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Renato T. Pinto

Improvement of Project Lines Coordination: a case study of automotive R&D innovation

Universidade do Minho
Escola de Engenharia

Renato Teixeira Araújo de Matos Pinto

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Master's Thesis

Master's in Engineering Project Management

Work done under the guidance of:

Professor Anabela Pereira Tereso

Doctor João Manuel Peixoto Faria

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INTEGRITY STATEMENT

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

Abstract

Improvement of Project Lines Coordination: a case study of automotive R&D innovation

The automotive industry is one marked by constant remodeling. A long road has been paved since electrical and internal combustion engines were invented, at the turn of the XIX century, and many more technological breakthroughs have since preceded this century's challenges. The driving force beyond such human prowess is innovation. Therefore, for companies like Robert Bosch GmbH to thrive, knowing how to innovate is key to harness present-day opportunities. Bosch's Chassis System Control, through its R&D department, has been focused on sensory technology for autonomous driving. New knowledge is furthered by the division's portfolio, which includes Sensible Car (SC), a joint innovation program with the University of Minho.

The primary goal of this research is to bring the rationale of Project Management (PM) to the aid of twelve subprojects within SC. To put it to use, this innovation context is depicted through a case study research strategy. Participant observation, document analysis, informal interviews and a questionnaire are used to check the projects' formal and informal processes.

This account portrays how the perception of the project environment influences the ability to fulfill its innovative purposes. The main issues found concern scope, resource and communication management. These were addressed through servant leadership, with the researcher assuming enabling traits of a facilitator in a functionalized project structure. A new take on communication management was produced to help align the project structure and stricter role definition is recommended to further project integration. The chance to adopt a hybrid project management life cycle, beside the traditional high-level program controls, was identified too. The produced insights serve to understand how agile, classical or hybrid PM configurations might emerge from the complex interaction of human and technological agents.

Keywords

Automotive, Innovation, Innovation Management, Project Management

Resumo

Improvement of Project Lines Coordination: a case study of automotive R&D innovation

A indústria automóvel está em constante renovação. Desde a invenção de motores elétricos e de combustão interna no final do século XIX, muitos foram os avanços tecnológicos que vieram preceder os desafios da atualidade. A força motriz por detrás deste percurso é a inovação. Para empresas como a Robert Bosch GmbH, saber inovar é, portanto, essencial para capitalizar as oportunidades do presente. A sua divisão de Chassis System Control, através do seu departamento de I&D, tem-se focado em tecnologia de sensores para a condução autónoma. A produção de novo conhecimento é conduzida pelo portefólio da divisão, que inclui o Sensible Car (SC), um programa de inovação copromovido com a Universidade do Minho.

O objetivo principal desta investigação é colocar a dialética da Gestão de Projeto (GP) ao serviço de doze subprojetos do SC. Para tal, o contexto de inovação é retratado através de um caso de estudo. Observação participante, análise documental, entrevistas informais e um questionário são usados para sondar os processos formais e informais do projeto.

Este trabalho demonstra como a perceção do ambiente de projeto influencia a capacidade de cumprir com o propósito inovador. As principais limitações identificadas concernem a gestão de âmbito, recursos e comunicação. A resposta a estas partiu de uma abordagem de *servant leadership*, com o investigador a assumir o papel de facilitador junto de uma estrutura de projeto funcional. É proposta uma nova abordagem à gestão da comunicação para auxiliar o alinhamento do projeto, sendo recomendada mais definição de papéis para aprofundar aspetos de integração. Foi também identificada a possibilidade de adotar um ciclo de gestão de vida do projeto híbrido, a par dos mecanismos tradicionais de controlo de alto-nível para o programa. As reflexões obtidas permitem perceber como modelos ágeis, clássicos ou híbridos de GP podem emergir da interação complexa de fatores humanos e tecnológicos.

Palavras-Chave

Gestão de Inovação, Gestão de Projeto, Indústria Automóvel, Inovação

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Abbreviations and Acronyms

AgPM – Agile Project Management

APM – Association for Project Management

APM BoK – Association for Project Management Body of Knowledge

ART – Agile Release Train

BES – Bosch Engineering System

BM – Business Model

BP – Business Plan

BU – Business Unit

CC/CC-PS – Bosch Chassis Systems Control division

CCG – Centre for Computer Graphics

CPM – Critical Path Method

FM – Functional Management/Manager

HR – Human Resource

INL – Iberian Nanotechnology Laboratory

IMT – Innovation management Methodologies and Tools

IT – *Instituto de Telecomunicações* (Aveiro)

LiDAR – Light Detection and Ranging (technology)

MVP – Minimum Viable Product

NPD – New Product Development

PBS – Product Breakdown Structure

PC – Project Charter

PERT – Program Evaluation and Review Technique

PI – Program Increment in SAFe®

PIEP – Innovation Hub in Polymer Engineering (*Pólo de Inovação em Engenharia de Polímeros*)

PIPE – Program Increment Planning Event

PL – Project Line

PMLC – Project Management Life Cycle

PO – Product Owner

PM – Project Management

PMg – Project Manager

PMI – Project Management Institute

PMBOK® – Project Management Body of Knowledge (by PMI)

PMO – Project Management Office

R&D – Research and Development

SAFe® – Scaled Agile Framework

SC – Sensible Car program

SG – Stage-Gate framework

SM – Scrum Master

TD – Technical Director

UM – University of Minho

WBS – Work Breakdown Structure

WIP – Work in Progress

WP – Work Package

1. Introduction

This introductory chapter comprises some premises on innovation and project management concepts, describes this thesis development context, its goals and the research design choices addressing the issues it faces. The document overall structure is also presented.

1.1 Background & motivation

Innovation has a pivotal role in ensuring long-term business sustainability and growth. Whereas some companies abide by market trends, others actively seek to expand their business portfolio. It is by entering new markets or further strengthening their control over core business that the latter effectively alter the competitive landscape. Moreover, innovation might be said of an incremental kind or encompass groundbreaking, disruptive change brought on by new technologies, services or processes (Dodgson, Gann, & Salter, 2008). When companies commit to develop innovative solutions, they often dwell in uncharted waters. Therefore, it is expectable for the management of innovation projects to set forth plenty of challenges. These can range from a broadly defined scope, to large, entrepreneurial, multicultural team and work environments. In such contexts, neither project performance nor research and development (R&D) investment will directly translate into financial or, likewise, easily quantifiable value (Tellis, Prabhu, & Chandy, 2009).

Innovation endeavor thrives in so-called innovation clusters, a concept drawn from the business cluster as defined by Porter (1998) at the turn of the century. The cluster environment, which may include both public and private entities, is the stage for cross-functional, intercompany projects, with particular managerial needs. The triple helix model, first proposed by Leydesdorff and Etzkowitz (1998), describes how academia, industry and government have come together to shape innovation systems. Project Management (PM), in its turn, proves a valuable tool in catalyzing the expectable benefits from such university-industry collaborations (Barnes, Pashby, & Gibbons, 2002; Fernandes, O' Sullivan, Pinto, Araújo, & Machado, 2020).

Nowadays, there are several pathways to PM, such as the widely known Project Management Body of Knowledge - PMBOK (PMI, 2017a) process-based approach, which breaks down the project lifecycle into five groups: initiating, planning, executing, monitoring and controlling, and closing. This type of partition resembles that of traditional, more classical methods that go by names such as waterfall, Stage-Gate (Cooper, 1990) or phase-based approaches. Because these rely on the upfront collection of requirements and laborious planning, they are often seen as opposed to agile methods. Indeed, agile frameworks, being less formal approaches, may prove the best suit to face innovative “high-uncertainty projects (that) have high rates of change, complexity, and risk”. They have developed “to explore feasibility in short cycles and quickly adapt based on evaluation and feedback” (PMI, 2017b, p. 7).

Even though in recent years Agile Project Management (AgPM) has been the emerging standard for project execution, one should bear in mind there is no ready solution for any given organizational context. In truth, plenty of researchers and authors advocate and report on the need for tailoring the PM practice to individual project characteristics, using traditional, agile or hybrid approaches (Burgan & Burgan, 2014; Meredith, Shafer, & Mantel, 2017). Given its ground-breaking nature, it must be considered that innovation projects are likely to be of high complexity. Such complexity may arise from things like the number of parts, the number of subsystems, the number of involved teams and organizations, or the existence of technological voids. Uncertainty must also be accounted for when considering the project and team autonomy in complex stakeholder environments. Project perception among its sponsors and mid-management, within one or among several interacting organizational hierarchies, influences both the effectiveness of decision-making processes and goal congruency (Jensen, Johansson, & Löfström, 2006). This can be quite detrimental for large, cross-institutional innovation projects, which are purposely created to facilitate communication and knowledge exchange between complementing individual and group competencies (Hoegl & Parboteeah, 2006).

This master thesis in Engineering Projects Management took place at Bosch Car Multimedia S.A., a company of the BOSCH Group, located in Braga, Portugal. Within Bosch Mobility Solutions Business Sector, its Chassis Systems Control division (CC-PS) has traditionally been supplying automotive Original Equipment Manufacturers with so-said classical sensors, which regulate and assist vehicle steering and directional control (Robert Bosch S.A., 2019).

Presently, the push for automated and safer driving has given way to several innovation initiatives, including the Sensible Car program (SC), which kicked-off mid-2018. SC enrolls some other entities, namely the Co-promoter, University of Minho (UM). The involved third parties include the Iberian Nanotechnology Laboratory (INL), *Instituto de Telecomunicações* (IT), Innovation Hub in Polymer Engineering (PIEP) and the Center for Computer Graphics (CCG). This implies that intercompany teamwork takes place within the program’s scope. Then, for LiDAR, which is a subset of 12 project lines within SC, the need for further team integration was identified.

1.2 Research goals

The main goal of this research is to improve team integration among SC.LiDAR 12 project lines. The corresponding research question can be formulated:

What issues affect SC.LiDAR project lines coordination and how to address them?

After a preliminary assessment of project reality, this question can be further divided into a more detailed goal subset. This research purpose would hereby translate to:

- Help SC.LiDAR teams to identify, define and agree on final deliverable(s) requirements.
- Improve team communication and draw out team interdependencies.
- Implement PM tools or PM methodologies for team coordination.

1.3 Research design

To address the aforementioned, the research strategy will be that of a case study. The case study allows bridging observed project specifics with the abstract concepts lying at the core of the issues it faces (Neuman, 2011). PM standards, in their turn, can provide the coding to such concept characterization, thus permitting a more structured approach to issue decomposition and resolution.
While looking for patterns and themes across the gathered data, moving from specific circumstance to general realization, this research focus will be so determined and redirected, accordingly. According to Flick (2015) this is characteristic of an inductive approach. While deduction aims to provide a certain reason for a given phenomenon, induction delivers a plausible or likely conclusion. Saunders et al. (2016) place typically inductive approaches within the philosophical domain of interpretivism. This philosophy acknowledges that the project environment is a social construct, where language and culture shape different interpretations, where complex and multiple realities coexist. This research is therefore anchored on perception and interpretation, i.e., the researcher's narrative becomes part of what is researched and subjective.
The present study resorts to a multi-method qualitative research design, with a cross-sectional time horizon. It is to say that methods such as observation, document analysis, surveys and informal interviews (e.g. project meetings) will be applied at discrete moments in time. Figure 1 shows the correlation between these data collection techniques, the case study strategy, and the wider philosophical approach.

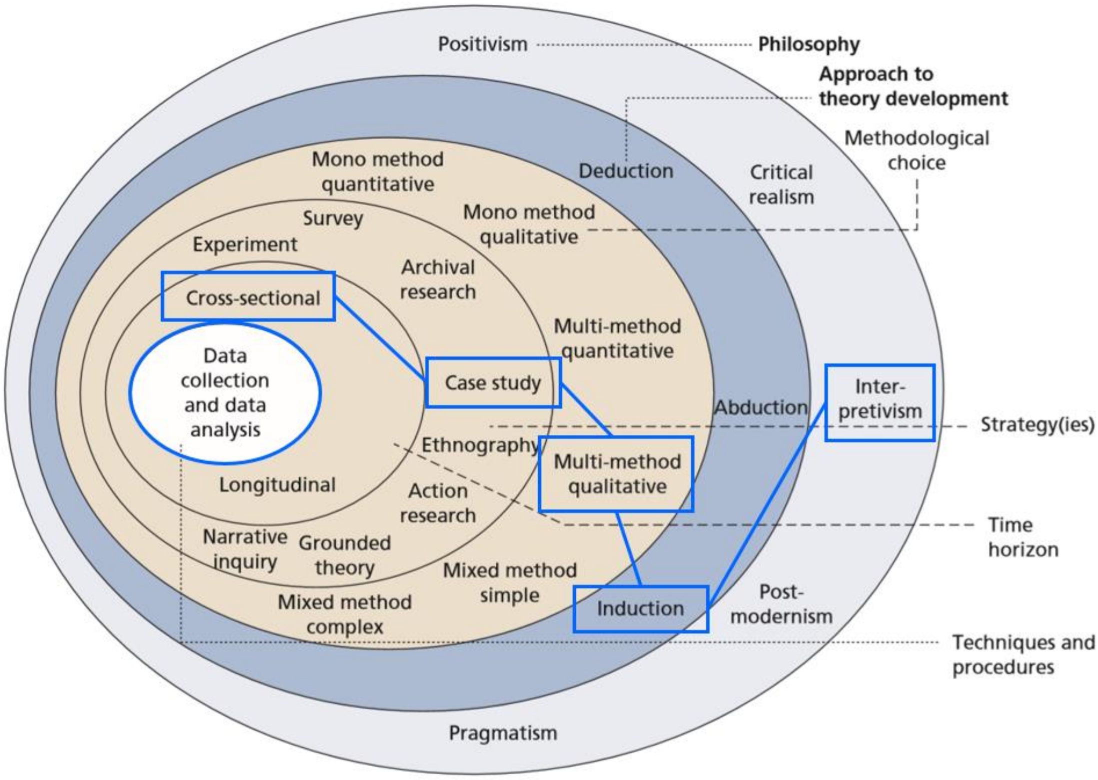


Figure 1 - Saunders' diagram (research onion) with this work's research design in highlight.
(Saunders et al., 2016)

The researcher will take the role of a participant-observer, doing what could be described as consulting, while simultaneously taking the role of a project coordinator. About the researcher's point of view, and on the nature of observation as a data-gathering technique, more will be said in Chapter 3.

1.4 Thesis structure

The present work includes a total of seven chapters. The introductory nature of this first one is followed by a second chapter of literature review on project management, innovation and innovation projects. The project management review encompasses not only traditional and agile frameworks but also some hybrid configurations. In the second chapter still, the criteria for the characterization of innovation projects are shown according to some authors. Approaches to the management of innovation projects are also explored.

A third chapter lays out the research methodology used throughout the study, placing the considerations and strategy that determined the course of the investigation. Chapter four goes through the detail of the research context. It presents the company where it unfolds, identifies the PM practices found there, and synthesizes the issues surfacing from the experienced project environment.

Chapter five includes results from the research, presenting observational and statistically gathered data, reflections and action drivers for its development. Artifacts produced within the research's domain are shown here too, and elsewhere, at the Appendix section. The sixth chapter discusses the findings and results of the research.

The seventh and final chapter concludes this thesis, hinting at additional project improvements and possible lines of future research.

2. LITERATURE REVIEW

This chapter covers the state-of-the-art on project management and innovation projects. The first subchapter introduces the emergence of PM and gives an overview of some common frameworks on the field. It would be impractical to cover in detail all available frameworks, so a selection based on relevance to this work was made from classical PM, Agile PM (AgPM) and hybrid approaches. The second subchapter describes the types and characteristics of innovation projects. Examples of tools and practices to manage innovative enterprises are also covered here. A chapter's summary is given at the end.

2.1 Project management

Project management is a social construct. Martin Barnes, ex-president of the Association for Project Management (APM), affirmed that "at its most fundamental, project management is about people getting things done" (APM, 2020). People get things done everywhere, all the time, as they go about their lives. They have been doing it for so long that it could be said, projects have been managed since immemorial times. Through generations of life goals and personal objectives, human society owes uncountable achievements to that entrepreneurial spirit. It was not until recently, however, that the language of contemporary PM started to take shape (Morris, Pinto, & Söderlund, 2011).

The inception of the field can be traced to the 1950s, to the Program Evaluation and Review Technique (PERT), which is credited for the fruition of the US Navy's Polaris Project (Engwall, 2012). Around the same time, also in the U.S.A., what would be known as the Critical Path Method (CPM) was being tried at DuPont, a company involved in the Manhattan Project. Both these projects would be determinant to the success of the American Second World War effort, thus placing PERT and CPM in the industry and business spotlight. In broad terms, while PERT focuses on monitoring work progress, the CPM highlights project planning, scheduling and cost control (Kelley, 1961). As Tereso et al. (2019) explain, this kind of rationalistic approach rests on the assumption that in managing projects "(...) there are identifiable patterns and generalizations, from which rules, controls, and guidelines for "best practices" can be established (...)". Through such practices, the settling of PM as a research and professional field has happened since then, aided by the foundation of standards and reference institutions across the globe. Products of the growing PM body of knowledge include *A Guide to the Project Management Body of Knowledge* (PMBOK® Guide) authored by the Project Management Institute (PMI); the *Individual Competence Baseline* (ICB4) from the International Project Management Association (IPMA); the *APM*

Body of Knowledge (APM BoK) published by the Association for Project Management (APM); among others.

According to the APM BoK, project management is “(...) the application of processes, methods, skills, knowledge and experience to achieve specific project objectives (...)”(APM, 2012). The PMBOK, in its turn, defines a project as “a temporary endeavor undertaken to create a unique product, service, or result” (PMI, 2017a, p. 4). In short, project management is a combination of organizational processes and resources (cost), that are bound in time to deliver tangible or intangible value (scope), under predetermined requisites (quality). The relationship between these variables has been condensed in the classical iron-triangle of PM (Figure 2) which, to this day, remains fundamental to how people perceive project success (Pollack, Helm, & Adler, 2018).

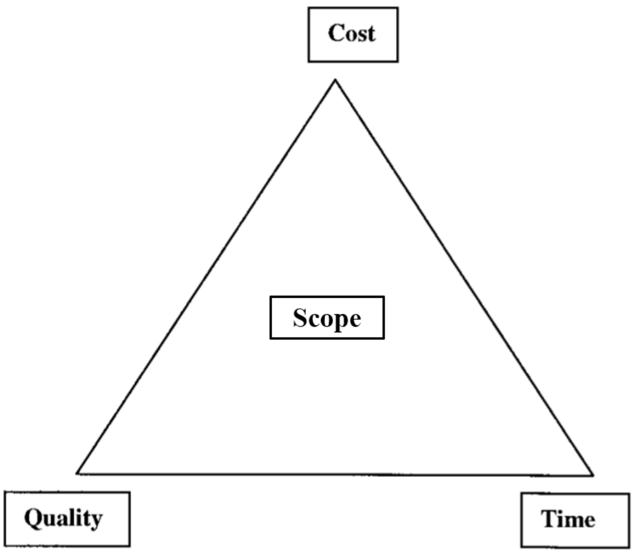


Figure 2 - The PM iron-triangle (triple constraint).
Adapted from Atkinson (1999).

Almost everyone understands how delays and cost overruns impact project performance – time and money are universally valued – hence their importance to what (good) management is supposed to be. But quality seems something harder to grasp. Representations of the iron-triangle may even use quality and scope interchangeably. Duarte et al. (2019) argue that to deal with numerous different projects, Project Management Offices (PMO) tend to simplify controls to the management of cost, time and scope, which do not accurately reflect all project dimensions, such as organizational strategy or stakeholder interests. For many decades now, balancing the triple constraint has proved insufficient to secure project success (Atkinson, 1999; Pollack et al., 2018). Such limitation is even seen as the precursor to the Agile Manifesto movement, as will be further explained. PMBOK’s 5th edition suggested that to the initial triangle constraints, project resources and risks were added (Figure 3). It adverts "(...) if any one factor changes, at least one other factor is likely to be affected"(PMI, 2013, p. 5).

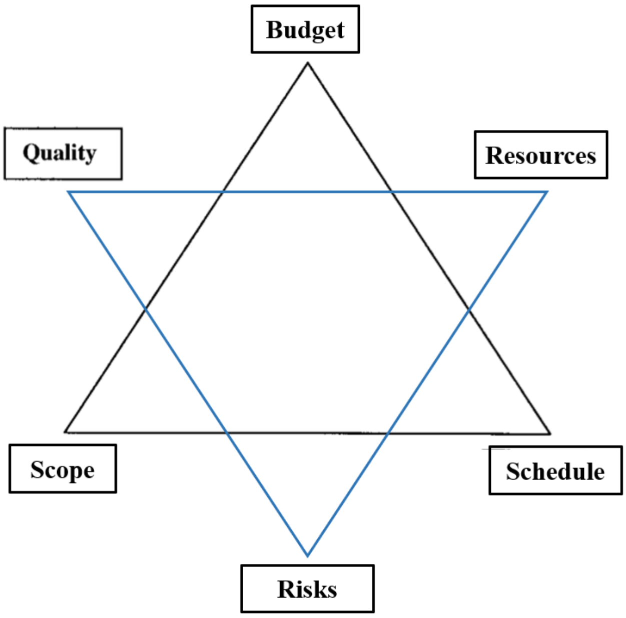


Figure 3 - The PM star, with Quality, Resources and Risks adding to the classical iron-triangle.
Author's elaboration based on PMBOK 5th ed. (PMI, 2013).

One aspect over which PM standards, researchers and practitioners agree is that there are no universal success factors, and likewise, no universal PM frameworks that apply to every project reality (Shenhar, Tishler, Dvir, Lipovetsky, & Lechler, 2002).

2.1.1 Agile project management

Agile is not so much a methodology, but rather a mindset that started to emerge among IT developers back in the 1970s (Larman & Basili, 2003). Already back then, even if projects were to finish within time and budget, the output of 2-3-year-old requisites could very well be outdated in quickly changing business environments (Collyer, Warren, Hemsley, & Stevens, 2010; Collyer & Warren, 2009). Although waterfall approaches (see subchapter 2.1.2) had brought a sense of structure to software development, there was growing discontent with application delivery lag. Thus came to be the Manifesto for Agile Software Development (Beck et al., 2001) with its four core values (Figure 4).

> We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:
>
> **Individuals and interactions** over processes and tools
> **Working software** over comprehensive documentation
> **Customer collaboration** over contract negotiation
> **Responding to change** over following a plan
>
> That is, while there is value in the items on the right, we value the items on the left more.

Figure 4 - The four core values of the Agile Manifesto
(PMI, 2017b, p. 8).

Its authors advocate New Product Development (NPD) need for more speed and flexibility, highlighting people's over process perspective, fitness for purpose, proximity to the customer, and reaction to ever-changing project requisites and conditions. Agile approaches to project management have increased in popularity since. According to the State of Agile™, a survey of the global software development community with over one million respondents, 97% of the surveyed companies were practicing agile development methods as of 2018 (VersionOne, 2018). The previous year, with over three million PM respondents across industries worldwide, PMI's Pulse of the Profession® survey revealed that 71% of organizations were using agile "sometimes or more frequently than in the past" (PMI, 2017c, p. 10). Agile comprises several team-level frameworks, e.g. Scrum, Kanban, Dynamic Systems Development Method (DSDM), Extreme Programming (XP). Scrum practices are still referred to as the most popular and extensively used (Hobbs & Petit, 2017; VersionOne, 2018). For large cross-functional team or enterprise-level projects, agile scalability might be achieved through practices such as the Disciplined agile Delivery, DaD, Large Scale Scrum, LeSS, the Scaled Agile Framework, SAFe, or Scrum of Scrums, SoS. Most of these scaled frameworks use Scrum at the team-level (Diebold, Schmitt, & Theobald, 2018).

Agile is known for being flexible, adopting 'just enough' planning at the design front end. Its frameworks are based on a series of timeboxes that gradually deliver business value, in close involvement with customer's changing needs. Project details and decisions are deferred in time, since change to the scope is seen as a natural and inevitable occurrence during the development cycle (Choudhury, 2019).

Scrum

Scrum is the most widespread agile framework on the field, being described as a set of values, principles and practices that enhance the aspects of fast feedback, continuous improvement, quick reaction to change and swift project delivery (Scrum Alliance, 2020). Releasing early and often has a positive effect on the return of investment compared to traditional projects, where all the work is released in full at the end. This allows for adjustment to customer, sponsor or end-user feedback, enhancing project value within a lean mindset. This strength can become a liability if no meaningful client involvement is secured throughout the project lifespan (Wysocki, 2019). Most importantly, Scrum is not a linear, standardized process to methodically follow, but a framework for organizing and managing work (Rubin, 2012, p. 13). Schwaber & Sutherland (2017), who were among the Manifesto signatories, identify transparency, inspection and adaption as the three pillars over which Scrum stands. Transparency means there is an explicit and shared understanding of the process, its aspects and responsibilities, assisted by rules, roles, and a common language for its participants. Scrum participants should be keen observers of the produced artifacts to detect issues early on. This way, inspection allows for adaption, and adaption means if the process outputs surpass the established limits, corrective actions will keep the project scope in check. Inspection and adaption are formally exerted during scrum events, also known as ceremonies. Together with roles, artifacts and rules they compose the Scrum practices summarized in Figure 5.

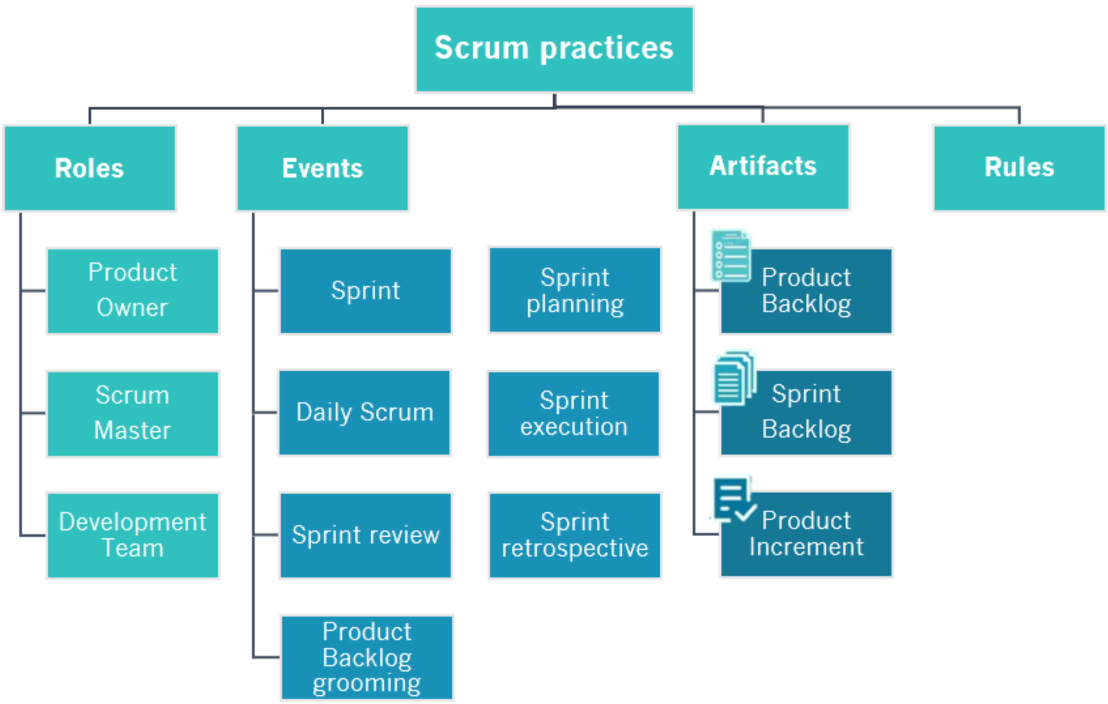


Figure 5 - Scrum practices.
Adapted from Rubin (2012, p. 14)

One or multiple teams can be enrolled in Scrum, each having its Product Owner (PO), Scrum Master (SM) and Development Team roles. Typically, teams are small, not exceeding 10 people. The PO is responsible for the technical viability of the working project solution, selecting and prioritizing the features to be developed on a given time-period (sprint). The SM, in its turn, stands as a mediator between the team and those outside of it. It is a servant leader, enforcing Scrum values and principles for all project stakeholders. Because of its pedagogical nature, the role resorts to soft skills such as communication, negotiation, openness, and other basic psychological and sociological traits (Maximini, 2015). It promotes the team and its individuals to the best of their performance and abilities, be it by translating to them the PO needs (project goals and scope), removing impediments to their productivity, facilitating Scrum events, etc. (Schwaber & Sutherland, 2017). The PO and SM roles replace the role held by the Project Manager (PMg) in classical frameworks. The Development Team role befalls those that do actual work on project deliverables. Ideally, Scrum teams are cross-functional and self-manageable, to a degree that they can define the best way to independently achieve the goals set by the PO for each sprint. Figure 6 shows how the Scrum process unfolds.

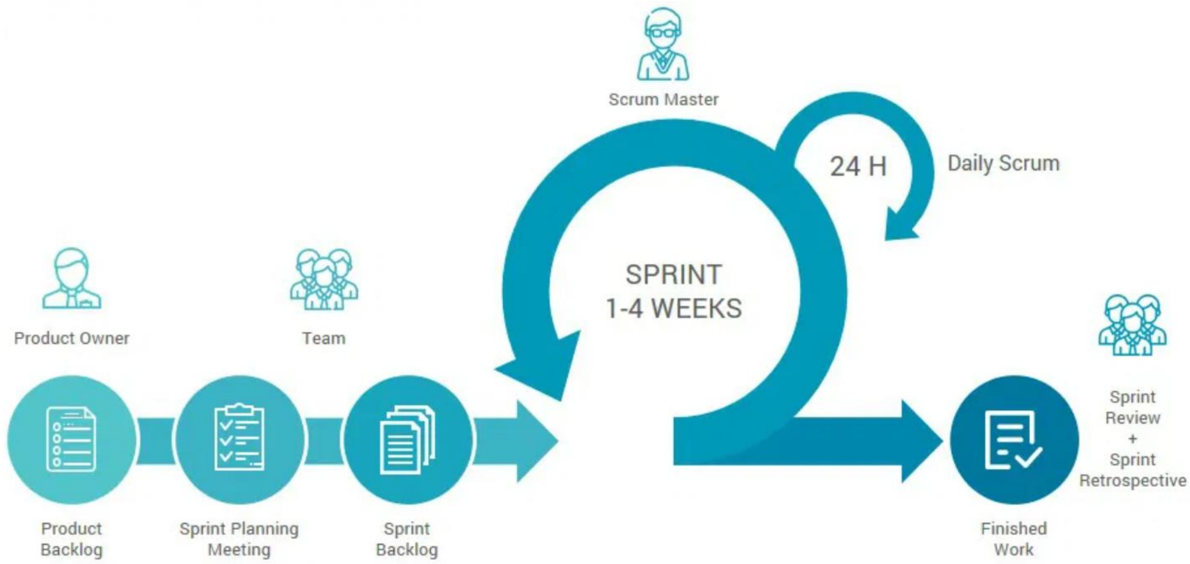


Figure 6 - Scrum workflow process
(Ringham, 2019).

The PO has product leadership and sole responsibility for defining what features and functionalities the finished Product Increment (PI) must include (Rubin, 2012). Those product characteristics go into a poll known as the Product Backlog. Since the PO is the customer's interface, it has the duty of grooming the Product Backlog, i.e. keeping it up to date, organized and clear to everyone. The PO consults with the team at the Sprint Planning, where the next to-develop features are loaded from the Product Backlog into the upcoming Sprint Backlog.

In Sprint Planning, the amount of work covered by a team sprint can be predicted by resorting to estimation techniques, which translate team effort into feature size, and that size into duration (Figure 7).

