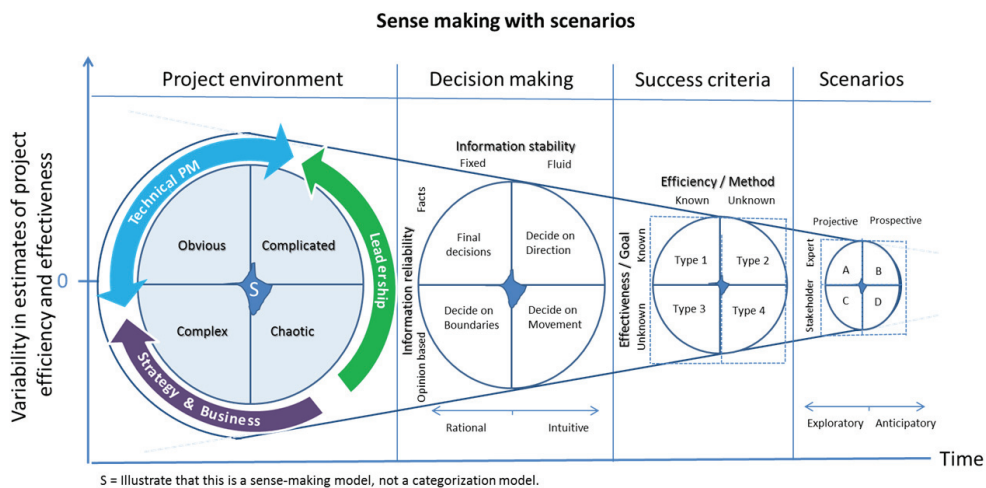
Figure 24 The sense making with scenarios model

If the aforementioned concept is questioned or changed during the project, the cone of uncertainty become wider, not narrower. Consider also, with scenario development the current situation is considered to be known and the future becomes increasingly uncertain, i.e. the (missing) arrow on the x-axis should point towards the left.

Right to left: The initial scenario definition phase should include four types of scenarios (A-D) identifying drivers for change and assumptions relevant for the project goal, variables affecting alignment project concepts (method) and organizational strategy as well as drivers for cost and time. Comparing and analysing the alternative scenarios will reveal to what degree the different stakeholders and experts hold the same images of project efficiency and effectiveness. If, e.g. the project efficiency criteria are found to be aligned (known) but the criteria for project effectiveness are unaligned (unknown), the scenario construction phase should continue to engage stakeholders and further develop projective and exploratory scenarios. By analysing the reliability and stability of the information used to develop the scenarios, one can start to prepare the project decision making process and insert decision points and criteria in the developed scenarios. Analysis of the available information can also help identify the project environment type, e.g. if much of the information used to develop the scenarios is opinion based and fluid it is likely that one is facing a chaotic project environment. In chaotic project environments it is recommended to emphasize project leadership and strategy & business management skills to make decisions that move the project environment towards "obvious", via "complicated" and "complex" states respectively.

Left to right: If facing, e.g., a chaotic project environment it is recommended to emphasize project leadership and strategic & business management skills to develop intuitive decisions processes, i.e. in a chaotic environment there is little use for rational, cause-effect analyses based on historical directions or known boundaries. When facing a chaotic project environment, it is important to critically review anything one believes to be known about project efficiency and effectiveness criteria. As the project develops and decisions are made it is important to update the scenarios and monitor/control that the project decisions are aligned with the success criteria, e.g. by using "what if scenarios". The continuous engagement of stakeholders to further develop prospective and anticipatory scenarios to analyse risk and opportunity related to movement in the efficiency and effectiveness criteria among stakeholders is of vital importance. The key objective is also to "move" the project from chaotic / type 4 projects to the more manageable type 2 or 3 (no research project should ever become a type 1 project).

The basic idea in both cases is to use scenario development to engage experts and stakeholders with the aim of defining clear and achievable, success criteria and building support for the implementation of decision points and criteria in the project decision making.

5.3.3 Balancing the rational vs. the intuitive project processes

Intuition, based on experience, has been found to be useful for business leaders for making judgments about people, culture and strategy, often unable to articulate why they reacted or what prompted them at the time of the event. E.g. Thomas et al. (2012) found that expert judgment and practice supported by intuitive, holistic, and relational thinking allowed project managers to navigate a sophisticated journey from ambiguity to accomplishment.

This dissertation distinguishes between instrumental rationality, e.g. PMBOK (2017), which defines ways that project managers focus on how to do things, and other rationalities that help them to decide what to do and why (Dane & 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 key practical contributions of this dissertation thus reside in the facilitating potential of integrating PM (instrumental rationality) and scenario development (other rationality) processes. The scenario development process is suited to the complex and complicated projects where discussion and agreement (stakeholders and experts) about boundaries and direction of the projects is more productive than a focus on causal relationships subject to low information stability or reliability.

Scenarios should portray a set of alternative futures that could occur no matter how improbable the occurrence is, i.e. they are not intended to be particularly probabilistic. Thus, 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.

Expert interpretations, judgment and practice are often supported by intuitive, holistic and relational thinking and most project managers perform informed intuitive actions every day. 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. Scenarios are thus suitable for modelling future conditions based on the intuitive thinking of experts. Scenarios are also well suited to address alternative futures that significantly vary from the past, e.g. where experts or key stakeholders intuitively anticipate changes that have not been, or cannot be, modelled according to known processes or extrapolations from the past.

Findings presented in the dissertation also include identification of some fundamental challenges in using scenario development in the management of single projects. However, scenario development processes still constitute a novel contribution to the practical efforts to structure, describe and analyse intuitive project processes in GCR projects.

5.4 Quality of the research

To discuss the quality of the research presented in this dissertation the *dependability* (reliability), *credibility* (internal validity), *transferability* (external validity), and *confirmability* (construct validity) are addressed (Wahyuni, 2012).

Dependability corresponds to the notion of reliability and promoting replicability or repeatability. The detailed explanation of the research design and process, enabling other researchers to follow a similar research framework, ensures that reasonable dependability has been achieved (Table 12). However, the lack of common standardized practices for scenario development constitutes a challenge to any exact replicability of the scenario development process.

Credibility deals with the accuracy of data reflecting the observed social phenomena. The selection and documentation of the case studies provide credibility to the claim that the study addresses GCR projects and the use of data and researcher triangulation provides a 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 author.

Table 12 Triangulation methods and applied to support research quality in this dissertation

Triangulation to improve dependability		
Method	Goal	Implementation
Theory	Apply different theoretical perspectives, framework and models	- Diamond perspective (Shenhar et al., 2001, Leavitt, 1964) - Four-quadrant perspective (Turner & Cochrane, 1993) - SM perspective (Eskerod et al., 2015a, Eskerod et al., 2015b) - PMI Talent Triangle (PMBOK, 2017) - Cynefin model (Snowden, 2000) - Cone of uncertainty (McConnell, 1996)
Data source	Different projects in diverse project phases and various industries	- Literature - Two case studies in all project phases (same industry) - Survey (1172 practitioners)
Data type	Combine qualitative and quantitative data collection approaches	- Document review and survey (Quantitative) - PAR and group interview (Qualitative)
Methods	Application of different methods for data collection	- Case study, document review, PAR, survey, workshop and group interviews
Researcher	Involve other researchers in the data analysis phases of case studies and survey	- Co-authors involved in the individual publications - Researcher triangulation / evaluation

Transferability refers to the level of applicability into other settings or situations. Transferability has not been the main objective and it is acknowledged that the empirical study and its result have limited transferability beyond the GCR projects (project type), EU projects (political and legal frameworks) and

new technology developments in the context of such projects (application area). However, the sense making with scenarios model could have applicability for other types of complex projects as well.

Confirmability refers to the extent to which others can confirm the findings. The 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. However, given the use of qualitative research methods and that any social setting is unique and hardly reproducible, it is acknowledged that the study has some limitations. In the following section we further discuss these limitations.

5.5 Research limitations

Both the research approach and the results presented in this dissertation have limitations that need better clarification. This section aims to describe these limitations in a way that allows the reader to understand better under which conditions the results should be interpreted. The limitations are addressed in three categories: - Known limitations with selected methods, e.g. surveys and interviews. - Limitations generated through choices and changes made during the research work. - Limitations in the original research approach.

5.5.1 Limitations of particular methods

Known limitations, or weakness, related to the use of *group interviews* include availability of appropriate settings that stimulate an expressive discussion. The risk of researchers failing to be accepted by the group, as either a member or researcher, needs to be considered. The risk of not capturing the latent variation of responses, thus failing to approach sensitive topics, may increase if group members tend towards conformity rather than diversity in their views. Posturing by respondents is also more likely in a group setting (Frey, 2004).

Opinion-based surveys as they are used in this dissertation (Paper VII) have known weaknesses regarding interpretation, definitions and scope of the addressed topic. The basic design of the survey questions builds on the notion that well implemented practice should correspond to lower cost overruns and less schedule delay while poorly implemented practice should correspond to higher cost overruns and greater delays. Thus, the weak correlation found may indicate that the studied practices are poor success factors for the success criteria for cost and schedule. However, there is little or no disagreement in the PM discourse that OS practices addressed in this study constitute key PM practices important for the success of projects.

Thus, results from this study may contribute to the discussion on what constitutes a success factor for project cost and schedule, and what does not (Fortune & White, 2006) but also support criticism of opinion-based methods (Hobbs and Besner, 2016) when investigating correlations of practices (as success factors) and success criteria, e.g. cost and schedule.

Case studies usually include a lack of dependability and transferability (generalizability) of findings beyond the immediate case context. Small sample size, biases and subjectivity are examples of known limitations that need careful consideration in research design, e.g. through triangulation.

Document analysis was performed in an informal, semi-structured approach that could create "you find what you look for type of 'biased selectivity' (Bowen, 2009).

5.5.2 Limitations introduced by changes and choices during the research process

Choices made during the research process reduced the number of case studies from five to two and the implementation of the planned survey imposed some limitations on the planned data triangulation. This section aims to provide a holistic understanding of the study choices made while offering clear descriptions of the limitations this imparted on the overall study.

The original research plan (Figure 3) included five case studies, all EU FPs with new technology development objectives. However, during the work with the two initial case studies the topic of foresight methodology and scenario development emerged.

The choice to adapt this focus in the dissertation was supported by a thorough researcher triangulation / evaluation. This resulted in the sub-heading "Exploring Scenario development", and arguably one of the novel contributions of this dissertation, but significantly reduced the number of (available) relevant case studies.

In the original plan (Figure 3), the use of questionnaire surveys was included as part of the triangulation approach in the research design, i.e. the plan was to design the survey for the informants and participants in the case studies. However, as the global perspective was identified as a key attribute of the case studies and new opportunities for cooperation were established, the focus of the planned survey changed. As a result paper VII and the global perspective (Fossum et al., 2019b) are integral parts of the typification of GCR projects, and arguably a novel contribution, although it did weaken the planned data triangulation in the case studies.

5.5.3 Limitations in the research approach

Acknowledging that constructive research approach and participatory action research (PAR) are methods with limited use in PM research, extra care has been taken to detail and clarify how these methods are used to investigate the concepts under research. Furthermore, both the construct under investigation (scenario development) and the project type theorized around/about (GCR projects) are subjects with very limited attention in the PM body of knowledge. Although these all are carefully considered ontological, epistemological and methodical choices, the "aggregated paradigm" of investigating novel artefacts with a novel approach has both intuitive and rational limitations.

Similarly, it should not be lost on anyone that the choice to study intuitive processes for decision making (scenario development) with abductive research approach (reasoning) has both ontological and epistemological limitations. In particular, the implication that constructive research, as a variation of design science research, implies an ethical shift from ambitions of describing and explaining the existing world towards an inclination to shaping it.

6. Conclusions and further work

This chapter presents the conclusions of the research presented in this dissertation. Section 6.1 provides concise answers to the research questions. Section 6.2 and 6.3 provide conclusions on the theoretical and practical contributions. The chapter concludes with a final perspective on the overall contributions of this dissertation to the identified research gaps and suggested areas for further research.

6.1 Answering the research questions

Building on the discussions in Section 5.1, this section provides concise answers to the research questions.

RQ1: What are the known PM challenges for global collaborative research (GCR) projects?

Findings from the literature, case studies and the survey resulted in four conclusions that make up the answers to RQ 1:

Conclusion 1): The global aspects and the combination of collaborative challenges and the unknown dimension of the project product created by the research aspect results in challenging (complicated or complex) project environments.

Conclusion 2): The contract types used for GCR projects like Moonwalk and Time Scale, the heterogeneity of stakeholders and goals and methods not being well defined results in ambiguities of project success criteria.

Conclusion 3): Missing or misunderstood application of intuitive, incremental and iterative PM processes represents a key challenge for research and development projects.

Conclusion 4): The combined effect of known challenges (conclusion 1-3) epitomizes the key PM challenge for GCR projects.

This four-part construct was used to structure and describe the investigation into RQ2 and RQ3, i.e. by addressing the inter- and intra-active nature of the three key areas of known PM challenges of GCR projects: The challenging project environment, ambiguities of project success, and implementation of iterative and intuitive project processes (Figure 22).

RQ2: To what extent are the known PM challenges linked to lacking focus on human factor & safety aspects in new technology developments?

Findings from the literature, case studies and group interviews resulted in three conclusions that make up the answers to RQ2:

Conclusion 1): Narrow focus in different project phases and insufficient information coordination contributes to marginalizing the role of human factors in design and development of new technology

Conclusion 2): Myopic safety/design philosophy in new technology developments can limit the performance of the complex sociotechnical systems they are imposed upon

Conclusion 3): Lack of attention to human factors and safety aspects represents risk to the strategic and business objectives in new technology developments

The conclusions from RQ1and RQ2 contribute to the structure of discussion and conclusions to RQ3. That is, considering the proposed structure of known PM challenges for GCR projects (RQ1) and findings indicating that known PM challenges may contribute to lack of attention to human factors and safety aspects in new technology developments (RQ2), to what extent does scenario development represent a useful method for project managers to address these challenges?

RQ3: To what extent can scenario methodology assist project managers in addressing known challenges of global collaborative research (GCR) projects?

Findings and conclusions to RQ1 and RQ2 resulted in three conclusions that answer RQ3:

Conclusion 1): Scenario development can be useful for structuring and analysing intuitive project processes.

Conclusion 2): Scenario development, like PM, struggles with issues related to myopic decisions, predict and provide attitudes, path dependency and inconsistent and missing identification of success criteria among different stakeholders.

Conclusion 3): Scenario development constitutes a contribution to strategy-based project management, i.e. the crafting, developing and operating of a long-term business entity which delivers the business objectives needed to manage the inherent uncertainty of the future and succeed in today's global environment.

The primary challenge of project management is to achieve all project goals within the given constraints. The next sections describe the theoretical and practical contributions to this primary challenge.

6.2 Theoretical contributions

Sternberg (1999) suggested seven types of contributions that can be made to a field of endeavour at a given time: Four types that accept current paradigms and attempt to extend them and three types that reject current paradigms and try to replace them. This dissertation builds on existing theories and literature with the aim of identifying and helping to close existing research gaps. As such, neither presumptions nor conclusions consider rejection or replacement of existing paradigms as appropriate avenues. That leaves four overall types of possible contributions to current paradigms of the PM body of knowledge to discuss: replication, redefinition, forward, and advanced forward increment (Sternberg, 1999).

Replication is a contribution considered an attempt to show that the field is in the right place and *redefinition* is a contribution considered an attempt to redefine where the field is. Neither type of contribution has been within the objectives of findings in this dissertation.

This dissertation constitutes a *forward increment* contribution, that is, an attempt to move the field forward in the direction it already is going. The limited amount of PM literature related to use of methods, tools and techniques to implement the appropriate combination of intuitive, rational management processes represents a PM research gap and the notion of combining PM processes, and foresight processes such as scenario development are novel. A*dvance forward increment* contributions are those that move beyond where the field is ready to go; an inherent risk is that the proposed constructs are too novel.

An important aspect of any research contribution is the distinction concerning "*theory building vs. theory testing*".

Theory testing is often defined using hypothetico-deductive approaches and, although not mutually exclusive with a constructive research approach, the research in this dissertation neither aspires towards nor satisfies the criteria for theory testing.

This dissertation contributes to theory building, i.e. extending (instead of reinventing) PM theory. That is, providing credible contributions to PM theory by building a methodologic approach upon existing research literature, collecting the candidate's own empirical observations and anchoring the research findings in existing theories.

Adoption of terms like "technical PM", "project leadership" and "strategy & business management" in the PMI perspectives is considered a result of, or a response to, PM research streams that during two decades accentuated the "one size does not fit all" and "beyond the hard paradigm" perspectives. This dissertation supports the efforts of an ongoing redefinition of the field and suggests that movements are in the right directions.

6.3 Practical contributions

The key practical contributions of this dissertation thus reside in facilitating the identification and management of GCR project by integrating PM (instrumental rationality) and scenario development (other rationality) processes.

The applications of scenarios to support PM of GCR projects demonstrated and discussed in this dissertation constitute a novel practical contribution to both problem structuring and solving. The conclusion is thus that the "sense making with scenarios" model constitutes a practical contribution to decision making in GCR projects.

6.4 Contributions to closing research gaps

The research presented in this dissertation was performed to meet the research objectives, answer the research questions and contribute to reducing the identified research gaps. The contributions of the individual publications to the research questions are discussed in Chapter 5.1 and the concise answers to the research questions are summarized in Section 6.1. This section extracts and summarizes an overall conclusion and the contribution to closing identified research gaps.

i)   Limited empirical research on GCR projects

The initial literature search for GCR projects in the PM literature yielded very limited results. This dissertation contributed towards closing this gap in three ways:

   a) The lack of references to GCR projects in PM literature made it necessary to typify and argue why GCR projects constitute a unique type of projects worth investigating.
   b) Applying a constructive research approach, the work presented in this dissertation represents a comprehensive empirical study. Both projects were funded under the Space work programmes of EU research programmes and satisfy the criteria for GCR project outlined above (in point a).
   c) With two case studies using PAR, group interviews and document reviews and survey, this dissertation makes considerable empirical contributions to understanding of GCR projects.

This dissertation did not identify any single PM challenge that is unique to GCR projects. Applied in the context of the theoretical frameworks proposed, the empirical contributions in this dissertation contribute to the understanding of GCR projects as complicated or complex undertakings that require strong leadership, business and strategic management skills.

ii)   Methods for balancing the rational and intuitive project leadership and strategic processes in GCR projects are lacking from PM literature.

Building on the differentiation of project management and project leadership roles and emphasizing the strategic & business aspects of successful projects, this dissertation investigated to what extent scenario development constitutes a useful method to support both leadership and strategic & business management tasks of the project managers.

The concepts of strategic management and futures studies both recognize the rising complexity and dynamics in an organization's environment and the need for managers to make decisions in such an environment. The "sense making with scenarios" model (Figure 22) supports the process of identification and management of challenges specific to GCR projects by:

   a) Supporting the translation of project goals into measurable success criteria
   b) Supporting the identification and analysing the information available about constraints and opportunities to support decision making
   c) Supporting the analysis of the project environment, e.g. complex or complicated
   d) Developing scenarios suitable for the knowledge available about the above points a) through c).
   e) Supporting the operationalization of the developed scenarios by (managing) constraints and (engaging) opportunities.

The "sense making with scenarios" model thus constitutes a contribution to strategy-based project management, i.e. the crafting, developing and operating of a long-term business entity which delivers the business objectives needed to manage the inherent uncertainty of the future and succeed in a global environment.

However, scenario development, like PM, struggles with issues related to myopic decisions, predict and provide attitudes, path dependency, and inconsistent and/or missing identification of success criteria among different stakeholders.

iii)   Frameworks addressing the full set of known PM challenges in GCR projects are lacking

Using three theoretical perspectives (global, collaborative and research) the combined effect of challenging project environments, ambiguous success criteria and missing or misunderstood application of intuitive, incremental and/or iterative PM processes epitomizes the key PM challenge for GCR projects. Figure 22 constitutes a key contribution to structuring and managing these known challenges.

In brief, the applications of scenarios to support PM of GCR projects demonstrated and discussed in this dissertation constitute a novel practical contribution (both problem structuring and solving) to the PM body of knowledge. It thus concludes that the "sense making with scenarios" model constitutes a theoretical (building) contribution to PM decision theory and provides strong support to the PM contingency theory.

However, more research is necessary for further testing and enhancing synergies of PM and scenario processes, further documenting the utility of different approaches and remedies they offer for the PM discipline in general, and GCR projects in particular.

6.5 Further work

The reflections and suggestions in this section are framed by an understanding of GCR as a specific type of projects and the role such projects have been given in the efforts of addressing the great challenges of our time.

Horizon 2020 and Horizon Europe (2021 – 2027) represent the world's largest research programmes with ambitions to understand and resolve climate challenges, the digital transformation, health and safety, the bio- and circular economy, agriculture and natural resources. Similar challenges are the objective of numerous projects funded under the UN, national and/or NGO charters. These ambitions and efforts will be implemented by funding large portfolios of research and innovation projects. Many of them will most likely be GCR projects. For the efforts and solutions in each single project to be both efficient and effective regarding these great societal challenges, they must make sense of the complex sociotechnical systems where the projects aim to implement their results. In the following five areas for further research are suggested.

I)   More research on GCR projects

Any comprehensive study of projects must be explicit about the project type, its context and the theoretical foundations used to generalize and typify the projects under study. This dissertation uses three perspectives (global, collaborative and research perspective) to structure relevant PM literature. The dissertation emphasizes and structures the key challenges of GCR projects around three main areas: The complex project environment, decision making, and success criteria. Furthermore, the research work presented in this dissertation is scoped by the PM schools of thought (Figure 5) from which the theoretical foundations builds upon.

However, for GCR projects to gain recognition as a unique type of project that has sufficient relevance in the PM body of knowledge, further comprehensive studies are needed. Further study of GCR projects should use different theoretical frameworks, research approaches and data types.

II)   More research on the use of foresight in parent organizations' strategy work

Today foresight in general and SD specifically are most commonly used at top management levels, both in governmental and private enterprises. Research literature on the use of scenario development in single project is very limited.

Findings in this dissertation indicate some fundamental challenges of using scenario development in the management of single projects. Given that most known use of scenario development is on corporate strategic levels it would be interesting to investigate how such strategic use of scenario development could extend and integrate into the programme or project portfolio level with the intention to support the front-end definition phases of research projects

III)   More research on foresight in projects

Foresight is already used in many organizations and companies in Europe but research on the application of foresight in "the sharp end" of project-based organizations, i.e. at project level, has an interesting research potential. Foresight methodology in general and scenario methods in particular are promising tools that can support strategic and future oriented action at the project level.

As a larger effort to (re)introduce scenario development 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).

IV)   Exploring the impact of stakeholders' core values on new technology development

Findings indicate that known PM challenges can be linked to a lack of focus on human factor and safety related issues, impacting strategic and business objectives of the project products. It would be interesting to a) explore differences in social standing and dynamics between different stakeholders in academia depending on core values, that is, technology versus social sciences, b) how such factors impact the role of human factors discipline in technology development projects and

c) Investigate the relevance and effects of developing separate approaches for uncertainty arising from the social world and uncertainty originating in the natural world.

Efforts to publish results from supplementing studies of high-technology industries and supranational organizations such as European Space Agency and European Union approach to uncertainty, complexity and risk in the management of projects developing new technology and concepts should be emphasized.

V)   Refining the constructive approach for PM research

Future reports from ongoing studies using a constructive approach and/or PAR in PM research are anticipated. Upcoming efforts should aim towards practical demonstration and validation of the constructive research approach. This is necessary to further improve its application in PM research and arrive at further conclusions on its usefulness. Such efforts should ideally encourage co-production of knowledge between the research community and industry to the level beyond the usual case studies, interviews or questionnaire / surveys.

As a conclusion of this dissertation and a key recommendation for future work is the importance of "*honouring the intuitive mind as a sacred gift and the rational mind as its faithful conscience*".

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Acronyms

AHP   - Analytical Hierarchy Process
APM   - Agile Project Management
CBA   - Choosing By Advantages
CRIOP - Crisis Intervention and Operability analysis
DOA   - Description of Action
DOW   - Description of Work
ESA   - European Space Agency
EU   - European Union
EVA   - Earned Value Analysis
FP   - Frame Program
GCR   - Global Collaborative Research
GP   - Global Project
HMI   - Human-Machine Interaction
HR   - Human Resources
HRI   - Human–Robot Interaction
HRM   - Human Resources Management
IFE   - Integrated Facility Engineering
IJMPB - International Journal of Managing Projects in Business
IJPM   - International Journal of Project Management
IPCC   - Intergovernmental Panel on Climate Change
ISS   - International Space Station
IT   - Information Technology
KSAE   - Knowledge, Skills, Attributes, and Experience
NASA   - National Aeronautics and Space Administration
NGO   - Non-Governmental Organizations
NTNU - Norwegian University of Science and Technology
MAIT   - Manufacture, Assembly, Integration and Test
MCDA - Multiple-Criteria Decision Analysis
MDCM - Multiple-Criteria Decision Making
MoM   - Minutes of Meeting
OBS   - Organization Breakdown Structure
OS   - Organizational Support
PAR   - Participatory Action Research
PBO   - Project Based Organizations
PBS   - Product Breakdown Structure
PDCA - Plan-Do-Check-Act
PhD   - Philosophiae Doctor
PM   - Project Management
PMI   - Project Management Institute
PMJ   - Project Management Journal
UN   - United Nations
RBP   - Relationship-Based Procurement
R&D   - Research & Development
RO   - Research Objective
RP   - Research Policy (Journal)
RQ   - Research Question
SD   - Scenario Development
SLR   - Structured Literature Review
SM   - Stakeholder Management
SME   - Small and Medium Sized Enterprises
STEP   - Sequentially Timed Events Plotting
TPM   - Traditional PM
WBS   - Work Breakdown Structure
WP   - Work Package
xPM   - Extreme PM

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PART II: INDIVIDUAL PUBLICATIONS

DECLARATION OF CO-AUTHORSHIP

The declaration describe the division of labour, specifically identifying the candidate's contribution. The co-authors have consented to the articles being included in the thesis.

Declaration of co-authorship on the following article (Paper I):
FOSSUM, K., DANIELSEN, B. E., MOHAMMAD, A. B. & JOHNSEN, S. O. 2015. Laying the basis for resilient Human-Robot Interactions in future space exploration missions. *Safety and Reliability of Complex Engineered Systems*. CRC Press.

The paper summarizes the preparation and present the execution and results from a workshop performed as a part of the Moonwalk project (Case study 1). The candidate was responsible for the conceptualization of the research problem, selection of research methods, the preparation and execution of the workshop. The candidate's involvement in the Moowalk project as a WP manager constitute participatory action research (PAR). All co-authors supported the execution of and reporting from the workshop.

Stig Ole Johnsen is a CRIOP (Crisis Intervention and Operability analysis) specialist and lead scientist for the development CRIOP methodology for the petroleum industry (not part of this thesis). Abdul Basit Mohammad made key contribution to the tailoring of CRIOP generic checklists for the Moonwalk purpose and Brit-Eli Danielsen made key contributions to the project (Moonwalk) technical report from the CRIOP.

Declaration of co-authorship on the following article (Paper II):
FOSSUM, K. & MOHAMMAD, A. B. 2015. Approaching human-robot interaction with resilience. *Space Safety is No Accident*, 295-302, Springer.

This paper present and discuss how the methodology of "crisis intervention and operability analysis" (CRIOP), developed for control rooms in the petroleum sector, was tailored to human-robot interaction (HRI) in human space exploration setting.

The candidate was responsible for the conceptualization of the research problem, definition of the research design and selection of methods. The candidate's involvement in the Moowalk project constitute longitudinal participatory action research (PAR).

Abdul Basit Mohammad made key contribution to the harmonization of CRIOP generic checklists with human spaceflight standards (NASA-STD-3001 and ECSS-E-ST-10-11C).

Declaration of co-authorship on the following article (Paper III):
FOSSUM, K., AHOLA, T., AARSETH, W. & ANDERSEN, B. 2016. Revisiting scenario development - A new framework for stakeholder management in projects. *European Academy of Management Conference (EURAM)* - Manageable cooperation? Paris-UPEC.

This conceptual paper revisits the common roots of scenario methodology and project management disciplines and discusses how an (re-)introduction of scenario development to current project management practices can support project stakeholder management.

The candidate was responsible for the conceptualization of the research problem, selection of research methods and introduction and description of the proposed framework.

Declaration of co-authorship on the following article (Paper IV):
Fossum, K.R., Danielsen, B.E. and Berg, C.H., 2017. Analyzing safety strategies at the front-end of projects. Risk, Reliability and Safety: *Innovating Theory and Practice: Proceedings of ESREL 2016* (Glasgow, Scotland, 25-29 September 2016).

This conceptual paper identify common challenges in project and risk governance and discuss how safety strategies in project based organizations can be applied toward these challenges. The candidate was responsible for the conceptualization of the problem domain, selection of theoretical frameworks and description and discussion of the proposed solution domain.

Declaration of co-authorship on the following article (Paper V):
FOSSUM, K. R., DANIELSEN, B.-E., AARSETH, W. & JOHNSEN, S. O. 2018. A project management issue of new technology developments: A case study on lack of human factors' attention in human–robot interaction. *Proceedings of the Institution of Mechanical Engineers*, Part O: Journal of Risk and Reliability, 232, 164-173.

This article investigates known project management challenges and how they can explain the lack of attention to human factors issues in the design and development of new technology.

The candidate was responsible for the conceptualization of the research problem, definition of the research design and selection of methods and supporting theoretical frameworks. The candidate's involvement in the case study constitute longitudinal participatory action research (PAR) and basis for the collected data and results.

Declaration of co-authorship on the following article (Paper VI):
FOSSUM, K.R, AARSETH. W. & ANDERSEN, B. 2018. Exploring scenario development - A case study of two collaborative research projects. *International Journal of Managing Projects in Business (Pre -Published) https://doi.org/10.1108/IJMPB-08-2018-0145*

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

The candidate was responsible for the conceptualization of the research problem, definition of the research design and selection of methods and supporting theoretical frameworks. The candidate's involvement in the two case studies constitute longitudinal participatory action research (PAR), constitute a qualitative research method and basis for data collection and presented results

Declaration of co-authorship on the following article (Paper VII):
FOSSUM, K.R, BINDER, J. MADSEN, T. AARSETH. W. & ANDERSEN, B. 2018. Success factors in Global Project Management - A study of practices in organizational support and the effects on cost and schedule. *International Journal of Managing Projects in Business (Pre-Published) https://doi.org/10.1108/IJMPB-09-2018-0182*

This paper identify and complete the existing lack of quantitative data at the crossroads between organizational support practices and project management success in global projects and discuss implication of the results in perspective of the theory–practice gap.