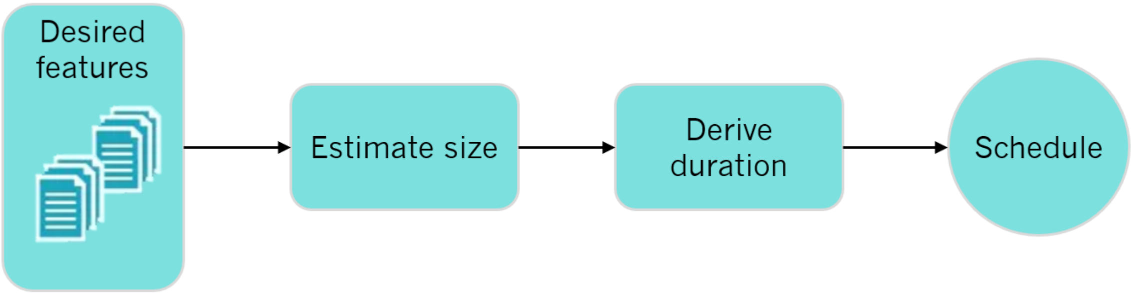


Figure 7 - Agile planning - estimating the duration of a project starts with estimating its size.
Adapted from Cohn (2005, p. 34).

Estimation techniques include expert opinion (asking someone who has the experience), analogy (comparing and rating items against each other), and disaggregation (breaking work items into more manageable bits). Planning poker is a famous technique that potentially combines the best of these (Cohn, 2005).

For the duration of the sprint, which can last for 1 to 4 weeks, the team will process the Sprint Backlog items. During that time, it will hold Daily Scrum meetings, coached by the Scrum Master. These meetings last for 15 minutes and are meant to inspect progress towards the sprint goal. An actionable plan should be defined for the next working day, which is why many prefer to have it early in the morning.

The remaining project meetings, Sprint review and Sprint retrospective, are both reflective ceremonies. The first has the Scrum team and other project stakeholders accessing the product increment achieved progress, discussing any changes to the project environment, and adjusting the Product Backlog in tune with potential risks and opportunities. It is not meant to be just another review presentation, but to foster discussion about project definition (Schwaber & Sutherland, 2017). Sprint retrospective also has that purpose, but it rather focuses on the framework improvement by eliciting individual feedback about interactions, processes and tools. With Sprint reviews, the team should be able to demonstrate PI functionality, which complies with an agreed Definition of Done (DoD). As a rule, if the processed Product Backlog item does not meet the DoD, it cannot be presented at the review, much less be a released product feature. DoD, along with short iteration cycles and continuous integration are deemed essential Scrum practices (Williams, 2012).

Kanban

Kanban, as an Agile method, is derived from a production process control system of the same name, created at Toyota. Kanban was incorporated into the renown Toyota Production System, a precursor to Lean production. At its core, Kanban is about reducing process waste, that is, all non-value-adding activities that lie in between system input and output (Holweg, 2007). This was first applied to workstreams of Toyota's manufacturing sites in the 1950s, but eventually made its way to project development offices everywhere.

One of Kanban's benefits is that it provides a visualization of the project workflow. The project team can map its value stream in a Kanban board (Figure 8), categorizing work items according to different states of execution (typically: to do, work in progress (WIP), done). Other principles, besides workflow visualization, aid the successful implementation of the Kanban method. These include limiting WIP, flow measure and management, explicit process policies and drive for continuous improvement (Tarne, 2011).

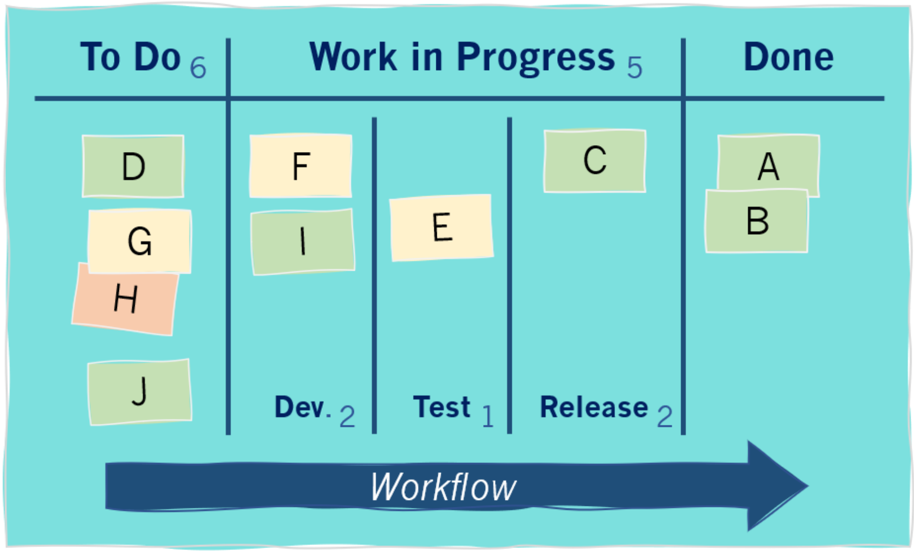


Figure 8 - Kanban board conceptualization.
Author's elaboration.

Kanban splits the project or development cycle work into pieces, which are given a certain status (it is up to the team to define which to differentiate). The team may meet on a daily stand-up meeting to review task progress. WIP is limited to a maximum number of items that can be under a certain development phase at a time (as exemplified in Figure 8). This should reflect the team's capacity and commitment to handle a certain amount of work. It also mitigates the entropy that would be caused by multitasking – like machines, people have non-productive set-up times shifting from one job to another. There is an average time for a work item to traverse from one end of the workflow to the other – this is the cycle or lead time, which should be optimized to be as small and consistent as possible (Tarne, 2011).

Like Scrum, Kanban is a pull scheduling system where the team decides to draw in additional Work Packages (WP) when ready to absorb them. As in Scrum, team self-organization and coordination play a crucial role in the framework efficiency (Poppendieck & Poppendieck, 2003). This is in contrast with prescriptive, traditional planning, where the schedule is pushed in from the outside.

Both Kanban and Scrum are lightweight PM methods, with some remarkable differences. Whereas Kanban limits WIP to workflow state, Scrum limits it to one sprint. This means value increments are scheduled independently in Kanban (Corona & Pani, 2013). In Scrum, changes to the workload of a planned, ongoing PI would be considered exceptional, whereas, in Kanban, task prioritization can be reflected on the process To Do queue, virtually, anytime, if WIP limits are respected. The framework does not prescribe roles, nor does it have established meeting times (ceremonies). The Kanban board can be of use to multiple teams and holds for more than one PI, while in Scrum, the Sprint backlog is team exclusive and resets after each cycle. All in all, Kanban poses fewer constraints and could be said to be a more flexible framework than Scrum. Differences between the two are summarized in Table 1.

Table 1 - Kanban and Scrum compared.
Abridged from Kniberg & Skarin (2010) *and Tarne* (2011).

Kanban	**Scrum**
Time-boxed iterations are optional. Can have separate cadences for planning, release, and process improvement. Can be event-driven instead of time-boxed.	Time-boxed iterations (sprints) prescribed.
Commitment is optional.	Team commits to a specific amount of work for the ongoing iteration.
Cross-functional teams are optional. Specialist teams allowed.	Cross-functional teams are prescribed.
Uses lead time as default metric for planning and process improvement.	Uses velocity as default metric for planning and process improvement.
WIP limited directly (per workflow state).	WIP limited indirectly (per sprint).
Can add new items whenever capacity is available.	Cannot add items to ongoing iteration (or very exceptionally).
A Kanban board may be shared by multiple teams or individuals.	A Sprint Backlog is owned by one specific team.
Does not prescribe any roles.	Prescribes 3 roles (PO/SM/Team).
Does not prescribe artifacts or events.	Prescribes backlogs, burndown chart, daily stand-up, sprint review and retrospective.
Prioritization is optional.	Prescribes a prioritized Product Backlog.

Scaled Agile Framework (SAFe®)

Agile frameworks have proven quite successful in managing small teams, given there is direct or close contact with the project's customer. Inspired by the paradigm change that Agile Project Management (AgPM) operated in IT development, companies have been trying to expand it to larger numbers of stakeholders (Hobbs & Petit, 2017). But, as it would be expected, coordinating multitudes will bring about additional challenges. A structured literature review from Uludag, Kleehaus, Caprano and Matthes (2018) revealed inter-team coordination, communication and system architecture issues to be the main obstacles in scaling Agile on IT enterprises. As mentioned, Agile scalability might be guided by a handful of better-known frameworks, among which SAFe is one, if not the most used to this day (Hobbs & Petit, 2017).

The guiding values, principles and practices of SAFe are rooted in three different bodies of knowledge. At the team level, SAFe may rely on methods like Scrum or Kanban and still claim the benefits of Agile development principles. But these do not suffice to properly organize at Program or Portfolio level. Therefore, SAFe builds also on systems thinking and lean principles for product development flow (Laanti, 2014). This is reflected in the scaled agile framework's nine principles. According to Knaster and Leffingwell (2019, pp. 55–74) these are:

- *Take an economic view* – Regard business action with parsimony. Deliver incrementally, early and often, to reduce committed cost and sequence jobs to maximize benefit;
- *Apply systems thinking* – Realize not only the developed solution is a system, but everything surrounding it, including the company. Enhance all value streams within the project and those supporting it, especially if they cross technical and organizational boundaries;
- *Assume variability, preserve options* – Change is an inevitable constant, defer commitment to a specific solution if possible;
- *Build incrementally with fast integrated learning cycles* – Deliver value before the end of the project (as opposed to traditional PM). Develop to create knowledge through integration (stakeholder synchronization) and learning (using methods like PDCA);
- *Base project milestones on objective evaluation of working systems* – SAFe iterations and PI milestones include all the major steps that prove there is an incremented value (requirements, design, develop, test, etc.), whereas traditional PM early phase or stage-gates (see 2.1.2 Classical methodologies) do not have working solutions available. In classical PM, the true test comes too late to react.

- *Visualize and limit WIP, reduce batch sizes and manage queue lengths* – Short lead times are more likely to translate into a fast return of investment;
- *Apply cadence, synchronize with cross-domain planning* – Centralized planning is "problematic" for large systems, as complexity is too great and facts change too quickly. SAFe cross-domain, face-to-face PI planning event is central to the framework. Routine communication and events allow people to focus on the variable bits of development.
- *Unlock the intrinsic motivation of knowledge workers* – Monetary compensation or fear of reprimand go only so far in keeping people engaged. The organization must tap into workers' personal drive and growth. Leaders ought to promote an environment of mutual influence, where people voice their opinion, needs and concerns.
- *Decentralize decision-making* – Information takes time to travel, thus escalation to higher authority levels will delay the process. However, infrequent decisions that have a long-lasting impact on the entire solution or economies of scale, should be kept central.

SAFe 5.0 has different scalability levels, each one fitting inside the other (Figure 9). From highest to lowest complexity, these include full, portfolio, large solution and essential SAFe configurations.

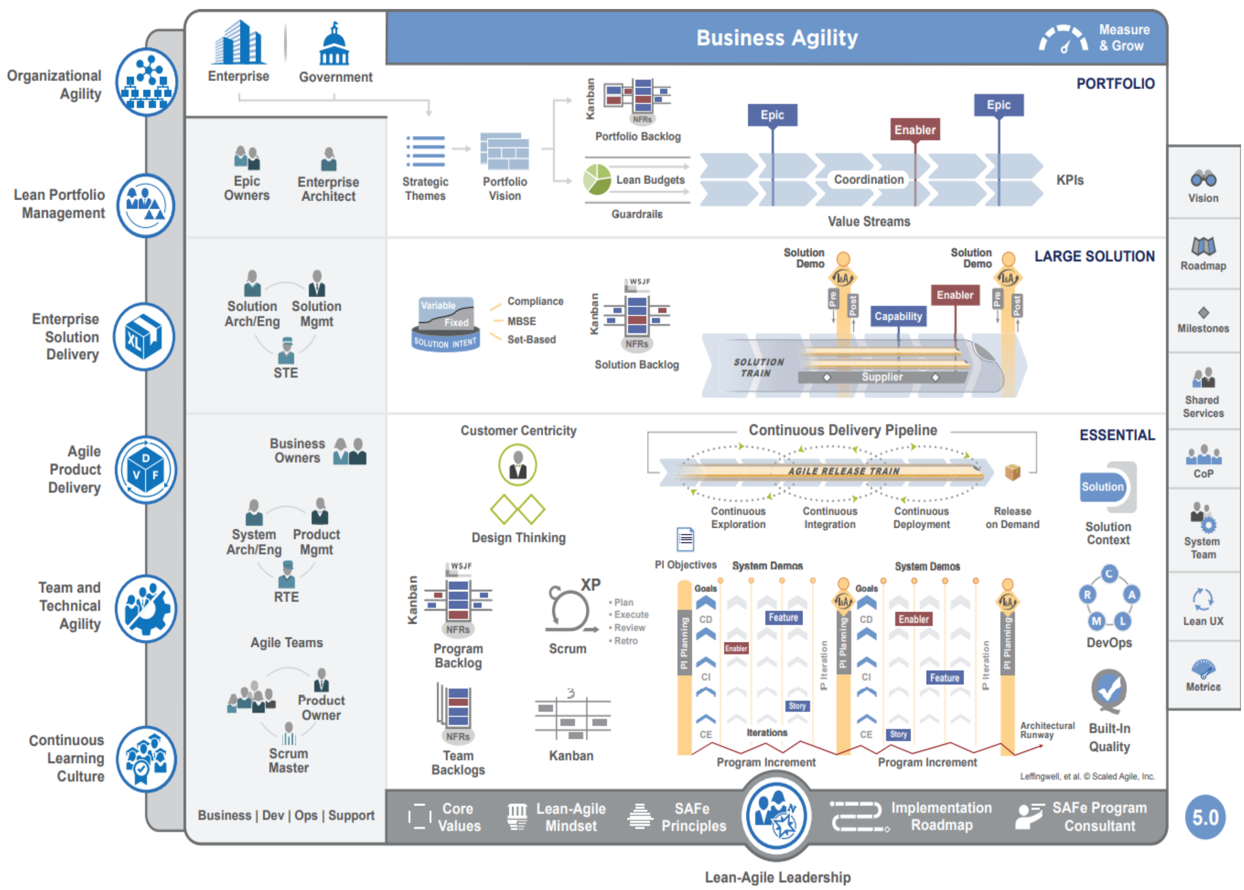


Figure 9 - Full SAFe 5.0 configuration.
(Scaled Agile Inc., 2019a)

Essential SAFe serves as the framework foundation, by merging team and program level in an organizational structure called the Agile Release Train (ART). The ART is a long-lived team of Agile teams and key internal stakeholders, which include e.g. Product Management and Business Owners (see bottom left field on Figure 9). The train sustainably delivers the features and technical infrastructure that makeup business value. Agile teams use Scrum, Kanban and XP (Extreme Programming – another agile method) techniques to build these functioning solutions and enablers. They do so every two weeks, through tested system-level increments, known as System Demos. After four of these, a Program Increment Planning Event (PIPE) is held (thick yellow columns on Figure 9). The ART alignment and coordination is secured through these large-scale, face-to-face meetings. A number of agents help with ART adaptation by synchronizing the teams (Table 2).

Table 2 - Essential SAFe roles.
(Knaster & Leffingwell, 2019)

Role	**Description**
Product Management	Represents the voice of the customer (VOC). Works with PO, which, in their turn, translates customer needs to the Agile Teams. Defines and prioritizes features and enablers on the PI backlog and establishes validation criteria (DoD).
Release Train Engineer (RTE)	Acts as chief Scrum Master for the ART. A servant leader that enables the flow of value e.g. through the program Kanban and by facilitating PI planning and Inspect & Adapt events.
System Architect/Engineer	A single person or a small cross-disciplinary team that defines the whole system architecture. Identifies non-functional requirements, plus the critical aspects and interfaces for its subsystems.

Because the ART is made of several Agile teams working on a single value stream, there is only so much complexity it can carry. Large solution SAFe configuration combines multiple value streams into the so-called solution train. It is another critical organizational structure that leads several ARTs and external suppliers towards a common solution vision, mission and backlog. This scalability level is concerned with a solution intent, a repository for present and future solution options, that supports system definition, its communication, verification and validation. Solution intent is expressed in set-based, option-enabling designs and cross-domain information systems. It also backs compliance and contractual obligations (Scaled Agile Inc., 2019c). At this level, the following roles are defined:

Table 3 - Large solution SAFe roles.
(Knaster & Leffingwell, 2019)

Role	Description
Solution Management	The VOC liaison. Responsible for the solution vision, backlog and roadmap, as well its requirements (features and enablers). Guides the work through the solution Kanban.
Solution Train Engineer (STE)	As does the RTE at the Essential level, the STE is a servant leader that coaches and value-drives the work of ARTs and suppliers alike.
Solution Architect/Engineer	A person or small team responsible for defining the technical and architectural vision of the solution at hand.

At the portfolio level, SAFe aligns strategy with execution by organizing solution development over one or multiple value streams. Portfolio SAFe has the highest level of decision-making and financial accountability. I.e. through budgeting and governance mechanisms, it ensures value streams are directed to the right products and solutions development, thus achieving the company's ultimate business objectives (Knaster & Leffingwell, 2019; Scaled Agile Inc., 2019b).

To summarize, portfolio SAFe is meant to guide the company in its mission, setting and governing the core strategic decisions that create value. Essential SAFe implements that mission, through synchronization and support of the multiple agile teams working at one or more moving solutions. This team-ground level within essential SAFe is the lowest in the framework. For large, complex systems development, there is the optative, intermediate large solution SAFe (Kalenda, Hyna, & Rossi, 2018).

Research findings on the success of agile scalability, hereby SAFe, at higher organizational levels, have yielded scant results (Dikert, Paasivaara, & Lassenius, 2016). Effective customer collaboration, greater project visibility and better communication, coordination and control were found to be driving success factors (Shameem, Kumar, Chandra, & Khan, 2018). Kaufmann, Kock and Gemünden (2020) mention that, in practice, companies have agile portfolio approaches following a combination of frameworks or a self-developed one. Regardless, their study suggests agile capabilities positively impact portfolio success, through emerging strategy recognition across organizational structures. Of course, implementation success factors can become serious handicaps if poorly managed. A recurring challenge companies face on framework rollout is resistance to change (Kalenda et al., 2018; Putta, Paasivaara, & Lassenius, 2018). On this regard, some Manifesto signatories have been generally disapproving of scaling Agile and even openly critical of SAFe® (Hohl et al., 2018). They believe that, despite its intent, it overburdens people with a plethora of new roles, processes, artifacts, etc., and will, in fact, undermine the core values of the Agile Manifesto (Figure 4). This echoes some organizations' perception that SAFe drove them "away from agile" (Putta et al., 2018). Without actual reform of practices and mindset, scaled Agile may be a mere guise of the same bureaucratic, imposed management process of traditional frameworks (Denning, 2015). Such findings highlight the importance of tailoring any PM framework instead of forcing it upon the organization. Communication processes (top-down and bottom-up) also have an important part to play in defining the appropriate configuration to achieve the best strategic, innovative, business potential.

2.1.2 Classic project management and PMLC

Traditional PM is the bedrock of contemporary project management. However, at the turn of the XX century and after decades of consolidation, the reliability of classic PM frameworks was starting to dwindle (Koskela & Howell, 2008). The simultaneous rise of Agile explains why, still today, classic and Agile methods are pitted against each other. Context is important to understand the merits and limitations of each, linked, as they are, to the kind of Project Management Life Cycle (PMLC) they propose to implement. The modern conceptualization of PMLC assumes all projects evolve through a sequence of steps or stages. This started with the representation of networks of project activities, such as PERT, CPM diagrams, Gantt charts and Work Breakdown Structures (WBS) (Maylor, 2001).

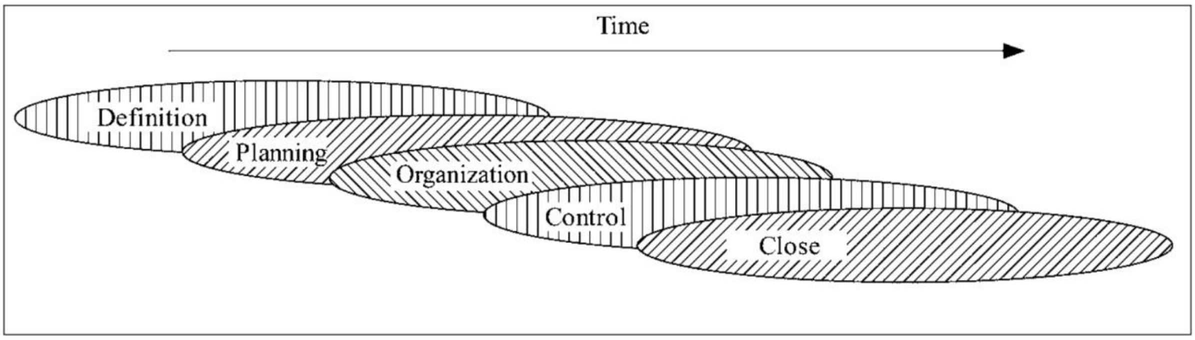


Figure 10 - The project management lifecycle stages.
(Dawson, 2007)

The project is regarded as a process through which system inputs (e.g. budget, resources, requirements) are transformed into outputs (e.g. new products, new processes, other benefits). Traditional PM follows a predictive approach, where project stages, or phases, succeed each other linearly (Figure 10). Dawson (2007) makes a point on how, historically, the PMLC and the product development cycle have been entwined, despite being different things. Royce (1987) described a systematized, product development cycle that became known as the waterfall method. Waterfall was then the paradigm of software development, with project status "cascading" from one project phase into another (Figure 11).

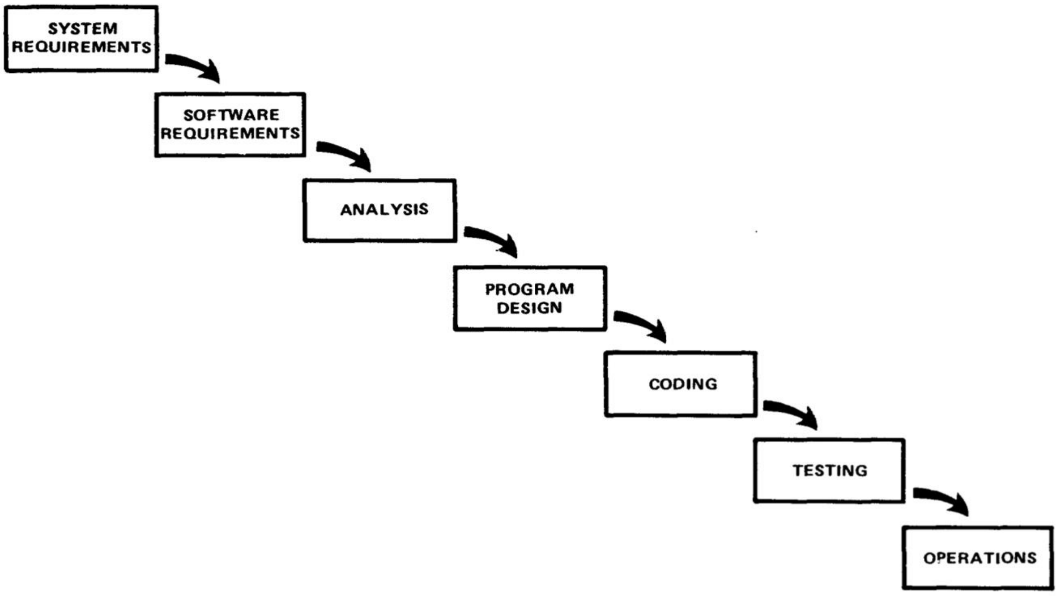


Figure 11 - The waterfall model - implementing steps to large computer program delivery.
(Royce, 1987)

Around the same time, Cooper (1990) made a similar analogy between managing product innovation and a physical production process. He reasoned that, to improve process quality, variance must be removed. According to the Stage-Gate (SG) rationale, project phases are like workstations and, in-between them, quality checkpoints exist to assess output conformity. Only by meeting predetermined criteria at these gates, can the project move on to the next level (Figure 12). In SG models, the call at the gate to either proceed, terminate or put the project on hold belongs to the sponsor and top management.

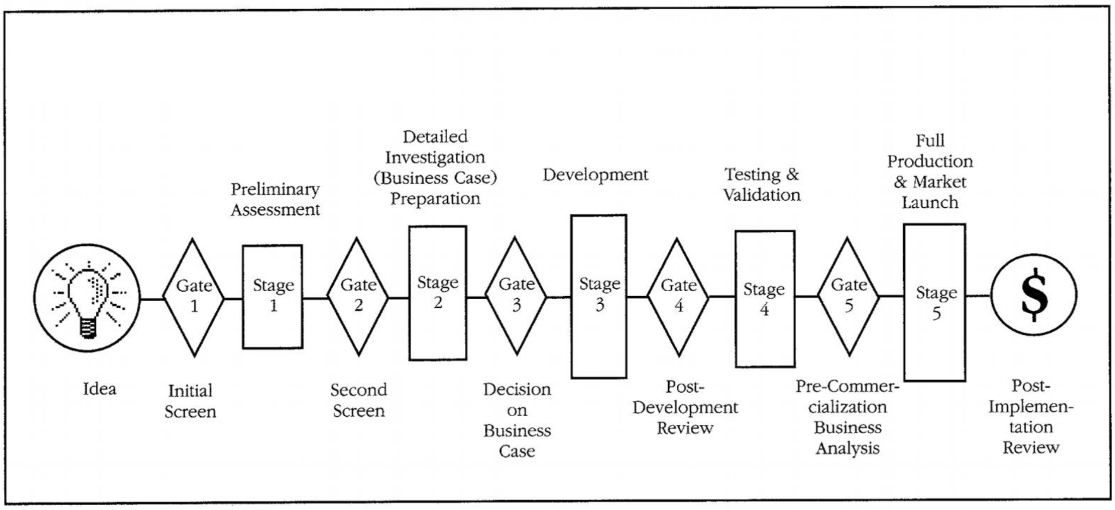


Figure 12 - Overview of a Stage-Gate system.
(Cooper, 1990)

The current PMBOK process-based approach still preserves some likeness to the SG system model. It divides the PMLC into five generic stages or process groups: initiating, planning, executing, monitoring & controlling, closing (Annex 1). About the predictive PMLC it says that it is “characterized by an emphasis on specification of requirements and detailed planning during the beginning phases of a project*”.* Each project phase includes a logically related set of activities that lead to the completion of at least one end deliverable (PMI, 2017a, p. 666)*.* As an ever-evolving body of knowledge though, the PMBOK came to acknowledge that not all projects can be planned beforehand. Its latest edition already mentions AgPM and hybrid management methods. The appropriate PMLC can be traditional (predictive), Agile or an intermediate solution (Figure 13).

Predictive	Iterative Incremental	Agile
Requirements are defined up-front before development begins	Requirements can be elaborated at periodic intervals during delivery	Requirements are elaborated frequently during delivery
Deliver plans for the eventual deliverable. Then deliver only a single final product at end of project timeline	Delivery can be divided into subsets of the overall product	Delivery occurs frequently with customer-valued subsets of the overall product
Change is constrained as much as possible	Change is incorporated at periodic intervals	Change is incorporated in real-time during delivery
Key stakeholders are involved at specific milestones	Key stakeholders are regularly involved	Key stakeholders are continuously involved
Risk and cost are controlled by detailed planning of mostly knowable considerations	Risk and cost are controlled by progressively elaborating the plans with new information	Risk and cost are controlled as requirements and constraints emerge

Figure 13 - Project management lifecycles.
(PMI, 2017a, p. 666)

By following a linear PMLC, classic methodologies are a good fit for carry-over projects or those of a kind that has been repeated multiple times, like construction and installation enterprises (Wysocki, 2019). It is not uncommon for companies or divisions to have one standard product development process, and one PMLC to see it through. It could be, however, that different phases of the same project require different PMLC approaches (PMI, 2017a). Furthermore, adherence to a PMLC depends on the organization's project management maturity level. Recounts from Pennypacker and Grant (2003) and Mullaly (2006) showed a majority of companies operate in environments where PM processes exist but are not an organizational standard. I.e. they are structured but not institutionalized. Management might support the implementation of PM but there is a lack of consistent understanding and involvement with the practice. Functional Managers (FM) gravitate towards the larger, more visible projects that get executed in a systematic way (Pennypacker & Grant, 2003). Wysocki (2019, p. 405) stipulates these low maturity level organizations apply PM methodologies that range from informal, *ad hoc* management to a "carefully crafted and monitored adaption of a commercial model". In practice, if not in theory too, these solutions could be considered hybrid PM approaches.

2.1.3 Hybrid project management

What hybrid PM is, is not consensually defined in the literature, but it can be argued that it reflects the need for a tailored PM solution, capable of answering each project's unique environment. For instance, Ali, Tirumala and Babu (2016) have worked on a hybrid agile model that merges Scrum and Feature Driven Development (another agile method). They have done so hoping to arrive at a solution that overcomes each framework's individual limitations, which is common ground for all hybrid PM attempts. Karlström and Runeson (2005) provide an early and often cited reference of combined use of Agile and classical frameworks. Their case study review of software development projects in large companies describes how Stage-Gate contexts are accommodated for XP (Extreme Programming) teams. Besides the expectable resistance that comes with the introduction of the reform, Agile showed to benefit microplanning and daily work management. It also significantly improved communication, with face-to-face meetings and functioning products yielding better results than written documentation. Cooper (2016) himself has been acknowledging similar gains over the past decade, from embedding AgPM within the stages of the SG model. Baird and Riggins (2012) chose instead to nest a classic planning phase within AgPM (Figure 14).

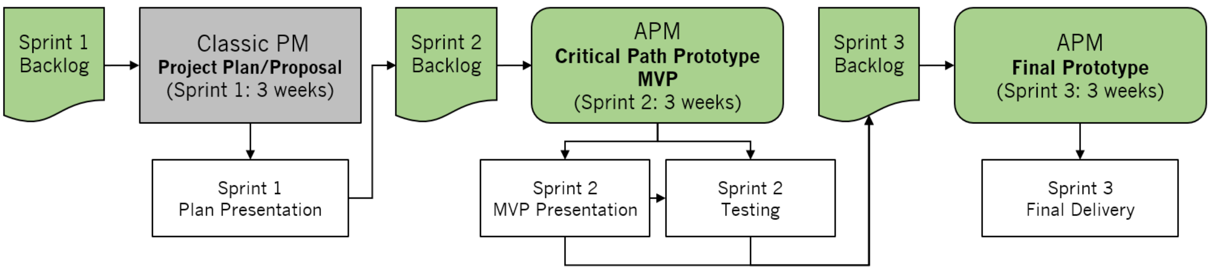


Figure 14 - Applied project process, schedule and deliverables.
Adapted from Baird & Riggins (2012)

The authors found traditional project planning worked well as a catalyst for Agile sprints. Even though it did nothing to reduce project uncertainty or its duration, it provided a well-thought-out kick-off. From a strategic standpoint, they held up the Agile core value of prioritizing working solutions, over extensive documentation, thus instructing the teams to focus the second sprint on "the tasks representing the core, essential components" of the project. By delivering a Minimum Viable Product (MVP), as early as possible, they removed the critical development aspects out of the way for the final sprint.

The hybrid PM approaches mentioned this far either embed or alternate classic and Agile PMLC, at specific abstraction levels or time-periods. This is in line with Wysocki (2019) and the PMBOK (PMI, 2017a) which recommend the selection of different, befitting PMLC to distinct phases of a project. Alternatively, other sources have proposed hybrid solutions by thoroughly mixing traditional and Agile approaches into a single framework.