The candidate was responsible for the conceptualization of the research problem, the literature review, the selected research approach and identification of the supporting theoretical frameworks.

Binder, J was responsible for the large survey and instrumental in the interpretation of the collected data Madsen, T was responsible for the statistical data analyse

PAPER I

FOSSUM, K., DANIELSEN, B. E., MOHAMMAD, A. B. & JOHNSEN, S. O. 2015. Laying the basis for resilient Human-Robot Interactions in future space exploration missions. *Safety and Reliability of Complex Engineered Systems.* CRC Press.

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<u>PAPER II</u>

FOSSUM, K. & MOHAMMAD, A. B. 2015. Approaching human-robot interaction with resilience. *Space Safety is No Accident*, Springer.

Not included due to copyright restrictions

PAPER III

FOSSUM, K., AHOLA, T., AARSETH, W. & ANDERSEN, B. 2016. Revisiting scenario development - A new framework for stakeholder management in projects. *European Academy of Management Conference (EURAM)* - Manageable cooperation? Paris-UPEC.

PAPER IV

FOSSUM, K., DANIELSEN, B. & BERG, C. 2016. Analyzing safety strategies at the front-end of projects. *Risk, Reliability and Safety: Innovating Theory and Practice*. CRC Press.

PAPER V

FOSSUM, K. R., DANIELSEN, B.-E., AARSETH, W. & JOHNSEN, S. O. 2018. A project management issue of new technology developments: A case study on lack of human factors' attention in human–robot interaction. Proceedings of the Institution of Mechanical Engineers, *Part O: Journal of Risk and Reliability*, 232, 164-173.

A project management issue of new technology developments: A case study on lack of human factors' attention in human–robot interaction

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Abstract
The complexity of today's sociotechnical systems has prompted researchers and practitioners to advocate new holistic approaches to safety. However, many engineering standards, methods and processes for addressing technical, human and organizational factors do not fully reflect this. This article investigates known project management challenges and how they can explain the lack of attention to human factors issues in the design and development of new technology. As such, the work contributes to a research stream investigating why the human factors discipline is repeatedly marginalized in engineering projects. This article reports on findings from a case study – a research and innovation project developing technology and concepts for human–robot collaboration. We conclude that a narrow focus on early project phases and insufficient information coordination contribute to marginalizing the role of human factors in the design and development of new technology.

Introduction

Today's sociotechnical systems are already complex and interrelated, and both researchers and practitioners are advocating new approaches to safety addressing the accompanying challenges.[1,2] The realms of robotics and automation represent one area contributing to more complex sociotechnical systems. Projects preparing for space exploration missions include development of concepts for collaborations between robots and astronauts.[3–5] Closer to home, and in the near future, our streets will be filled by self-driving cars interacting with corresponding traffic control infrastructures, healthcare activities will be managed by intelligent information infrastructures and many physical work activities will be performed by robots.[6] The last 40 years of system safety engineering and safety research have offered strong evidence of the crucial role of human factors knowledge in the design and construction of new systems.[7] As such, research efforts have focussed on advancing human factors methodology and its application in engineering projects.[8] Recent studies also investigate new perspectives that may help explain why

human factors continue to be marginalized in the development of new technology and systems.[9]

In the same timeframe, projects have become a dominant way to organize research, development and construction efforts. The main focus of the project management research has been on challenges, failures and success of projects.[10–13] Project management is strongly rooted in scientific disciplines such as engineering and economics, and traditional methodology is dominated by technical risk analyses calculating expected benefits and monetary costs as part of engineering planning and design.[14] However, streams of project management research also investigate the role of social, organizational and institutional factors. Moreover, contemporary project management

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discourse recognizes the importance of managing lack of information, lack of knowledge, ambiguity, characteristics of different project parties, trade-offs between trust and control mechanisms, and diverging agendas in different stages of the project life cycle.[15,16]

The indications we discovered in course of our research,[17–20] and what this article addresses, is that in many cases, the lack of attention to human factors is rationalized by referring to existing work package objectives, scope and agreed plans for the project. This article reports on findings from a case study, a research and innovation project developing technology and concepts for human–robot collaboration, and addresses the question: *to what extent is lack of attention to human factors issues linked to known project management challenges?*

The outline of the article is as follows: *First*, we introduce known challenges from the human factors discipline. *Second*, we address known challenges from the project management discipline. *Third*, we recapitulate the context of the study and the research approach. *Fourth*, we describe the main results. *Fifth*, we draw upon our findings in the literature and results from our study to discuss the link between lack of focus on human factors issues and known challenges from the project management discipline. *Finally*, we offer some conclusions and proposals for further work.

We do not claim to be exhaustive in our accounts. The literature and selection of references are based on the authors' expert knowledge of the human factors and project management disciplines.

The human factors discipline – known challenges

The human factors discipline is traditionally divided into three areas: physical ergonomics, cognitive ergonomics and organizational ergonomics.[21] Physical ergonomics is mainly concerned with human anatomical, physiological and biomechanical characteristics as they relate to physical activity.[22] Cognitive ergonomics focuses on perception, memory, information processing and reasoning relevant to, for example, task analysis, human–machine interactions (HMI), workload, and alarm philosophies.[21,23] Organizational ergonomics address issues relevant to organizational structures, policies, processes and operational philosophies.[22,24] We acknowledge the different perspectives on the human factors discipline,[25] for example, versus human reliability[26] and human factors engineering (HFE).[2] For the purpose of this article, we use the following definition:

> Human Factors is a body of knowledge about human abilities, human limitations, and other human characteristics that are relevant to design. Human factors engineering is the application of human factors information to the design of tools, machines, systems, tasks, jobs, and environments for safe, comfortable, and effective human use.[27]

Incident investigations have revealed that cognitive ergonomics and organizational ergonomics are seldom mentioned or explored sufficiently. It is suggested that insufficient knowledge and misconception of HFE have resulted in poor HMI design and latent errors. It is also known that risk analysis seldom includes human and organizational factors.[28] Investigations of serious accidents in the petroleum sector such as Piper Alpha and Macondo have shown that triggering causes include the little understood interaction of factors at various system levels, such as technical, human, social, organizational, managerial and environmental.[29–35] Key examples from the space industry include the investigation reports from the two fatal space shuttle accidents that point towards human, organizational and political aspects as root causes[36,37] and clearly state that the accidents were a product of long-term organizational problems.[38] Such major accidents are highly relevant and interesting. However, we also take great interest in studying the more daily consequences of lack of focus on human factors issues: those that do not generate accidents but result in expensive re-designs, cause minor human errors, breed inefficiency in operations and, most likely, result in some form of dormant, aggregated risk in the organization. After studying the development of new automated drilling technology for offshore oil and gas production, Sætren et al.[9] concluded that homogeneous competence involving technical aspects contributed to developers' lack of understanding of the need for sufficient analyses of end-user requirements and of the human tasks that would be affected by the new technology. Consequently, they argued that technological development could benefit from including human factors experts from the project's outset. Sætren et al.[9] also found narrow focus in different project phases to be one of two main categories that contribute to insufficient human factors analyses in the development phase, the second category being insufficient information coordination in the development phase. As part of preparations for future space exploration missions, a need to address the significant human factors challenges related to human–automation integration is acknowledged.[39,40] We list a few of these challenges here:

1. Human factors standards are very high level and not tailored for specific systems.
2. Human factors knowledge and expertise are lacking in the teams specifying, designing and engineering systems – leading to poor requirements and poorly designed systems.
3. There is a need for methods that support evaluation and development of human–automation–robotic collaboration for long-duration, long-distance missions.
4. There is a need for design guidelines for effective human–automation–robotic systems in diverse operational environments and conditions.

Leva et al.[2] provide a good overview of current industrial practices and standards promoting inclusion of human factors knowledge in structured system design processes. They contribute to a stream of

researchers advocating the need for new approaches to fully address the challenges of increasingly complex and interrelated sociotechnical structures.[1,6,8,41] We maintain that such challenges require novel holistic approaches to safety and reliability and need the participation of experts from a wide range of fields, especially human factors. New technologies instrumental to continued improvement of robotic systems working in proximity to humans and other dynamic obstacles are developing at a fast pace. An example is the advances with Dynamic Road Map (DRM) approach[42] and new methods like Parallel DRM (PDRM)[43] designed to allow robots to react to changes to their surrounding in a fast and concise manner. These are technologies which clearly improve the safety of robotic operations. However, it is not clear how such technologies affect the role and requirements for the human counterpart, such as new tasks, need for situational awareness, need for new training and new performance requirements.

The project management discipline – known challenges

Projects have become a dominant way to organize development and construction efforts.[44–47] Project management plays a central role in the process of research and innovation and impacts the way firms organize their design of new products.[47] Project management constitutes the accomplishment of a clearly defined goal within a specified period of time and consistent with budget and quality requirements. Project management 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.[48–50] In his investigation into different explanations for known project performance problems, Sanderson[51] examines different assumptions about decision makers' cognition and views on the future (risky or uncertain). He revisits the work of Simon[52] and highlights the proposition that 'decision makers are intendedly rational, but only limitedly so'.

A major part of project management literature focuses on challenges, failures and success of projects. For an introduction to known challenges of project management, we propose Samset and Volden,[10] Morris[11] and Brady et al.,[12] from which most of our insights are drawn. In the following, we introduce seven aspects of project management known to create challenges. We present them in two groups: challenges related to narrow focus in different project phases and challenges related to insufficient information coordination.

First, we introduce four aspects of project management that are known to contribute to narrow focus in different project phases. Such a narrow focus makes it challenging to take the right decisions at the right time, especially in early phases of projects.

Front-end management refers to analyses and decisions made before a project actually starts, that is, at the front-end phase of projects. It is the process that defines the major characteristics of a project, for example, budget, timeframe, objectives and core concepts.[11,48] Samset and Volden[10] advocate that the potential to reduce uncertainty and risk is largest in the project front-end phase and decreases substantially during the project implementation. They further point out that most projects' planning resources are spent on detailed planning and engineering while too little are spent on getting the core concept right from the start, that is, many sub-optimal project deliveries can be traced to a lack of knowledge or erroneous focus in the project front end.

Predict-and-provide approaches most often create challenges when the project needs and benefit assessments get decoupled from overriding goals and priorities. An example of a predict-and-provide approach would be to solve any capacity problems with an increased capacity, usually based on trend predictions of future demand. However, needs should not be defined narrowly as a need to increase capacity, but rather as a need to solve a congestion problem. The latter allows for a variety of measures regulating demand, including legal and informative measures.[10] Thus, emphasis on predict-and-provide strategy in individual projects should be avoided, unless a development driven by trend extrapolation is clearly defined and desired.

Neglecting the opportunity space is most often caused by path dependency.[53] Projects are initiated to solve some problem or fulfil some needs, and much evidence suggests that discipline experts often have an inherent tendency to emphasize some aspects and downplay others when selecting solutions. The same is expected to apply to organizations planning their rules, processes, and procedures. In practice, path dependence 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.[54,55]

Myopic decisions often result in sub-optimal choices because planning horizons are too short, for example, short-term challenges and benefits are emphasized at the expense of long-term viability.[10]

The following three aspects of project management are known to contribute to insufficient information coordination. Such insufficient information coordination often results in sub-optimal or erroneous decisions.

Early information overflow confronts decision makers with an abundance of detailed information at an early point in the project and may result in 'analysis paralysis'.[56] This abundance of information often consists of quantitative and historic data that have a complex relevance to a specific project context, for example, needs, priorities, and stakeholders. For example, exact information about failure rates in existing systems may have limited relevance with the introduction of new technology or concepts. Exact information about the demand in a fast-developing market is another example. This suggests that the major problem may not be the

quantity of available information, but rather the capability to carefully select facts and judgmental information relevant to the essential issues of a specific project.

Erroneous logic of causalities and probabilities is usually most noticeable when project objectives misalign with the fundamental need, or problem, that motivates the initiation of a project. Alignment of objectives is the exercise of defining the basic logical structure outlining the project by following the causal link from the basic needs of users, through defined goals to the delivery of project results (outputs), their outcome (effects) and long-term benefits.[10] Failure to establish such logical cause-and-effect structures will usually result in erroneous assumptions about the probabilities of realization and can result in significant underperformance compared to expectations.

The measurement of success may be in absolute or in relative terms, but it is usually calibrated against our expectations. Thus, without clear and realistic expectations, the term 'success' becomes a highly complex and aggregated measure. The project management discourse related to the definition of success and success factors is comprehensive.[57–62] Insufficient information on how different stakeholders define the success of a project often leaves room for varying definitions on success to exist throughout a project. A classic struggle in projects is between stakeholders who emphasize the importance of the project's tactical success, that is,. on time, on budget and to scope, and those with a key interest in the strategic success, that is, long-term viability and efficient operation of the project product.[48,63]

As part of the 'Results' section, we address the link between the human factor and project management challenges in more depth.

Research approach and context of the study

We first describe the background of the case study and the role of this article in its context. We then outline the approach used to investigate links between known project management challenges and the lack of attention to human factors.

The foundation for the work presented was laid during a study performed for the European Space Agency (ESA).[17] The study focussed on shortcomings of human factors standards in the space industry.[39,40] The ESA study included a review of human dependability methods from aviation, the nuclear industry, the petroleum industry and railways. Although there is little systematic research on the applicability of different safety management methods across different industries;[64] it was deemed interesting to investigate whether safety methods and processes developed for the petroleum sector[65] could be useful in the space industry. The decision to focus on the space and petroleum sector was one based

on opportunity. Also, two of the authors have detailed knowledge of the Norwegian petroleum sector, from both safety and project management perspective, while the two other authors have their background from the space sector. Standards developed for petroleum industry on the Norwegian continental shelf[66] (NORSOK) recommends crisis intervention and operability analysis (CRIOP) as the preferred methodology for 'validation of the design, manning and procedures, and the ability to control process disturbances and emergencies' of a control centre in all modes of operation. The findings from the ESA study were subsequently used to tailor the CRIOP method[67] to support the development of collaborative human–robot systems.[18] The modified CRIOP method was tested in the case study.[19] The case study was a 3-year cooperative research and innovation project funded by the space calls from the European Commission. Thus, the investigation presented in this article was not initially included in the case study. However, based on initial findings, it was included towards the end of the study.

Participants in the study included key project members from six out of seven organizations involved in the project, including the project manager. A total of 10 persons participated, 3 women and 7 men, aged 30–60 years. All participating organizations were represented by senior managers and engineers with 10 + years of experience from their representative field of expertise. The research team was composed of two CRIOP and human factors experts and one person dedicated to reporting and documentation. There was no participation from the client/project owner.

Both preliminary and final results from the case study identified a lack of attention to human factors in the project. Furthermore, we found that in many cases, the lack of attention to human factors was rationalized, that is, explaining why it was not a priority, by referring to existing work packages and task descriptions, project objectives, scope and agreed plans for the project. These findings initiated discussions and further investigation along these lines: *So the lack of focus on human factors is not design (process) oversight but a project management error?*

The main purpose of this article is to describe this investigation. As such, the main contribution in this article is the discussion on how lack of attention to human factors issues[9,29,68] can be linked to known project management challenges.[10,11,63] These investigations constitute an exploratory research approach aimed at gathering information that will help define problems and suggest hypotheses.[69,70] We investigated the research streams of the two knowledge areas, human factors and project management. In the following, we present our findings and provide propositions for how known project management challenges are linked to lack of attention to human factors issues in design and development of new technology.

Results

The results are provided in two parts. The first part recapitulates the main findings from the human factors study.[19] The second part reports from the exploratory investigations addressing links between known project management challenges and lack of attention to human factors discipline when developing new technology and concepts.

From a human factors perspective, the results from the case study identified a lack of attention to the operation phase, and an unclear allocation of responsibility and authority of the operation organization was identified as the main concern.[19] In the following, we list the top seven items that were identified and agreed by the project team. The actions are sorted in the prioritized order as decided by the project team. The numbers in parenthesis reference the corresponding item from the modified CRIOP checklist. The complete action item list including proposed responsibilities was included in the final report to the project management team.

(O1)   *Operations organization*: There is a need to appoint/name responsible persons and mandate them as the core team (for) planning simulations (and operations).

(O2.2) Allocation of clear, complete, known and accepted responsibility and authority should be the goal when addressing the action in O1.

(P3)   A verification and validation scheme for the procedures should be defined and documented.

(O3.1) *Procedures for communication* ensuring operators and supervisors are continuously aware of all critical and hazardous tasks in progress. Need to be considered during the system development and definition of operational organization and products.

(P1.1) *Approach to developing, using and maintaining procedures and work descriptions*: Which authors what procedures must be identified as well as who, how and where to verify and approve them.

(C2)   *Guidelines for communications operations and support*: A communication plan needs to be developed, that is, who can talk to whom about what and when.

(A4)   A clear policy for the assignment of autonomy levels of the automated agents: Need to investigate whether this is an objective of the project.

The action (A4) shows clearly how the project team believed the development of such policies was outside the project scope. Although no project objective, work package and task description included the development of such policy, it is hard to argue why assignment of autonomy levels in collaborative human–robot systems should not have a clear policy, especially in the early technology development phase. In the case of (O1) and (O2.2), there was full agreement in the project team that

this was of high importance, especially for planned field testing and simulation of the system. During the field test campaigns, clear roles and responsibilities were assigned for technical and site safety. Furthermore, health and medical safety of the test subjects working with the system was addressed. Also, the technical teams compiled valuable technical data and experience from different components of the systems. However, it was argued that the tests and simulation had little relevance for any existing or planned operational organization. Although the need to (de)scope technology development projects has clear merits, there are also clear and known risks generated by limiting any realistic involvement of end users and their organizations.

Linking the human factor and project management challenges

The results in this section constitute a summary of the information gathered and the investigation of how these findings link the lack of attention to human factors to known challenges of project management. The results are structured based on the seven challenges from project management literature addressed earlier.

Sætren et al.[9] found that homogeneous groups of engineers tend to have a strong focus on technology and what technical problems are the important ones to solve. This supports the findings of Samset and Volden[10] suggesting that most projects' planning resources are spent on detailed technical engineering analyses. We suggest that this contributes to lack of focus on human factors in the *front-end management* of technology research and development projects. That is, evaluating the merits of alternative technologies, the causalities between their strengths and weaknesses and the probabilities of realization within the project envelope take precedence over assessments of end-user needs, limitations as well as the operational environment. In our case study, the project team responsible for writing the grant proposal, that is, part of the front-end phase of the project, was in most aspects a heterogeneous group and the topic of human factors was assigned to a dedicated task. However, the action items identified during the human factors analyses, that is, the tailored CRIOP, indicate several key issues related to the operational organization, and responsibilities were still not addressed at the project mid-point.[19] We suggest a twofold explanation for this. First, a misconception identified human factors as limited to physical ergonomics. Second, the selection of technologies as a key part of the project concept was strongly driven by the interests of the participating organizations. The development of certain technologies was the main motivation, not the fundamental needs and long-term viability of the end result from the project.

We suggest a link between lack of focus on human factors and project management *neglecting the opportunity space*, in both front-end and implementation phase

of projects. That is, the existence of *predict-and-provide* approaches and path dependency are amplified in technology development projects with homogeneous engineer development teams.[9] Discipline experts often have an inherent tendency to emphasize some aspects and downplay others when selecting solutions, for example, a focus on technical safety and risk analyses of technical systems. We suggest this as a cause contributing to lack of attention to human factors knowledge.

Sætren et al.[9] found that developers had a general comprehension that automation leads only to less human error. However, several studies show that when new automated technology is introduced, human errors tend to move to other areas, such as those described by Lee.[71] We propose this as an example of *erroneous logic of causalities and probabilities* that may result in a lack of focus on human factors. Given the large number of accidents where the triggering causes have shown to include the interaction of factors at various system levels, such as technical, human, social and organizational, any development project with a lack of focus on human factors displays a general erroneous logic of causalities and probabilities as a basis for their safety strategies and risk assessment.

In most cases, we have a substantial amount of technical data and empirical information collected from past and present systems and situations that can be used as a basis for our probabilities. However, for the case of developing and/or implementing new technology and novel concepts, we suggest that this more often results in an *early information overflow*, or 'analysis paralysis', that is, decision makers are confronted with an abundance of detailed information at an early point in the project decision-making process. We propose that such 'paralysis' contributes to lack of attention to the human factors discipline, that is, losing sight of the need to analyse how alternative technology solutions and concepts impact the organizations and individuals in the larger sociotechnical system.

We suggest that known challenges from project management related to *the measurement of success* and *myopic decisions* can contribute to explain the lack of focus on human factors in technology developments. A variety of project management literature acknowledges the challenges of balancing the inward-focussed, task-oriented and 'single-delivery' view of projects and the strategy-focussed and wider organizational and society views.[11,72,73] We believe that due to the nature of stakeholders involved in technology development projects, there will be a key focus on the technical and project tactical success. In most cases, any negative consequences resulting from lack of or insufficient focus on human factors will exist as latent errors (or confusion), stay dormant and not materialize before operational phases, or at best, during rigorous testing phases involving user testing. In other words, the short-term success of the project tends to divert attention away from the long-term success of the system.

Discussions

Sætren et al.[9] found that homogeneous development team contributed to a lack of understanding of the need for sufficient analyses of end-user requirements of the tasks that would be affected by the new technology. In our case study, the project group was heterogeneous in age, gender and disciplines, and lack of attention to human factors was also identified in this project. Thus, such findings indicate a need for more elaborative explanations. Spurred by the findings in our case study, we postulated connections between known project management challenges and lack of attention to human factors when developing new technology. We investigated the research streams of the two knowledge areas – human factors and project management – and in what follows we discuss to what degree lack of attention to human factors is a project management issue.

In modern project management, 'a project' is defined as a temporary endeavour undertaken to create a unique product, service or result.[74] However, the word *project* comes from the Latin verb *proicere*, meaning 'before an action'. The term *design* refers to the creation of a plan for the construction of an object, system or measurable human interaction, for example, engineering design. Our main point is that any contemporary engineering efforts are projected before they start. We also know that many known challenges of project management are rooted in the *front-end management* of projects, that is, referring to analyses and decisions made before a project actually starts. This has resulted in a large research stream known as management of projects. The management of projects and project management collectively refer to management of portfolios, programmes and individual projects, all which coexist within a corporate management framework.[75] Corporate management is the system by which business corporations are directed and controlled.[76,77] Project management refers to the management of individual projects, while management of projects refers to the management of a group of projects, for example, within a programme or portfolio of projects. It is important to emphasize the importance of coordinated decisions on different management levels in the project front-end phase. Insufficient information coordination in this phase, where projects are chartered and filled with 'purpose', often seeds *erroneous logic of causalities and probabilities, predict-and-provide* approaches or *neglecting opportunity space*, which results in lack of attention to the role of human factors in development of new technology and concepts.

If those responsible for analyses and decisions made before a project starts do not recognize the important role of human factors knowledge, the project resources and objective will be defined accordingly. However, as our case study shows, even when human factors are recognized as important, there is a need to be vigilant towards misconceptions and conflicting interests among different stakeholders. Similarly, if early project

deliveries have no or little requirement or accountability towards the operational phase, there is considerable risk that short-term project goals, that is, on time, on budget and to scope, take priority, often leaving the long-term viability and efficient operation of the project product to suffer.

Leva et al.[2] propose that educational programmes for engineers should include some basic HFE elements for system design and that HFE principles should be integrated in broader technical engineering and design standards. Such measures would indeed also contribute to better knowledge of human factors discipline among decision makers at corporate and project management level. In addition, we see the need for both human factors verification and validation activities to ensure that the human factors perspective is taken care of through all phases of the project from concept, design and finally implementation.

From a project management perspective, the concept of emergence could be useful to explore. Emerging risks are described by International Risk Governance Council (IRGC)[78] and are relevant risks that emerge as time passes and should be evaluated in a project. Key emergent issues in project management are as follows. (1) *Scientific unknowns/technological advances*: The development of automatization and robotics introduces new technology that may have unknown vulnerabilities that can be understood and mitigated by the field of human factors. Risks may emerge when technological change is not based on prior investigation or surveillance of results. Risks can also be exacerbated when policy or regulatory frameworks, for example, in the front-end definitions phase, are insufficient. (2) *Loss of (safety) margins/increased connectivity and new interactions*: Project management of new integrated technology may pose a substantial challenge due to poor understanding of consequences such as couplings. Tight couplings may lead to loss of buffering or margins and emergent problems have been seen when automated systems resolve too many issues before the human enters the control-loop, that is, 'human in the loop' challenges. This is also a challenge that may be related to scientific unknowns. (3) *Conflicts about interests, values and science/social dynamics*: Public debates about emerging risks seldom show a clear separation between science, values and interests. Thus, there is a need to support open information sharing and trust between the different actors from technology area and human factors area, for example, psychology.

Future work

The main focus of this article is how project management decisions impact the role of human factors knowledge in development of new technology. However, an interesting avenue of research would be to investigate how human factors methodology in general, and a specific validation and verification (best practice) tool such as CRIOP, could support project organizations when planning new projects for development of novel technology and concepts. It would also be interesting to explore differences in social standing and dynamics between different stakeholders in academia depending on core values, that is, technology versus social sciences, and how such factors impact the role of human factors discipline in technology development projects.

Conclusion

The human factors discipline includes a vast set of methods and processes, and there is clear merit to and, to our knowledge, no major dispute about the recommendations of most human factors standards that technological developments could benefit from including human factors experts from the project outset. However, the literature is rich in examples and explanations of why relevant human factors analyses were excluded or inadequately performed, for example, Sætren et al.[9] and Johnsen and Liu.[79] We addressed the question 'to what extent is lack of focus on human factors issues linked to known project management challenges?' We found that narrow focus in different project phases and insufficient information coordination contributes to marginalizing the role of human factors in design and development of new technology.

The work constitutes an interesting and novel case that warrants further investigations into how project processes can be tailored to address a lack of attention to human factors. We acknowledge that the limited amount of empirical research data limits our possibility to provide any systematic contribution to a specific body of knowledge. However, we do consider the research and our findings to encourage further studies into the nature of projects and how their organizational context impact the role of the human factors discipline in the development of new technology and novel concepts.

It may appear elementary rather than novel, but we conclude that the importance of including human factors knowledge in early (project) phases is just as much about 'doing the right project', as it is about 'doing the project right'.[56] Thus, lack of attention to human factors primarily involves project management issues that need to be addressed on corporate management level.

Declaration of Conflicting Interests

Funding

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PAPER VI

FOSSUM, K.R, AARSETH. W. & ANDERSEN, B. 2018. Exploring scenario development - A case study of two collaborative research projects. *International Journal of Managing Projects in Business (Pre -Published)* https://doi.org/10.1108/IJMPB-08-2018-0145

International Journal of Managing Projects in Business

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Exploring scenario development – a case study of two collaborative research projects

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Abstract

Purpose – The purpose of this paper is to explore 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). The authors 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 – The authors found the SD method to be useful for structuring and analyzing 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 the authors' knowledge, never been described in the PM literature.
Keywords Scenario development, Project management, Collaborative 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 cannot 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:

RQ1. 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 (SoA) regarding

management of collaborative research projects. The second part of the literature review focussed 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, 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, 2016; 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 plan-do-check-act (PDCA) 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, 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 *et al.*, 2013). 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 the Second World War (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 SD. 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 1973–1974 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 per cent 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 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 analyzed literature use the terms scenario development, scenario analyse, scenario planning, scenario method, scenario methodology and scenario 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 focussed more on the steps for carrying out the process and technique focussing 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 SD 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 III 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 I).

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

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 focusses 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 and 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)

Table I.
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
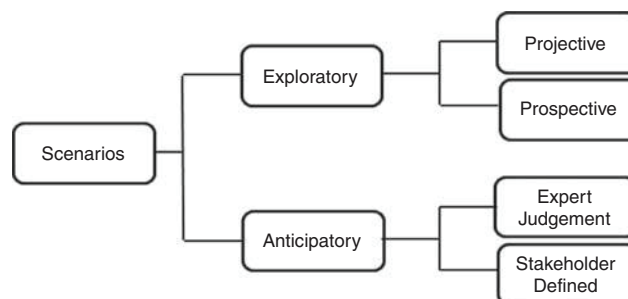
Figure 1.
Four different scenario types: projective, prospective, expert judgement and stakeholder defined

Source: Mahmoud *et al.* (2009)

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.

Expert interpretations, judgement 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 judgement-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 participatory action research (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, analyzing 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

IJMPB

(Lenfle, 2008, 2016) we also included this as a key search word (Table II). 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 analyzing, 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.

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 (PM)" the search gave four 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 – SD (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: the 2013 special issue of *Technological Forecasting and Social Change* on scenario methodology (Wright *et al.*, 2013); and the top five hits on "SD" 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: "SD", "scenario planning", "scenario analysis/analyse" and "scenario methodology". For the next step we selected three

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

Table II.
Summary from the literature search

top-ranking PM journals and reviewed them for the selected search words (Table III). The selected PM journals were *IJPM*, *JPM* and *IJMPB*.

To exemplify role of SD in context of non-PM journals a search in the *IEEE Transactions on Engineering Management* journal was performed. "SD" as search criteria resulted in 75 papers but when combined with "PM" the search gave only three 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 and Lessard, 2001; Williams *et al.*, 2009; Loch *et al.*, 2006). 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).

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

	Scenario development	Scenario planning	Scenario Analysis/Scenario analyse	Scenario methodology	
IJPM	2	13	13/1	0	**Table III.** Key search words were "scenario development", "scenario planning", scenario analysis/ analyse" and "scenario methodology"
PMJ	0	3	11/0	0	
IJMPB	0	3	1/0	0	

Notes: 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

Monitoring and audit/feedback loop
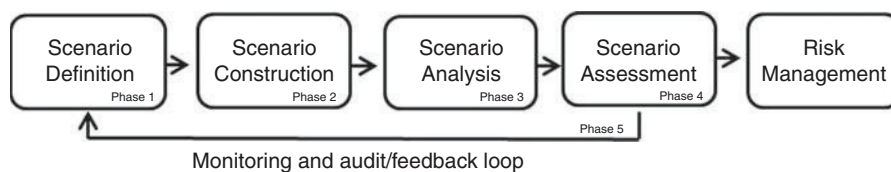
Note: Scenario assessment is the step of SD process where one crosses back into the realm of PM risk assessment and where the SD process has a natural convergence point with PM risk management processes

Figure 2.
The five phases of the implemented SD process proposed by Mahmoud *et al.* (2009)

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 IV 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.