Traditional PM is usually the starting point for organizations looking to improve their PM processes and SG hybrids are a kind of common approach (Sommer, Hedegaard, Popovska, & Jensen, 2015). For instance, Conforto and Amaral (2016) propose an iterative development approach guided through a phase-based process. Their Iterative and Visual Management Method (IVMM) is stratified into 3 levels, each having a visual whiteboard to promote visibility of project status and performance. The upper level is a SG system, with phases, milestones and macro-deliverables, i.e. the high-level planning. Iteration belongs in the intermediate and lower levels. The authors go to describe how the intermediate level is where the team breaks down and prioritizes the deliverables to develop in each project phase. The lower level is kept for weekly activity planning. These are very much like Scrum practices, especially considering the visual whiteboards (Kanban boards) that aid in the process. Even if without a reference to Product Owner or Scrum Master, the intermediate and lower levels correspond, in fact, to product backlog grooming and sprint backlog. Another Agile/Stage-Gate hybrid proposal by Sommer et al. (2015) similarly divides the NPD framework into 3 levels.

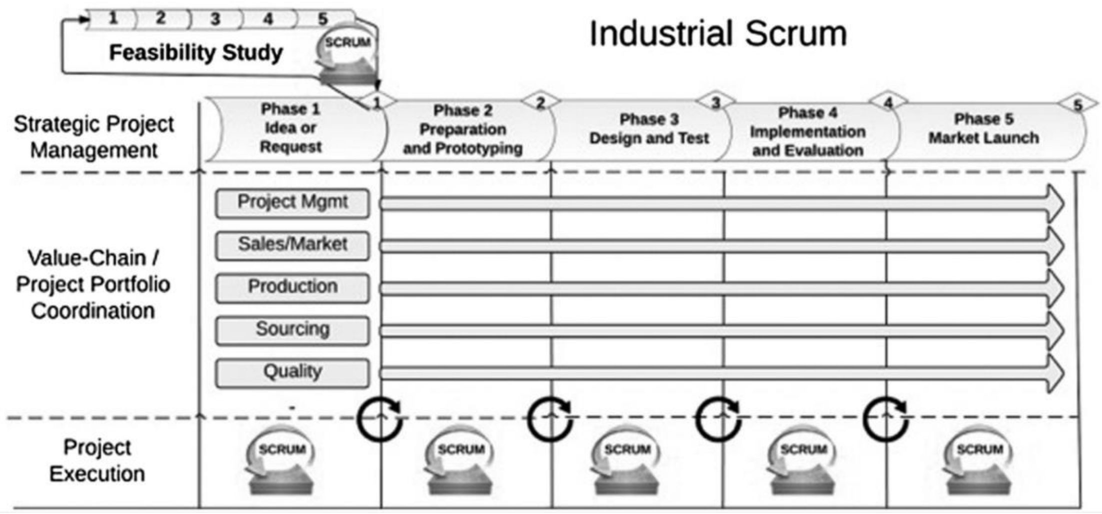


Figure 15 - Agile/Stage-Gate hybrid framework for NPD.
(Sommer et al., 2015)

The higher-level concerns strategic project management and preserves the phases and gates of the SG model. It is overseen by product portfolio management and a steering committee. The intermediate level concerns the value-chain/project portfolio coordination. It is managed by stakeholders from across the organization, who periodically meet around a physical board to coordinate resources. The lower level of project execution concerns the development team, is aided by a PM and applies Scrum methods. What both IVMM and Industrial Scrum (Figure 15) frameworks do is to preserve the SG system at a high organizational level, while using Scrum or other Agile framework at the lowest levels. Schuh et al. (2018), writing on an Agile-Waterfall hybrid, systematized this in a model over which, project high and low abstraction levels interact with the dimensions of structure and process (Figure 16).

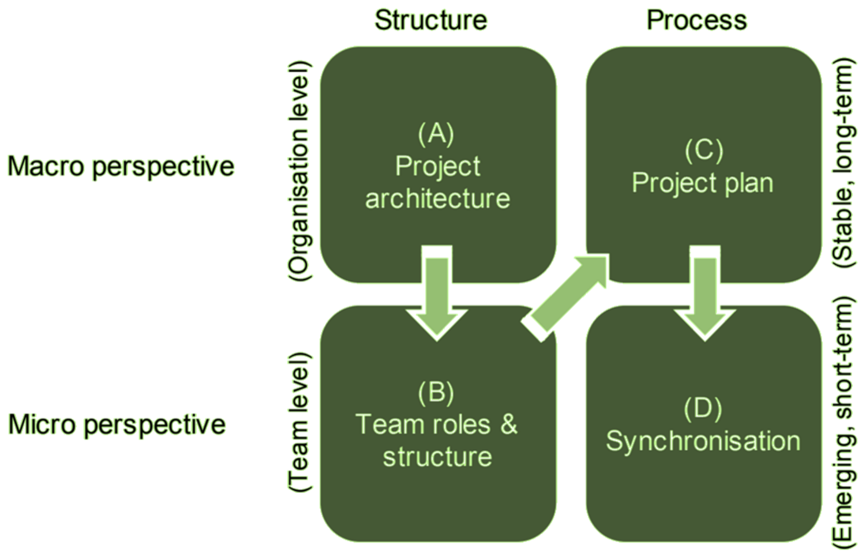


Figure 16 - Hybrid project design defining features.
Adapted from Schuh et al. (2018)

This hybrid PM solution has both traditional and AgPM running parallel through the project life cycle. The overall project organization and long-term commitments belong to the macro perspective layer, which follows SG systems. The micro perspective concerns the emerging, short-term facets of the project that are managed at the team level through AgPM. The structural dimension contains the more fixed elements of architecture, design and work organization features. Process concerns time-related aspects (Schuh et al., 2018). Project architecture (A) should be modular to mitigate change propagation across integrated product scopes. Adapting AgPM beyond software development emphasizes the need for cross-functional teams (B). Even if Scrum roles are not fully adopted, a Product Owner team made up of area specialists should be established. The project plan (C) is long-term but Agile teams can iterate their development cycle several times in between phase gates. Some iterations may even stretch across gates, so long as the teams remain focused on delivering an MVP for assessment. To be self-manageable, the Agile team level requires fully dedicated personnel (Conforto & Amaral, 2016; Schuh et al., 2018). Although Agile values working solutions, documentation shall not be forfeited (Karlström & Runeson, 2005; Schuh et al., 2018). Not only is it essential for operational management, but it also supports project synchronization (D). Synchronization, in its turn, is the centerpiece of this hybrid PM model. As such, Agile practices, such as daily stand-ups and large, face-to-face stakeholder assemblies, should be held regularly (Karlström & Runeson, 2005; Schuh et al., 2018). According to Sommer et al. (2015) the mechanisms that drive the benefits of this hybrid PM model have much left to uncover. There is no quantitative data attesting the parallel use of AgPM in traditional PM based organizations (Schuh et al., 2018). Cooper (2016), who conceived the first SG system nearly thirty years ago, summarizes its most common qualitative impacts: increased process visibility, improved team ownership and motivation, and overall better project communications.

2.2 Innovation projects

Semantically, innovation is associated with novelty: a new idea, a new method, the creation or reinvention of both what is palpable and intangible. Authors such as Lepak, Smith and Taylor (2007) tie knowledge creation and innovation to organizations' ability to create value. Furthermore, the definition of innovation's value in university-industry collaborations and other cross-institutional settings is blurred by multiple innovation sources and recipients. Even so, Chesbrough, Lettl and Ritter (2018) reason that maintaining these symbiotic relationships between institutions is only possible if there is value to be gained for everyone, either during the collaboration's term or later in time. This means that even when such prospect is not formally recognized (Lee, 2000), organizations engagement with innovation may be driven by the management of its perceived benefits (De Fuentes & Dutrénit, 2012; Fernandes & O'Sullivan, 2021).

2.2.1 Innovation typology

In some academic writings, the precept for innovation can be said business or value-driven. Writing on Schumpeter's theory for innovation, Hagedoorn (1996) described innovation as the successful introduction of new products and processes. Around the same time, the distinction between sustaining and disruptive innovation was penned by Christensen (1995). Christensen's perspective rests on the assumption that innovation can be a continuous improvement, based or adding on answers to established consumer needs. Or it can be a breaking force that displaces previously existing solutions, claiming their market share and *in extremis*, rendering them completely obsolete. The premise here is that disruptive innovation challenges the present value propositions/Business Models (BM) on the market, even if it is a by-product of imitation (imitative, copy-cat or me-too innovation) that does not represent a technological breakthrough (Edwards-Schachter, 2018). According to Christensen's model, disruptiveness is a measure of market impact rather than a sign of inherent technological prowess. In Schumpeterian theory, innovation is tied to the concept of creative destruction and the pace of economic and business cycles. Therefore, in reshaping and ensuring the competitiveness of BM, innovation lies in the key-factors that define a company's value function. Not only it resides in patented technology or protectable intellectual property, but also in the organizational structures and arrangements that often prove harder to replicate (Teece, 2010).

Many terms are attributable to innovation as its typology changes across time and literature. It can be defined as a dichotomy (sustaining vs. disruptive, incremental vs. radical, product vs process, open vs. closed) or through standalone epithets (BM, imitative, frugal, social, radical, reverse, value, etc.) (Edwards-Schachter, 2018; Klarin, 2019). Another possible way to look at innovation is problem-centric. Innovation is essentially about addressing new challenges, finding answers to a certain problem. And the same can be said of the purpose of innovation projects. In this light, defining innovation becomes the definition of the problem at hand. In the June 2017 edition of Harvard Business Review, Satell (2017) presents us with four types of innovation (Figure 17): sustaining, breakthrough, disruptive and basic research.

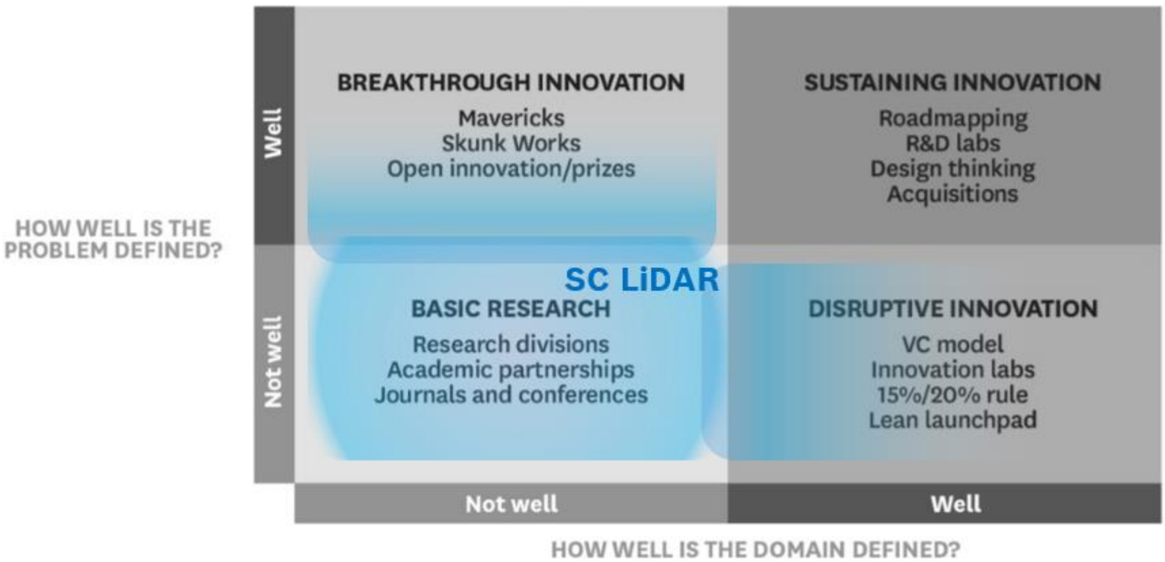


Figure 17 - Types of Innovation.
(Satell, 2017)

Considering the elusiveness of its boundaries, it might be difficult to frame the developing LiDAR technology for automotive application inside a single domain. Nonetheless, it would be safe to say that SC, an academic-business partnership, was primarily designed to expand LiDAR state of the art and knowledge in specific scientific areas. That is the purpose of basic research projects that deliver low technology readiness level products. These require special handling before the stages of application, industrialization and marketing can take place (Kerzner, 2019). This does not exclude, however, that the project benefits from an open innovation kind of model. The problem is exposed to a not well defined, varied set of individual skills and competencies across institutions. Furthermore, there is also a chance for disruptive solutions to sprout from ingenious team members working on the project. There could also be room for personal pet-projects (15%/20% rule) since the problem scope is not too well defined at the subsystem level.

2.2.2 Innovation project factors and features

Categorizing innovation can be a strenuous task. Gatignon et al. (2002) approach to assessing innovation exemplifies that, sometimes, innovation types and innovation characteristics are used interchangeably. Even so, there must be some common features that characterize innovation projects and environmental factors that typically influence them too.

Looking at the factors that influence the outcome of this kind of project, a distinction between internal and external variables can be made. External factors include, e.g. the company's relation to human capital and the extent of innovation spillovers. Issues about Human Resource Management can also be entwined with a number of factors at the internal level, including project leadership style, existing decision-making processes, and the larger organizational structure and *ethos.*

Innovation spillovers and HR

Knowledge creation and diffusion play a crucial part in a company's innovation projects. Spillovers can be defined as the involuntary escape of critical information from the collaborative innovation process. There is evidence that such transfer not only happens between institutions in geographical proximity but, perhaps even more importantly, within technological proximity (same knowledge base) (Azoulay & Lerner, 2012; Bouba-Olga, Carrincazeaux, Coris, & Ferru, 2015). Innovation spillover effects are further complemented by the social proximity, or degrees of separation, between innovation agents (researchers, scientists, engineers, etc.). Different types of non-geographical proximity were factored in by Marrocu, Paci and Usai (2013) when analyzing interregional knowledge transfer across 29 European countries. They have found that all proximity dimensions significantly affect innovative performance, again, suggesting that technological proximity is more important than geographical nearness. Although some authors argue that innovation spillovers are not as impactful as direct R&D investment (Ugur, Churchill, & Luong, 2020), it does not demerit the importance of its driving factor: human capital; specifically of graduates, crucial to internal knowledge creation and its absorption from outer sources (Donate, Peña, & Sánchez de Pablo, 2016). Thus, even if spillovers are an inevitable factor in the business environment, it can be argued that managing them is linked to the project ability to seize and maintain its assigned Human Resources (HR). Features such as innovation incentive systems and team motivation, often referred to in literature, are key to counter employee mobility and the sensitive information leakage from the organization's projects that it entails (Azoulay & Lerner, 2012, p. 578; Haneda & Ito, 2018).

Leadership style

Leadership is a driving feature in managing projects (Dias, Tereso, Braga, & Fernandes, 2014; Hunter & Cushenbery, 2011). Along with strategy, it is a critical factor for successful product innovation (Cormican & O'Sullivan, 2004). In the face of the project's exploratory nature, leaders have to balance a number of aspects. They must assist the development of the innovatory content through several stages, motivate and stimulate a creative environment, mediate stakeholder dynamics, all the while ensuring the project remains time, cost and quality compliant (Enninga & Van Der Lugt, 2016). Research on leadership covers multiple styles, transformational leadership being one regularly associated with innovation (Haneda & Ito, 2018). The PMBOK describes the transformational leader as someone capable of "empowering followers through idealized attributes and behaviors, inspirational motivation, encouragement for innovation and creativity, and individual consideration" (PMI, 2017a, p. 65). The project lead is then tasked with nurturing team development, providing opportunities for the individual to perform and learn (Jiang & Chen, 2018). Empowering leadership behavior includes e.g. coaching, delegating, informing and displaying concern for the team. Leadership exertion, however, should not be static in time. Different projects, or different moments, may ask for distinct leadership styles. Empowerment is, according to one of Merriam-Webster's online Dictionary entries, "(...) the granting of the power, right, or authority to perform various acts or duties" (Merriam-Webster, 2020). When spreading out power, or authority, a transformational or servant leader is making concessions. Although increased individual and team autonomy is desirable, empowering leadership should not be seen as bland or indecisive. Certain teams, or certain work cultures, may even be predisposed to a more directive kind of style. In such contexts, managers are left with no choice but to take control of the work process and be leaders by example (Jung, Chow, & Wu, 2003). Otherwise, a lack of purpose may hamper the teams' creative focus and leave the project in disarray.

Overall, research on hierarchy of authority has yielded mixed results. As suggested, delegating on the team can potentially increase the sense of ownership, responsibility, and proactivity, however, it might introduce behavioral ambiguity within its structure. As such, team members in loosely defined roles, having divergent goals, will likely compromise performance of any type of project (Nederveen Pieterse et al., 2019). It is up to the PMg or project leader to provide measure and keep this balance in check. Leadership and authority exertion are felt not only at team level, but at upper organizational levels too.

Organization type and structure

Hierarchy and organizational structure are often used as exchangeable terms. Primarily, this formal hierarchy reflects the expectable relation between the organization's employees across its ranks, i.e. the formal, vertical alignment of positions (Figure 18), from which top-down monitoring and control are exerted (Diefenbach & Sillince, 2011).

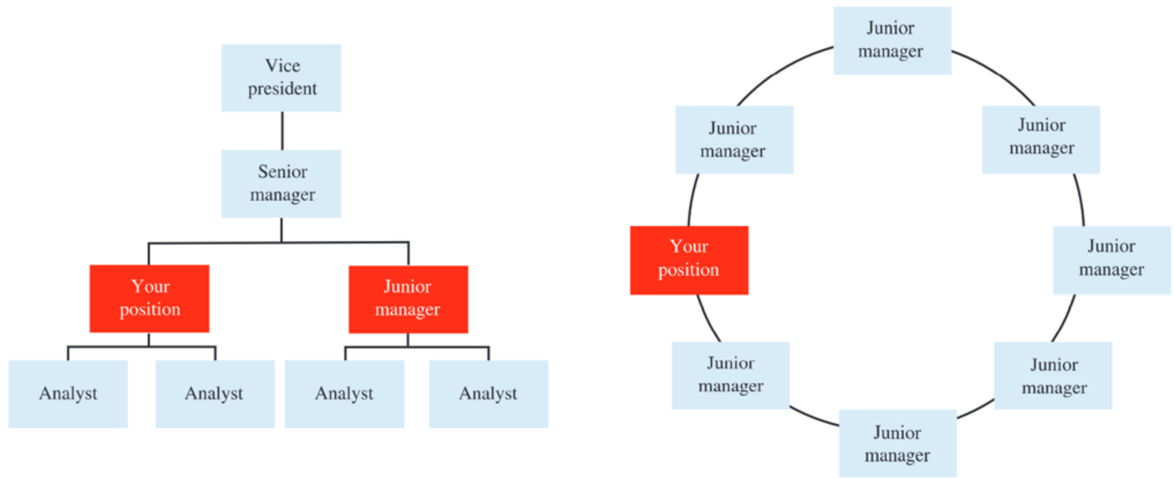


Figure 18 - Hierarchy vs. No hierarchy (polyarchy).
(Keum & See, 2017)

Despite the rules and procedures that characterize a departmentalized work environment, employees are social beings. Through e.g. personal values, attitudes and speech identification, their interaction will gradually build into informal hierarchical systems. This way, informal hierarchy binds people through a sense of affinity, while formal hierarchy does so by a sense of duty. Some argue that organizations, especially new ones, have a better response to innovation challenges because of the collaboration ease that more prominent informal hierarchies allow (Naranjo-Valencia, Jiménez-Jiménez, & Sanz-Valle, 2011). The establishment of implicit, informal hierarchies, also known as organic structures, is not without its problems. When individuals, whole teams, or even managers derive sense from different underlying networks (social recognition vs. functional expertise), lack of peer and decision legitimacy will torment project coordination (Lahiri, Pahnke, Howard, & Boeker, 2019). The potential power play that stems from this is vernacularly known as workplace politics. Former research already signaled that innovation projects, reliant on the coordination of heterogeneous groups of people, tend to shift from holistic stakeholder interests towards politics of process and politics of meaning, i.e. to networks of people that form, coordinate and fold around particular project interpretations (Swan & Scarbrough, 2005). It should be noted that these informal structures stretch beyond department or organizational boundaries, whereas the manager's formal power does not. Keum and See (2017) argue that de-emphasizing (formal) hierarchy's influence is, in fact, good for creating ideas at the project start. Still, as tempting as it may be to democratize the innovation process, they found more centrality and control during the phases of evaluation, selection and development, will limit participant bias and improve idea worthiness.

Research has also investigated the types of organizational structures that are more likely to carry innovation projects through. Annex 2 shows a summary of possible organizational types and how they relate to some project characteristics. Without going into detail, a brief comparison between the project-based and the traditional or function-based organization will be made. As the names suggest, the first is high on project-centeredness and low degrees of bureaucracy and hierarchy. The latter revolves around organizational silos, or departments, led by Functional Managers (FM) who have almost absolute authority over divisional resources. In project-based organizations, project interests are of utmost importance and often represent those of a specific customer. The aerospace, automotive, computer and electronics industries are typically project-based (Kerzner, 2017). At these companies, PMg influence and authority

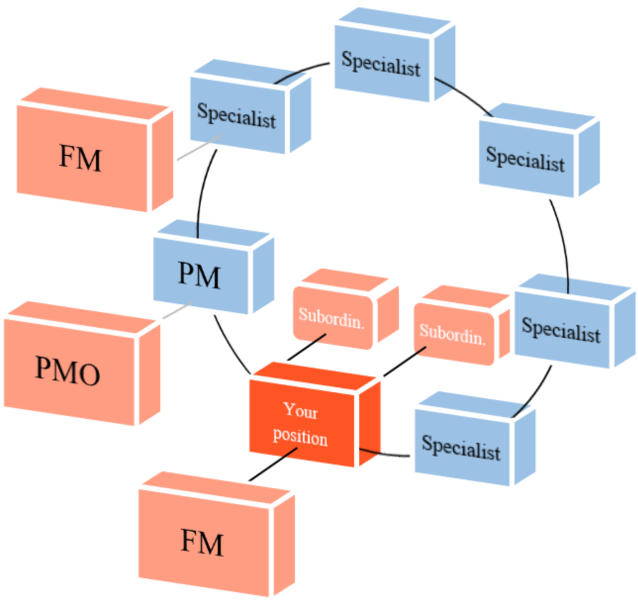


Figure 19 - Conceptualization of hybrid project structure with functionalized PM. Author's elaboration.

outweighs that of the FM. The same might happen in strong-matrix and other hybrid configurations where management itself is functionalized within the structure (Figure 19).

Usually, PMs do not exist in centralized, traditional structures, and when they do, they likely act as coordinators whose decisions have to appeal FM. Evidence found by Blindenbach-Driessen and Van Den Ende (2010) shows that strong project leadership is more significant for innovation performance in project-based than in non-project-based firms. The authors hypothesize that project leaders might assume different roles in each structure. While they tend to "(…) coordinate, translate and integrate demands (…)" in functional organizations, in project-based settings, they champion innovation and ensure its outputs are incorporated into future business projects. This is what they do best, hypothetically, since, the authors argue, having fewer divisional boundaries frees them from their coordinative concern. But what about that they cannot do? One could argue that with poor role adaption or definition, strong project leadership could be nullified by the clash of interests where project and functional leads coexist (e.g. functional, matrix or hybrid structures) (Kuprenas, 2003). This would suppress strong leadership expression in non-project-based settings as well. Rallying senior management support was found to be equally important for the innovative ventures of all organizational types (Adams, Bessant, & Phelps, 2006; Blindenbach-Driessen & Van Den Ende, 2010). The pivotal role of innovation promoters (champions), and other key persons in proven innovative organizations, is substantiated by abundant research too (Goduscheit, 2014; Hauschildt & Schewe, 2000).

Decision-making

As mentioned in the first chapter (1.1 Background & motivation), decision-making in innovation projects is influenced by complex stakeholder environments. It is to say that the form and size of the organizational structure will proportionally shape the company's decision processes. Up until recent years, an idea has been gaining hold, that project-based organizations make fast and better use of the knowledge delivered by their project portfolios (Gemünden, Lehner, & Kock, 2018). This might be ascribed to the organization's willingness to let its innovation policy be guided by demographically diverse project teams, with rich and complementary knowledge backgrounds (Reagans, Miron-Spektor, & Argote, 2016). Or it could be because less regulatory, open innovation models have seen organizations setting up projects that tap into external, differentiated resource polls, now that they work closer to academia and other business (Chesbrough, 2012; Zhang & Wu, 2017). Despite the evidence, and likeliness, that successful innovation benefits from more available ideas and better-informed decisions, today, there is still not an ideal decision level or organization type, that proves superior to deal with agent bias and the many risks that surround project decisions (Will, Al-Kfairy, & Mellor, 2019). In an increasingly *projectized* society, attempts at devising and implementing the ideal project-based organization are checked by the perils of dismissing the classical foundations of hierarchy and line management. Organizations leaning towards the project-based rationale should be aware of this "(...) and find ways for the functional hierarchy and project structures to work together" (Miterev, Mancini, & Turner, 2017).

2.2.3 Practices in managing innovation projects

Literature has come to describe innovation as a buzzword, and innovation projects as soft or explorative in kind. As previously referred, innovation differs from conventional projects in the sense that its fundamental uncertainties are at odds with the deterministic, controlling instruments of classical management methods (Kapsali, 2011). Because of its exploratory nature, it is an empirical, iterative process of trial and error, with unforeseeable uncertainties that, some argue, "render the rational approach irrelevant" (Lenfle, 2008). However innovative, projects do not share the same amount of uncertainty, nor does that uncertainty lie along the same project dimensions. Unclear or intangible goals, incomplete information, multiple solutions, subjective measures and stakeholder expectations are some of the many variables that make for a soft project scope (Atkinson, Crawford, & Ward, 2006). To manage innovation, management itself might have to innovate, steering from the plan-driven or agile methodologies' domain, where both ends of the project (problem and solution) are known and defined to some extent (Chapman & Andersson, 2017). Furthermore, other research fields, like design theory, start to mingle with PM. Some organizations' business development (through innovation) is now drifting from project-based management to design-based approaches (Ben Mahmoud-Jouini, Midler, & Silberzahn, 2016; Maniak & Midler, 2014). Hidalgo and Albors (2008) compiled a generous list of Innovation management Methodologies and Tools (IMT) from a number of sources. The authors surveyed industry and services across 15 European Union member states and, from nearly 500 retrieved questionnaires, found that PM and Business Plan (BP) development were the mainly used IMT, with 82 and 67% adherence, respectively. Albeit not making use of IMT, 32% of respondents were knowledgeable of these. Figure 20 puts PM techniques in perspective, as it represents one of many possible aspects to innovation's management. Some thinkers reason that the rational process model has kept PM practitioners from considering other kinds of project logic (Eppinger, 2001; Lenfle, 2016). It would be fair to assume, nonetheless, the use of IMT to be complementary. In other words, the answer to the unique degree of uncertainty each innovation project has, lies not in just one technique, but in a combination of many. Design thinking, systems thinking, concurrent engineering and other research fields do not rule out traditional PM, but rather look for the better balance between these and more flexible instruments (Kapsali, 2011). Detail on the some relevant IMT follows.

IMT typologies	Methodologies and tools
Knowledge management tools	Knowledge audits Knowledge mapping Document Management IPR Management
Market intelligence techniques	Technology Watch/ Technology Search Patents Analysis Business Intelligence CRM: Customer relationship management Geo-marketing
Cooperative and networking tools	Groupware Team-building Supply Chain Management Industrial Clustering
Human resources management techniques	Teleworking Corporate intranets On-line recruitment e-Learning Competence Management
Interface management approaches	R&D - Marketing Interface Management Concurrent Engineering

IMT typologies	Methodologies and tools
Creativity development techniques	Brainstorming Lateral Thinking TRIZ Scamper Method Mind Mapping
Process improvement techniques	Benchmarking Workflow Business process re-engineering Just in Time
Innovation project management techniques	Project management Project appraisal Project portfolio management
Design and product development management tools	CAD systems Rapid Prototyping Usability approaches Quality Function Deployment Value analysis
Business creation tools	Business Simulation Business Plan Spin-off from research to market

[1]Developed by authors based on various sources (Thom, 1990; Cordero, 1991; European Commission, 1996; Ram, 1996; Libutti, 2000; European Commission, 2005; Scozzi and Garavelli 2005; Phaal et al., 2006).

Figure 20 - Innovation management methodologies and tools.
Adapted from (Hidalgo & Albors, 2008)

Planning and controlling

There are two predominant approaches to planning, rooting back to the rational and adaptive schools of thought. According to Mintzberg (1987) "(...) strategies can form as well as be formulated", i.e. planning for a project can be an explicit, deliberate effort or have an implicit, emergent approach.

The rational take on planning is an act of prediction. Generally, it comprises a linear sequence of activities, including the project main path (baseline), and some contingent detours that accommodate for the possibility of setbacks. Classical PM references, such as the PMBOK® and PRINCE® (Projects in Controlled Environments), are corollary to such an established practice of structured, prescriptive planning. Even if readily associated with time (schedule) constraints, formal planning processes may apply to all project knowledge areas (see Annex 1). Under such logic, project execution is preceded by a planning phase. In traditional PM, the project plan is typically elaborated from the Project Charter (PC). Therefore, the level of definition of the charter will be reflected on the level of detail of the plan. Such detail will include the project purpose, overview, schedule, stakeholders, resources, risk and evaluation methods (Meredith et al., 2017). If both project uncertainty and complexity are low, classical planning with integrated risk management should equate to high project performance, as opposed to project learning and selection during execution, which are more expensive approaches (Loch, Solt, & Bailey, 2008).

For highly explorative innovation projects, planning has limited applicability however, because of the absence of traditional elements to it, like a schedule, feasible task breakdown (WBS) and clear, concrete objectives (Lenfle, 2008). Furthermore, innovation is a complex learning process that often needs to repeat past tasks, because of interdependencies. New findings might change the worth of the already executed portion, and their frequency can make of constant re-planning a burdensome effort. Whereas classical PM actively resists such change, to enable the application of formal process controls, AgPM iterative development expects and embraces it (Meredith et al., 2017). PM standards, such as the PMBOK®, have now updated to include agile frameworks, recognizing the need for such adaptability during project execution. In between classical PM and formal AgPM frameworks, some intermediate solutions have emerged since. Collyer et al. (2010) summarize a few planning styles in dynamic project environments:

- "Environmental manipulation" – traditional methodologies, like waterfall detailed planning, where change to project environment and scope is suppressed to better control execution.
- "Emergent planning" – also known as rolling wave, iterative or progressive planning. The plan is a sketch or temporary grid over which experimental work is laid on (Lenfle, 2008). AgPM frameworks belong in this type of planning, with feedback or learning loops at its core; also associated with prototyping.
- "Staged releases" – the smallest possible scope is released early on. It is associated with the Minimum Viable Product (MVP) concept for lean start-up enterprises (Hart, 2012). The least expensive pilots are released to market to collect quick feedback for further versioning. Not to be confused with release planning, which is belongs with formal AgPM frameworks.
- "Competing experiments" – simply put, the strategy of launching several investigation routes simultaneously, to rapidly pin down the optimal or most promising one.

- "Alternate controls" – whereas classical PM focuses on the in-between process control, this approach focuses on the involving inputs and outputs, like team selection, clear goals and reward (Collyer & Warren, 2009).

The importance of alternate, informal controls counterbalances project reliance in traditional ones. Some research has shown that initiating projects are more dependent on formal process control and may gradually shift towards more serviceable configurations (Heales, Susilo, & Rohde, 2007). This appliance of IMT parallels the previously discussed effects of hierarchy on the project's outcome. I.e. organic (informal) and mechanistic (formal) control forms seem to have complementary effects and contribute to enhanced innovation performance (Ylinen & Gullkvist, 2014). Barbosa et al. (2020) configurations for high achieving, open innovation R&D projects include a planning approach combined either with partner integration or open and continuous communication. Less formal control is not always the answer, however. For instance, at higher organizational levels, a Stage-Gate systems approach proves effective for managing NPD contexts, even if traditional PM at project level starts to lose its efficiency as the degree of innovativeness increases (Schultz, Salomo, De Brentani, & Kleinschmidt, 2013).