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, 2014).

Both projects had a dedicated work package (WP2) named "SD". 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 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

	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
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

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

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. Figures 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.

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 "SD" 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 per cent, 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 per cent
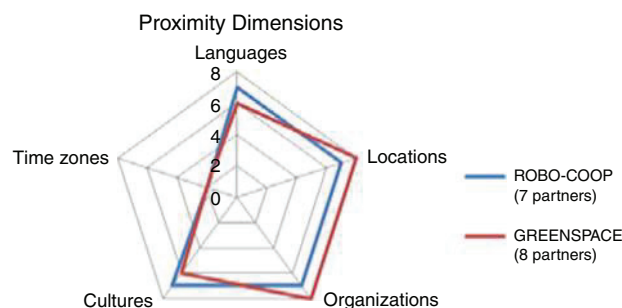
Using the five
challenge variables to
illustrate aspects of
the case studies
impacting the
collaborative setting

Type of Organizations

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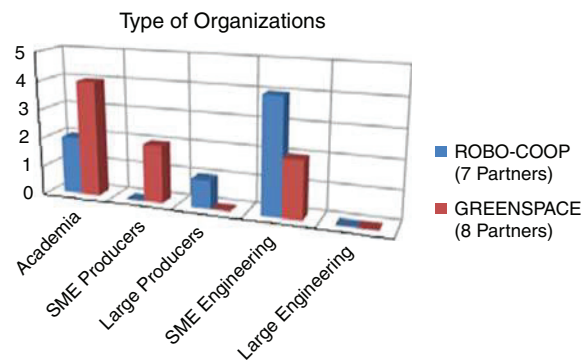
Notes: Large>250, small<250 employees

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 "SD" 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 focussed 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 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 focussed 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 judgemental technique using visualization. Judgemental 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 focusses 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 two-fold 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 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-PM. 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: first, 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. Second, 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.

5.1 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.

5.2 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-PM.

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 SD 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 SD was virtually non-existent. However, we did find the SD process was helpful for structuring the intuitive project processes in the initial project phases (one to six months). This resulted in useful scenarios that were implemented in the further project process.

5.3 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.

5.4 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. Second, 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.

5.5 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 PM.

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".

6.1 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.

Notes
1. Available at: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/space
2. ISS = International Space Station.
3. Grant Agreement.
4. X and Y are used to anonymize two major project stakeholders.

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PAPER VII

FOSSUM, K.R, BINDER, J. MADSEN, T. AARSETH. W. & ANDERSEN, B. 2018. Success factors in Global Project Management - A study of practices in organizational support and the effects on cost and schedule. *International Journal of Managing Projects in Business (Pre-Published)* *https://doi.org/10.1108/IJMPB-09-2018-0182*

International Journal of Managing Projects in Business

Success factors in global project management: A study of practices in
organizational support and the effects on cost and schedule
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Success factors in global project management

A study of practices in organizational support and the effects on cost and schedule

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Abstract

Purpose – The purpose of this paper is to identify and complete the existing lack of quantitative data at the crossroads between organizational support (OS) practices and project management success in global projects (GPs) and discuss implication of the results in perspective of the theory–practice gap.

Design/methodology/approach – Building on classical organizational theory and GP knowledge areas, a survey addressing GP practitioners was designed. This paper focuses on OS practices as success factors and addresses a subset of the survey (1,170 respondents across 74 countries).

Findings – OS practices included in the study were found to have high importance for managerial success. OS practices for selection and training of team members show significant correlation with project efficiency but have low adaptation in many organizations. Statistically correlations were found to be weaker than expected, indicating that the relation between OS practices (as success factors) and project efficiency (as success criteria) is more complex than expected.

Research limitations/implications – The work constitutes opinion-based research and is vulnerable to variations in OS practices and the definition of success in different organizations and industries. The granularity level of the theoretical framework brought about relative high-level survey questions and may impact the applicability of the results.

Practical implications – To improve the efficiency of GPs, better implementation of OS practices for selection processes and training personnel has been suggested.

Originality/value – The theoretical alignment of classical organizational variables with GP knowledge areas and associated practices provides an original approach to the "theory–practice gap" discourse.

Keywords Global projects, Project success, Practice studies

Paper type Research paper

Introduction

Project management (PM) literature on global projects (GP) focuses to a large extent on contextual and relational factors and how global organizations should adapt their practices to the global context of their projects. However, there is still a lack of research investigating correlation of such practices to managerial success and project efficiency using a large sample of global expert PM practitioners across several countries. Our efforts are motivated by the number of GPs with cost overruns, delayed deliverables and low stakeholder satisfaction reported by several authors (Aaltonen and Sivonen, 2009; Aarseth *et al.*, 2011; Lind and Brunes, 2015; Orr *et al.*, 2011; Ainamo *et al.*, 2010; Tang and Shen, 2013).

In this context, one observation holds true for many PM practitioners and academics: the human factor[1] creates challenges as well as solutions. Whatever undertakings we humans set out to complete, even efforts to create fully autonomous systems, they are imprinted with aptitudes and flaws spawned from the nature of human beings. Within the PM discipline, such a perspective is most familiar to the behavioral school, which highlights the importance of the relationships between people on the project, team building, leadership, communication and human resource management (HRM) (Bredillet, 2008a). Knowledge of human nature is also prominent in stakeholder management literature and in the key ideas put forward by the marketing school (Bredillet, 2008b). The understanding and modeling of organizational, behavior and political issues affecting projects are also part of the modeling school soft-system methodology and sense-making literature (Bredillet, 2007). The capacity of an organization to provide appropriate support to its managers and employees, i.e., management of the human factor, should thus be a topic of interest within several schools and research streams in the PM discipline.

Drouin and Jugdev (2013) highlight the importance of translating knowledge from more established fields to PM research. PM is still evolving and there are merits in the concept of drawing from solid theoretical foundations, such as those found in organizational theory. However, the theory–practice gap dilemma in organization studies (Bredillet *et al.*, 2015) as well as the shortcomings of organizational models (Bolman and Deal, 2017; Morgan, 1998) and more specifically the shortcomings of management models and management theories in terms of understanding and guiding practitioners (Ghoshal, 2005; Mintzberg, 2004) form the central argument that organizations are, and must be, viewed from different theoretical perspectives – and that single theories or approaches cannot address the full complexity of organizations.

The effects of organizational support (OS) on project teams working across locational, temporal and relational boundaries to accomplish an interdependent task are addressed by Drouin *et al.* (2010). They found that few publications have examined OS with the perspective of discussing how OS is an area with a strong impact on project success. This paper addresses GP from the viewpoint of the success school, i.e. with a focus on factors influencing the criteria by which success is measured (Bredillet, 2008a). The study addresses the lack of large-scale quantitative data addressing a novel link between OS practices and managerial success (as a qualitative measure of success as assessed by GP practitioners) and at the same time to the project efficiency elements of cost, schedule and scope.

Literature analysis

This chapter starts with a short introduction GPs and the key challenge variables that define them. Second, the classical organizational theory which this study draws upon and the role of OS in PM research are discussed. Third, OS practices in GPs are conceptualized. Finally, the notion of practices, success and project efficiency is explored, and the research hypotheses and questions are defined.

Global projects (GPs)
Globalization changed the way in which organizations design and develop their products and created a need for additional research addressing factors of specific interest for projects in such settings (MacDonald *et al.*, 2012; Orr *et al.*, 2011; Binder *et al.*, 2010; Aarseth *et al.*, 2011; Anantatmula and Thomas, 2010). This study adopts the GP definition as a "[…] temporary collaboration between organizations across nations and cultures with the intention to jointly deliver a unique product or service in a complex external context requiring relationship management" (Aarseth *et al.*, 2013).

The categorization of projects is a central and conceptual tool allowing PM researchers to be explicit about the types of projects they are theorizing about (Söderlund, 2011), i.e. – no project can be studied comprehensively without considering its context (Hanisch and Wald, 2012), and support efforts to compare similarities and differences across projects. As an example, research on "temporary multi-organisations" and "inter-organizational projects" (de Blois *et al.*, 2016; Lizarralde *et al.*, 2011) address topics that are highly relevant for GPs. However, they do not address all aspects that make project global, e.g. addressing projects where all organizations are from different countries and involve people from different languages and cultures.

Thus, to typify GPs and separate them from projects with similar and relevant challenges such as virtual, multicultural, inter-organizational, multi-organizational, inter-institutional or cross-functional projects, this paper build on the frameworks of Binder and Aarseth (Binder *et al.*, 2009; Binder, 2007; Aarseth *et al.*, 2011, 2013) using five "GP challenge variables," i.e. (multiple) languages, locations, organizations, cultures and time zones to define GPs.

From a different angle, previous studies (Lyytinen and Newman, 2008; Binder *et al.*, 2009) proposed that five areas of knowledge have relevance for the management of GPs: teams, communication, OS, collaborative tools and collaborative techniques. Verburg *et al.* (2013) analyzed several critical success factors in current GP literature and concluded that OS is of special important for the success of GP. GPs are typically carried out in institutionally demanding environments (Aaltonen *et al.*, 2008) and an extensive case study performed on GP defined OS as the most important factor for the success of GP and an "[…] area of global PM that pertains to how the global organization can support its projects and project staff to enable their best performance in GPs" (Aarseth *et al.*, 2011). The notion that traditional success factors were previously focused on internal project issues, while more recently global success factors are mainly focused on the role of the global management, global leadership and the human side of management is supported by several authors (Binder *et al.*, 2010; Anantatmula and Thomas, 2010; Orr *et al.*, 2011; Aaltonen *et al.*, 2008). As such the focus on contextual and relational factors, and how global organizations should adapt their processes and practices to the global context of their projects, is prominent in the GP literature. Our focus in this paper is to understand which of these practices are applied in GPs, and with what results.

Organizational theory and organizational support (OS)
One of the early contributions to categorizing the socio-technic study of organizations is the Leavitt's diamond model depicting four interdependent variables: task, technology, structure and people (Leavitt, 1965). Like Leavitt, Clark (1972) used four basic variables. Scott (2003) further adapted Leavitt's model and suggested that an organization comprised the following elements: social structure, goals, technology and participants. Bergman *et al.* (2013) drew upon organization theories from Scott (2003) and Scott and Davis (2007) using four different perspectives, i.e. product, process, people and structure, as a depiction of an organization. In an effort to demonstrate how project success is dependent on the selected PM approaches, Rolstadås *et al.* (2014) applied an analytical

model, referred to as the Pentagon model. The model (Schiefloe, 2011) depicts five aspects of an organization, i.e. structure, technologies, culture, social relations and networks and interaction. In a recent study, Gemünden *et al.* (2018) revisited the variables and proposed a new concept of the project-oriented organization composed of three segments, i.e. values, structures and people. A common agreement in most of these studies and categorizations is the relevance of the structure variable, which is the focus of our study. This is not because the impact of other variables is considered less significant, but to focus our analysis on this segment in more detail, and for our findings to be more specifically understood, assessed and applied by practitioners when defining OS practices.

OS can be both intangible, such as showing care and understanding during the project, and tangible, for example, by providing adequate technological infrastructure (Gelbard and Carmeli, 2009; Aarseth *et al.*, 2013; Drouin *et al.*, 2010). Both are highly relevant and research describes many shortfalls in project performance that are rooted in intangible support gaps such as inadequate inter-firm collaboration and low attention to social dynamics (Suprapto *et al.*, 2015).

When investigating conditions that project managers in dispersed settings perceive as relevant to doing their work, Verburg *et al.* (2013) included OS aspects such as multimedia and technical support, and corporate support in terms of tools, infrastructure, policies, rewards and incentive systems for dispersed work. Aarseth *et al.* (2011) defined OS as an, "[…] area of GP management that pertains to how the global organization can support its projects and project staff to enable their best performance in GPs." In their research into effects of OS on components of virtual project teams, Drouin *et al.* (2010) outlined a conceptual framework where OS is divided into seven categories of support systems and 18 different mechanisms associated with the different support systems. Zwikael *et al.* (2005) used a PM planning quality model (Zwikael and Globerson, 2004) to study cultural differences in PM capabilities, using 33 products and processes, including 17 focusing on OS. Berssaneti and Carvalho (2015) found relations between high maturity of PM practices and project completion on time and at cost, thus supporting findings by Gelbard and Carmeli (2009) reporting that interaction between team dynamics and OS was significantly related to budgetary, functionality and time performance. Based on such studies, OS can be defined in the scope of our research as the use of governance systems, structures of authority and processes, aiming at coordinating, controlling and supporting the efficient and successful delivery of projects.

OS practices in GP management – the structure variable
Guided by the notion that GP success factors are often related to the role of global leadership and the human side of management, this paper focuses on OS related to the structure variable of socio-technical organizational studies (Leavitt, 1965; Lyytinen and Newman, 2008) and the GP knowledge area of organization (Binder *et al.*, 2010). Table I shows the links between these two areas and summarizes the six categories of practices that will now be defined in more detail: definition of a GP structure, selection and training, Global PMOs, executive support and collaborative strategies.

GP structures – team specialization. GP structures are rooted in the general PM knowledge and practices written in bodies of knowledge such as the PMBOK (2017), PRINCE2 (2017) and APM (2012). There are various ways to organize the project teams, e.g. centralized or distributed PMs, local coordinators vs functional coordinators (Binder *et al.*, 2010; PMBOK, 2017; Rad and Levin, 2003). When defining a GP structure, one must consider that project team members with the same discipline specialization, e.g. software development teams, usually share a common frame of reference in the principles, tools and jargon of their discipline, and often this is the case even across country borders. Such homogeneity represents factors that can reduce or compensate for other challenges of GP teams.

Thus, the adaptation of GP structures to the specialization of the team members represents one important OS practice in GP.

GP structures – geographical distribution. The geographical dispersion of the project teams is a hallmark of GP. Such geographical dispersion can be the result of strategic and fiscal decision making made at top management levels of parent organizations. The implementation of multiple geographical locations across countries is the original decision that potentially exacerbates the other categories of GP challenges (different languages, cultures and time zones). GP structures should align with the approaches and procedures of parent organizations and can be tailored to national settings, systems and technology necessary for effective processes and communication for each GP (Aarseth *et al.*, 2013). As such, key OS practices for GP are related to how GPs' organizational structure is adapted to the geographical dispersion of the team members.

Selection and training. The selection and training of GP team members are in some cases performed at project level, at the discretion of the project manager (Keegan *et al.*, 2012). However, more often the allocation of people to project teams is based on availability of resources in the parent organization and partner companies and is influenced by key stakeholders (Drouin *et al.*, 2010; Gelbard and Carmeli, 2009; Aarseth *et al.*, 2013; Binder *et al.*, 2010). OS practices related to selection and training often reflect HRM policies and practices of the parent organizations, focusing on corporate staffing mechanisms, career development and performance and rewards systems. Furthermore, companies define, select and refine competence requirements for personnel based on their key activities, environmental and organizational characteristics (Keegan *et al.*, 2012). As one example, an engineering company with a prime contractor role tends to emphasize legal and technical skills over cultural and relational skills (Aarseth *et al.*, 2011; Orr and Scott, 2008). Key OS practices for selection and training of GP personnel are therefore related to skills and processes needed to overcome GP challenges, such as communication norms, role clarity and trust (Henderson *et al.*, 2016).

Project management offices (PMO). PMOs represent both the permanent organizational structures where PM specialists interact with PM process owners, portfolios and programs within a parent organization (Huemann *et al.*, 2004), and the temporary organizations that are established to support a large program or group of projects (Aubry, 2015). The PMO may be responsible for knowledge sharing, training and management of PM personnel, sometimes in cooperation with the HR department (Huemann *et al.*, 2004; Aubry, 2015; Lee-Kelley and Turner, 2017). Key OS practices in global PMOs are often related to the implementation of mechanisms such as coaching and assistance, information and knowledge sharing related to political, legal and cultural factors (Gelbard and Carmeli, 2009; Aarseth *et al.*, 2013; Drouin *et al.*, 2010).

Organizational variables (Leavitt, 1965; Lyytinen and Newman, 2008)	Areas of GP knowledge (Binder *et al.*, 2010; Aarseth *et al.*, 2013)	Global PM practices
Structure	Organization	GP structures – specialization GP structures – geographical Selection and training Global PMO Support from senior executives Global collaborative strategies
People	Teams	Out of the scope of this study
Task	Communication	
Technology	Collaborative tools	
	Collaborative techniques	

Table I.
The scope of this research, positioned in the perspective of the organizational variables and GP areas of knowledge

Support from senior executives. Support from senior executives is an important OS practice for GPs (Young and Poon, 2013; Suprapto *et al.*, 2015). Aarseth *et al.* (2013) identified lacking OS from the parent organization as one of the main challenges for GP managers, and Binder *et al.* (2010) recommended that senior executives in global organizations adapt processes, policies and procedures to cope with the challenges of GP. When investigating conditions that project managers in dispersed settings perceive as relevant to get their work done, Verburg *et al.* (2013) recommended senior executives to provide support to their teams as a prerequisite for the implementation of tools, infrastructure, policies, rewards and incentive systems for dispersed work. Aarseth *et al.* (2011) defined OS as an "[…] area of global project management that pertains to how the global organization can support its projects and project staff to enable their best performance in global projects." As such, OS practices related to senior management support include allocation of resources needed for global teams to develop the relational aspects of GP (Suprapto *et al.*, 2015).

Global collaboration strategies. As globalization drives organizations to reach out in a cooperating manner to entities previously viewed only as competitors, such networks become cornerstones of global collaboration strategies. OS practices related to these strategies include policies, plans and processes for partnership and relationship management, increasing access to a deeper pool of personnel with broader competences early in the collaboration (Aarseth *et al.*, 2013).

Practices as success factors
Research addressing success factors represents an important stream in PM literature. Four decades of research have brought up a variety of new success factors and extended the number of success criteria (Joslin and Müller, 2015; Hobbs and Besner, 2016). Zwikael and Globerson (2006) and Fortune and White (2006) presented a broad review of the success factors found in the literature and reported several limitations, such as unclear definitions, limited agreement on what factors influence project success and the proportion of success explained by success factors.

Hobbs and Besner (2016) proposed a distinction between success factors and PM practices, which can be defined as the common PM norms, routines, traditions and rules that guide the behavior of project managers in general circumstances and are described in bodies of knowledge and textbooks (Blomquist *et al.*, 2010; Thomas *et al.*, 2012). Practices, within OS, can manifest as emotional (intangible) and technical (tangible) artefacts (Aronson *et al.*, 2013; van der Hoorn and Whitty, 2015). If these practices are found to be successful, recognized and adopted by other project managers, they become part of accepted practices (Blomquist *et al.*, 2010). Such practices only become success factors if they can be linked to PM success (Hobbs and Besner, 2016) by assessing their impact on project efficiency or qualitative factors such as product success, quality of deliverables, team performance and satisfaction of team members (Aladwani, 2002; Drury-Grogan, 2014; El-Sabaa, 2001). GP practitioners can assess these qualitative factors for each of their projects, in the form of managerial success. The successful delivery of benefits by individual projects is expected to contribute to the parent organization's capability and/or performance (Cooke-Davies, 2002), increasing their efficiency-effectiveness and competitive advantage (Shenhar *et al.*, 2001).

The impact of OS practices on PM success in GPs
Previous GP research is motivated by a high number of GPs with cost overruns, delayed deliverables and low customer satisfaction (Aaltonen and Sivonen, 2009; Aarseth *et al.*, 2011; Lind and Brunes, 2015; Orr *et al.*, 2011; Ainamo *et al.*, 2010; Tang and Shen, 2013).

An examination of the PM success factors reveals that a vast majority is influenced by contextual conditions such as organization or management support (Young and Poon, 2013), highlighting a potential correlation between OS practices and successful projects. Although there appears to be little or no agreement on how to measure the contribution of such practices to PM success (Gauthier and Ika, 2012; Shenhar *et al.*, 2001), the idea of studying practices as success factors has merits if it can be shown that they have a significant differentiating effect on project efficiency (Hobbs and Besner, 2016). Project efficiency factors such as scope, cost and schedule can thus be considered directly linked to PM success (Jugdev *et al.*, 2013; Neves *et al.*, 2016; Reich *et al.*, 2014; Hobbs and Besner, 2016; ul Musawir *et al.*, 2017).

Hypotheses and research questions

Having described the theoretical foundations underpinning our study, GP and OS were discussed and defined, and the notion of OS practices as GP success factors was put forward. The analysis of GP discourse indicated that OS practices related to the structure variable may be of specific importance, related to definition of a GP structure, selection and training, PMOs, executive support and collaborative networks. Based on this analysis, two hypotheses and three associated research questions were formulated.

Our first research hypothesis (*H1*) is that:

H1. A large proportion of GPs are not delivered on budget and schedule, which must be assessed in larger samples of projects covering multiple countries, organizations and industries.

This hypothesis leads to our first research question:

RQ1. How efficient are GPs (delivery on budget and schedule), in comparison to local projects?

The analysis of extant research on GP, OS and OS practices in GP suggests a second research hypothesis that:

H2. GPs in which OS practices are implemented have a higher probability of success.

Such a hypothesis can be tested in a large sample of projects and leads to two research questions, first assessing the project success from an efficiency perspective and measuring the project costs, schedule and scope:

RQ2. What is the correlation between implementation of OS practices and GP efficiency?

From a practitioner perspective, success criteria vary for each project and are defined at early stages at the project charter (PMBOK, 2017). In this respect, the third research question assesses the managerial success of GPs from a qualitative perspective through the standpoint of the GP practitioners, which might combine elements beyond cost and schedule, and can be better assessed by experienced professionals who understand how successful their projects are in comparison to the unique success criteria specified for them:

RQ3. What OS practices are considered important by GP practitioners for project success and are implemented in their projects?

Our research objective is therefore to assess the OS practices in GP contexts and to determine the practices that are deemed successful by expert practitioners (managerial success), and also identify the practices that can be correlated to project efficiency.

The next section presents the research approach and method used to collect evidence from the experience of GP practitioners and address the three research questions.

Methodology

Scholars hold different views about the concept of organizations, e.g. whether they consist of artefacts or processes (Van de Ven and Poole, 2005; Aubry and Lavoie-Tremblay, 2018). Such distinctions can be traced back to antiquity and differing philosophies, e.g. those of Democritus and Heraclitus. The Heraclitean doctrine that "all things flow" and "nature is a process" is contrary to the Democritan view that nature consists in changeable interrelations among stable, unchanging units of existence (Rescher, 1996). Along the lines of David Graeber (2001), understanding critical realism as a form of "Heraclitean" philosophy, we emphasize a world view of flux and change over stable essences. Furthermore, maintaining that critical realism constitutes a powerful approach to describe the interface between natural and social worlds: an interface that is arguably central to the understanding of what brings success and failures to projects. In this respect, the natural world can exist irrespective of human activity, while the social world cannot. Although human activities are analytically and statistically separable from agential activities, they are relatively autonomous from the dynamic intricacy of both social and natural worlds (Allen *et al.*, 2013). As such this study follows a constructionist ontology, in which the reality and meaning of social phenomena are created by the interaction of the social actors with the world (Bredillet, 2010).

An abductive research process is followed by this study, in line with the hypermodernity values of reflexivity over reason and the learning and adaptation of practices through experience that allow an understanding of the OS and PM actions in complex organizational arrangements (Gauthier and Ika, 2012; Cicmil, 2006; Blomquist *et al.*, 2010; Winter *et al.*, 2006). Such process also satisfies the need for an interplay "[…] between theory and practice, between academics and practitioners" (Winter *et al.*, 2006) and the use of empirical inquiries (Bredillet, 2010) such as hypothesis testing and statistical analysis to "[…] match the achievements of natural science in explanation, prediction, and control" (Lee, 1991). This is in line with the study of Bryman (2012) since, "[…] quantitative research can play a significant role in relation to a constructionist stance" using Likert scaling techniques to investigate the GP practices through the eyes of the practitioners participating in the study.

The literature analysis was performed to identify the role of OS practices as success factors in GP literature and to define the categories of practices to be investigated (previously shown in Table I). A survey instrument was then used to assess the extent to which these practices are considered successful and are being used by GP managers, as well as their correlation with project efficiency. The survey-based research was selected for its ability to collect experience data from a large sample group, thus allowing generalization to a broader population and addressing the constructionism concern with issues of representation (Bryman, 2012). The survey comprised questions (in Appendix) that were designed in direct alignment to our research questions as illustrated in Table II and Figure 1.

RQ	Research questions	Survey questions
RQ1	How efficient are GPs in comparison to local projects?	SQ1, SQ2, SQ11, SQ12, SQ13
RQ2	What is the correlation between implementation of OS practices and GP efficiency?	SQ6, SQ11, SQ12, SQ13
RQ3	What OS practices are considered important by GP practitioners for project success and are implemented in their projects?	SQ6, SQ15
–	Demographic questions	SQ16–SQ22

Table II.
Design of survey questions in alignment to the research questions
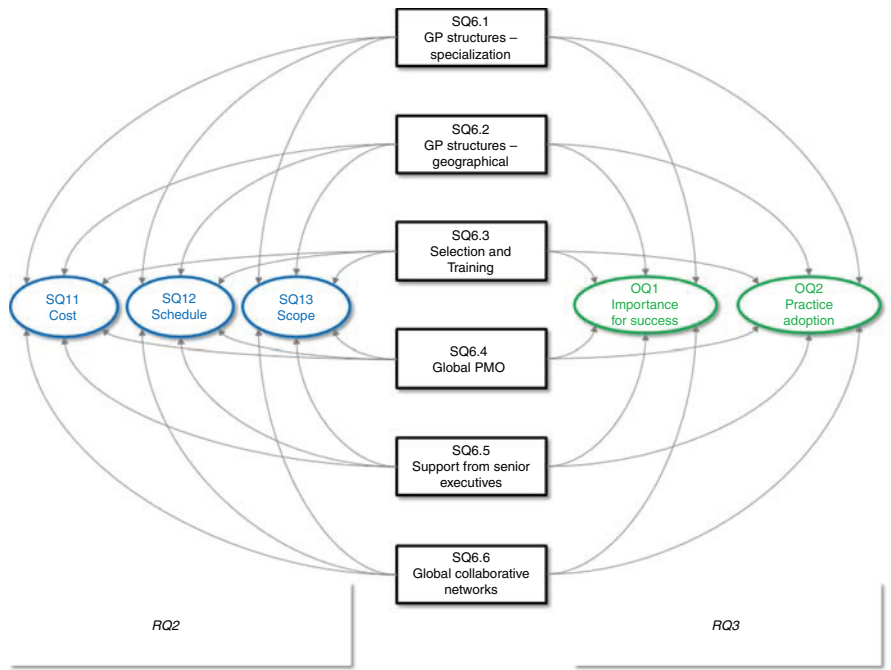
Figure 1.
Research design, with
possible correlations
displayed in
alignment to *RQ2*
and *RQ3*

The survey questions were designed according to the principles established by Bryman
(2012) and Oppenheim (2000). SQ11, SQ12 and SQ13 used scales to address *RQ1* and *RQ2*
(see Appendix). In order to address *RQ2* and *RQ3*, SQ6 used a Likert scale to allow
participants to assess the extent to which a particular practice is important to the success of
their projects (managerial success) and the extent to which the practice is implemented in
their project organization (see Table III). This approach is in line with similar PM studies
(see e.g. Hobbs and Besner, 2016) and rests on the assumption that respondents, as expert

GP OS practices	SQ	The statements presented to the respondents	Importance of practices	Adoption of practices
GP structures – specialization	SQ6.1	The project organizational structure is adapted to the specialization of the team members	OQ1	OQ2
GP structures – geographical	SQ6.2	The project organizational structure is adapted to the geographical dispersion of the team members	OQ1	OQ2
Selection and training	SQ6.3	Effective processes exist for selection and training of the team members	OQ1	OQ2
Global PMO	SQ6.4	A project management office provides support to the project manager	OQ1	OQ2
Support from senior executives	SQ6.5	Senior executives provide effective support to the project manager	OQ1	OQ2
Global collaboration strategies	SQ6.6	Senior executives define collaboration strategies with third parties during early stages	OQ1	OQ2

Notes: OQ1 = (1 – not important, 2 – moderately important, 3 – important, 4 – very important, 5 – critical);
OQ2 = (1 – not at all, 2 – to a little extent, 3 – to a moderate extent, 4 – to a great extent, 5 – to a very great extent)

Table III.
Six statements part of
SQ6, addressing OS
GP practices related to
the structure variable

PM practitioners, adopt the perspective of practitioners' bodies of knowledge to project success, which is that success criteria vary for each project and are defined at early stages at the project charter (PMBOK, 2017). To confirm such premises the survey questions are divided in three types:

(1) demographics questions to ensure our sample represents experienced professionals (SQ17–SQ22) and to determine which of these professionals manage GPs (SQ1, SQ2 and SQ15);

(2) questions on the success factors under study, i.e. the importance and implementation of OS practices (SQ6); and

(3) questions on PM success criteria (SQ11–SQ13), i.e. the status of PM efficiency (cost, schedule and scope).

The questions were adapted after a review by two independent professors with published PM research. The adapted survey was submitted to eight pilot PM practitioners in three different companies and countries to assess the clarity of the questions and the overall assessment instrument. The survey was updated based on their comments and submitted to renowned PM associations and distributed among global organizations and PM practitioners. The online LimeSurvey™ software was used to collect the data, which was later exported to SPSS™ to perform statistical analyses. While 1,170 answers were received, some respondents interrupted the survey before completion; therefore, each table presented in this study contains the number of valid and complete responses for each of the corresponding questions (consequently, the variable "N" has a different value for each result presented in the findings). This sample is considered sufficient to support the findings in this paper, based on other studies with large survey data in PM field (see e.g. Hobbs and Besner, 2016).