Brainstorming

Brainstorming is an individual or group ideation process that gained popularity as a problem-solving technique. The term was first penned in the 1950s, on Alex Osborn's seminal work *Applied Imagination*. Osborn (1953) originally defined four working principles or rules to conduct brainstorming sessions. Since then, brainstorming and its rules have been tried, expanded and contested in several research fields, mainly those of Psychology and Management (Litchfield, 2008). The original four principles come as follows:

- (a) Criticism is ruled out – judgement must be deferred. The purpose of brainstorming is to generate, not evaluate, as many ideas as possible.
- (b) "Free-wheeling" is welcomed – even the wildest ideas should be voiced. Today, this is known as thinking outside the box.
- (c) Quantity is wanted – the chance of a useful idea increases with the number of ideas; the more, the better.
- (d) Combination and improvement are sought – participants might suggest improvement on previously shared ideas, or that two or more ideas are combined into a single prospect.

While the first three points promote quantity and flexibility of ideas, the fourth is meant to enhance conceptual combination. One challenge organizations face when resorting to brainstorming is the ability to define expectations for idea generation (Kalargiros & Manning, 2015). It is to say, brainstorming does seek to be a creative process, but goals must be set to keep it a bound effort. The facilitator, a role that may befall the PMg, is the one ensuring brainstorming remains focused. Research has shown, the preceding expectation that managers have will influence the creativity output of project teams. Management initiation, support and recognition of creative effort will yield better results (Tierney & Farmer, 2004). But even if teams dispose of rules and a referee, one cannot but wonder, looking at Osborn's rules: how can we combine and improve ideas without judging? Would it not be violating one of the other premises?

The truth is that brainstorming as a tool for innovative enterprises faced tight scrutiny from the beginning. Since Osborn's first work, a number of authors consistently proved that idea generation of single individuals outperformed, both in quantity and quality, the output of brainstorming groups (Furnham, 2000; Lamm & Trommsdorff, 1973). Kalargiros and Manning (2015) reason these comparative studies mostly happened in the absence of facilitators. For this, they point to research also supporting that groups can match or surpass the combined output of individuals working in isolation, when trained facilitators guide those groups. Such findings hint at underlying trade-offs that come with each rule or expectation given to brainstorming participants. Litchfield (2008) explains these phenomena derive from the different interpretations each individual has of brainstorming rules. These rules function as temporary project goals. He argues that even if brainstorming's main goal is idea creation, "other goals may be inadvertently activated" in the process. For instance, the goal set to increase the quantity of ideas (c) might trigger competition for the greater number of contributions between participants. Leaving criticism out (a) is no easy feat either, as some people do not try to, nor do they believe others can refrain from judging. Judging may then turn brainstorming sessions into status auctions, by putting participant reputation at stake. While some personalities thrive with such exposure, others might shy away from sharing their knowledge. Furthermore, combining ideas (d) manifestly requires cognitive processing of others' ideas, and individuals might abandon their own line of thought to participate in someone else's. Given such dynamics, it is fairly evident how the summed-up ideas of individuals could surpass the work of a group, or when a facilitator could intervene to keep the latter in check.

Brainstorming popularity comes from its early years and lingers to this day. However, group brainstorming keeps being mistaken by a complete problem-solving process (Trott, Hartmann, Van Der Duin, Scholten, & Ortt, 2015). What often happens is that the phases of idea generation, refinement and evaluation are confounded into a single brainstorming event or, worse yet, into a single task (Kalargiros & Manning, 2015; Litchfield, 2008). Such eagerness to get results undermines this IMT usefulness. To address it, both Osborn and other authors built over the original four principles, by incorporating lessons from years of application. One of such attempts was authored by Rossiter and Lilien (1994), who redefined brainstorming principles as:

- (i) Brainstorming instructions are essential – should emphasize quantity, not quality.
- (ii) A specific, difficult target should be set – make it a bound effort, set expectations, clear goals.
- (iii) Individuals, not groups, should generate the initial ideas – individual thought and idea uniqueness benefit from reclusiveness.
- (iv) Use group interaction to amalgamate and refine ideas – judgment previously deferred should now be applied, making use of the teams' complementary knowledge; ideas should be anonymized by the facilitator/manager.
- (v) Select final ideas by individual votes – each participant weights in its own anonymous vote; enhances individual buy-in and team commitment to the arrived solution; management should not pass judgment on ideas.
- (vi) The time required should be kept remarkably short – brainstorming sessions do not have to be cumbersome and take up whole mornings or days e.g.; lack of structure and meeting preparation often requires follow-up sessions, with loss of focus and morale.

Brainstorming has obviously had its share of critics. Group brainstorming might suffer the downside of social inhibition if people do not contribute to avoid criticism (Lamm & Trommsdorff, 1973). There could be production blocking when waiting times make people forget the idea they had before they could speak; or social loafing could mean teamwork might be covering for underperforming individuals (Furnham, 2000). Given its potential inefficiency as an idea generation tool, it remains remarkably popular in most business sectors. That can be explained by the enthusiasm and broader participation the technique instills. In brainstorming sessions, people come together as thinkers, with roles and hierarchy falling to the second plan. It increases decision acceptance and develops team spirit (Furnham, 2000), in part because it also gets credit for the subsequent phases of idea evaluation and refinement. It could be said that, in the end, its biggest accomplishment, especially for innovation projects, is the convergence around a team solution everyone sees as their own (Seeber, de Vreede, Maier, & Weber, 2017).

Prototyping

Prototypes have long been used in the context of product development. Physical prototypes are traditionally used to assess new products along the dimensions of form, fit or function. The degree of realness put into a prototype, its fidelity, will dictate the ability to reproduce the desired behavior. A physical prototype gives a preliminary experience of look and feel to the user. A great advantage is that it may reveal unknown phenomena, which had been concealed in earlier stages of concept ideation (Toche, Fortin, Pellerin, & McSorley, 2017). There are also virtual prototypes. These evolved from early computer assisted design and modeling tools that primarily provided concept visualization. Today, digital models allow not only 3D representation, but the simulation of the whole system environment, potentially, at a fraction of the cost of physical samples (Wang, 2002). Functional virtual prototypes may suffer still from major limitations, if no available technology can simulate complex component behavior and interaction, under variable working conditions (Toche et al., 2017). Therefore, virtual and physical models are expected to have complementary roles in NPD. Prototyping strategies will have to consider many variables, such as time, cost, size, materials, reliability, level of detail, etc. The ideal solution will be one that can provide the best possible quality, with the lowest cost, at the shortest time (Zorriassatine, Wykes, Parkin, & Gindy, 2003). These are, not coincidentally, the same classical constraints of PM practice.

Organizations can be differentiated not only by how they handle projects, but also by how they manage prototypes. Schrage (1996) distinguishes two types of innovation culture in companies. Some are specification-driven, others are prototype-driven. Big enterprises, that need to coordinate great volumes of information and people, tend to belong in the first category. In such environments, prototypes are developed to meet certain requirements, and improvements to performance result from a gradual refinement process. Besides the objective of design refinement, Camburn et al. (2017) explain that prototypes may serve the additional purposes of communication, exploration and active learning. Prototypes as communication vehicles are a particularly intricate subject, because they can be used as persuasion tools in front of project sponsors, or act like artifacts around which team discussion happens (Bogers & Horst, 2014; Schrage, 1996). It can be argued that a specification-driven mindset will regard prototyping just as another IMT, a means to an end – i.e. conformity with requirements. A prototype-driven mentality, however, will value the knowledge-gaining process that comes with trying, failing and trying again. Prototyping has an end in itself – continuous improvement.

Prototyping can be a source of project convergence or divergence, something the literature treats as the level of design fixation. Physical prototypes may not cause fixation *per se*, but the sunk cost effect that comes with prototyping activities was found to do so (Viswanathan & Linsey, 2011). The prototyping speed that available manufacturing technologies allow will influence design fixation too (Camburn et al., 2017). This means project teams are more unlike to deviate from a specific solution, on which much time and money have already been invested. Time itself assumes great significance on prototyping competitiveness (Schrage, 1996). Although it appears that the time spent on prototyping does not correlate with improved design outcomes (Häggman, Honda, & Yang, 2013), the timing of prototype building initiation does. There is evidence that starting to prototype early on the project leads to better project results (Häggman et al., 2013; Jang & Schunn, 2012).

2.3 Summary of literature review

This chapter's review allowed to frame present-day PM practice and understand how different types of PLCM may suit each project's needs. While iterative planning and AgPM frameworks may seem better fits to innovation projects, particularly those showing high levels of uncertainty, it could be that detailed planning and intensive requirement elicitation are a good approach within some project stages. The more recent genesis of hybrid PM results from a widespread tendency to tailor both traditional and AgPM into more serviceable frameworks. This review also allowed to summarize the most distinctive features of AgPM, in an attempt to understand where its flexibility resides. Within its most common solutions, the aspects of project transparency, workflow visualization, adaption and improved communication processes are particularly relevant.

Innovation project types, its characteristics and some IMT have also been reviewed. Organizations and PM practitioners alike ought to recognize the importance human resources' mobility and absorptive capabilities have in knowledge creation and exchange. This becomes ever more relevant as innovative enterprises transition to more cooperative, open innovation settings. Within the organization's boundaries, hierarchical arrangements and leadership exertion define how innovation might be championed across its ranks. These insights will inform potential action routes for the participant observation phases of this work. They will also be determinant to stakeholder handling within SC.LiDAR's sphere. Amongst the tools for managing innovation, the processes of planning and controlling were reviewed. Much like between traditional and AgPM, options vary between tight formal controls and freewheeling approaches. The processes for brainstorming and prototyping were also covered due to their importance in birthing unifying ideas. It is around them that successful teams and technical solutions will be developed.

3. Research Methodology

Research methods are, themselves, object of research, with vast knowledge backgrounds to attest both their strengths and inadequacies. In Chapter 1 the research design was laid out, so this chapter will contextualize the chosen research strategy and data collection methods. A succinct overview of their characteristics, advantages and disadvantages will be given, as well as the motive for their selection for the current research purpose.

3.1 Research strategy

The chosen approach for this research is that of a case study. According to Saunders et al. (2016), a case study sets out to understand the relation between the research topic and the environment where the research unfolds. This seems appropriate, considering the vast body of knowledge that precedes PM practice and the researcher's initial unfamiliarity with the real-life setting where it happens. Case study research has a degree of flexibility not found in other qualitative approaches, like phenomenology or grounded theory (Hyett, Kenny, & Dickson-Swift, 2014). This versatility proves useful when the boundary between the studied phenomena and the environment where it occurs is unclear (Saunders et al., 2016). The research question "*What issues affect SC.LiDAR project lines coordination and how to address them?*" implies there is a problem that not only needs identification but early answers too. It is expectable that, from a researcher's point of view, the researcher and project coordinator functions will start to merge. That is, the frontiers between studied phenomena and environment will become increasingly blurred.

Case studies are often criticized as a research approach because they struggle to deliver the generalizable, consistent results that set the foundations for theory building. Saunders et al. (2016) see this as a misunderstanding stemming from the perspective of positivist philosophers. Positivism is synonym to empiricism, and in empiricism, knowledge can only be earned *a posteriori*, through sensory experience. Case studies such as this, however, can be interpretive, i.e. resort to both intuitive, introspective knowledge, as well as naturally occurring sources of knowledge in the physical space (Hyett et al., 2014). In other words, both researchers' *a priori* knowledge and experience, as well as other people's testimony and interaction, will substantiate the findings of the study. This contextuality may be in the way of generalization and theory building. However, the purpose of a case study is not to describe the world, but to describe the case (Johnson & Stake, 1996).

A case study does not strictly adhere to a single paradigm or assumption. It resorts to varied data collection and analysis methods, in order to better comprehend the case, guided by context and emergent data (Hyett et al., 2014; Saunders et al., 2016). Ultimately, this strategy was chosen on the principle that if the PM approach should be tailored to project reality, within reason, the same should happen with the research strategy and applied methods.

3.2 Data collection

This research applied a mixed-methods data collection approach. Mixed methods not only allow to be on the lookout for emergent data sources, but they also improve the confidence in the research's empirical findings. Using multiple methods may provide information that would otherwise not be retrievable through one single method. Besides, having redundant information from different sources can reduce sampling errors; and not relying on one single method can reduce potential bias (Axinn & Pearce, 2006). This research used observation, surveys and document analysis as its primary probing methods.

Observation

Observation is a widely used data generation method, where the researcher immerses itself in the studied environment. It involves consistently observing, registering, analyzing and interpreting people's interactions, events and the like (Hox & Boeije, 2004). This research was based on qualitative participant observation. Saunders et al. (2016) distinguish between this and quantitative structured observation. While participant observation is concerned with the action motive, structured observation cares about action frequency. The main advantage of participant observation, especially when compared to other data gathering techniques, derives from the high involvement that it allows. According to the same authors, there are 4 possible ways of positioning observational research (Figure 21).

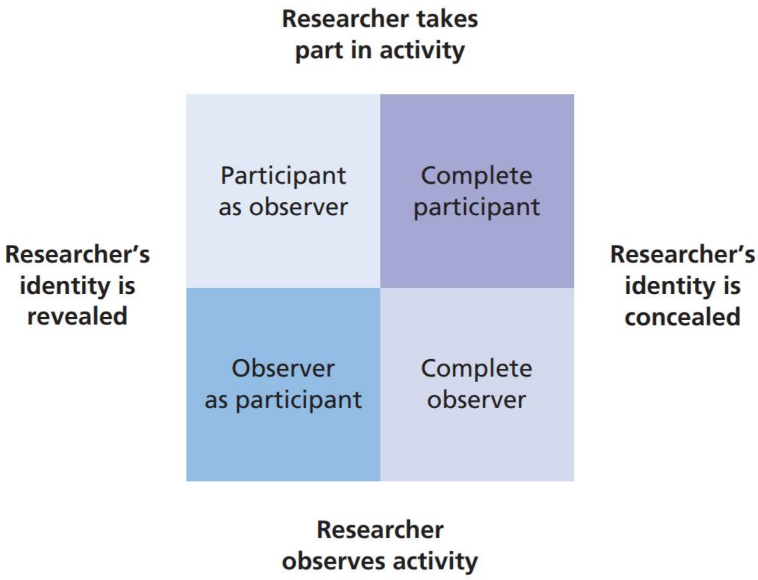


Figure 21 - Types of observational research roles.
(Saunders et al., 2016)

The main distinctions in observer positioning consist in taking an active or passive stance – upper vs. lower quadrants, on Figure 21 – and being a declared or concealed observer – left vs. right quadrants on the same figure. The chosen approach was that of participant-as-observer. Not only was the researcher admitted as a company employee, which presumes a degree of participation in business processes, but also the research and its purpose were known to project stakeholders from the start. There could be some doubt on whether to take a more active or passive role, were it not for the sense of urgency in finding answers to the research question. By the time this research kicked-off, the project was already past its mid-life. Furthermore, when the researcher was introduced to the project, there was no preceding PMg role to fill in, so intervention in the project course was, in a way, legitimized through the observational role.

Participant observation is time-consuming and early interpretations may be erroneous because the researcher must first understand the environment where it operates. Similarly, observer error may affect late observations, as interpretation might drift from early meanings to deeper ones. Another important aspect stems from how the researcher's known presence or purpose affects the observed sample's behavior. This is recognized in numerous Psychology and Sociology works as the Hawthorne effect, Pygmalion effect or, as Saunders et al. (2016) called it, the observer effect. In short, these effects account for the possibility that observed individuals will change their behavior either to show improved performance, satisfy the observer's expectations or, in any other way, try to conscientiously condition the study results (Rosenthal & Jacobson, 1968). This poses an unavoidable threat to overt observation's validity, which can be countered to some extent. Because a participant-as-observer role was chosen, having minimum interaction between researcher and participants was not an option. Alternatively, habituation to the researcher's presence must occur, i.e. trust must grow between the parties so that the target sample's behavior recovers its normality (Bryman & Bell, 2011; Saunders et al., 2016). Some participant observation advantages and disadvantages are summarized in Table 4.

Table 4 - Participant observation advantages and disadvantages.
(Kawulich, 2005; Saunders et al., 2016)

Advantages	**Disadvantages**
- Good for explaining what is happening in specific social contexts.	- Might be very time-consuming.
- Sharpens the researcher's awareness of significant social processes.	- Can pose difficult ethical dilemmas for the researcher.
- Particularly useful for researchers working within their own organizations.	- The researcher might experience high role conflict (colleague vs. researcher).
- Allows the researcher an opportunity to experience how the observed feel.	- Close involvement with observed situations or specific informants might introduce observer bias.
- Improves the quality of data collection and interpretation and facilitates the development of new research questions or hypotheses.	- The researcher is a naturally biased observation tool. Personal traits might determine access to certain information.
- Virtually all collected data is useful.	- Data recording is often very challenging for the researcher.

Survey

Survey data collection techniques are commonly associated with the application of questionnaires, structured interviews, and some types of structured observation. This research applied the first only. Moreover, the terms survey and questionnaire may be used interchangeably. Questionnaires are perhaps the most popular survey approach because of their vast, economical reach in collecting feedback from large numbers of people (Saunders et al., 2016). Questionnaires can retrieve information about people's attitudes, preferences and beliefs. The collected data may be quantitatively analyzed to provide project statistics. It may also allow to identify or explain the relationship between measured variables and observed project phenomena.

The application of a questionnaire faces some drawbacks. E.g. the number of questions will be limited to a reasonable amount of questions that people are willing to respond to. Also, the questionnaire success is dependent on respondent adherence too (Saunders et al., 2016). Feedback thus obtained might not

be substantial or take too long to be used as an improvement tool. Bryman & Bell (2011) point to the potential issue of provoking a reaction effect through survey techniques. This is analogous to the previously described observer effect and happens when the respondent consistently gives the same type of answer (e.g. always yes or no, always agrees or disagrees), regardless of what is being asked. Although it can have its interpretations, such feedback is unconstructive and prone to statistical exclusion.
The survey (questionnaire) was the chosen approach to further validate participant observation findings. It was picked mainly because of its potential to reach many participants in a short time-period. Although not as insightful as semi-structured interviews would be, it removed the social inhibition variable. From the researcher's perspective, by anonymizing the collected answers, the survey could be a way of guaranteeing genuine feedback from most project participants.

Document analysis

Recorded data can be a valuable source of information too. Document analysis is regarded as a secondary information source because its contents were not originally produced for the purpose of the research (Saunders et al., 2016). Possible sources range from written documents to audio and video records that might be collected by the researcher. Their use is not simple, neither should it be considered less time-consuming than other research methods. Document analysis demands considerable interpretative skills to understand who wrote the record, in which context and, among other things, to what purpose (Bryman & Bell, 2011). This research resorted to organizational documents. Documents can be also categorized as personal, public, visual or virtual. Table 5 provides a short description of document typology.

Table 5 - Document typology.
(Bryman & Bell, 2011; Saunders et al., 2016)

Document type	Description
- Organizational	- A very heterogeneous document source that may include documents in the public domain or not. The richest sources will probably be those used internally, such as organizational charts, contracts, meeting minutes, company regulations, company policies, development standards, to name a few.
- Personal	- Includes communications between individuals or groups, such as emails, letters and personal records like agendas, diaries or social media postings.
- Public	- Includes governmental and non-governmental organizations (NGO) publications, reports and statistics.

Document type	Description
- Virtual and Visual	- Some authors might differentiate these types. Generally, they encompass audio records, video records, and the use of photography as main or supplementary data sources. Corporate communications, products, advertisements, graphic or artistic images, etc., fall into this category too.

As previously mentioned, to be able to understand the observed environment, the researcher must first get acquainted with it. To interpret current project reality, it might be necessary to bring past elements into the analysis. Besides spoken accounts, which can be more easily biased, documents are the only trace of those past circumstances (Prior, 2007; Saunders et al., 2016). In qualitative research, there are revealing aspects beyond the document's actual contents. Namely, what documents omit and how they are circulated can be equally telling (Prior, 2007). There are several documents that typically accompany a project through its lifecycle. Contracts, signoffs, early versions of project charters or project plans might give useful insights about the evolution of current-day problems. In the broader company environment, internal R&D standards and directives were consulted as well.

3.3 Data analysis

Data analysis has an iterative nature to it. It is a continuous process where interpretation (e.g. through reflection) follows each recorded interaction or observation. Although this case study rests on an inductive approach, oftentimes deduction and *a priori* knowledge inevitably influence the investigation's course. I.e., even though multi-method qualitative data sources were chosen, the influence of pre-existing theories and frameworks must be acknowledged on their analysis (Saunders et al., 2016). In this case study, specifically, the PMBOK's knowledge areas (Annex 1) were often used to frame or cluster perceived issues about SC.LiDAR's PM. Thematic narrative analysis and discourse analysis were the preferred techniques in the observational stages of the research. While the first preserves the data's narrative form, its chronology and context, the latter focuses on how the written or spoken use of language shape social relations and hence, meanings and perception of the work environment (Saunders et al., 2016). A thematic analysis was also used in conceiving and analyzing the survey's results, again, referring largely to PMBOK's project management areas. Theme clustering or coding could be done either manually, through a MS Excel spreadsheet or using computer assisted qualitative data analysis software (e.g. NVivo, MAXQDA, ATLAS.ti, etc.)(Grbich, 2006; Saunders et al., 2016). Here key words in context were used as a category frequency filter to aggregate the answers to open questions (Grbich, 2006). Otherwise, where Likert scales apply, the statistical mode was looked at for inference.

4. Case Study

This chapter is meant to provide context for this research development. It gives an overview of the company where it unfolded, with a resume of its background, purpose, structure and some key figures. A second subchapter summarizes the PM practices and auxiliary processes that have been identified. Considerations about them are made. It concludes with a preliminary diagnosis of the managerial challenge to be addressed.

4.1 Company presentation

This field research took place at Bosch Car Multimedia, S.A., an affiliate of Robert Bosch GmbH, established in Braga – Portugal since 2013. The latter, hereby called Bosch, started as a small precision electronics and mechanics business, in 1886 Stuttgart – Germany, where it is still headquartered. From its home base, Bosch started diversifying its product portfolio and, within its first two decades of existence, expanded to the UK and France. At the turn of the XX century, Bosch was producing the only, truly reliable ignition magnetos, establishing its reputed and long-lived position as an automotive supplier. It went on to become an engineering and technology conglomerate of global reach. In 2020, the Bosch Group counted nearly 400 000 associates spread across 60 countries (Robert Bosch S.A., 2020b). Its logo remains a homage to the ignition magneto and its motto, "Invented for life" reflects the values it builds upon: Future and results focus, responsibility and sustainability, initiative and determination, openness and trust, fairness, reliability, credibility, legality and diversity (Robert Bosch S.A., 2020a) .

Figure 22 - The Bosch Group logo.
(Google search images)

Bosch is organized worldwide around four business sectors having several divisions inside each business sector. This research takes place within the Chassis System Control division (CC-PS), which belongs to the highest grossing sector of Mobility Solutions. As of 2019, it represented 60% of the company's global sales, with Industrial Technology, Energy and Building Technology and Consumer Goods making up the remaining 40%. Its main areas of activity include injection technology, powertrain electrification and peripherals for combustion engines, systems for vehicle steering, safety and driver-assistance technology, infotainment as well as cross-vehicle and vehicle-environment communication (Robert Bosch S.A., 2020b).

In what concerns CC-PS, its portfolio includes several products serving active and passive safety, driving and breaking assistance. The Braga Plant currently produces some CC-PS classical sensors, while the Development and Technology Center, located elsewhere in the city region, hosts the development of new ones. For the last decade, Bosch has been celebrating consortium agreements with the local University of Minho, to deepen its research focus in innovative sensor technology. This research started nearly halfway through the execution of one of such innovative programs, the Sensible Car (SC).

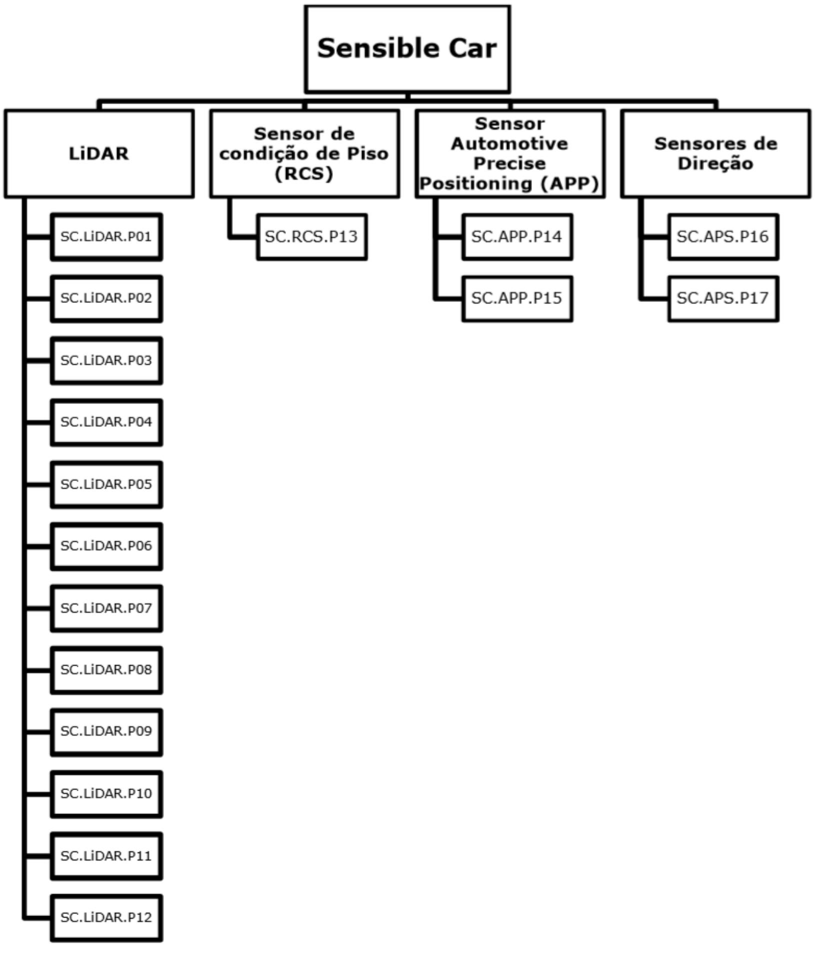


Figure 23 - Sensible Car program structure.

(SC.LiDAR.P09 Project Charter)

Figure 23 provides the overall structure of SC. The program began in June 2018 and is to end in June 2021. It committed to developing four projects dedicated to a type of sensor each: Light Detection and Ranging sensor (LiDAR), the Road Condition Sensor (RCS), the Automotive Precise Positioning sensor (APP) and Direction Sensors. LiDAR is arguably the most ambitious system. Its scope having been split in 12 project lines (PL) gives an idea of the complexity of the work it entails. The challenge that arose from SC.LiDAR management gave purpose to this research. SC.LiDAR technology encompasses several research fields, such as optics (physics), electronics, hardware (mechanics) and software (SW), thus requiring cross-functional expertise.

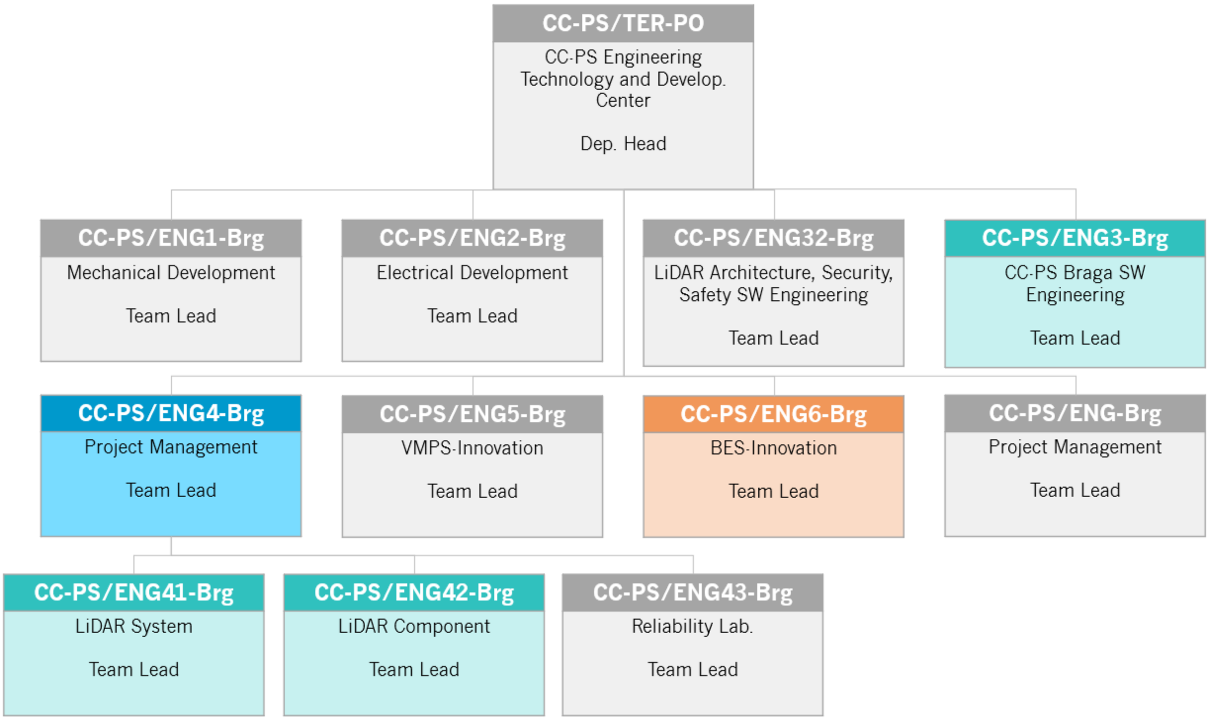


Figure 24 - CC-PS divisional structure at Braga.

Figure 24 shows how the CC-PS structure is organized in Braga. The Technology and Development Center has an Office Head to whom several engineering (ENG) team leads report to. These team leaders act as Functional Managers (FM) of several core competence areas. The ones directly involved with SC.LiDAR have been highlighted in a non-gray color. ENG3 develops software functions, while ENG41 and ENG42 are responsible for hardware (system and component) features. The project has a Project Management Head (ENG4), which will be referred to as Technical Director (TD) throughout this work. The researcher is allocated to ENG6, a team whose scope includes the responsibility for supporting the Bosch Engineering System (BES) – Innovation. The 12 SC.LiDAR project lines are managed by three FM. Besides, a virtual

PL named P00 Coordination was created by Bosch to accommodate for this research (Table 6). Beyond FM's responsibility level, each PL has a responsible and co-responsible person.

Table 6 - SC.LiDAR project line managerial oversight.

Responsible Functional Manager (FM)	**Project line (PL)**
ENG3	SC.LiDAR.P12
ENG41	SC.LiDAR.P02 / SC.LiDAR.P03 / SC.LiDAR.P05 SC.LiDAR.P06 / SC.LIDAR.P09 / SC.LiDAR.P11
ENG42	SC.LiDAR.P01 / SC.LiDAR.P04 / SC.LiDAR.P06 SC.LiDAR.P07 / SC.LiDAR.P08 / SC.LiDAR.P10
Researcher	SC.LiDAR.P00

4.2 Standards, processes and PM practices in place

To speak of PM practices, it is necessary to mention the standards and processes supporting project development at Bosch.

The standard for engineering is the Bosch Engineering System (BES) that is ruled by a central directive (CD 04510) of mandatory adoption for every organizational unit of the Group. Its purpose is to raise engineering activity effectiveness and efficiency, through methods and approaches that mitigate the typical threats of the development process. This way, Bosch ensures improved, in-built quality for its products and services. BES contains a set of regulations, which include, work organization (WO) requirements, product engineering (PE) requirements, and engineering product quality (EPQ). Both project level WO and PE requirements apply along the Bosch Innovation Framework (Figure 25)(Robert Bosch S.A., 2020d).

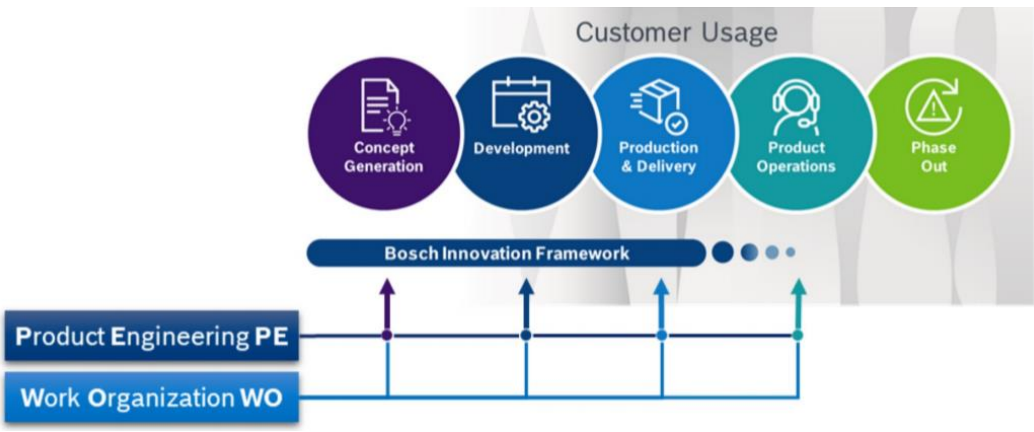


Figure 25 - Bosch Innovation Framework.
(Robert Bosch S.A., 2020d)

Being mandatory, the directive anticipates the need of tailoring its requirements either at the business or at project/operational level. At the business level, it shall be done by the business owner (Dep. Head in Figure 24), who in turn, shall have designated people tailoring the requirements at the project/operational level. As such, customization can be done e.g. by an agile coach/master, an RTE or PM-coach for the projects pertaining to an organizational unit such as CC-PS (Robert Bosch S.A., 2020e).

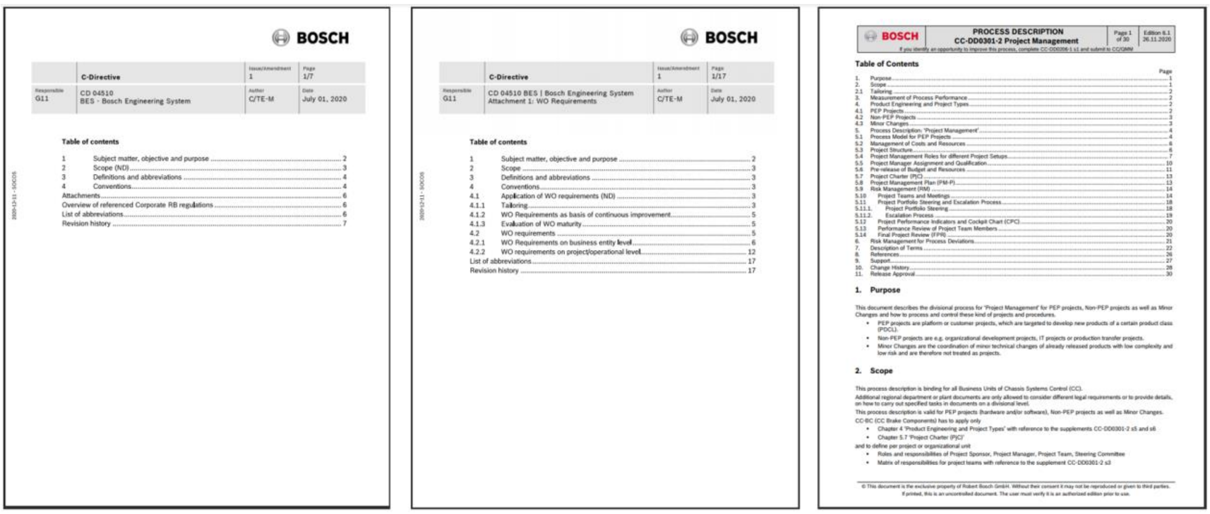
From a PM perspective, the most meaningful of these regulations is the work organization (WO), as it addresses organizational and operational structures, as well as the rules and principles of collaboration. The project level WO has a total of 14 requirements, 11 of which concern process. There is 1 requirement of business & architectural concern and 2 of organizational concern.

Table 7 - BES work organization requirements.
Abridged from (Robert Bosch S.A., 2020e)

BES – WO requirements (project level)	**Description (implementation hints)**
Business & Architecture	
2.1 Project-specific decisions take risks (threats and opportunities) into account.	Identify, prioritize and quantify risks systematically and continuously. (...) Derive risk response strategies for threats (avoid, mitigate, transfer, escalate, accept) and opportunities (exploit, enhance, share, escalate, accept). (...) Consider PMI (project management institute) risk management process.
Process	
2.2 Project or operational management is established.	For projects see CD 02500 Project Management at Bosch, Bosch Project Management Handbook. Consider alternative leadership concepts if reasonable, e.g. derived from SAFe.
(...)	
2.4 Value add is reviewed regularly by relevant stakeholders.	Value add should be created in appropriate iterations/loops and reviewed continuously, e.g. by fast provision of prototypes, fast verification of models and assumptions. (...)
(...)	
2.6 Measures are implemented to control the workload and avoid multitasking.	Workload and bad multitasking can be avoided by e.g. using team or Kanban boards, introducing pull principles and limits for work in progress, small work packages with clear acceptance criteria. (...)

BES – WO requirements (project level)	Description (implementation hints)
Process	
2.7 Concepts creating transparency are established.	(...)Define and implement concepts to ensure availability of the right information at the right time to the right people. Transparency is a basis for e.g. a common understanding, aligning work, avoiding double work. Consider transparency e.g. for communication of project status, comprehensible decisions, availability of relevant information.
(...)	
2.9 Nominated members are allocated to complete project phases/activities with sufficient capacity.	Maximize consistency in resources, i.e. teams stay the same as long as possible.
(...)	
Organization	
2.13 All required roles are established.	A role contains the description of tasks, capability, responsibilities, authorities and competencies. Roles can be included in e.g. project management plan.
2.14 For teams the level of self-organization and authority to decide is defined.	(...) Teams should achieve a maximum of self-organization and authority to decide. (...)

Table 7 shows some of the project-level WO requirements. All directive attachments include implementation hints, from which passages were transcribed. These include multiple references to PM standards and frameworks e.g. PMBOK's risk management process (2.1), iterative PMLC (2.4), lean principles for work management (2.6) as previously described in Chapter 2. Requirement 2.2 mentions another Bosch central directive for PM. The CC-PS division, specifically, has a divisional directive (DD) for PM: CC-DD0301-2 Project Management (Figure 26 – right side).



BOSCH

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1. Purpose

This document describes the divisional process for 'Project Management' for PEP projects, Non-PEP projects as well as Minor Changes and how to process and control these kind of projects and procedures.

- PEP projects are platform or customer projects, which are targeted to develop new products of a certain product class (PDCL).
- Non-PEP projects are e.g. organizational development projects, IT projects or production transfer projects.
- Minor Changes are the coordination of minor technical changes of already released products with low complexity and low risk and are therefore not treated as projects.

2. Scope

This process description is binding for all Business Units of Chassis Systems Control (CC).

Figure 26 - CD 04510 BES, CD 04510 BES Attachment 1: Work Organization and CC-DD0301-2 Project Management front pages.
(Robert Bosch S.A., 2020d, 2020e, 2020c)

The divisional directive is quite comprehensive, once more, contemplating the need of tailoring. Among other things, it defines how the division distinguishes its project types, considers risk, change management, and traditional project elements such as the Project Charter (PC) and the project management plan. It describes a phase-based process flow for PM, from initiation to project closure, with all intermediate steps having associated roles, responsibilities, inputs, tools and outputs. It contextualizes the PM role in traditional, hybrid and agile project configurations. It defines the roles of PMg and the project management office. The PMg "(...) is responsible for the entire project (...) has the managerial authority over the employees who have been assigned to him/her within the project". The PMO "(...) acts as both a competence center of and a 'home' for project management (...) Training, coaching, consulting, guiding and controlling for project management are the main PMO commitments".

Looking past company standards, some PM practices were almost readily observable from the start at CC-PS Braga.

The division has a two-week onboarding process for new employees. Besides multiple info sessions with business specialists, newcomers, who are gathered into temporary teams, go through a Scrum basics training. It is hoped that, later, this will make for smoother integration in their actual teams.

At CC-PS multiple product lines are explored, among which, LiDAR is but one. This research is dedicated to the subset of 12 LiDAR project lines, within the Sensible Car program. At the office, these are generally referred to as the Innovation project. However, LiDAR is also being developed on the Business Plan (BP) side. This distinction was neither transmitted nor immediately apparent to the researcher so, during the first weeks, some attention was paid to how BP operates. BP LiDAR is organized according to the SAFe® framework. The general working principles of this Agile framework have been laid out on Chapter 2. As for LiDAR Innovation (SC.LiDAR), no evidence was found that there was any kind of standard framework in place for its management. More considerations on LiDAR ART will be made at the beginning of the next chapter.

4.3 Diagnosis/problem definition

Not much was known about CC-PS Braga at the beginning of this research. The researcher applied to an internship at Bosch, with the premise that there were 12 project teams, or project lines, as they will be mentioned, struggling to coordinate amongst themselves.

The researcher was admitted at the end of October 2019. Introduction to project personal happened on the first days of December 2019. During that time, which was partially spent at the onboarding process, the researcher tried to understand how the organization worked, mainly through the scheduled info sessions and by talking to those available around him. The following points summarize the most relevant considerations gathered in that time:

- The 12 teams are working to deliver a LiDAR sensor for automotive application, which is considered an innovative feat;
- The degree of technological readiness was unknown to the researcher;
- The project team was potentially large, but exactly how many and who these people were was unknown;
- The ability of the 12 teams to function as a single team was unknown;
- The scope of SC.LiDAR and how it relates with each individual project line was unknown;
- It was not clear if the project was following a defined PM methodology.

After an initial observation period, the research question "What issues affect SC.LiDAR project lines coordination and how to address them?" was further elaborated into three objectives:

- Help SC.LiDAR teams to identify, define and agree on final deliverable(s) requirements;
- Improve team communication and draw out team interdependencies;
- Implement PM tools or PM methodologies for team coordination.

To better understand how these three leitmotifs – scope, communication and management – surfaced, reading the first entries of Chapter 5 might be needed.

5. Results

Amongst the challenges that come with taking a new job at a company, the ability to relate with one's peers proves paramount to establish the reach of the newly acquired functions and access the breadth of the tasks at hand. If at first the researcher might benefit from the deference his novelty grants him, chances are that access to certain people and information will vary over time, as relationships grow beyond mere formality. In other words, the researcher's point of view will become increasingly more influenced by the surrounding work environment. Therefore, such starting period is a proper, if not the best time to engage in the observational activity.

This chapter is largely based on observational research into the project environment. Because the collected data is emergent it requires on-the-go analysis and constant researcher adaption in the best of the project's interest. It is to say, diagnosis, action planning, and action-taking (intervention) coalesce into one another as events unfold. For comprehensibility, observation stages are presented in chronological order. Reflection boxes along the way provide further consideration about the project environment. Document analysis punctuates the observational account. In between periods, a summary of the taken action routes is presented. Finally, the results of a survey distributed to the project team gives further validation to the perceived project reality.

5.1 Observation, reflection and intervention

5.1.1 Prologue - LiDAR ART

When starting this research, the researcher could not tell the difference between SC.LiDAR and its twelve project lines, and LiDAR ART, the Business Plan (BP) development stream of the same technology. Recognizing a Program Increment Planning Event (PIPE) was coming up in his first weeks at the office, the researcher decided to attend the event, and then a couple more, between November 2019 and April 2020. This subchapter entry encapsulates that impression.

Bosch has started transitioning to Agile years ago, but it seemed not all development teams had adhered to the SAFE framework. Some said this was because they found out that the methodology pace did not sync with their development rhythm. LiDAR ART PIPE were set 10 weeks apart, with team sprints lasting for 2. The last (fifth) sprint was purportedly meant to innovate and plan the next PI, but in practice, many teams used it solely as a buffer to catch up with execution delays. Bosch puts up a lot of effort in providing the physical means for PIPE sessions to run smoothly. LiDAR ART was developed together with CC-PS teams located in Schwieberdingen, so team stations were carefully set up in a large auditorium where the event was livestreamed to all. Each team had its own camera and sound devices to communicate with its other "half" back in Germany, when time for team level planning came. The PI Planning sessions were led by the RTE. Product Owner and Scrum Masters, the lowest coordination roles in SAFe, are overwhelmingly assigned in Germany. All upper responsibility levels, including System Architect, Product Management and RTE are in Germany too. On this regard, someone mentioned there was significant information filtering between Braga and Schwieberdingen.

Reflection
The researcher sat through a few of these PI sessions, the first one on November 26/27 2019. Communication during the PIPE seemed stiff, with most of the "action" happening "over there". From the prevailing passiveness of the audience at Braga, it seemed the responsibility imbalance was either enforced or complemented by a mix of cultural differences and diverging interests between locations. Be it as it may, there were few or no experienced associates in the SM or PO roles to work with at Braga. Most of them did not work on SC.LiDAR anyway, so this would be a challenge if SAFe was to be tried out with the innovation project. From a theoretical standpoint, some shortcomings were observed in the application of SAFE to Business Plan LiDAR. Because it was virtually impossible to have all personnel physically present, occasionally, some people would travel in-between locations for PI Planning Events. It is questionable if the same results could be expected from such a virtual gathering, considering many of the associates in Braga kept a detached attitude throughout the sessions, e.g.: • Plenty of people would miss the session's start (which was early and outside typical working hours); • Some people would keep coming and going out of the Auditorium for extended periods; • Some teams only had a couple of people present or were totally, physically absent (even if connected from elsewhere in the building); • A marketplace session, which was intended to have teams trading interdependent features, produced little to no results on the November 26/27 planning event; • Kanban boards were filled in Germany, but in some cases did not reflect the same in Portugal (or were left unused by the absent teams). No deeper inquiries were made as to why some teams opted out of SAFe. However, people working on hardware (components) expressed the nature of their job did not allow them to commit to a certain amount of work, at least, not as easily as software teams would. After failing to deliver a number of times, they decided to stop attending planning sessions, although it remained unclear how they coordinated with the ART from then. If indeed, their developing rhythm was much different from other teams, ways to inspect and adapt to their speed could be devised, to sync them with the remainder ART in a hybrid configuration. One central aspect of Agility is ensuring project transparency, process visibility, and top-down and bottom-up communication flow throughout the hierarchy. Such a mindset does not seem to be present. Not only process visibility seems disregarded by some teams in PIPE, but the role imbalance between locations also suggested decision power is centred in Germany, leaving Portugal in a subordinate, executional position.

Also, training sessions of Scrum and SAFe, guided by an Agile coach sent in from Germany, showed they were meant to be taught to software teams. For the average employee, with no AgPM background, it would be hard to relate to the given epic, story, and feature design examples. It is hypothesized that apprehending the framework logic and usefulness would be, thereby, complicated for people working on system or hardware functions.

5.1.2 December 2019 records

Research kick-off meeting

The first diagnostic phase started a few weeks after entering Bosch. The introduction to SC.LiDAR personnel happened during a meeting, the afternoon of December 4, 2019. This meeting was organized by the researcher's mentor and its invitees included the project technical director (TD), the two main Functional Managers (FM), three project line responsible, and two PMO representatives. The actual attendee list includes at least two additional individuals besides the researcher himself. Later on, when asked why there were more attendees than expected, the researcher mentor (ENG6 team lead – Figure 24) answered that several people had shared the meeting invitation at their own discretion. As he saw it, this was in part a sign of genuine concern but also because some people felt like they needed back-up from some third parties. Throughout the meeting time, a couple of aspects became evident:

- For one, different people addressed the issue that there was still no overall system architecture for the project lines to refer to. This is first brought up by ENG41 FM.
- Simultaneously, there seemed to be an underlying animosity between some of the participants, coming from past events.
- At a point, the TD expressed concern that in Germany, the Portuguese location interests (innovation projects) were being taken lightly. The same FM, a German national, uncomfortably laughs it off.
- People shared different perspectives on what should be of this virtual project line, P00, and how to approach the line coordination effort.

The meeting was held under the subject "*Sensible Car - LiDAR P00 next steps*" and its main determination was that the researcher would team up with the project TD to revamp the twelve project lines coordination. There was no preceding meeting agenda and no minutes were written afterward.

The technical director's strategy following this event was to meet all project lines, grouping them by development domain or scope affinity. Meeting times with both project line responsible and co-responsible were sought, focusing initially on schedule and risk management (see Table 8). Because the TD availability was limited, him being involved in other affairs, the researcher opted to conduct some meetings on his own as the year's end holidays closed in:

Table 8 - First status meetings held by P00 with the other twelve project lines.

Project line(s)	Domain	Meeting date	Meeting coordination
P08 + P10	Hardware (mechanics)	05/12/2019	TD + Researcher
P01 + P04 + P12	Hardware (electronics) and Software	16/12/2019	TD + Researcher
P02 + P03	Hardware (optics)	18/12/2019	Researcher
P09 + P11	System testing	12/12/2019	TD + Researcher
P05	Optics	17/12/2019	Researcher
P06	Electronics	19/12/2019	Researcher
P07	Electronics	18/12/2019	Researcher

Meeting the project lines

The very first of these meetings had a couple of project teams, P08 and P10, producing a development cycle schematic as shown on Annex 3. It was done together with their external Program peers (UM and PIEP) and displays three development loops, for which an estimated duration was found. It shows the natural sequence of large WPs and where other project line inputs are to be expected. It also shows how this all fits in the remainder project timespan.

From the feedback gathered during the encounter:

- Schedule management turned out to be one of the prevailing concerns.
- Another recurring theme was that of individual team dependency on other project lines. Many team members saw the lack of definition in specific domains of the overall system design as a major hindrance and a risk hovering their own success.

To different degrees, the attendees referred to the teams "at fault" in strained and exasperated fashion.

Reflection
Because parts of the overall sensor system were still to be defined, there was no product breakdown structure (PBS). This means no work breakdown structure (WBS) would be devisable either. The schematic shown by the teams (Annex 3) reflected the iterative nature of project work. They were aware that concept development could not be done linearly, thus development loops ran parallel for most of 2020 1st semester. There were Go/No go decision points (phase gates) where the sensor system

concept either proceeded or was abandoned. The 2nd semester of 2020 should be reserved for refinement of the winning concept. The large platform, laboratory, simulation (etc.) testing blocks might take from 3 to 6 weeks maximum. The team confirmed that these were estimations that did not account for delays. It should be noticed that many tasks, from part machining to numerical simulations, were done outside of Bosch. Those responsible for them were far from the researcher's reach. The schematic's development strategy seemed appropriate for the exploratory nature of the project, but the document itself was probably of no use for planning. To update a plan for a project already one and half years gone into execution, with an unknown number of interdependencies, might be an extremely challenging feat. It is noteworthy that, again, underlying tensions between different project lines became apparent and some team members seemed skeptical of the course the project had taken.

On the meeting held with P09 and P11 a week later, a representative for each project line was present. Scheduling the meeting was not easy in the first place. Some of the responsible team members were uninterested or resisted making themselves available. They did write back, nonetheless, trusting their colleagues to voice their perspective and concerns. During the meeting, the responsible were defensive when asked for the reasons beyond these project lines issues and delays. There was a searing overtone to some answers as well, and often, the more vocal of the two members would rather make eye contact with the researcher than with the TD. The team said the difficulties they face included limited team capacity, lack of know-how on some technical topics, and having to deal with tasks they felt out of their responsibility:

- Most of the project team was simultaneously working on another project (the BP LiDAR), which would compete for their working time. When asked by the researcher they explain the FM decided the allocation percentage for each team member.
- P09 project charter included development tasks that were left there because no proper place was found at the Program start. The team struggled to address them. They should be getting the support of other PL, but no one had taken the lead still.
- Some project acquisitions were made having the BP needs in mind. The team was concerned equipment specifications might be ill-suited to SC.LiDAR objectives.

These issues came on top of a late project start. Actual work began nearly one semester after the Program's official kick-off - something the researcher's mentor had alluded to on occasion.

Reflection
In retrospect, it is important to set apart technical and behavioral issues coming out of this meeting. State of the art in certain technical domains was still incipient, which is understandable considering the project innovativeness. From a management standpoint, only so much could be done other than

checking if the team referred to existing, internal or external standards for NPD. These would determine the quality of their deliverables. It would be informative to check the PL project charter and see if such standards were available or at least pointed to. The PC content should also include mention to the tasks the team said to be outside of their competence area. From a behavioral perspective, multiple readings can be made into the attendees' dynamic. If a team member constantly gazed at the researcher, it could be that the intent was to impress or convey a message specifically to him. It could happen that the newcomer was being perceived as an aide or at least someone to whom the information was, indeed, new. It may also be telling of team members relationship with authority or how they saw the TD as someone capable of challenging the current project status. Lastly, this withdrawal can also be interpreted as a sign of weariness with the project lead, which would explain why some people exempted themselves from attending in the first place.

The most cross-functional meeting was perhaps the one that gathered P01, P04 and P12 on December 16. For several months then, it had been apparent that a product structure was needed to give the PL the focus they were missing. Even if this was a rather recent finding to the researcher, it was certain for the TD as well as for the most seasoned team members in attendance. An evening was spent around whiteboards and flipcharts, and from it, a schematic for a prototype sensor emerged (Appendix 1). It represents the links between the prototype's main elements, including a few notes concerning risks and timeframes for concept iterations C1, C2 and C3.

Reflection
The P00 prototype sensor was perhaps the most important deliverable expected by the end of SC.LiDAR. If technically things appeared to have started taking shape from there, some of the prototype subsystems, or associated development tasks, seemed without a designated responsible. To check what was in and out of each project line (PL) scope, access to PL project charters would be sought. P01, P04 and P12 team's dynamic was very cohesive and the discussion fruitful. Maybe that happened because they all reported to the same FM and were used to work with one another.

On December 18 a short meeting was held with P02 and P03. Both PL dwelt in the optics competence area and reported to the same FM. Their project charters had already been made available to the researcher at this point, so a deliverable and milestone revision took place. Most importantly, the meeting focused on the dynamics between Bosch employees and their respective Program partner teams that worked at UM and INL.

The two PL interacted with their external counterparts mainly through PhD researchers who worked for both the aforesaid institutions. A particular instance of a PhD student that seemed to have dropped his research was discussed. Communication with external team members was said to be erratic, so this bit of information was supposititious. Anyhow, the teams were apprehensive about it because much of the work, including concept and component fabrication, was being advanced by INL/UM and “decision power, well, most of it, is on their side”. This might significantly impact their schedule adherence.

Another issue the team struggled with, at least as far as the two PL responsible were concerned, was balancing the workload they had for SC.LiDAR (project) and BP. The two PL co-responsible, also present, were 100% on innovation.

P02 contribution to the LiDAR prototype build was not expected until later stages of concept development. P03 was not expected to integrate the P00 LiDAR prototype at all.

Reflection
This meeting served to confirm that, in the project structure, the figure of a project manager (PMg) did not exist. When technical topics were up for discussion, either side of the team, internal or external, would directly reach for their Program peers. Also, recurring project follow-up meetings were set, typically monthly, by an assigned PL PM Officer. Those meetings included high-level milestones, tasks, risk revision, etc. With some exceptions among the 12 PL, it was the University PMO that organized and led such meetings. Therefore, it is this research’s interpretation that the PMOs, Bosch and University, were the overarching structure that could be resorted to whenever a communication deficit afflicted team level coordination between institutions. Project workload balance was becoming a recurring topic that also P02 and P03 mentioned. Noticeably, they answered to the same FM as P09 and P11, so there might be some correlation there to be explored. Finally, another take from the meeting is that not all PL would participate in the LiDAR prototype build that was being coordinated through P00. According to P02’s project responsible, that happened because of incompatible technological maturity amongst all PL.

Between December 17 and December 19 three other PL were met separately.

P05 one-on-one meeting took place at a lab where the project line responsible was overseeing an ongoing installation. A summary of the PL scope was given upon request, followed by a depiction of how P05 interacted with the university side of the team. To understand how involved the TD had been with all project lines, the researcher inquired if he ever met with P05 responsible. He never did. The line lead reported to the FM only. P05 had an assigned project co-responsible like other PL, but he had just joined the company and was not present. A fixed-term intern, recently admitted as well, completed this team’s composition.

Technology readiness level was first mentioned when meeting P06 line responsible. It was a reason why the PL would not be able to partake in the main prototype build. Another aspect that differentiated P06 from the other PL is that it was not working with the Program co-promoting institution (UM). In its place were Corporate Research (CR), a separate Bosch Business Unit (BU), and *Instituto de Telecomunicações* (IT).

P07 had only two team members, its responsible and co-responsible. They were working 50% on Innovation and 50% on BP – split-heads is how these headcounts were known. Much of the work was being done alongside the external (UM) side of the team. Everything seemed to be on track, the PL being between the second and third iteration of their own prototype concept, which was presented to the researcher with a level of detail.

Reflection
At this stage, it was not quite clear what the scope of P00 LiDAR coordination was. This research premise was that improvement on LiDAR project lines coordination was sought. It turned out that some of the PL - including P05, P06, P07, but also P03 - were not expected to integrate, or coordinate, into the unifying LiDAR prototype build. With no need for integration, this left it to the researcher's interpretation if these PL should also be monitored. These last status meetings revealed a strong emphasis on how much the co-promoter UM (INL for P03) was determining and doing. Even the majority of experimental set-ups were at their facilities. Even though P05, P06 and P07 had team members allocated to the BP also, no one raised capacity concerns dealing with the assigned project workload.

Besides the aforementioned status check meetings, a way of getting insight into project reality was to have access to the purely technical meetings where the PL had been interacting. This could help in many ways and, fortunately, the researcher had been invited to attend one right after the *Research kick-off meeting*. Not only would it allow to see how teams behaved in a more familiar setting, but it could also provide a chance for the researcher to introduce some managerial concerns for deliberation.

SC.LiDAR prototype optical design

A technical meeting was called for December 6 to present an optical concept proposal for the LiDAR prototype. This represented a breakthrough of sorts, as such a concept felt long overdue by many. An agenda had been sent beforehand and it included slots for concept presentation, concept discussion, and the assignment of tasks drafted in advance.

Throughout the presentation, the concept proponent sounded reticent, uneasy at times. The presentation ended with no immediate reaction from the team. Eventually, a new team member voices some questions. He was soon joined in by a second, young-looking colleague and the discussion started to warm up from there.

Follow-up actions were discussed afterward. Tasks were assigned according to the organizer's proposal or with someone volunteering. There was still hesitancy when the debate came to the production of custom-made prototype components. It would require committing large expenses into tooling, without much guarantee the concept would work. Some people voiced this concern and it was at this point that the researcher decided to intervene. The outcome was an agreement on the course of action with a slight readjustment of the tasks. At the end of the meeting, the presenter approached the researcher and asked for advice concerning meeting organization.

Reflection
In retrospect, this meeting was characterized by an uneasy exchange between participants. The concept presenter did not sound or look confident. This could be an assertiveness issue or signal a lack of confidence over a concept that was being rushed by the recent push for project development. Either way, judging by the attendees' body language, either the messenger's or the message's consistency was affecting their reaction. The standstill was interrupted when two colleagues, both happening to be interns, shared some questions. The presenter and they worked together on the same BP development area. Their detached attitude contrasted with that of older project contributors, who may have been conditioned by historical reasons. This stimulus opened the concept for discussion. The main issue at hand became some of the components' highly specific requirements. The researcher noted that sourcing specific material designs might be prohibitively expensive, with potential no return should the concept fail. The team agreed to the suggestion of probing the market for representative, off-the-shelf components, so that a first physical set-up could be assembled for proof of concept. This marked the first time the researcher actively intervened in the project course of action. The presenter asked for advice to keep the meeting on track. Although an agenda had been sent, time slots were not respected, and the meeting was way past due. People needed to discuss and talk about important issues. It was a technical meeting after all. The researcher praised the agenda and recognized it could not be helped if people chose not to prepare beforehand. It was suggested that he could approach some key-people in advance and have small conferences to pre-align the main discussion topics with them.

5.1.3 December 2019 action route

Table 9 summarizes the coordination issues found during the first weeks of interaction with the teams. It also presents the actions that were started to address them.

Table 9 - December 2019 issues and action routes.

Issues found	Action route
Project plan Schedule concerns prevailed among several teams and other stakeholders, such as the TD and the research mentor. P08 and P10 produced a roadmap for 2020 development activities.	• Check with Bosch PMO the existence of an initial project plan. • Refer to PL project charters to check their contents, e.g. milestones and due deliveries.

Issues found	Action route
Project scope System architecture's lack of definition was a source of conflict. The optical subsystem definition was overdue. This was a clashing point both at management and team level. P09 and P11 complained they had been assigned tasks out of their competence area.	• Refer to PL project charters to check how the project has been designed and how the system scope is divided between them. Lookout for interdependencies and references to other PL.
Project resources Some associates had trouble managing multiple project workloads. This was mentioned by P02, P03, P09 and P11. P09 and P11 mentioned some project purchases might have not been made in the project's best interest.	• Be on the lookout for this issue. These team members report to the same FM, so there might be some correlation with the priorities they are given. • Figure the strategic alignment of SC.LiDAR in the CC-PS division.
Project awareness P03, P05, P06 and P07 were not contributing to the sensor prototype system that had to be built. This research premise was to help coordinate 12 PL, but some seemed to have project scopes of their own.	• Hold individual PL meetings to get to know the teams and their project better. • Support all teams addressing risks and roadblocks.
Meeting organization Generally, meeting agendas and meeting minutes were not used. People had only the emailed subject as a reference to prepare. Meetings systematically exceeded their planned time.	• Improve meeting organization and record (make use of agendas and meeting minutes to raise awareness and commitment). • Consider limiting the number of participants.

Besides these follow-up actions, a P00 coordination meeting would be put in place to assemble all project lines contributing to the LiDAR sensor prototype.

5.1.4 January – April 2020 records

P00 LiDAR Coordination Meetings

LiDAR coordination meetings are an offshoot of the first technical meeting the researcher attended to. The first occurrence happened on January 16 and the last of the same name on August 7, 2020 (Figure 7 and Figure 33). Instead of focusing on technicalities, this recurring meeting was meant for defining, correlating and assigning the activities leading to the LiDAR prototype completion. Through it, component tracking for the optical concept and other subsystems was done on a weekly basis.

The researcher determined this meeting to be not only a monitoring mechanism but also a place to bring in the results from individual PL and foster discussion among them. On one hand, it helped the project to gain momentum, through task assignment and by holding team members accountable. On the other hand, it allowed the researcher to position himself as a coach or a mediator, instead of a conventional PMg. P00 LiDAR coordination was a project line without an official Program scope. It should start to be perceived as a node in the project structure.