The survey data were analyzed using Pearson correlation and contingency tables, also known as crosstabs. Pearson correlation evaluates whether there is statistical evidence for a linear relationship among the pairs of variables in a population. Pearson correlation between two variables X and Y has a value between $+1$ and -1, where 1 is full positive linear correlation, 0 is no linear correlation, and -1 is total negative linear correlation. In cases where the Pearson correlation was significant at the 0.01 level (two-tailed), a crosstab was performed to further analyze interactions between the variables. This study presents the key findings using two correlation matrices and one crosstab.

The demographics questions were designed to assess the respondents' level of experience and their spread across geographies. The survey results included 1,170 respondents from 74 different countries as shown in Figure 2, satisfying our intention to have a large sample that was not biased toward one specific country. Table IV shows that the majority of respondents work with IS and ICT projects.

There is also a large proportion of GPs being managed by the survey participants, since only 133 out of 1,050 (12.7 percent) responded that they have all team members located in the same country (SQ2). The majority of respondents have significant experience in managing projects and more specifically GPs, which is demonstrated by the following factors:

- 90 percent have a leadership role such as project leader, project manager, program manager, PMO manager, senior manager or director (SQ17, $n = 656$).

- 91 percent use a PM method or body of knowledge such as the PMBOK® Guide, PRINCE2, IPMA ICB or APM-BOK (SQ19, $n = 656$).

- 78 percent of the respondents have more than five years of PM experience (SQ21, $n = 656$).
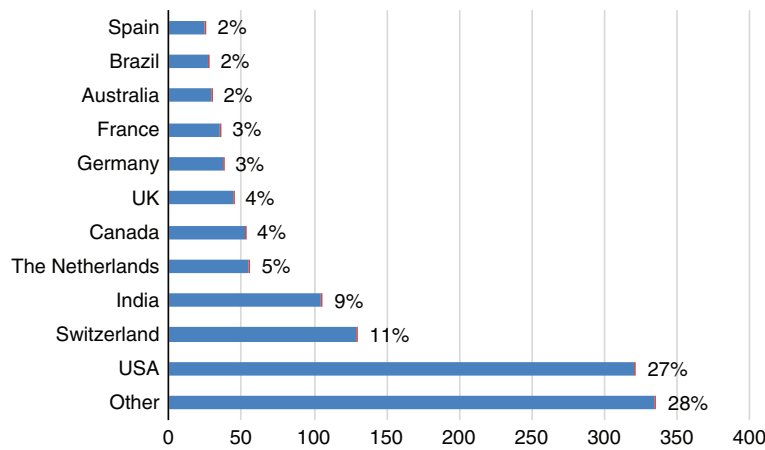
Figure 2.
Geographical
distribution of survey
respondents

In what type(s) of projects do you usually participate?

Answer options	Response %	Response count
IS projects (information systems: implementation or development of business applications)	55.6	365
ICT projects (information and communications technology)	29.9	196
Building construction	8.8	58
Naval construction	0.8	5
Aerospace construction	1.7	11
Infrastructure projects (roads, bridges, etc.)	5.6	37
R&D projects	15.1	99
Product development projects	23.8	156
Organizational change projects	24.4	160
Strategic projects	29.3	192
Events projects	6.1	40
Other		81
Answered question		656
Skipped question		515

Note: Respondents could select more than one project type

Table IV.
Distribution among
respondents over
industry/project type

- 62 percent have been working for more than five years in projects that involved people from different countries (SQ22, $n = 656$).
- Approx. 85 percent of the respondents work with IS and ICT projects.

Thus, ensuring the opinions come from a relevant sample (experienced practitioner project managers, several of which managing GPs), the survey allow investigations of correlations between success factors (OS practices) and success criteria (Cost, schedule, scope) for the management of GPs.

SQ3–SQ5 and SQ7–SQ10 were later deemed not relevant for the scope of this particular study and were not analyzed/described in this paper.

Findings

After confirmation that the sample of respondents satisfies this study's premises of geographical diversity and a high level of PM experience across country borders, the first research question is now addressed. An analysis of the answers to SQ11, SQ12 and SQ13

(see Table V) does not show significant differences between local and GPs (despite the different proportion represented in the sample) and is in line with practitioner literature on the topic (PMI, 2015; APM, 2015):

- Cost – 56 percent of respondents report that their GPs have cost overruns (Nos 4 and 5), but only 21.6 percent have reported a variance of more than 10 percent costs above budget (No. 5). A higher percentage of local projects (No. 3) have the same costs as the original budget (19.1 percent in comparison to 13.8 percent) or have variances of more than 10 percent below/above budget (Nos 1 and 5), with, respectively, 11.3 and 24.3 percent in comparison to 8.6 and 21.6 percent. This may indicate a slight tendency of GPs to have more cost variances that have smaller financial impact.

- Schedule – the percentage of GPs (No. 3) completed later than originally planned (49.6 percent) is much higher than those that finish earlier (No. 1, 10.4 percent) or on schedule (No. 2, 40 percent). The percentage that complete earlier is slightly higher for local projects (14.1 percent) than for GPs.

- Scope – while 29.1 percent of GPs have the same scope as originally planned (No. 3), 42.6 percent have a scope that increased with impacts on cost or schedule; 20.7 percent of respondents report small variations in scope that do not affect cost and schedule (Nos 2 and 4). This is a unique finding from this study, since other studies typically assess only changes in scope without categorizing their impact on the project efficiency. Only 7.8 percent reported a reduction of scope with impact on schedule or costs (No. 1).

In addition, there is a significant correlation between project scope, cost and schedule variations (significant at the 0.01 level, two-tailed), which gives a higher level of confidence in the construct validity of the survey instrument:

- cost vs schedule: Pearson correlation of 0.415;

- cost vs scope: Pearson correlation of 0.189; and

- schedule vs scope: Pearson correlation of 0.226.

The second research question was then addressed, first by analyzing the correlation between different types of practices and their effect on completing a GP within baseline costs and schedule (see Tables VI). A Pearson correlation between SQ6 and SQ11 and SQ12 for each of the survey statements (SQ6.1–SQ6.6) shows that only one OS practice (SQ6.3) correlates with both factors of PM efficiency with significance at the 0.01 level (two-tailed). No significant correlation was found with SQ13 (scope), which was removed from the tables for simplification purposes.

Crosstabs between SQ6.3 and SQ11 and SQ12 were used to further analyze the interrelation between the variables (see Tables VII and VIII). The crosstab SQ6.3 × SQ11

Table V.
Comparison of cost, schedule and scope variances between global and local projects (refer to the text above or to the Appendix for the detailed explanation of ratings 1–5)

	Global Projects, n=450				Local Projects, n=57		
	Cost	Schedule	Scope		Cost	Schedule	Scope
1	8.6%	10.4%	7.8%	1	11.3%	14.1%	5.1%
2	21.6%	40.0%	3.1%	2	17.2%	38.6%	5.7%
3	13.8%	49.6%	29.1%	3	19.1%	47.4%	26.2%
4	34.4%		17.6%	4	28.2%		15.7%
5	21.6%		42.4%	5	24.3%		47.3%
	100.0%	100.0%	100.0%		100.0%	100.0%	100.0%

SQ	SQ6 – To what extent does each statement describe the situation in your project?	SQ11 – How is your project cost in comparison with the original budget?		SQ12 – How is your project schedule in comparison to the original plan?	
SQ6.1	The project organizational structure is adapted to the specialization of the team members	0.105*	0.026	0.056	0.239
SQ6.2	The project organizational structure is adapted to the geographical dispersion of the team members	0.044	0.357	−0.019	0.691
SQ6.3	Effective processes exist for selection and training of the team members	*0.139**	0.003	*0.149**	0.002
SQ6.4	A project management office provides support to the project manager	−0.006	0.893	0.044	0.355
SQ6.5	Senior executives provide effective support to the project manager	0.080	0.091	0.073	0.120
SQ6.6	Senior executives define collaboration strategies with third parties during early stages	0.053	0.262	0.090	0.056
n = 450		Pearson correlation	Sig. (2-tailed)	Pearson correlation	Sig. (2-tailed)

Notes: *,**Correlation is significant at 0.05 and 0.01 level, respectively (two-tailed)

Table VI.
Correlation analysis between OS practices and project cost and schedule

Table VII.
Crosstab – the extent to which practices for effective processes for selection and training of the team members (SQ6.3) are implemented vs cost (SQ11) variances

Likert (n=450)	+10% lower	1–10% lower	The same	1–10% higher	+10% higher	Total
1 Not at all	0%	2%	2%	6%	4%	14%
2 To a little extent	2%	6%	4%	7%	7%	24%
3 To a moderate extent	4%	7%	3%	11%	6%	31%
4 To a great extent	2%	4%	4%	8%	3%	22%
5 To a very great extent	0%	2%	2%	3%	1%	8%
Total	9%	22%	14%	34%	22%	100%

Table VIII.
Crosstab – the extent to which practices for effective processes for selection and training of the team members (SQ6.3) are implemented vs schedule (SQ12) variances

Likert	Earlier	The same	Later	Total
1 Not at all	1%	4%	9%	14%
2 To a little extent	3%	8%	14%	24%
3 To a moderate extent	3%	13%	15%	31%
4 To a great extent	3%	10%	9%	22%
5 To a very great extent	1%	5%	3%	8%
Total	10%	40%	50%	100%

shows that 22 percent of all respondents have costs more than 10 percent higher than original budgets, and there is a slight tendency for these deviations in projects where practices were not implemented or only to a little extent (11 percent) in comparison to projects where the implementation was done to a great or very great extent (4 percent). In the other categories (where costs are lower, equal or 1–10 percent higher), a normal distribution is observed.

In the crosstab SQ6.3 × SQ12, this tendency is even stronger. In total, 40 percent of the surveyed projects finish with the same schedule and the proportion of projects that have OS practices implemented to a great or very great extent is 15 percent, in comparison to 12 percent where practices are not implemented or only to a little extent. Within the 50 percent projects that finish later than original schedule, there is a tendency for these deviations in projects where practices were not implemented or only to a little

extent (23 percent) in comparison to projects with implementation to a great or very great extent (12 percent).

It was previously discussed that, beyond efficiency factors such as cost and schedule, success criteria vary for each project and are defined at early stages. The correlation between the importance of OS practices and managerial success (as assessed by the experienced GP practitioners) was then assessed to address the third research question (see Table IX). In all categories, there are more respondents who consider the practices as very important to critical, in comparison to not important or moderately important, indicating that all OS practices are considered to have high managerial importance for GPs. The importance of four types of practices is even more salient:

- the majority (72.9 percent) of the respondents consider that senior executives' effective support to the project manager is very important or critical; and

- for the other three categories of OS practices, a majority of respondents consider them as important to very important: 71.5 percent for selection and training, 61.6 percent for PMO and 61.2 percent for collaboration strategies.

The implementation rate of OS practices (as assessed by the experienced GP practitioners) was also assessed to address the third research question (see Table X). In total, 47.4 percent of GP practitioners consider that senior executives' effective support to the project manager is provided to a great or very great extent, which shows that almost half of GPs are able to benefit from an OS practice that has a high rating of managerial importance. In the two practices related to organizational structure, there are also more respondents applying them to a great or very great extent. However, this is not the case for the other three practices with high managerial importance:

(1) 30.3 percent of respondents have implemented selection and training practices to a great or very great extent, in comparison to 38.6 percent who had no such practices or only to a little extent. Considering that these practices have a correlation with project efficiency, in addition to managerial importance, there are clear opportunities to be explored in this area by the GP practitioners.

Table IX.
Answers to SQ6.1–6.6 (OQ1 = "How important is each statement to the success of your project?") filtered to select only GPs

Global Projects, n=469						
	Org structure – specialization	Org structure – geographical	Selection and Training	PMO	Senior executives	Collaboration Strategies
1 Not important	4.7%	11.7%	3.6%	9.6%	0.6%	6.2%
2 Moderately important	20.3%	20.3%	15.1%	13.9%	6.6%	17.9%
3 Important	35.1%	33.8%	35.5%	30.3%	19.9%	30.3%
4 Very important	30.1%	25.2%	36.0%	31.3%	36.7%	30.9%
5 Critical	9.8%	9.0%	9.8%	14.9%	36.2%	14.7%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Table X.
Answers to SQ6.1–6.6 (OQ2 = "To what extent does each statement describe the situation in your project?") filtered to select only GPs

Global Projects, n=469						
	Org structure – specialization	Org structure – geographical	Selection and Training	PMO	Senior executives	Collaboration Strategies
1 Not at all	8.1%	13.0%	14.3%	21.5%	4.9%	13.9%
2 To a little extent	18.1%	20.5%	24.3%	18.8%	18.1%	29.9%
3 To a moderate extent	35.7%	30.9%	31.1%	20.1%	29.6%	26.1%
4 To a great extent	27.9%	28.1%	22.0%	27.7%	30.3%	19.4%
5 To a very great extent	10.2%	7.5%	8.3%	11.9%	17.1%	10.7%
	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(2) 39.6 percent of respondents have implemented PMOs to a great or very great extent, in comparison to 40.3 percent who had no such practices or only to a little extent. Of respondents, 21.5 percent do not have a PMO, a percentage much higher than for other OS practices, which suggests that this is also a gap to be explored.

(3) 30.1 percent of respondents have implemented collaboration strategies to a great or very great extent, in comparison to 43.8 percent who had no such practices or only to a little extent, a percentage point higher than other practices.

The correlations between OQ1 and OQ2 were also assessed (Table XI). A significant correlation between OQ1 and OQ2 for the same SQs suggests that organizations tend to implement the practices that they consider important for the success of their GPs. Taking SQ6.4 as one example, respondents who consider that PMO support is important to the success of their projects (SQ6.4 OQ1) also tend to consider that such support is currently being provided by their organizations (SQ6.4/OQ2). The results also imply that practices are not applied in isolation, as illustrated by the following correlations which were also found to be significant:

- Organizations that recognized the importance of senior executives' defining collaboration strategies with third parties during early stages (SQ6.6/OQ1) also implement all other OS practices (SQ6.1–SQ6.5/OQ2).

- Organizations that were able to adopt effective processes for selection and training of the team members (SQ6.3/OQ2) attributed importance to most other OS practices (SQ6.1, SQ6.2, SQ6.4, SQ6.6/OQ1).

- Organizations that value the adaptation of project organizational structure to the specialization of the team members (SQ6.1/OQ1) were also able to adapt such structure to the geographical dispersion of team members (SQ6.2/OQ2). The opposite relationship also exists (SQ6.1/OQ2 vs SQ6.2/OQ1).