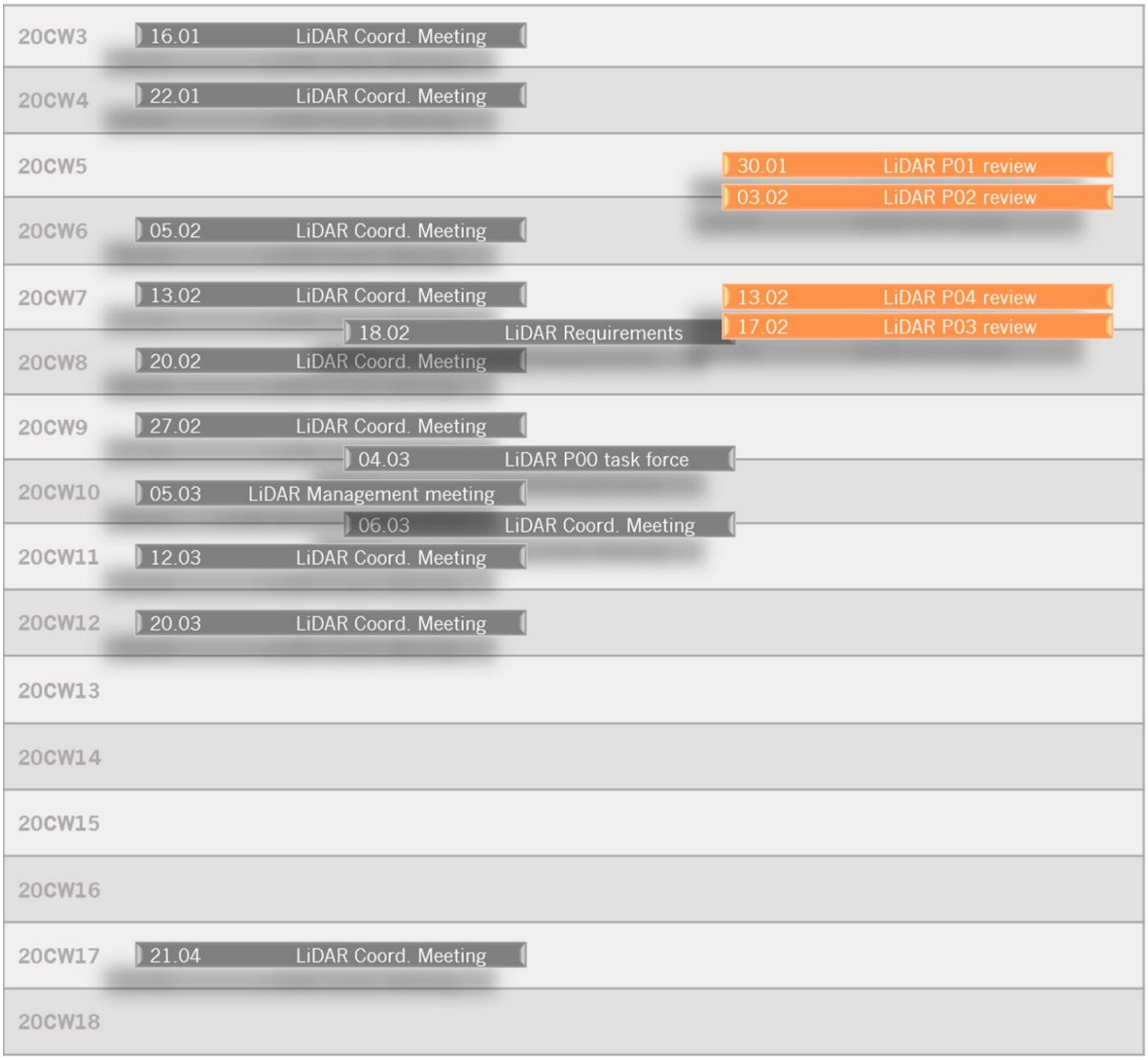

Figure 27 - Chronogram of meeting moments for January – April 2020 stage.

LiDAR Project Charters

The first couple of weeks into 2020 were split in between preparing this research proposal plan and consulting SC documentation, namely, LiDAR 12 project charters (PC) (Annex 4).

On the project server multiple document versions coexisted, therefore, the official ones were asked from the PMO. From PC analysis a level of redaction heterogeneity was evident. All Indexes were English, even if the documents were mostly written in Portuguese. Most of the signoffs happened as late as March 2019, although the Program had started nine months earlier. All PC were scanned, signed-off documents, except for P12's. All included identification of the PL responsible, co-responsible and designated PM Officer – totaling six people, three from Bosch and their external counterparts. The same Bosch PMO was assigned to all LiDAR PL. There was no role and responsibility matrix, nor project governance definition. The information on Bosch representatives was outdated. Some fields were left incomplete (Annex 4). Overall, the project goals and expected results were loosely defined, even if concrete performance metrics were present.

Besides the purpose of getting acquainted with each project line scope, the PCs were analyzed to see what references of the prototype sensor existed. As it happened, most PC mentioned prototypes at some point, but little to no reference of other project lines or their integration into a common prototype build.

Reflection
If the main objective of P00 Coordination was to have most of the 12 PL contributing to a single prototype, it seems odd that the PC did not reflect that purpose.

Through inquiry with ENG42 functional manager, the researcher learned that the PC were, in fact, adaptations of an original, called "Anexo Técnico" (Technical Annex). This large, single document was the one that, upon submission to the sponsoring authorities, got approval for the SC Program. SC.LiDAR 12 PC were the outcome of breaking that content into more manageable bits, so they could be handled by smaller, dedicated teams.

Furthermore, the researcher learned that the common prototype build was committed in the Technical Annex. In that document, it was referred to as Prototype A.

Reflection
Looking back at the charters, only P01, P02 and P04's mentioned Prototype A. Speaking with P04 line responsible later on, the researcher would learn that reference was a last-minute addition to the charter. Also, even if without clear instructions coming from the PC, the team was developing a modular architecture for their electronics subsystem. It would allow adapting more easily to the other subsystems of the common prototype. A rushed translation of the Technical Annex into the 12 PC would explain why original English titling was preserved and, most importantly, why PL integration was left underdeveloped.

A striking detail was that some PC signatories no longer worked in SC.LiDAR, either because they were then on the BP or had since left the company. At this point the team composition was still unclear, however, there was at least a handful of foreigners working on the project. Their Portuguese proficiency ranged from basic to average, at best, which raised the question, how could they use the PC as working documents?

P00 LiDAR coordination meeting from February 13

The February 13 coordination meeting had 14 people in attendance. 7 PL responsible and 7 team members. The project TD was invited but was not present. Each PL reported on their progress and spoke of the feedback they needed from other teams in order to advance with the work. The meeting agenda went over the pending tasks and defined new ones. Less than an hour before the meeting start, P09 responsible had called, asking to introduce a topic concerning system and subsystem testing. So, after nearly exhausting the planned meeting time, all there was to discuss is P09 last-hour addendum.

The subject happened to be the same concern they had reported in December. There were tasks assigned to P09 for which they did not felt responsible. Support from P10 was agreed upon the signing of the PC and the line co-responsible was claiming it. The problem was that P09 was responsible for system-level testing once the final prototype became available. However, it was expected of them to test and know how to diagnose problems at the subsystem level. Besides, for this, they did not have the means or competence. The meeting devolved into a heated debate. At a point, the discussion became about the requirements for the sensor prototype, with people right, left and center arguing it had to be Automotive compliant or that it would never be Automotive compliant.

The researcher and meeting organizer, collecting himself, put an end to the discussion, acknowledging both sides' concerns, promising to go through the PC and readdress the issue the following week. As for the prototype requirements, he said that the ultimate goal would always be to develop an Automotive compliant technology. Even if, by the end of SC.LiDAR, the delivered prototype did not met those standards.

Reflection
The number of people going to LiDAR coordination meetings was becoming unsustainable. The invitation list had 7 PL responsible and 1 supporting team member. The TD was invited but did not attend. It was a good sign that interest in the project status was picking up, but it was unmanageable to have so many people gathered, especially if they all wanted to speak. P09 responsible had an exalted intervention and was met with a similar response, not from P10 actually, but from P08 co-responsible. The PC had to be consulted to see what was said about system and subsystem level testing, and under which PL responsibility they fell. Also, special attention would be paid to references of development standards, Automotive or not.

At this point, the researcher was already having individual PL meetings to check their scope and status (Figure 27– right side meeting blocks, in orange). Despite being overtime, P04 PL responsible had stayed behind the departing crowd. P04 *Data Handling and Advanced Processing* status was reviewed. When asked about potential roadblocks, issues with a supplier agreement and a specific decision that implied the optical subsystem were referred. The researcher vowed to escalate the supplier issue if needed and solicit commitment from the optical experts in the next coordination meeting. Upon finishing, the line responsible asked what the purpose of P00 was. It was explained that its purpose was to help coordinate all other project lines, among other things, by drawing out their interdependencies. The line responsible said that had already been done before. In the beginning of 2019, a P00 task force had been assembled with that same purpose. Before leaving, he pointed to some contents on the server, produced at the time.

SC.LiDAR requirements and P00 detraction

To clarify the requirements agreed for the LiDAR sensor prototype, the PC were consulted once more. There was barely any reference to development guidelines. Only P09 PC mentioned an ISO standard. Because there were concerns that the final system would not survive the strict automotive testing standards, which include e.g. rigorous temperature cycle or free-fall tests, the researcher looked for admission criteria in the texts (Annex 4). As mentioned before, because of the exploratory nature of this kind of project, both PL scopes and expected results were vaguely described. The expected results were not qualitatively set. For example, even when testing was referred, the goal was any result, whether the system passed the test or not. Unambiguously, P09, named *LiDAR Evaluation and Testing Platform*, had system-level responsibility for the complete prototype system. On the subsystem level, the other PC referred to testing activities, but did not explicitly address who would validate the PL results or through which means. The researcher summarized these findings in a presentation and invited all 12 PL responsible for a meeting on February 18.

Reflection
It was important to clarify and help the teams prioritize project issues. This was an innovation project and as such, its scope was more explorative than directive. Some people were more prone to being told what to do, so they needed guidance in interpreting the objectives of their individual PL and of the common prototype build. It was important to instill a sense of responsibility, and PL responsible should be called to their own. Holding them accountable for leading the PL was a way of recognizing their authority so that they could become someone that team members would look up to. At this point, it was questionable if FMs had been enforcing this structure. The fact that it took so long to come forward with an optical subsystem concept, suggested responsibility was poorly defined or, at least, not enforced in practice. The issue with testing responsibility also showed that there was a problem in project design. There the message should be clear. Each PL should identify its testing needs and take responsibility for characterizing its results. They should look for the means to do so, not only in the project structure but across the organization and beyond it too. CC-PS had a manufacturing site nearby, with control of production and auxiliary testing labs. Besides, the project was co-promoted with UM and supported by a handful of other organizations. Yet, at the meeting of February 13 people behaved as if they had nowhere to turn to and no one wanted to take up the job. The other aspect to be addressed was prioritization. Some team members were concerned the final prototype system would not be Automotive compliant. It was important to frame their expectations and have them focused on delivering an MVP first. Several area experts believed that, from a technical standpoint, the final system requirements were a long shot from their current capabilities. The teams must then aim to a target up close. Only by practicing with short-range objectives could they gather the indispensable know-how that innovation requires. Getting that point across could be a challenge because openly admitting the project would not achieve the final system requirements could have a demoralizing effect. In resume, interesting research questions could be derived from this. What did people make of their PL requirements? Were they using their PL project charters for reference?

The invitation to discuss SC.LiDAR requirements were sent through e-mail, to the project TD and all 12 PL responsible, which included ENG41 and ENG42 functional managers (Figure 28). Both of them were identified as responsible for P06. ENG41 FM was responsible for P09 but, in practice, P09 co-responsible had been showing up to P00 coordination meetings.

-----Original Appointment-----
From: FIXED-TERM de Matos Pinto Renato (CC-PS/ENG6-Brg) <fixed-term.Renato.deMatosPinto@pt.bosch.com>
Sent: 17 de fevereiro de 2020 10:32
To: [redacted] (CC-PS/ENG-Brg CC-PS/ENG4-Brg); [redacted] (CC-PS/ENG42-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG42-Brg; [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG42-Brg; [redacted] (CC-PS/ENG42-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] -PS/ENG42-Brg); [redacted] (CC-PS/ENG41-Brg)
Cc: [redacted] (CC-PS/ENG32-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG42-Brg)
Subject: P00 LiDAR Coordination - System and Sub-system testing requirements and responsabilities
When: 18 de fevereiro de 2020 15:00-16:00 (UTC+00:00) Dublin, Edimburgo, Lisboa, Londres.
Where: Sé catedral (Rua do Barrio, 1 - Sequeira » Brg 055 » Brg 055/1)
Importance: High

Good morning, everyone,

Following the live discussion we had last Thursday concerning the requirements for our first physical LiDAR Prototype, and the responsibilities that lie with each project line regarding its testing, I'm inviting you to join us tomorrow to clarify these issues.

As one representative for each Project Line is required to attend there will be agenda conflicts for sure. I'd ask you to make an effort and adjust to the proposed timeslot. If you really cannot make it please delegate in your *de facto* Project Line co-responsible. Do not forward this invitation to anyone else.

Get back to me should you have any questions.

Thank you for your time,

Cumprimentos / Best regards,

Renato de Matos Pinto
CC-PS/ENG6-Brg

Figure 28 - Invitation to discuss SC.LiDAR testing requirements and responsibilities.

This e-mail prompted an answer from P12 responsible, to which the researcher replied once, in order to amend for some misunderstandings. The feedback, however, was not reconciliatory (Figure 29).

From: [redacted] (CC-PS/ENG32-Brg) <[redacted]@pt.bosch.com>
Sent: Monday, February 17, 2020 10:42 AM
To: FIXED-TERM de Matos Pinto Renato (CC-PS/ENG6-Brg) <fixed-term.Renato.deMatosPinto@pt.bosch.com>; [redacted] (CC-PS/ENG-Brg CC-PS/ENG4-Brg) <[redacted]@pt.bosch.com>
Cc: [redacted] (CC-PS/ENG42-Brg) <[redacted]@pt.bosch.com>; [redacted] (CC-PS/ENG41-Brg) <[redacted]@pt.bosch.com>; [redacted] (BrgP/PJ-INV) <[redacted]@pt.bosch.com>
Subject: RE: P00 LiDAR Coordination - Sy[redacted]-system testing requirements and responsabilities

Hello,

In this timeslot, I will be out-of-office. However, I would like to suggest [redacted] and [redacted] as a "required attendee".

And, I am confused: if "one representative for each Project Line is required", I shall not be optional.

-

Thank you.

Hi [redacted],

My main concern is having a team-level agreement on these subjects. [redacted] and [redacted] are usually quite busy so I've put them as optional. I was unsure whether or not to include your Project Line since I was told [redacted] will be coordinating it from now on, that's why you're appearing as optional. Could you see if [redacted] is available instead?

Thank you for the feedback.

Hello again,

[redacted] is P12's PMO, which is not related with P00 LiDAR Coordination. **Please make sure that the Sensible Car's coordination structure is clear to everyone.**

I'm replying to you that I will be out-of-office. Please forward the meeting to the correct person.

Figure 29 - E-mail exchange with P12 line responsible.

Reflection
P12 competence area was software. Its scope was to provide software solutions that allow LiDAR prototypes to function. However, because it could not wait for SC.LiDAR prototypes readiness, its workflow would be mostly parallel to the bulk of PL involved in building Prototype A. As such, P12 neither was invited nor usually attended P00 Coordination meetings. The same happened with P03, P05, P06 and P07, for other reasons. Anyway, because SC.LiDAR requirements concerned all PL, it was important to promote and support a common interpretation of the project's purpose. P12 responsible questioned the researcher's interpretation of SC.LiDAR stakeholder dynamics. At this point, they remained somewhat unclear, as the addition of a new Project Management Officer to the coordinative structure illustrated. She mentioned the SC Program structure, although this only concerns the 12 LiDAR PL. From a behavioral standpoint, one could question why she chose to make this a public exchange. Besides keeping the TD and FM in copy, she added a PM Officer (BrgP/PJ-INV) to the distribution list. This was before that new associate was first mentioned. Her replies had passages written in bold (and highlighted in yellow). Even if the purpose was not to disparage the researcher's approach, it is striking that first, she claimed her role should be marked as required, to subsequently acquit herself from that responsibility by refusing to forward the invitation to P12 co-responsible. Acknowledging this kind of transaction was unproductive and piled up in everyone's inbox, it was better to leave it unanswered and personally approach her when possible. P12 co-responsible presence would be asked for in parallel.

In the hour leading to the meeting on February 18, the researcher decided to stop by P12 responsible desk and try to understand the animosity behind the e-mail replies. No notes were taken of the actual conversation. The researcher's statement of intent and impressions about project reality were met with condescending observations in an ironic overtone. Unable to get to an honest exchange and feeling patronized, the researcher found it time to go and prepare the meeting room, excused himself and suggests continuing the conversation another time.

At the meeting room, people were starting to gather. All PL responsible were present, including P12 co-responsible. ENG41 FM had come, whether as FM or P09 responsible was unclear. The TD was also present. The researcher started by thanking everyone's presence and began with the presentation. After giving an overview of the first physical prototype sensor architecture and highlighting which PL were included or excluded from its definition, the requirements topic was introduced. He was stopped short by ENG41 FM, who asked if the LiDAR prototype would be built according to BES standards. This questioning from a senior figure in the project structure sent the researcher off-track, who in turn, looked to the TD for support. The TD answered the question and reminded all of the paramount need of having a first functioning prototype by the next Program audit, due in few weeks. This information shocked ENG41 FM who was unaware of such a requirement. The researcher proceeded with the presentation and stressed that the LiDAR technology emerging from the SC.LiDAR would always aim to be of automotive worth, even if that maturity would not be achieved by the end of the project. Before leaving, everyone was told to refer to their PL charters, and if they had any doubt, to get in contact with the researcher or the PMO. ENG41 FM talked to the researcher on the side and asked to meet him and the TD, immediately, about what would be needed for the upcoming audit.

Reflection
ENG41 FM intervention came off as a bit discouraging, as if to question the researcher's interpretation and approach to SC.LiDAR requirements. The question could have been rhetorical because a FM would know which standards the teams are referring to. If not all the teams, at least those under her responsibility. Her posture contrasted with that of other attendees. Some of these participants, who also had been in other project meetings where management was present, did not utter a word. It is striking that a team that felt so strongly about requirements' definition did not pronounce itself when given the chance to discuss it with management. Early in January, during a P00 coordination meeting, the TD had set the goal of having a first functioning prototype before the Program audit, which would happen sometime between March and April. This was an internal agreement, as neither the Technical Annex nor the PC had such milestone defined. Because ENG41 FM did not frequently attend to P00 coordination meetings and, apparently, had not been reading the distributed meeting minutes, the information was new to her. This incident also revealed that information was not properly flowing at the upper management level.

ENG41 FM and the researcher gathered in a small room and, after awaiting the TD for some moments, decide to go through the purpose of P00 once more. The researcher said that he was looking for a chance to apply PM methods to improve coordination between SC.LIDAR PL. He recognized it was still early to go forward with a proposal. The physical prototype was discussed. ENG41 FM acknowledged the worth of the initiative and suggested that a recurring meeting at the management level should be held too, to align project priorities and support the researcher on his errand. She stressed the need of having a system overview of the prototype system. The TD had arrived in the meanwhile but remained inattentive for most of the conference. The researcher clarified that the physical prototype was not meant to be shown in the upcoming audit, which was just being taken as a reference to have a ready MVP. A LiDAR management meeting was set for the next weeks.

Reflection
ENG41 FM willingness to talk to the researcher and TD after the meeting is a positive sign. The research kick-off meeting left the impression that ENG41 FM and TD's relationship was strained. Questioned about it, the researcher's mentor (ENG6 team lead) said that, from what he knew, they would be on good terms one day or not speaking to each other the next one. These LiDAR management meetings could be a chance to observe and strengthen that bond, if possible.

P00 Task Force

Reflection
If P00 had already existed before, it meant this research context was not the first time Bosch tried to align SC.LiDAR by eliciting the interdependencies between PL. The project server contained some presentations where the strategic purpose of the task force was explained. Its focus had been to provide the overall system architecture for the prototype sensor. The temporary team had been cross-disciplinary and had had 6 members, including ENG42 FM, the responsible for P03, P04, P10 and P12 line responsible and co-responsible. P10 responsible had since left the company. P03 did not integrate the common sensor prototype, but its responsible had been included as the optical expert. Some aspects of the proposed architecture became outdated since. The same could be said of team interdependencies. It would be interesting to know what had been made of this past coordinative effort. A meeting with the remaining task force members would be scheduled.

Figure 30 - Cover for P00 task force presentation.

To the meeting held on March 4, P03 and P04 line responsible answered, as well as P12 line co-responsible. ENG42 FM and P12 responsible did not attend. The following notes were taken:

- After some introduction, to confirm the purpose and acknowledge the work of the task force, the participants were asked why it seemed that work was of no consequence. P12 co-responsible said P00 had several meetings throughout 2019 then "for several reasons the PL diverged". Asked to elaborate on those reasons, they mentioned e.g. limited team capacity, lack of focus, upcoming (individual PL) deliveries, and internal audits. P12 co-responsible added "some of them started working towards integration, others not so much".
- Upon being asked if they knew of the Technical Annex and what was committed with the project sponsors: "(it was) never shown to the teams".
- About the common prototype build and how its integration aspects were largely absent from the PC: "Prototypes already existed, at least implicitly, before the project charters sign-off". The line responsible stated of P04 "(we) edited the PC to include prototypes and line testing (...)". It was done to "include integration aspects absent from the initial version and also to secure support from UM side".

Reflection
The assembling of a task force one year before the current events showed that management had long been aware of integration issues. That same management seemed to have failed to see through the task force results. As PL responsible testified, they had been unable to uphold that purpose because some PL, i.e. their members, did not abide by management directives, as things gradually reverted to

their former state. The teams did not have access to the Technical Annex, which meant they were reliant on the PC. The PC, in their turn, seemed to inaccurately translate SC.LiDAR scope. Interestingly, these task force members were present at the research kick-off meeting of December 4. It might explain why some opinions they shared that day were so strongly felt. These people were once invested in P00 and their work was, in some way, disregarded. P12 line responsible has not answered this meeting invitation. Her uncollaborative attitude could be rooted in a feeling of contempt towards the researcher's purpose, which once was hers.

The PMO and the Sensible Car audit

An upcoming audit of SC had been a talking motive among project participants. Although it seemed natural to consider it in P00 coordination meetings, some stakeholders had a different interpretation. This motivated the following e-mail exchange between the researcher and his ENG6 colleague, who worked at the PMO.

From: [redacted] (CC-PS/ENG6-Brg) <[redacted]>
Sent: Thursday, February 27, 2020 9:50 AM
To: FIXED-TERM de Matos Pinto Renato (CC-PS/ENG6-Brg) <fixed-term.Renato.deMatosPinto@pt.bosch.com>
Subject: Auditoria - P00

Bom dia Renato,

Segundo nos comunicaram oficiosamente, a reunião de hoje da P00 tem planeado passar informação sobre a próxima auditoria ao Programa SensibleCar.
Tem atenção que o principal responsável pela auditoria é o Sr. [redacted] (PJ-INV), portanto qualquer processo de preparação deverá ser comunicado e validado por ele.
Se precisares de alguma informação fala com o [redacted] ou passa cá em cima, sendo que eles são os que mais experiência têm na realização das auditorias.

From: FIXED-TERM de Matos Pinto Renato (CC-PS/ENG6-Brg) <fixed-term.Renato.deMatosPinto@pt.bosch.com>
Sent: 27 de fevereiro de 2020 10:45
To: [redacted] (CC-PS/ENG6-Brg) <[redacted]>
Subject: RE: Auditoria - P00

Olá [redacted], bom dia,

Na reunião da LiDAR P00 irei referir as possíveis datas de Auditoria e o status a que nos reportaremos (dez19). Poderei mencionar que existe um esboço para a apresentação das linhas de projeto do subprograma LiDAR. Entendo que os detalhes da preparação serão passados posteriormente às equipas pela [redacted] e [redacted], conforme o que o [redacted] e [redacted] concretizem junto do Sr. [redacted]. O ponto da reunião é um de informação geral realmente, não sairão ações dali. Obrigado por avisares!

From: [redacted] (CC-PS/ENG6-Brg) <[redacted]>
Sent: Thursday, February 27, 2020 11:04 AM
To: FIXED-TERM de Matos Pinto Renato (CC-PS/ENG6-Brg) <fixed-term.Renato.deMatosPinto@pt.bosch.com>
Subject: RE: Auditoria - P00

Eu não tenho experiência em auditorias, mas o habitual é que tudo o que está definido e planeado hoje seja mudado até lá. A começar pelo programa inicial até aos responsáveis por apresentar e o respetivo tempo para cada projeto.

Antes de passares qualquer tipo de informação para as equipas, deixa que os responsáveis tomem uma decisão final, caso contrário vamos ter mais confusão e ruído.

P.S.: não era um aviso, nem me entendas mal. É mesmo pelo que vejo no tipo de reações cá em cima ☺ Começa a ser criado ruído (que não queremos), que depois com a constantes mudanças aumenta e que temos que lidar com ele.

Figure 31 - E-mail exchange with PMO representative.

Reflection
According to the colleague's report and from what reactions he witnessed, the fact that the audit was being mentioned at P00 coordination meetings disturbed some stakeholders in the PMO's sphere. He warned that the main responsible for the audit is the PMO's head office. In a direct translation, "any preparation process must be communicated and validated by him". The PMO structure belonged to another BU in Bosch and it became increasingly apparent that it was highly centered. This perspective seemed to disregard that PL teams had their own agenda and any extraordinary event would take from their usual workloads. The likely date of occurrence was being tracked in P00 coordination so that the teams were aware and could better accommodate for the additional preparatory work when the time came. This would be one of the given reasons for sharing audit information on P00 meetings. One may question why these concerned parties chose not to directly talk with the researcher about the issue. CC-PS PMO's behavior did not quite correspond to the roles described at the CC Divisional Directive (subchapter 4.2). I.e. it seemed more focused on program execution control than on overseeing and guiding managerial processes. On one occasion, upon learning from P09 co-responsible that they would not be able to comply with all their PC goals, the researcher talked to a PM Officer representative about a scope change request. This was downplayed on the PMO side, which declined to be informed by e-mail about the researcher's findings. Furthermore, the office came across as overly secretive about the information it shared. Because PC seemed to be in low account and inaccurately reflected the committed prototype sensor definition, access to the Technical Annex was asked. That request was denied. The document was obtained through UM's PMO, which is odd, considering it was easier for an insider to get access to a document from outside the organization. For confidentiality reasons, only the first page can be presented (Annex 5).

LiDAR Management meetings

A first SC.LiDAR management meeting happened on March 5. This was the first time the researcher had the management structure all for himself. He reintroduced his research purpose. FM was asked what PM methods were being applied to SC.LiDAR and to the BP project. They replied SAFe was used on the BP, but the methodology could be abandoned shortly because it had not been fruitful. On the innovation side, they did not follow any specific PM methodology. Asked how they tracked project progress for SC.LiDAR, they said they used excel and notebook sheets for that purpose. The researcher asked for support in trying to diagnose, devise and implement a PM approach to improve SC.LiDAR coordination. A survey would be given to the development teams, to assess which management aspects they found most critical. The FM pledged their support and stated that the researcher was free to experiment with the PL. The upcoming audit was mentioned. The TD said it might take place on April 3.

This was the only management meeting that took place. To the one held two weeks later, only ENG41 FM attended. Both TD and FM had significant agenda conflicts and found it troublesome to attend.

Reflection
Despite FM word that they would allow the researcher to experiment with the PL, SC.LiDAR personnel were divisional resources. I.e. even for those associates working full time on innovation, who charged their work hours to the project, their workload was managed by functional management (ENG41, ENG42). The researcher had no real control over project resources and would be reliant on an informal agreement. Furthermore, the researcher's authority seemed undermined by the sustained absence of both FM and TD from P00 coordination meetings. The fact that management first suggested and then quickly abandoned these LiDAR management meetings, reinforces the half-hearted commitment they had either to the research purpose or to SC.LiDAR as a whole. The researcher disbanded the management meetings since, as it turned out, they did not seem to answer management information needs. Because SC.LiDAR does not follow a PM framework, classic, agile or hybrid, perhaps taking classic PM knowledge areas could be a starting point to frame the informal processes that are in place.

The pandemic

The researcher and his mentor at Bosch met with the research supervisor at UM, on February 20. SC performance metrics were discussed, as well as the emerging issues concerning SC.LiDAR management. Scope, communication and risk management seemed to be the most relevant topics, but schedule and cost management were also addressed. The researcher was suggested to meet with the UM PMO and see if it was possible to refine project deliverables from a high-level chronogram it reportedly kept. Other research methods, such as questionnaires and semi-structured interviews, were discussed to advance the research purposes at Bosch.

The researcher arranged a meeting with one of UM PM Officers on March 2. The high-level chronogram UM had been using was the same Bosch PMO had access to, through the Technical Annex. Although it was not thoroughly reviewed, the project timeline, milestones and deliverables (large WP) had been directly transposed to the 12 PL charters. Therefore, there was no increased activity detail to work with, as both offices found it sufficient to monitor high-level execution. The researcher and the PM Officer discussed project design, the concerns teams had regarding system architecture, as well as synchronization issues between Bosch and UM. Some information was exchanged. The UM PM Officer took interest in the P00 task force of early 2019. Therefore, after consulting with his mentor and the TD, the researcher provided some outdated information on it. "In return" he got access to the Technical Annex.

A few weeks after these events, there were news of a possible pandemic outbreak at UM facilities. On March 11 the researcher was told to preventively isolate at home, since he had recently been at the University. The following week everyone at CC-PS Bosch was given the same order. The researcher's return to Bosch facilities would not happen before May 25. Meanwhile, Bosch implemented lay-off measures to counter the pandemic effects, which significantly delayed this research and SC.LiDAR advancement. Semi-structured interviews were indefinitely abandoned as a potential research method.

Project transparency and clashes

Since January 2020, an alternative prototype optical concept had been brewing in the mind of P01 line responsible. She found support for this in her FM (ENG42). The TD has been informed and wanted this concept to be developed off-the-record, as a backup to the main one. Understanding the polarized nature of the project structure, seemingly divided between those that responded to ENG42 and ENG41 FM, the researcher pleaded the TD to bring this parallel experiment to P00 coordination. The TD rejected the proposal.

The prototype optical concept had long been a source of contend in SC.LiDAR. Since the optical subsystem did not belong to any PL scope, optical experts under ENG41 FM supervision were responsible for defining it, but not formally committed to do so. Because it took so long to come forward with the first optical concept, the relationship between these teams and those under ENG42 FM had become strained.

Reflection
The development of an off-the-record prototype might divide the project team even further. If management were found to have been supporting a hidden, parallel experiment, it could alienate some people from P00's coordinative purpose. From a technical standpoint, the backup solution was the idea of a single person. Although she was qualified on the field, any concept worth of trying should be scrutinized by capable peers.

Meanwhile, P01 and P02 had been working on committed PL deliveries, which included the architectural design freeze for Prototype A. This was bound to a second, committed prototype architecture (Prototype B in the Technical Annex), which more directly concerned P02.

P01 line responsible asked the researcher for a project distribution list. After sending the deliverables to SC sponsoring authorities, they wanted to distribute the frozen prototype concepts to all team members. The researcher, who had been gathering information with the purpose of surveying team members, readily provided the e-mails.

Reflection
In hindsight, such solicitousness might have been a disservice to project alignment. Also, it was striking that in a project so far advanced, there was no overall team organogram, contact information, etc. accessible to all.

There was a high probability that an e-mail by P01 having the "final word" over the optical concepts would distress the other teams within the optical competence area. Sensing this, the researcher suggested the information be sent to him, and then distributed as if sanctioned by P00. P01 line responsible thanked the offer, but she was going to do as told by her FM.

From: [redacted] (CC-PS/ENG42-Brg)
Sent: Wednesday, March 25, 2020 4:28 PM
To: [redacted] (CC-PS/ENG42-Brg); [redacted](CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG42-Brg); [redacted](CC-PS/ENG41-Brg); [redacted](CC-PS/ENG32-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted](CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted](CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG42-Brg); [redacted] (CC-PS/ENG42-Brg); [redacted](CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG42-Brg); [redacted](CC-PS/ENG42-Brg); [redacted](CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG42-Brg); [redacted](CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG42-Brg); [redacted](CC-PS/ENG42-Brg); [redacted] (CC-PS/ENG42-Brg); [redacted](CC-PS/ENG42-Brg); [redacted](CC-PS/ENG42-Brg); [redacted](CC-PS/ENG41-Brg); [redacted] (CC-PS/ENG42-Brg); [redacted] (CC-PS/ENG42-Brg)
Cc: FIXED-TERM de Matos Pinto Renato (CC-PS/ENG6-Brg); [redacted] (CC-PS/ENG42-Brg); [redacted] (CC-PS/ENG-Brg CC-PS/ENG4-Brg); [redacted](CC-PS/ENG41-Brg)
Subject: SensibleCar System Overview - Prototypes
Attachments: SensibleCAR_SystemArchitecture_prototypes.pptx

Good afternoon,

I hope everything is fine with you and your families. ☺

Attached to this e-mail you can found the system architecture for Sensible Car prototype A and prototype B.

In the future, if you need some information about the system architecture or if you have some doubts, this presentation could be found in the Lidar Share/Innovation/System Eng.

Link

If someone is missing on this e-mail please forward to them.

Thanks in advance and have a nice day!

Figure 32 - E-mail from P01 line responsible with system architecture.

The following day, the researcher's concerns were confirmed, as he learned that some people felt sidelined by the e-mail content. Trying to lessen the damage, and unable to get to the project TD, the researcher reasoned with ENG42 FM that the prototypes' architecture should be ratified by management (i.e., the TD). Over the phone, and then through e-mail, ENG42 FM said the TD would look into the matter.

The subject was dropped, however. The researcher would posteriorly acknowledge and mention the e-mail (Figure 32) through P00 email distribution list.

Reflection
Such incidents illustrate management had been unable to mediate information flow between project stakeholders. P00 coordinative efforts would be hampered if the other PL worked their way around it, especially, if they kept abiding by FM instructions, as P01 line responsible did. This research needed to get closer to ENG41 and ENG42 FM *modus operandi*, understand it and try to, somehow, influence their handling of SC.LiDAR. It was argued with management that there were some insufficiencies in the e-mailed content of Figure 32. For instance, it did not say why it was being sent then, nor did it explain why was P01's line responsible the one sending it. From this research's perspective, project awareness was split between different networks. Closely involved PL were those contributing to Prototypes A and B, i.e. P01, P02, P04, P08, P09, P10 and P11. On their respective ends P05, P06, P07 and P12 were mostly ignorant of how SC.LiDAR integration was progressing. P00 coordination meeting minutes were being occasionally sent to all PL responsible. This did not guarantee, however, that all project team members were being reached. There was no formal communication channel linking the project team structure.

5.1.5 January – April 2020 action route

Table 10 summarizes the evolution of coordination issues perceived between January and April 2020. It also presents the actions that were derived to address them.

Table 10 - January - April 2020 issues and action routes.

Issues found	**Action route**
Project plan Schedule management was only defined at a high-level. The project's planned timeline respected what was defined in the Technical Annex. Further breakdown of tasks would be trying to micromanage the workload of too many teams, which was impossible to compute with the available resources and support.	• Focus on Prototypes A and B follow-up. • Keep on meeting project lines outside of P00 scope (P03, P05, P06 and P07) and check their schedule progression. • Avoid conflict from interaction with P12, which is remotely connected to Prototypes A and B anyway.
Project scope Prototypes A and B architectural and integration needs were poorly defined by PC. The documents had never been updated after signoff and teams did not seem to rely on them.	• Use PC as working documents when following-up with project teams. • Consider individual PL deliveries when organizing "prototype work" within P00 scope.

Issues found	Action route
Project resources Team members responded to functional management. Team composition was fragmented in divisional silos. Many headcounts were shared between SC.LiDAR and BP.	• Determine the full composition of SC.LiDAR team. • Check if project resources are effectively assigned to the project workload. • Understand the use FM makes of project resources.
Project awareness P00 seemed loosely anchored in the project structure. It existed once as a task force that had been since disbanded.	• Increase P00 visibility by brokering interaction between other PL. • Keep P03, P05, P06, P07, P12 and the PMO informed of Prototype A and B progression. • Acknowledge SC.LiDAR problems and invite teams into the solution by surveying individual opinions.
Project communication	• Improve communication awareness alongside team members and managers. • Understand information flow between internal stakeholders. • Lookout for informal communication networks.

5.1.6 May – August 2020 records

This observational period has been significantly disrupted by the pandemic. On one side, the interface with project reality became much more virtual, deprived of the elements of physical interaction. Simultaneously, to face off the economic impact on business revenue, Bosch laid off significant parts of its workforce during this period, which, towards the end, was also affected by the summer holiday season. Therefore, even if P00 coordination follow-up could be maintained (Figure 33), task execution at the team level suffered delays, and exchange with the project team members was somewhat more limited. A survey was given to the project team to diagnose the more prominent problems it perceived (5.2 Survey). These results would be processed between June and July and a strategy for project improvement developed. Its actuation would only be presented in the next observation subchapter of September-December records.

Figure 33 - Chronogram of meeting moments for May – August 2020 stage

SC.LiDAR status survey

On May 4, a questionnaire was sent to all project team members (Appendix 2). The questionnaire structure and its findings are presented in the 5.2 subchapter. This entry focuses on its reception and the stakeholder involvement around it.

After confirming with FM and P12 responsible all team members' names, some of whom the researcher never spoke to, an e-mail was sent asking for participation (Figure 34).

Dear all,

I hope this email finds you well.

As most of you know, my tenure at Bosch has the main purpose of bringing further harmonization to the twelve Sensible Car LiDAR project lines. Another goal of my term is to produce evidence of academic worth, which will confirm my graduation as Master of Engineering Projects Management. Both will require not only the informal, daily contact I've had with most of you, but also some data collection. With this in mind, I thought that surveying the project teams would be a sound, democratic approach, to gather everyone's opinion over a number of management topics. So, if you're willing to participate, please follow the link below:

Sensible Car LiDAR Status

With this survey we should be able to identify (or confirm) which project dimensions are in most need of attention, and then figure what we can do about our working practices so that we get improved project outputs. I will later contact project line representatives to discuss it with them and also inform everyone of the results. If this goes well, another, smaller survey will be passed around, occasionally, to check development and redirect our focus accordingly.

I also had planned to conduct some individual interviews to gather more insight into project issues but, given the recent context we're living, I'll postpone them indefinitely. Just so you know ☺

As always, let me know if you have any questions.

See you soon,

Cumprimentos / Best regards,

Renato de Matos Pinto

BES-Innovation (CC-PS/ENG6-Brg)
Bosch Car Multimédia Portugal, S.A. | Apartado 2458 | 4701-970 Braga | PORTUGAL | www.bosch.pt
Tel. +351 253 182372 | fixed-term.Renato.deMatosPinto@pt.bosch.com

Figure 34 - E-mail to SC.LiDAR team with project status survey.

By May 12, a third of the project team had adhered to the survey, however, answers had been piling up slowly since. Some weekly reminders had been sent in the meanwhile, and support from FM was asked. ENG42 FM quickly replied and asked his PL for participation in their next weekly meeting. Because P12 line responsible had offered to rally her teammates, ENG3 was also involved in deference. ENG41 FM, on her turn, required some insistence before asking her PL for participation. The TD would also be asked to e-mail a reminder to all team members because after nearly one month, adherence was not as high as expected.

Reflection
Relationship with ENG42 FM had been cordial. Both his and ENG41 FM agendas were quite busy, so they only showed up to P00 Coordination meetings very occasionally. Through project team members' feedback, it was possible to confirm when they have asked their PL to answer the survey. It took ENG41 FM three weeks to address the issue with her teams, while ENG42 FM's action was much swifter.

At this point, ENG3 FM had been kept informed out of consideration. P12 line responsible was *de facto* responsible for the subproject, with her manager focus seeming to be on the BP only. After being inquired about team composition, she promptly offered to ask for P12's team members' participation. This contrasted with her initial unwelcoming stance. ENG3 FM eventually made himself available to do the same. However, despite the interest and assurance from both, the number of answers did not reflect the alleged full participation of P12's team members. The TD was also asked to send an e-mail reinforcing the researcher's call for participation. Which, after some insistence, he did. Both ENG41 FM and TD requests happened in late April and did not really influence the total number of answers.

During the survey availability time, a team member shared some remarks about its contents. He found some questions too generic and others too technical. This was acknowledged and justified in an attempt to balance both the researcher's reality and those of the respondents. While one section was inspired in traditional PM areas and uses typical PM terminology, another section provides more readily accessible statements, closer to what was understood to be the everyday experiencing of the project environment. The colleague also asked if some questions could have not been "downgraded from management level to associate level". To this, it was replied that *"It's everyone's perspective at the associate/team level that's so valuable to this process. When answering "How do you think the overall project management has evolved?" think of what matters to you, if you see meaningful change, for better or worse, that you understand management is responsible for"*. Besides him, a couple of colleagues asked for the researcher's support to understand some terminology, while filling out the survey.

Reflection
Having to distribute the survey, made it evident that there was no visual project team structure for SC.LiDAR. The responsible FM oversight respects the logic of Table 6. The PC merely identified PL responsible and co-responsible at the project start. With the help of PL responsible and P12 co-responsible, an organogram of SC.LiDAR PL was elaborated (Appendix 3).

Procurement management

At this point, P00 Coordination was defined by the SC.LiDAR prototype build. This was the main concern around which the PL worked. Some subsystem features were being custom designed and made, but the concept remained much reliant on off-the-shelf components. This should be the fastest and cheapest route to proof of concept. But it also meant there was a big reliance on external parties to get the needed parts.

Bosch had specific procurement policies and procedures in place to ensure a compliant and lawful market search. Like other big businesses in the automotive sector, it adhered to quality standards that determine the use of certified supply chains. I.e. Bosch's direct suppliers were all approved and ranked vendors. Sometimes, however, innovation's unpredictability dictated the need of very specific components, unavailable at the standard supplier fold. In such cases, project team members had a standard supplier acting as a third party, who placed the order on their behalf. As it would be expected, this could delay the purchasing and arrival of parts. Furthermore, all purchasing needs seemed to be processed by a handful of people. Everyone, working on ENG41 or ENG42 teams, had only a couple of colleagues with access to the online buying platform, where purchase requests were placed. From there, these usually needed two management-level approvals before proceeding to a person who created all CC-PS purchase orders. From what has been observed, this process could typically take from a working day to more than a week.

Reflection
Trusting all purchase requests to a single person had its downsides. For one, it made the process much dependent on individual organization, with the risk of some orders falling down the processing list or even being forgotten. Although those few with access to the buying platform had designated proxies, it was hard to pass on task prioritization whenever such replacements happened. On the other hand, it made it unfeasible to sustain order tracking. Based on this research's inquiries, neither the team associates nor the person closing the purchasing order process were used to track order status. Sometimes weeks would go by before word of a delay reached Bosch. Of course, this made it difficult to plan project activities weekly, both at P00 coordination meetings and at the individual level.

ENG42 FM had been asked at some point if it would be possible to give platform access to all PL responsible, but this was answered negatively.

LiDAR prototype B

SC started on June 2018, but the first attempt at a common prototype build (prototype A) had only happened after the December 2019 optical concept. As per PC, both prototypes should be ready between the end of 2020 and 2021 first trimester. To prevent prototype B from dragging as the first concept did, some relevant stakeholders would have to be reunited to define possible concepts. A meeting was set to May 20. P01, P02 and P03 line responsible were summoned as optical experts. P04 responsible too, as the electronics interface expert. Besides them, the technical director and the two main FM were present. The meeting started by framing the development of Prototype B on the SC program scope. Only P02 PC explicitly mentioned it. Prototype B was supposed to build, partially, on top of Prototype A. The meeting summarized two distinct approaches, however. P03 line responsible, the original proponent of Prototype A concept, argued most of it could be adapted. P02 line responsible, a reference optical expert, had P01 and ENG42 FM support in definitely departing from it. The latter option had still many uncertainties, which the optical team was trying to clarify through simulation tests. Both approaches implied some sacrifice of the final system specifications, as required by PC and Technical Annex.

Reflection
P01 line responsible and P03 co-responsible were the duo that has been doing most of the laboratory work on Prototype A. P03 responsible, albeit being the concept originator was 50% on BP and had less availability. It was evident the initial skepticism towards the concept still prevailed among his peers, even after weeks of hands-on experience with the physical set-up. P02 line responsible did not question the concept viability. Perhaps out of politeness for his colleague. Nonetheless, he did not believe it could be adapted to Prototype B specifications, with many of the attendants agreeing with him. The TD did not express an opinion in this regard neither did ENG41 FM, despite being responsible for both P02 and P03. P02 line responsible was 80% on BP, which meant that, theoretically, he only had one day per week to work on SC.LiDAR. He himself admitted it was very difficult to keep up with project demands. Despite it, the optical nucleus under his guidance came up with possible alternative concepts for Prototype B, which were under evaluation.

It was agreed that work on Prototype A would continue as planned. The viability of its conversion to Prototype B would be simulated, as well as the alternative approaches that most of the team backed-up. The researcher agreed to track the findings on Prototype B concepts outside of P00 coordination meetings, which would remain focused on Prototype A.

Reflection
At that point, the alternate, off-the-record, concept for Prototype A had still not been publicized to all SC.LiDAR team.

Informal networks

Throughout this research, relationships were developed with some project team members. This entry is an account of accidental occurrences across the project space.

P01 MEMS – microelectromechanical systems – had a crucial role to play on prototype definition. Therefore, its line responsible had been very close to P00's coordinative effort. This optical engineer was active, resourceful, had strong opinions, and kept a high commitment level. Naturally, she became a reliable source in helping to understand the intricacy of the whole prototype system.

The cordial relationship between P00 and P01 started to change sometime around April 2020. On P00 weekly follow-up meetings, the researcher's considerations and requests for information started to deserve some haughty remarks, even when not directly addressed at her. The impatient tone, verging on rudeness, was not valued at first, as it was thought to be some mood fluctuation. However, such behavior became increasingly apparent, also through hasted or declined phone conversations. At several moments, either on private or meeting times, she would question P00 concerns and legitimacy to intervene on certain topics.

Reflection
This kind of resistance to collaboration and sudden disregard for the researcher's role and understanding of the project seemed unprecedented. In hindsight, there had been some underlying signs of a change in attitude. After the happenings described in *Project transparency and clashes* (p.78), the possibility of using P00 to distribute technical information to all project teams became a talking topic. At least on two occasions, P01 line responsible reacted defensively, as if P00 (i.e. the researcher) was trying to appropriate and take credit for other PL work. There was only one other occasion when such open resistance to P00 intervention was seen. Back in March, when the PLs were being met individually, an invitation was sent to P12. The purpose was to meet the subproject team, get to know them, review their objectives and goals, and see if there were managerial concerns they could be assisted with. At the time, P12 responsible vehemently rejected any chance of meeting, with the excuse that P12 had no dependencies with P00 integration prototypes.

It did not go unnoticed that P01 and P12 line responsible, together with PMO representatives, could often be found together on their breaks, back when everyone worked from the office. Historically, it is known P12 responsible once worked for the PMO before coming to CC-PS development teams. Adding it to the report from *The PMO and the Sensible Car audit* (p.74), it could be that this collective was not keen on allowing P00's interference in the project *status quo*.

P05 New polarization concept – was an independent PL that did not participate in the common prototype build. Like other PL in this circumstance, it was being monitored, nonetheless. Its team composition included the line responsible and co-responsible, both assigned 20% to SC.LiDAR and 80% to the BP. The PL co-responsible was frequently being replaced by FM. An intern, assigned 100% on Innovation, completed team composition.

Sometime around May, the intern approached the researcher, concerned his contract would come to an end the following month. He wanted to know about the chance of his continuity at the company. The researcher told him he did not have information on it, but that he could, anyway, approach his FM (ENG41) and ask her about the prospect. The intern was told the concern for his future was legitimate, but it would take some encouraging talks before he got to do it.

Reflection
Noticeably, the intern was the only team member working fully on Innovation. This could mean his exit could significantly impact the team workload capacity. He was reluctant on addressing the issue with his manager. ENG41 FM would be asked if there would be continuity for him or if a replacement was being planned.

As it turned out, she was completely unaware the intern's contract was coming to an end. On a call, on May 11, she expressed surprise that his term had been so short. She expected it to be a year-long internship, instead of the contracted nine months. She would look into the possibility of extending the intern's stay for a maximum allowed period of two months.

Reflection
The researcher, as an intern himself, knew this type of contract could take from three up to twelve months. He had looked up how many people worked under these conditions on SC.LiDAR, and when were their contracts due so that they could be adjourned, and their contribution acknowledged before the team ahead of their leave. As this instance shows, ENG41 FM appeared to be much focused on BP. In such context, it would be a legitimate concern to gather the PL team, or talk with the responsible, and understand how it would cope with the change before a certain member was gone.

Despite her suggestion of having SC.LiDAR management meetings, ENG41 FM availability throughout the research was quite limited. She did not usually attend P00 coordination meetings. Furthermore, keeping her attention over the phone proved a challenge, as she would quickly dismiss any inquiry if she found the questions ambiguous or delivered unassertively. Although not publicized, it was known that she would be leaving the project in some months. Between May and June, an additional effort was put into reaching out to her. This was done to get to know how some project-specific topics were faring under her ward, especially concerning P09, for which she was still the formal line responsible (project team structure on Appendix 3).

Calls with ENG41 FM were held on May 11, May 18, and May 27. On June 8, the researcher ventured some questions concerning SC.LiDAR management. Upon being asked how priorities were defined for balancing SC.LiDAR and BP workloads, she admitted favoring the latter. Not only the development pace was faster, because LiDAR ART had defined sprints, but its goals were also clearly set for each PI. She saw Innovation more as if a "playground", i.e. a sandbox, a project with relaxed requirements, where teams could "experiment more freely". This was the last one-on-one talk with ENG41 FM before her departure.

Reflection
In a way, this corroborates that ENG41 FM was more aligned with BP objectives than those of SC.LiDAR. Because she is a German national, first admitted to the company in her home country, it was understandable that her priorities would be more aligned with the German location of CC-PS, rather than with the current (and temporary) Portuguese one. Additionally, this reverberated with a couple of instances, where at least two distinct ENG42 team members said that people working on Innovation strived to get to work on the BP. Judging by SC.LiDAR charters, several original PL responsible under ENG41 FM followed this course. Which could mean she had been using Innovation as a training ground, from where, in time, resources would be channeled to the more competitive BP environment.

At the start of July, P05's intern corporate accesses were deleted. This meant the associate had no access to his e-mail or any other company-sanctioned communication channel. His personal computer configuration and associated program licenses were lost too. Perhaps due to ENG41 FM own impending leave, the processes for the intern exit could not be stopped when a prorogation of his term was requested. He would stay working for SC.LiDAR until the end of August.

This was not the last interruption affecting PL work, however. Because of the pandemic, Bosch countering measures included the possibility of doing home office for most associates. After a stabilization period, a phased return to the office started in June. By the end of July, the researcher learned that P05's intern failed to return to the office and only had been at his station sporadically since. An ongoing argument between him and his P05 line responsible for working conditions had been going for weeks then. The intern himself reported on this.

Reflection
P05's intern term extension seems to have been poorly managed, which yielded in the loss of working tools and the subsequent loss of work efficiency. The ensuing argument with his line responsible showed a lack of arbitration. P05 responsible inability to escalate the issue could be a sign that there was no replacement for ENG41 FM, now departed from the project, or that previously, that link with FM was not resorted to.

From the diligences made, there was no apparent responsible for the intern's actions within the project. Some opinions had it that in ENG41 FM's absence, the TD would be responsible for the PL once under her supervision. This was suppositious, however. ENG42 FM was consulted but had no authority over the matter either. The researcher eventually reached the BP team supervisor of P05's line responsible, who decided to intervene and reach HR in this regard. HR then called the intern, demanding his return to the office the following week.

Reflection
Evidently, the contentious nature of the relationship between P05's line responsible and intern had flown under management's radar. This was suspected, months before these events, but because contact with P05 had been marginal (outside of the prototypes' A & B build) not much was made of it.

P05 intern would be back at the office on August 17. A meeting would be scheduled with the PL to broker an agreement between the clashing elements and organize the work for the remaining two weeks of the intern's contract.

These episodes, involving P01, P05, and PMO associates, illustrate how growing personal relationships can shed light on deeper project meanings and motives, and on what struggles may afflict proper project understanding and execution.

Communication strategy

ENG42 FM was deeply involved in the ideation, submission, and approval of SC. The personal stake he had in the success of SC.LiDAR was, therefore, higher than what could be expected of other functional managers. He was consulted frequently to make sense of the observed project reality. With ENG41 FM's departure from the project structure, it was expectable that his influence on the project's direction would grow. Therefore, the actuation of the survey's findings has been done in close collaboration with him.
Based on the survey's findings, i.e. the teams' feedback (5.2 Survey), communication management was perceived as the area with the greatest potential for improvement. This agreed with the researcher's impression of the observed project reality. As such, the researcher and ENG42 FM opt to rethink the meeting rationale for SC.LiDAR (Appendix 4). As it was, meetings limited to a single project line team or those of P00's coordinative space, did not reach all stakeholders nor answer their information needs. Besides those work organization meetings, some people met sporadically in technical subsystem meetings.
P00 coordination meetings, led by the researcher thus far, would give place to P00 *Strategic and System Integration* (Figure 35). Its scope would remain centered in the common prototypes' evolution, with a

contribution of all relevant PL responsible. That way, the number of attendants was reduced and responsibility for representing the PL is centered in the line lead. A PMO representative would be invited to this meeting, to safeguard alignment with external stakeholders.

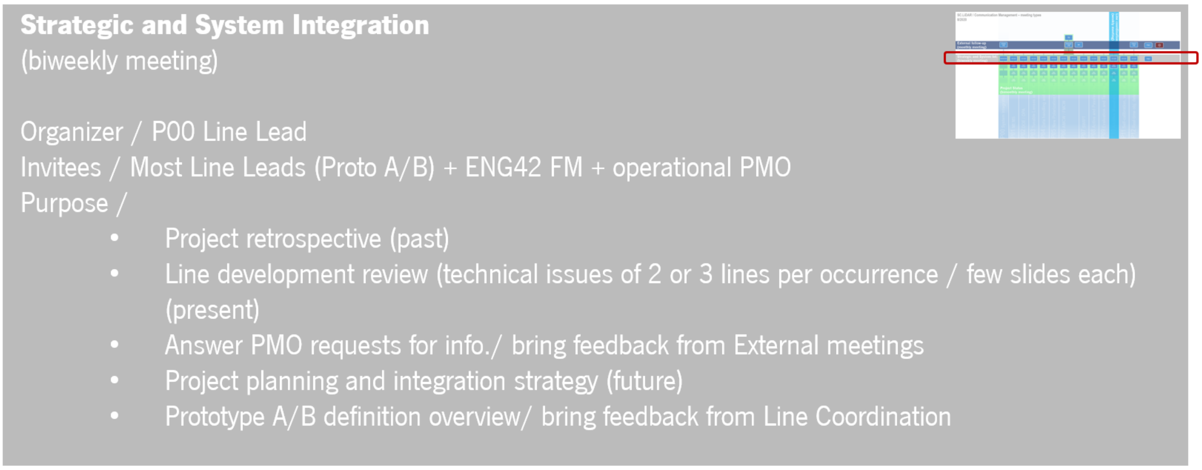

Figure 35 - New meeting rationale - Strategic and system integration definition.

Strategic and System Integration meetings should happen every two weeks, although they might be done weekly during the transition period. Feedback would be brought in from each PL from line coordination (Figure 36). The following figure expresses management expectations of what line responsible should organize at the PL level. No hard rule would actually be enforced, although a meeting frequency was suggested. Likewise, ENG42 FM expressed the want for the line responsible to fill a standard template with PL status. However, no standard format had been agreed when the research ended.

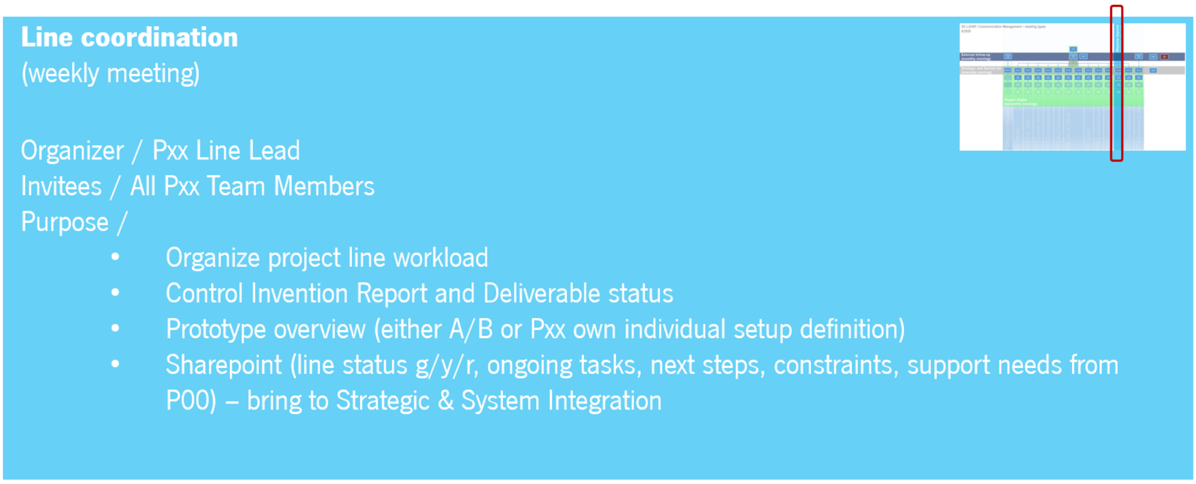

Figure 36 - New meeting rationale - Line coordination definition.

To improve project transparency and visibility, a large reunion of all SC.LiDAR internal team members was idealized too. Project status periodicity was set in two months. Besides giving everyone an update on the common prototypes' status, PL were invited to present a summary of their own progression. This way everyone got to see what specific PL challenges existed at any time and knowledge sharing was encouraged (Figure 37).

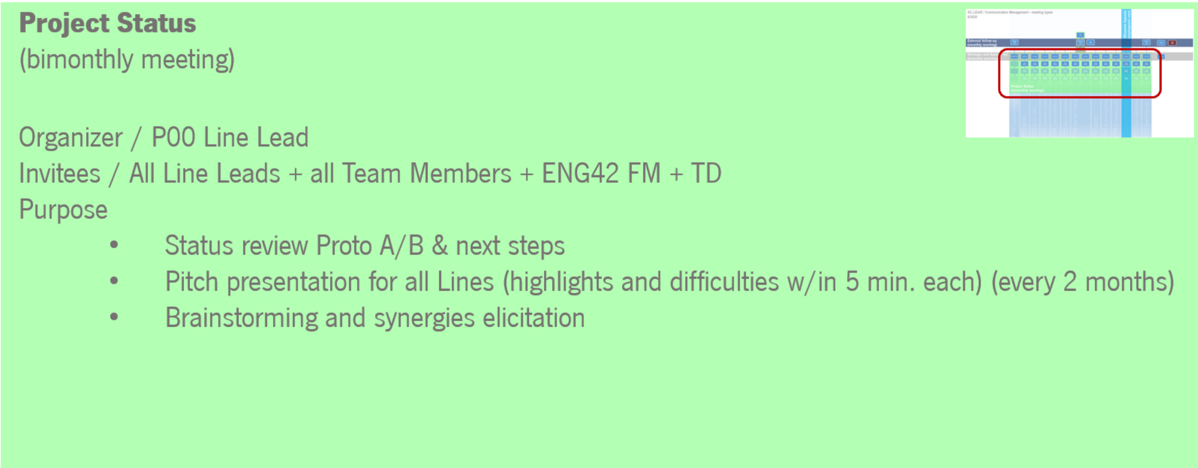

Figure 37 - New meeting rationale - Project status definition.

Another communication channel that was considered was the high-level coordination with the external co-promoting entity, the University of Minho. The researcher did not have access to this channel, which was reserved for FM and TD contact with the university's PL responsible and both PMOs. As per FM suggestion, this would be a modal meeting, which could be used for management topics or to cover a particular PL technical issue. It was also considered the appropriate channel to broker the development of new ideas with external stakeholders.

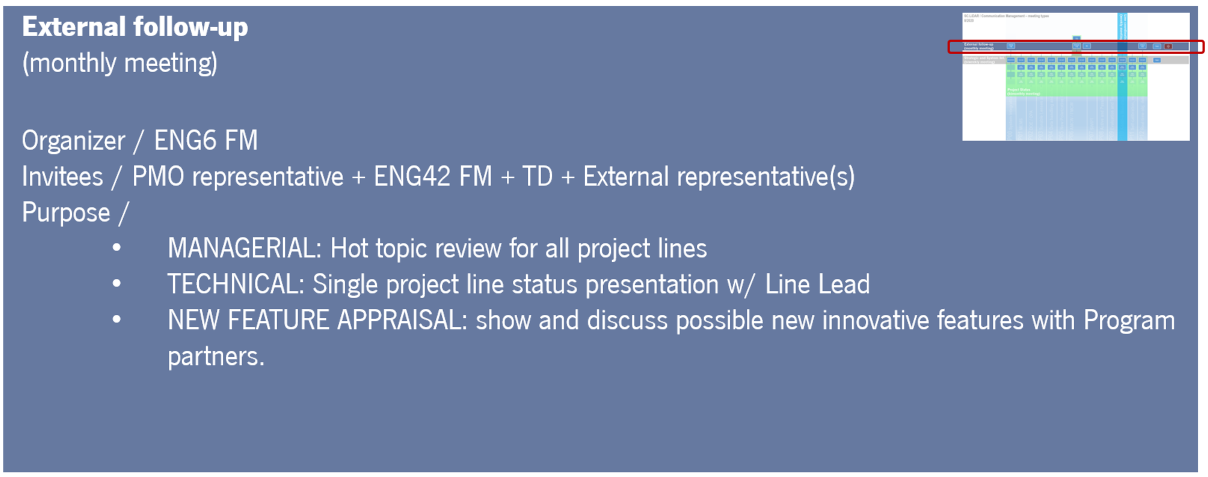

Figure 38 - New meeting rationale - External follow-up definition.

Reflection
All PL formerly under ENG41 FM would likely be transferred to ENG42 FM's responsibility. The revised organogram in Appendix 4 already reflects this. Implementation of a viable communication strategy had to have his endorsement; therefore, the new meeting structure was tailored with him. The researcher's influence would have continuity through *Strategic and System Integration* and *Project Status* meetings. In this regard, PL level coordination would continue to be mostly organized by each line responsible. In the same way, *External follow-up* meetings would be out of reach, because they are reserved for higher management. Some aspects remained unclear on this new communication strategy. For instance, ENG42 FM wanted a standard PL status template, but observations suggested each line responsible had its own way of organizing. A tentative reporting template was presented, and it was suggested that PL responsible (line leads) should have a say on it. Furthermore, stakeholder responsibility and accountability were still vaguely defined for each meeting moment, which was something that could be improved.

On August 3 a small workshop was held, including the Technical Director, ENG42 and ENG6 FM.

After reviewing the survey's findings, the reassigning of project personnel was discussed. Impressions about key project members were exchanged. One of the most significant changes was the reduction of split-heads working simultaneously on Innovation and BP. Project awareness was then addressed, with managers suggesting the use of company channels, like *Boschtube* or *TechTalks*, to increase stakeholder involvement with SC.LiDAR. The new meeting rationale was presented next. The moment could be particularly useful to clarify the meeting type's purpose, determine if the relevant stakeholders were being considered, and what responsibilities were expected of them. In preparing the workshop, the researcher had produced some artifacts, namely a Responsibility Assignment Matrix (RAM - Appendix 5). A particular concern for the researcher was to understand the dynamics of *External follow-up* meetings, which only upper management attended Management, however, was not explicit on details, and meeting roles remained unclear, as the appended diagram shows. The RAM did not gain much traction alongside the TD. The meeting was overtime and before leaving, the TD's concerned remarks were about guaranteeing ENG42 FM knew how to persuade certain people to remain, or perhaps rejoin the project structure. A stakeholder engagement matrix had been also prepared, focused particularly around the twelve PL leads, but it was found to be much subjective for communal use.

Reflection
The workshop was proposed by the TD, ahead of SC.LiDAR reorganization, which was meant to happen at the start of September. Workshops are intensive training sessions that focus on techniques or skills to use in a particular field. The produced artifacts did not garner much interest from management, however. Getting the appropriate project resources to work on the PL was mentioned repeatedly

throughout the meeting. Authority and responsibility concerns voiced by the researcher did not seem to have much impact. Despite the effort to validate the RAM and use it as a reference tool for the teams, it did not impress the TD. A positive outcome was that in reviewing meeting typology, the researcher managed to better understand what ENG42 FM expected of *Strategic and System Integration* meetings, which will replace P00 coordination.