- Organizations where senior executives define collaboration strategies with third parties during early stages (SQ6.6/OQ2) also consider it important to receive support from a PMO (SQ6.4/OQ1) and from senior executives (SQ6.5/OQ1).
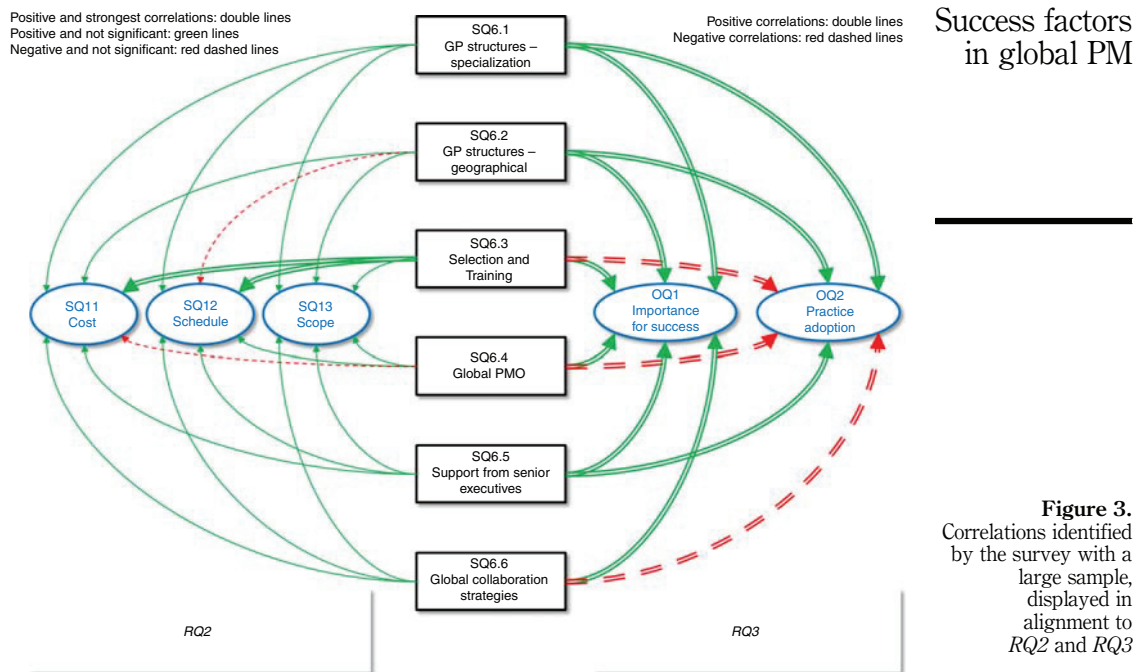
Discussion

Our analysis of a large sample of experienced GP practitioners spread across several countries has shown that a large proportion of GPs are not delivered on budget, on schedule or to scope. Our survey shows that these efficiency factors have a similar variance in global and local projects, which answers our first research question and leads to the suggestion that GP practitioners and organizations executing GPs must invest more in creating the right conditions for such projects to be more efficient. Understanding which practices can be implemented at project and organizational level is therefore of utmost importance. Figure 3 summarizes our findings, which will now be discussed.

When addressing our second research question in a large sample of projects, it was found that OS practices did not have a significant correlation with scope variance, and only one OS practice had a significant correlation with GP efficiency as measured by cost and schedule variance: the selection and training of GP team members. Such a finding is especially important to support the advancements of past years in establishing and improving bodies of knowledge, certifications and training in PM. It also suggests a continuous need for training in the global aspects of PM. Organizations should focus on HRM and elaborate a list of GP management practices that are required for their GPs. Such a list can then be used in interviews and selection processes when staffing GP teams, and it could also serve as a basis for global organizations to train their resources to work in GPs.

Table XI.
Correlation analyses of OQ1 ("How important is each statement to the success of your project?") and OQ2 ("To what extent does each statement describe the situation in your project?") for SQ6.1–SQ6.6

	SQ6.1/OQ2		SQ6.2/OQ2		SQ6.3/OQ2		SQ6.4/OQ2		SQ6.5/OQ2		SQ6.6/OQ2	
	Pearson correlation	Sig. (2-tailed)	Pearson correlation	Sig. (2-tailed)	Pearson correlation	Sig. (2-tailed)	Pearson correlation	Sig. (2-tailed)	Pearson correlation	Sig. (2-tailed)	Pearson correlation	Sig. (2-tailed)
SQ6.1/OQ1	0.578**	0.000	0.207**	0.000	0.165**	0.000	0.057	0.217	0.103*	0.026	0.092*	0.047
SQ6.2/OQ1	0.223**	0.000	0.613**	0.000	0.173**	0.000	0.085	0.065	0.027	0.555	0.034	0.467
SQ6.3/OQ1	0.104*	0.025	0.178**	0.000	0.471**	0.000	0.092*	0.046	−0.016	0.736	0.041	0.378
SQ6.4/OQ1	0.068	0.139	0.112*	0.016	0.161**	0.000	0.511**	0.000	0.106*	0.022	0.165**	0.000
SQ6.5/OQ1	0.082	0.076	0.114*	0.014	−0.010	0.828	0.071	0.127	0.403**	0.000	0.147**	0.001
SQ6.6/OQ1	0.144**	0.002	0.153**	0.001	0.182**	0.000	0.177**	0.000	0.193**	0.000	0.557**	0.000
$n = 469$												

Notes: *, **Correlation is significant at 0.05 and 0.01 level, respectively (two-tailed)

Figure 3.
Correlations identified
by the survey with a
large sample,
displayed in
alignment to
RQ2 and *RQ3*

This list of practices should be aligned to GP challenges of languages, locations, organizations, cultures and time zones, ensuring that OS practices in GPs are well understood and implemented across all projects in global organizations.

This is not to say that other OS practices are irrelevant. *RQ2* only deals with three efficiency variables and success is a broad concept with multiple parameters, which can be better assessed by experienced GP practitioners in comparison to the unique success criteria defined at early stages of their individual GPs. This dilemma was addressed in *RQ3*, which assesses the managerial success from the perspective respondents with considerable experience in projects and more specifically GPs. As a first conclusion of this assessment all OS practices are considered important for GP success. This shows that all OS practices have strong managerial importance, and as they do not all correlate with cost, schedule and scope, they might affect other project success factors. In terms of adoption, three OS practices were found to predominate in the GPs being surveyed: Senior executives provide support to their GPs, and the project structures are aligned to both specialization and geographical dispersion of team members. This answers our third research question.

Weak or missing correlations
Based on the existing PM theory and research literature it was expected to find clear correlations between the OS practices and cost and schedule. A general trend of the results is that statistical correlations found are weaker than predicted. Three possible explanations for this are discussed. Many respondents do not consider efficiency (cost and schedule) as key success criteria. The studied OS practices are poor success factors for project efficiency (as success criteria). The survey design had weaknesses.

To what extent do practitioners consider efficiency as key success criteria? All OS practices addressed in this study are considered to be of high importance for managerial success,

i.e. the respondents consider them important for the success of their projects. The weak or missing correlations between the OS practices and project efficiency could be an indicator that "at cost and on time" is not what the respondents think of when considering the success of their projects, i.e. the OS practices are important for success criteria other than cost and schedule. There is no evidence in this study for such argument but it is a plausible cause that align with known challenges related to cost creep (Samset and Volden, 2016; Flyvbjerg, 2007).

Are OS practices poor success factors for project efficiency? Most respondents believe that the OS practices are of importance for the success of their projects. They also consider most OS practices to be well implemented in their organization. With the weak correlation with project efficiency, one may conclude that the studied OS practices are poor success factors for the success criteria for cost and schedule. However, there is little or no disagreement in the PM discourse that OS practices addressed in this study constitutes key PM practices important for the success of projects. Results from this study may contribute to the discussion on what constitutes a success factor for project cost and schedule, and what does not (Fortune and White, 2006; Hobbs and Besner, 2016). A high proportion of respondents in this study work with IS and ICT projects while most studies used as basis for the hypotheses (e.g. Aarseth *et al.*, 2013), are from other industries. As such, these results support the notion that the importance of OS practices differs depending on the type of project external environment.

Is the survey design to blame? The basic design of the survey questions is based on the concept that well-implemented OS practices should correspond to lower cost overruns and less schedule delays. And vice versa, poorly implemented practice should correspond to higher cost overruns and greater delays. With opinion-based surveys, such an approach has known weaknesses regarding interpretation, definitions and scope of the addressed topic. The practitioners (respondents) may have varying ideas of when a practice is well implemented in their organizations and when it is not. The survey design unfortunately did not provide a clear frame of definition for this. The same applies to the definition of success. The OS practices addressed are also high level. The results of this study thus support criticism of opinion-based methods (e.g. Hobbs and Besner, 2016), when investigating correlations of practices (as success factors) and success criteria, e.g. cost and schedule.

Contribution to the theory–practice discourse
Blomquist *et al.* (2010) and Bredillet *et al.* (2015) are examples of important contributions to the PM theory–practice discourse. At its core, there is an acknowledgment that research and practice is about the creation of different types of knowledge. Spawning the problem of what is "science that matters," the notion of (bad) management theories becoming self-fulfilling and the challenges of propagating "practice within (strict) context" type of knowledge.

This paper do not claim to contribute to the academic theory–practice discourse itself but results from this study do offer an important contribution toward understanding the implications this discourse have for practitioners concerned with "management of the human factor." That is, as all organizational theory has its limitations and all best practices depend on context, it is of key importance that organizations develop the appropriate practices for selection and training, ensuring the proper skillsets, knowledge of the organizational context and the rationale for existing processes and practices.

Limitations and future research
This paper focused on OS practices related to the structure variable (shown previously in Figure 1). More research is needed to assess the correlations between GP efficiency and

success with other organizational variables such as people, tasks and technologies – linked to GP areas such as teams, communication, collaborative tools and collaborative techniques.

Future studies could analyze OS practices in GPs in more detail and assess their individual correlation with project success in specific contexts, in order to allow organizations to prioritize the training topics that are more beneficial to their GPs. Other studies could also investigate the training formats that are more adequate to suit the geographical dispersion of global teams, and recommend practices to select and interview resources that are based in distant countries. Another area of potential study is the consideration of reducing bias due to cultural differences in selection processes in order to increase diversity and inclusion in GP teams.

Conclusion

GPs are temporary collaborations between organizations across locational, temporal and relational distances with the intention to jointly deliver a unique product or service. Six areas of OS practices related to the structure variable were addressed and approached from the viewpoint of the success school. Building on mature organizational models and theories, a framework for GP knowledge areas was elaborated, using OS practices as our unit of analysis to investigate correlations between OS and project scope, cost and schedule.

In the context of our study, four main conclusions can be made based on the surveyed GP practitioners, in alignment to our three research questions. A large proportion of GPs are not delivered on budget, on schedule or to scope (*RQ1*). To address this, one OS practice can be implemented that was found to have a significant correlation with cost and schedule efficiency: the selection and training of GP team members (*RQ2*). In addition, all OS practices investigated by this study have strong managerial importance to other project success factors (*RQ3*). As an additional conclusion from *RQ3*, three of these practices are adopted in most GPs being surveyed: senior executives provide support to their GPs, and the project structures are aligned to both specialization and geographical dispersion of team members. All other practices could be further adopted in order to increase project efficiency.

Overall, our findings align with previous results from the studies of Hutchinson (1994), Gelbard and Carmeli (2009), Huemann (2010), Drouin *et al.* (2010) and Aarseth *et al.* (2013). OS practices related to selection and training of team members have the strongest correlation with completing a GP within baseline costs and schedule. Considering the important volume of investments in GPs, the implications for practitioners are that appropriate selection processes and training can reduce the occurrence of budget overruns and schedule delays. Similar to other studies (see e.g. Hobbs and Besner, 2016), our research found that all OS practices have high importance for managerial success, despite their low correlation with efficiency factors of cost and schedule.

Our novel contribution was to address the lack of quantitative data which has led to the realization that all OS practices suggested by previous studies have high managerial importance in GP contexts and are deemed successful by expert practitioners, with one practice having in addition a significant correlation with project efficiency. However, even as one tries to label and describe project practices, the socio-technical situation mutates and projects are often agents of change that also undergo changes. PM processes and practices try (and often fail) to make PM a rational and safe activity, putting limits on what can and cannot be done. However, although humans are intendedly rational they are more often only limitedly so, supporting the central argument of Bredillet *et al.* (2015) that managers are rarely reduced to theory-applying decision makers. With this realization at heart, one can conclude that organizations relying on GPs need "better best practices" for selection and training processes. Organizations need to prepare project personnel to identify and manage uncertainty originating from the social worlds with the same excellence that they prepare them to use natural and engineering science to understand and manage the natural world.

Note

1. This study refers to the human factor as the human abilities, limitations and other characteristics that are relevant to design of tools, machines, systems, tasks, jobs and environments for safe, comfortable and effective use.

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Appendix. Survey questions

SQ1: What is your current office location? In case you work in different offices, please specify where you spent more time in the last three months.

SQ2: Think about your current or last project. In which countries were/are your team members located? Consider the team members that communicate with you during meetings, using e-mails or any other media. Do not include other stakeholders, for example: suppliers, end users, customers, governmental agencies.

SQ3–SQ5 were later deemed not important to the scope of this study and were not analyzed/ described.

SQ6: Think about the same project as the previous question. For each statement below, answer the following two questions.

How important is each statement to the success of your project? (Not important – Moderately important – Important – Very important – Critical)

To what extent does each statement describe the situation in your project? (Not at all – To a little extent – To a moderate extent – To a great extent – To a very great extent)

SQ6.1: The project organizational structure is adapted to the specialization of the team members.

SQ6.2: The project organizational structure is adapted to the geographical dispersion of the team members.

SQ6.3: Effective processes exist for selection and training of the team members.

SQ6.4: A project management office provides support to the project manager.

SQ6.5: Senior executives provide effective support to the project manager.

SQ6.6: Senior executives define collaboration strategies with third parties during early stages.

SQ7–SQ10 were later deemed not important for the scope of this study and were not analyzed/ described.

SQ11: How is your project cost (estimated total costs at completion), in comparison with the original budget?

(1) Costs are +10 percent LOWER than original budget.

(2) Costs are between 1 and 10 percent LOWER than original budget.

(3) Costs are THE SAME as original budget.

(4) Costs are between 1 and 10 percent HIGHER than original budget.

(5) Costs are +10 percent HIGHER than original budget.

SQ12: How is your project schedule, in comparison to the original plan?

(1) Expected completion date is EARLIER than original plan.

(2) Expected completion date is THE SAME as original plan.

(3) Expected completion date is LATER than original plan.

SQ13: How is your current project scope, in comparison to the original scope?

(1) The scope was REDUCED, WITH IMPACTS on costs or schedule.

(2) The scope was REDUCED, WITHOUT IMPACTS on cost or schedule.

(3)   The current scope is THE SAME as the original scope.

(4)   The scope was INCREASED, WITHOUT IMPACTS on cost or schedule.

(5)   The scope was INCREASED, WITH IMPACTS on costs or schedule.

SQ14: Consider all projects conducted by your company in the last year, and situate your project in perspective to them. (Rate Complexity, Budget, Duration, Team size and Importance on a Likert scale 1–5).

SQ15: To what extent do you face each of these challenges in your projects? (Not at all – To a little extent – To a moderate extent – To a great extent – To a very great extent)

- Geographical distance (locations in different countries).

- Multicultural collaboration (people from various cultures).

- Multilingual communication (people with different languages).

- Asynchronous interactions (people in various time zones).

- Cross-organizational relationships (people from various companies).

SQ16: What is your country of origin? (where you were born).

SQ17: Your current job is best described as? (Project team member, Project manager, Program manager, PMO manager, Senior manager/Director or academic position)

SQ18: In what type(s) of projects do you usually participate?

SQ19: What project management methods/bodies of knowledge do you use as a reference? (None, PMBOK®, PRINCE2, IPMA ICB, APM-BOK or Other/Specify)

SQ20: What is your age?

SQ21: How many years of project management experience do you have?

SQ22: For how many years have you been working in projects that involve people from different countries?

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