5.1.7 May – August 2020 action route

With the processing of survey results, the research's focus would be prevalently on communication management aspects. This would be done by continuing to raise stakeholder awareness about this dimension (Table 11). Other formal tools would be sought to aid in the implementation of a new meeting rationale, as previously described. As the project entered its final year, scope management, particularly the aspects surrounding the unifying prototypes, would become ever more pressing. However, this was also the last observational period before the research's end, and expectedly, of the researcher's ability to contribute to a favorable project outcome. Therefore, promoting cohesion, through integration and enhanced project awareness seemed a suitable course.

Table 11 - May - August 2020 issues and action routes.

Issues found	Action route
Project scope	• Follow through with Prototype A & B concept concretization
Project resources	• Check periodically if PL resources are overloaded and escalate the issue if necessary. • Observe how ENG41 FM exit from the project structure impacts the teams.
Project awareness	• Publicize team organogram. • Present survey results and follow-up strategy to the project team.
Project communication	• Improve communication awareness alongside team members and managers. • Devise alongside FM and TD a new communication rationale to improve information flow and cross PL coordination (ongoing).
Project integration	• Work on aspects of authority and responsibility in the project structure.

5.1.8 September – December 2020 records

2020 summer months were partially spent on preparing for ENG41 FM's return to Germany. After establishing that, except for P12, all PL would be under ENG42 FM's supervision, the team composition was revised. According to the researcher's mentor, upon ENG41 FM's arrival, back when the Program started in 2018, she pushed for the existence of split-heads. Purportedly, this would allow for synergies to grow between Innovation and BP. But evidence suggests that, in practice, that balance was hard to keep by team members and management alike. With this in mind, ENG42 FM and TD convened on some rearrangements to the team structure, which was to take effect at the beginning of September. It was agreed to delay the presentation of SC.LiDAR survey results until that period.

Survey presentation

On September 4, the SC.LiDAR survey of three months prior was presented. This was done virtually to 22 attendants. Half a dozen people were at the University for the day or on vacations. Another half dozen had since left the project (between fixed-term interns and expatriates). Counting off FM and TD, 56% of team members heeded P00's call, which was slightly less than the respondent percentage. After the presentation, the team was encouraged to place questions, which with some reluctance it did. P08 line responsible raised a question about the survey's representativity. The researcher directed this to question 3.1.16 (Appendix 6), using it as an example to show that there is some indication that respondents have been predominantly people working on SC.LiDAR. Absent split heads, who should be more aware of potential conflicts of interest with BP, could be the reason why non-opinioned answers took so much expression. After a small exchange and without further questions, the team was told that the results would be sent to them and to call back, should they have any doubt.

Reflection
Attendance to the presentation did not differ much from the initial survey's adherence. The team was by then smaller, nonetheless. The pandemic started to take its toll on the project structure, with interns having no perspective of being hired and some expatriates having chosen to return to their home countries. Some people justified being busy with other appointments, while others were out of the office. A quarter of the team, however, had not given any answer, so its absence was without a seemingly valid reason. This result was shared with management, to have them reflect on the current reach of the integrative purposes of P00. How responsibility fares across the project structure could also be inferred, not only from this specific presentation, but from how people would respond to the new meeting rationale.

From a behavioral standpoint, the team did not seem overly curious about the yielded results, with only a couple of associates voicing some questions. It could be that the survey had lost its momentum because it took a long to present its findings. Or it could be that the team was uncomfortable with being openly critical of the management practice, while managers were present. The main purpose of the presentation was to provide context for the communication strategy on the making. But it was also meant to promote exchange and a better understanding of certain perceived problems. Even so, both management and the team remained quite passive throughout the session. Those who could not attend were offered a second presentation, but barely anyone showed interest. The survey results were shared by e-mail and ENG42 FM exhorted everyone to join the upcoming project meetings under the new arrangement.

Coordination with UM

From the research onset, the researcher's mentor spoke of enhancing coordination between both PL team sides, working at Bosch and UM. This need, identified by him and the TD, has been transmitted to the teams on several occasions. The PL responsible, in their turn, complied to different degrees, with some inviting the researcher to their meetings with UM. Those meetings were usually presided by UM's PMO. Over time, Bosch's PMO, which had been mostly absent from such encounters, started to take a more participative role.

One of the researcher's immediate concerns was that in participating in such meetings, he could be overstepping the PMO responsibility on the project structure. After sharing the instructions he got from FM with his ENG6, PMO teammate, the researcher opted for a non-participant observer posture. This meant assisting to stakeholder dynamics, without intervening or sharing information with them.

The researcher was at some meetings for P04, P05, P08, P10, and P11, between May and September 2020. Typically, these occurred every two weeks, although both the lay-off and vacation periods contributed to some interruptions.

A particular episode stood out from one of such encounters with UM. By the end of May, on a meeting with P08 and P10, the team came to the revision of project risks. The impacts of the pandemic had been reflected on project follow-up in previous sessions. When the PM Officer asked the team, whether the risk was still relevant or not, the UM PL responsible argued the situation seemed stabilized. Eventually, everyone agreed to remove it from the risk follow-up list.

Reflection
This sort of behavior, particularly regarding risk analysis, was prevalent across PL meetings. Although teams proved capable of identifying risks, there seemed to be a tendency for downplaying their impact on project execution. It was as if people did not want to stir up things too much. Excluding the possibility

that they did not care, it was either because they did not genuinely think the risks' impact would be significant, or because they did not want to estrange their institutional counterparts. The fact is, several Bosch associates have had setbacks when trying to access, not only the University's but external facilities elsewhere, because of the additional health and safety measures.
From a cultural perspective, this also hinted at latent power imbalances that could affect a transparent exchange between participants from both institutions. Because Bosch's line leads were relatively young, less experienced engineers, they might find it troublesome to speak up to their counterparts, who were knowledgeable academics with longer life experiences. Yet, Bosch teams often attended these meetings with no backing from their own PMO or FM, who could help to tip the power balance.

On the afternoon of September 15, the researcher accompanied P05 and P11 to their meeting at the University. The small auditorium barely allowed everyone to keep socially distanced. From what the researcher could make, most PL team members were present. Some people, including a second UM's PMO, had joined in virtually. From Bosch's side, P05 team members and P11 line responsible were present. Bosch's former P05 intern was also present, although it was unclear under which pretense.

Most of the meeting time of P05 was reserved to present technical themes, interwoven with some programmatic concerns. As SC end closed in, it was paramount that several promised invention reports (IR) would be identified and submitted within the program's scope. Because submission and deliberation over an invention's worthiness could be a slow process, the ideas had to be identified as soon as possible. P05 line responsible shared three possibly patentable ideas, which involved light polarization, but excluded using it for LiDAR technology. A team member doubted this would fall under the project line scope. The researcher consulted P05's PC there and then, to find under the IR description that it was expectable ("*espectável*", in the Portuguese original) that they had a LiDAR application. This was not shared with the audience. One of UM's PM Officers offered to check it out later. As the P05 meeting was about to conclude, Bosch's line responsible had a request to make. He asked, rather harshly, that Bosch had to have access to the raw data that had been collected by the experimental set-ups at UM. His counterpart seemed puzzled by why it would be so and asked to what purpose would it be needed. P05 line lead reiterated that Bosch had to have access to the raw data. Realizing his rough tone was not unintentional, faces across the audience shared the same confused expression as to what is happening. UM's line responsible asked if it was a project requirement, but the answer was, again, a rephrasing of the same blunt request. Eventually, the UM PM Officer stepped in and said he would look into the Technical Annex to sort it out.

On the break between meetings, the researcher talked with the team on the side, and told them the first steps of invention report appraisal within the company were taking, on average, more than half a year.

Therefore, identifying potential ideas and preparing them for submission was a priority. They were also told the PC expected IR to apply to LiDAR technology.

Reflection
This first session with P05 showed that the team's perception of their PL scope was still flawed, with the Bosch line lead proposing patent ideas that did not adhere to Sensible Car's purposes. His strict demand for the University to share raw data seemed to take everyone by surprise. The lack of decorum in his demeanor could not go unnoticed as it could potentially harm the relationship between institutions. This incident illustrated there is room for individual competence improvement, if not of all, at least of this PL lead. Of course, the larger question here was if management at Bosch was aware of such shortcomings in PL leadership. It was also inevitable to think that Bosch could be left exposed by bestowing its representation on unseasoned team members, and that such stakeholders' dynamics should be being overseen by someone higher up in the command chain. Lastly, diligences were made to understand why P05's former intern, who had left the company weeks before, was present at the session. He had been promised a research contract to remain working on the project at the university, but this had not been formalized still. Considering the unamiable terms in which he departed from his supervisors at Bosch (*Informal networks* – p.87), it is a risky decision to grant him access to the project without a legal bond.

P11 meeting started without an agenda and jumped right into technical matters, which would take most of the available time. In the end, the UM's PL responsible presented the audience with a challenge. He asked for potential new ideas to explore in future collaborations between institutions. Both UM and Bosch had been working on the prospect of future innovation programs, which would succeed SC. He gave an example involving optical filters, which many wrongly interpreted as being a support request for one of the already existing PL of SC. It took a while to sort out the misunderstanding. Eventually, someone asked if the challenge could not be a bit more specific, i.e., if from an "engineering perspective", was there a problem they should be trying to answer to. The same participant said that sometimes "this type of project" felt like an impossible quest to check too many options. The debate went on for a bit longer. The team was dismissed having to search for new ideas for homework. No due date was mentioned for coming forward with them, however.

Reflection
The discussion between project participants at the end of P11's meeting was much interesting to watch. It was a decal of the challenge's innovation projects present when there is no clear execution path to follow. It also resonated with the difficulties that teams typically face in ideation processes, such as brainstorming. It seemed a bit worrying that no deadline was set for the call of new ideas. This was a widespread aspect of the observed meetings with the University. As stated before, there never seemed to be too great a risk that could not be downgraded, nor was there a sense of diligence calling for hard-line commitments. Even when ongoing tasks ran overtime, people reasserted the delays were

recoverable. But one could not help but ask, if delays kept piling up, what would happen when there was no buffer left, at the end of the Program?

Resource management

P09 – LiDAR Evaluation and Testing Platform – former line lead was ENG41 FM herself. In practice, the PL co-responsible had been the one working alongside P00 towards integration. This co-responsible complained about workload balance for SC.LiDAR and BP from the research onset (*Meeting the project lines,* p.56). In addition, from May 2020 she assumed a new Scrum Master role on the LiDAR ART. From meeting attendance and through open talks with the researcher every now and then, it was clear she was increasingly unengaged with SC.LiDAR.

P09 had several investigation routes. One of such routes mimicked what was being done in the German quarters of CC-PS until it was found to lead nowhere. ENG41 FM was the main liaison on the topic and, before leaving, conceived a strategy to redirect the PL towards its goal. One of the contemplated changes included the return of a project resource to the project structure. In a way, this was a kind of reposition, as the associate has been contracted through SC.LiDAR but worked on the BP. This transition was to happen the first weeks of September, but as it turns out, by late October 2020 the topics that awaited him were still to be picked up.

P02 – OPA/DOE – was responsible for the optical concept of Prototype B. The line lead was a very knowledgeable engineer, who was mostly devoted to the BP, however. FM and TD had been adamant that he would remain on the project after the team restructuring, even if with the same limitations as before. Through informal talks (*LiDAR prototype B*, p.86), it had been agreed to bring forth a concept for Prototype B sometime during September. This was later postponed to October. As late as December 2020, parts were still being ordered to advance with the physical build of the concept.

Reflection
The described instances show that, despite the intent, project resources continued detached from SC.LiDAR priorities. Reducing the split-head count seemed to have had a peripheral impact on the project development speed. For the last weeks of this research, a passive stance has had been adopted in advance of exiting the company, so no inquiries were made alongside management in this regard.

P00 Strategic and system integration

The beginning of September, P00 Coordination meetings are replaced by *Strategic and System Integration* ones. The meeting series invitation is sent to most PL responsible by ENG42 FM, without the researcher's former knowledge. The same happens for *Project Status* meetings, which have the full team structure in attendance.

Reflection
Theoretically, it was up to the P00 line responsible to set up these meetings, but FM got ahead and decided to take the lead here. Anticipating his own exit from the project, the researcher decided to not object to this. Any expectation he might have had of still directing these meetings was quickly put aside. ENG42 FM did not give up control of them. Even so, the researcher tried to remain an impartial critic of the format and would interrupt the meetings' course to raise questions he understood the team should consider. For instance, it was not uncommon for the PL leads to lose sight of the meeting purpose and dwell in deep technical discussions. These would consume a lot of the available time and subject those not directly involved, or even knowledgeable on the field, to long waiting times. As meeting occurrences went by, this had another perceivable side effect. Even with the meetings being overtime, there was not enough time to speak of the second prototype (B), which seemed to be getting forgotten. Meanwhile, the alternate concept that management chose to develop off-record had been brought to light, and it would also compete for the available time and team resources. A file directory was set afresh in MS Teams for SC.LiDAR. During the first meetings, no one seemed willing to write down the ongoing tasks and research routes, and when compelled to do so, the records would not register things like the assigned person or the expectable due date. In this sense, it was a regress from the previous P00 arrangement. After the meetings, the researcher would revise (or compose) the online records and leave them for the team's approval. Bills of materials (BOM) were proposed by some line leads and this was backed up. It helped to keep track of the prototypes' concepts and allowed everyone to better see the overall component availability.

In setting up *Strategic and System Integration*, ENG42 FM invited in all line leads directly involved in building prototype A, prototype B and the backup version. Even before BOMs were considered, he instructed P01, (P02), P04, P07, P08 and P10 to fill in the component specifications and status of each element of the prototypes' subsystem. In parallel, he asked P01 line responsible to compile a system test list that the prototype systems would have to go through once completed. Noticeably, P09 and P11 were not readily included in meeting occurrences, nor were they told of the system testing list, despite system testing and end of line testing being, respectively, of those PL direct concern. Access to the file directory in MS Teams for P09 and P11 line leads was asked from ENG42 FM, but he declined the researcher's request, arguing the leading team had to focus on prototype completion first.

Reflection
In assuming the backup prototype concept as an open research route, P07 was added to the coordinative PL fold. Simultaneously, P09 and P11, which had been present in P00's coordinative meetings, were left out of *Strategic and System Integration*'s first months. It is questionable if the P01 line responsible should have been the one defining which tests ought to be performed when there were two PL specifically dedicated to the topic within SC.LiDAR's structure. Even if they did not get a say on which tests were needed, something unlikely considering their scopes, they should at least know what was expected of their ability to test system performance. After commenting with P01 line responsible that P09 and P11 should be made aware of the testing list, ENG42 FM was talked to as well, in the same regard. He downplayed the need to give P09 and P11 immediate access to Strategic and System Integration's file directory. Despite being responsible for all these PL, ENG42 FM seemed less concerned about some PL that were formerly under ENG41 FM ward. It can be that he was more focused on prototype building than on prototype testing. However, there was an inherent risk of keeping system testing PL ignorant for too long. When completing 2020's last trimester, they would have only half a year to make any betterment or adjustment, until the end of the program. Regardless of P01's line responsible intentions and the will of ENG42 FM, the researcher decided to make an offline copy of the system testing list and share it with P09 and P11. Its line leads were told that a status review of what they could or could not test would be held at the start of October. They were asked to criticize, propose and justify changes to the list, as well as to think of possible correction plans to recover from any delay they might be facing.

Reflection
As the last observational period went by, the researcher experienced a growing feeling of estrangement from the project. With the new meeting rationale, and with ENG42 FM taking over the coordination meetings, he was being stripped of what authority he once had. P00 was becoming more functional management and less project management. Despite the company's instructions to favor remote home office, many PL leads, and the FM himself was frequently at the company's facilities. This more than physical distance between the researcher and the team had grown ever since it became evident the pandemic came to last. Line leads were increasingly drawn to ENG42 FM and in having to report to him, they were less likely to share information with the researcher or would feel burdened if I asked to do so. The researcher discussed it with his own FM, who suggested maybe setting up his station next to the teams, but it felt too late for that. Even more so because it would be trying to compensate for access the researcher no longer had.

As ENG42 FM was wrapping up the last meeting before the years 'end holidays, the researcher intervened to address the team one last time. Besides the appropriate cordialities of the moment, they were left with two pieces of advice:

- To make progress visible to their teammates. E.g. by taking pictures of the prototype set-ups in the build; to keep, update, and publicize records accessible to all.
- To go across organizational boundaries and speak to each other, even when if it was not customary or expected of them. To try and let go of notions such as ENG41 and ENG42 and work as the unified brand Bosch is meant to be.

5.2 Survey

In order to get a broad understanding of the challenges afflicting SC.LiDAR management, the thought of surveying team members came up. As explained to the team, this seemed a fair way of balancing everyone's opinion about what needed to change. An anonymous questionnaire was set to collect feedback from all 38 project participants, working within Bosch, at the team level. The management structure was left out, despite the two main FM holding PL lead positions in the project organization. Team members working at UM and other external entities were not considered either, as this research increasingly focused on issues between the PL inside the company. The survey can be consulted in Appendix 2. It was subordinate to the subject "Agile vs. Classic Project Management in Innovation Projects – SC LiDAR status". Although one of this research's initial presumptions was to see how Agile or classical PM could be used to benefit SC.LiDAR, this questionnaire focused more on the latter part of the title: project status. The questionnaire was made available through a sharable MS Excel survey function. It was so to avoid using services outside of Bosch, which could compromise data protection. The downside of using such a tool is that it does not allow to narrow down questions. As such, the questionnaire is linear, and everyone is presented with the same set of questions.

The questionnaire structure takes the PMBOK's traditional management areas as reference. In the first section, respondents are asked to give their satisfaction level with each project management area, as identified by the PMBOK (questions 1.1.1 to 1.1.10). Still in this section, open questions are presented with the purpose of finding what project areas people find more critical (1.2 to 1.3) and what they believe could be further improved (1.4). A second section, also open question-based, tries to summarize people's perception of recent past changes to PM practice within SC.LiDAR (2.1 to 2.3). Finally, a third section, provides twenty general statements about project reality, for respondents to agree or disagree with.

Introduction – sample characterization

The survey was available from May 4 to June 3, 2020. A total of 23 answers were obtained in a universe of 38 possible respondents. This represents an adherence of approximately 61% (Figure 39). Gender and age distribution of the respondents can be seen in Figure 40.

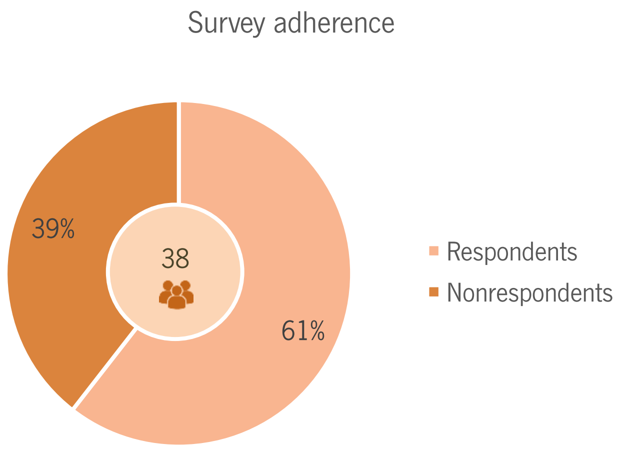

Figure 39 - Survey adherence.

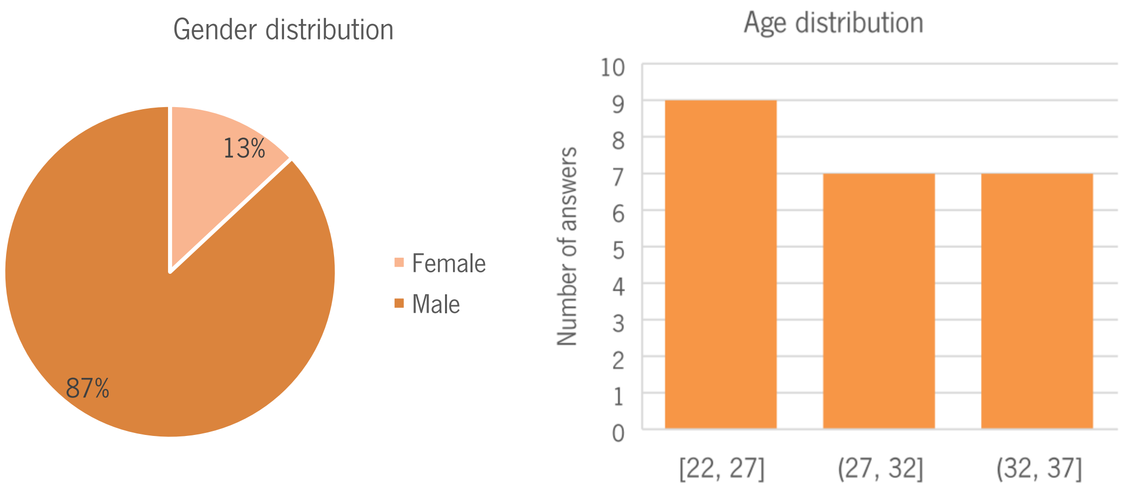

Figure 40 - Survey respondents' gender and age distribution.

Nationality and job function were marked as optional fields, to concede respondent anonymity, as some specific combinations would give away certain identities. Most respondents opted to leave those fields blank, so the data was not processed.

Section 1 – LiDAR Innovation project areas

The first questionnaire section presents the respondent with traditional project management areas or dimensions. Short project area descriptions were transcribed from the PMBOK for reference. In questions 1.1.1-10 a Likert scale applies to the selectable satisfaction level choices, which range from "Very

Dissatisfied" to "Very Satisfied". The scale includes a neutral option, which is meant to reflect a lack of opinion, but that can otherwise be interpreted as a lack of comprehension about a certain project domain. The results in Figure 41 show an overall positive trend for satisfaction level, with a majority of participants (>50%) being "Satisfied" or "Very Satisfied" across all project areas, except for risk (48%) and stakeholder (48%) management. In absolute terms, risk management gathers the greatest number of non-opinioned answers (35%), a result closely followed by quality, procurement and stakeholder management (30%).

Figure 41 - Satisfaction level with SC.LiDAR management areas.

In absolute terms too, the areas with the greatest number of “Dissatisfied” or “Very Dissatisfied” respondents are scope and communications management, where they account for 26% of total answers. Considering this roughly represents a quarter of two-thirds of all project team members, it is still slight evidence of managerial issues to act upon.

To get further insight into the challenges of SC.LiDAR management, some open questions concerning these project areas were presented in continuity.

The answers to question 1.2 “What area of LiDAR Innovation do you find most critical?” varied greatly. While some respondents mentioned more than one project area, others could not find an answer. To weigh in all responses, the qualitative data were analyzed for emerging themes (Figure 42).

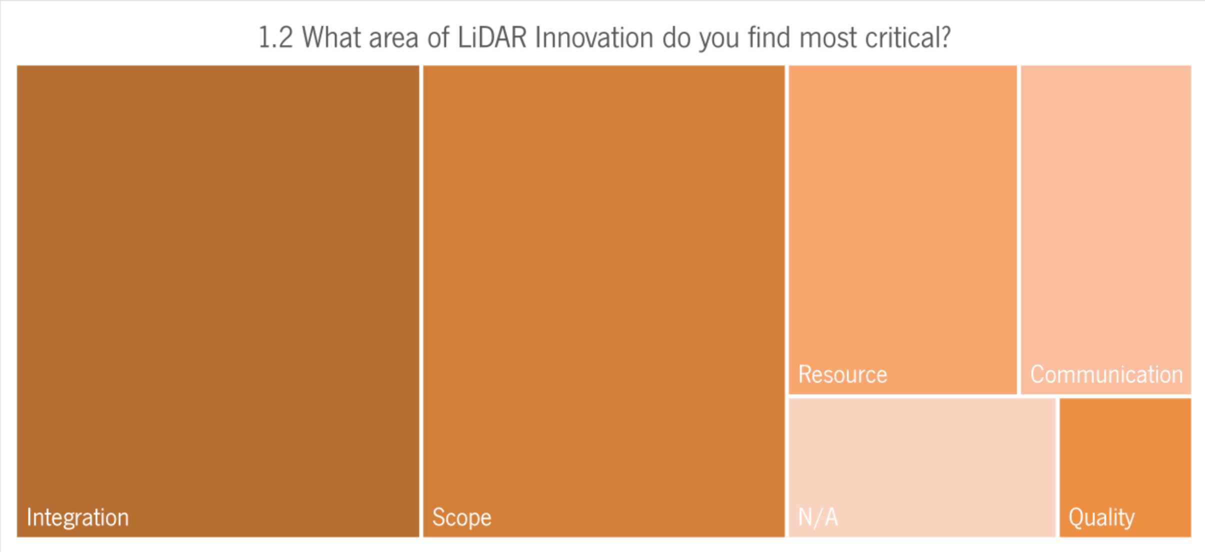

Figure 42 - SC.LiDAR most critical project areas.

Integration and scope management come on top as the most critical areas, with 43% and 39% answer occurrence rates, respectively. Integration issues can be exemplified by:

- Respondent 4, that says "*Defining exactly what are the responsibilities of each line(...)*";
- Respondent 6 points to the "*Interconnection between different lines for a single prototype*";
- Respondent 7 talks of "*Combining all areas and deliver something that works(...)*";
- Respondent 12 mentions "*The coordination between innovation lines(...)*";
- Respondent 24 testifies that "*The interconnection between different lines is not ideal, although it has improved in the last months with the creation of P00*".

Such issues are transmitted to project scope, through the absence or changeability that afflicts the common prototype system breakdown structure, as mentioned by:

- Respondent 13, that states "*Optical is the most sensitive area to care about*";
- Respondent 16 worries about the "*Detection*" subsystem;
- Respondent 23 mentions "*The RX development*" (detection subsystem).

Some answers, specifically, enforce the idea that both these areas' issues were entwined at the inception of SC.LiDAR:

- Respondent 4 wrote it was so "*because on the beginning of the project there was no strategy to get the big picture of the overall project and to get each line working together(...)*";
- Respondent 6 reinforces that "*Most of the single project lines were not defined with an overall system in mind*"

This is in line with the observed findings on project reality within the period of January-April 2020. The data on system architecture references was further filtered to decompose its issues (Figure 43).

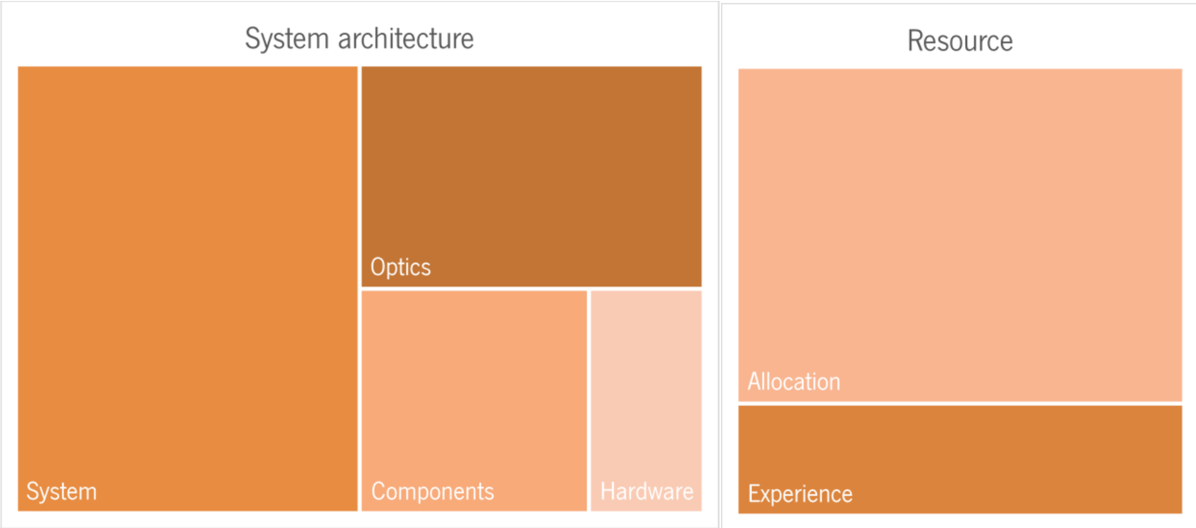

Figure 43 - Detail for issues on Scope and Resource management areas.

The same was done for resource management, the third most referenced critical project area (Figure 43). According to question 1.3 "Do you think it jeopardizes work efficiency?", 57% understand these issues negatively affect work efficiency. This means a significant part of people did not get to elaborate on question 1.3.1 "If yes, can you explain how?". Those who did, explain that, historically, SC.LiDAR resources have not been fully assigned to the project:

- Respondent 3 says "*People that should be working 100% into Innovation are working as well in BP activities*";
- Respondent 5 finds that "*If people are working a bit on several different things it's hard to be concentrated and efficient*";
- Respondent 15 thinks a human resource deficit affects ideation processes and project execution as "*Fewer people working/thinking, less work done and ideas given*" and now "*workload is quite soft considering the people involved, but it was not the case at the beginning (…)*".

To wrap up the questionnaire's first section, team members are asked what they think could be improved about SC.LiDAR (Figure 44). Just above half of the respondents (52%) identify communication management as an area for potential improvement.

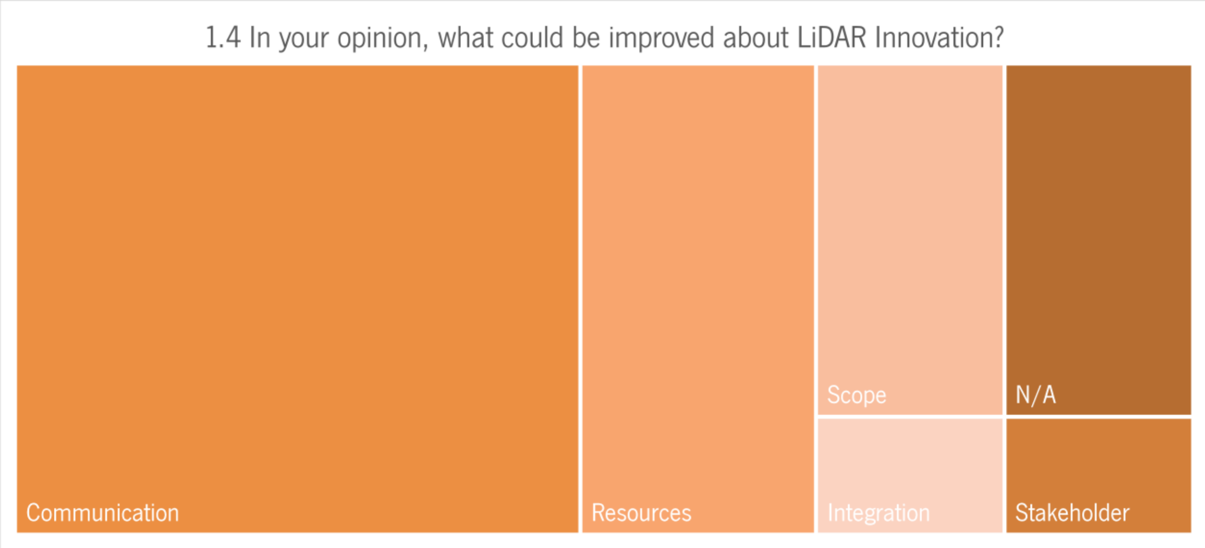

Figure 44 - SC.LiDAR management areas that could be improved.

Section 2 – LiDAR Innovation recent past

The second survey section is meant to measure how PM within SC.LIDAR evolved recently. This segment was thought out to be repeatable in future questionnaires, as a means to assess long-term evolution of project management practice. It has one multiple-choice and two open-ended questions. The first question asks 2.1 "How do you think the overall project management has evolved (all areas considered i.e.)?". Respondents mostly find that it "Improved", 78%, with one person thinking it "Greatly Improved", 4%. Some participants, 18%, see no net change to PM practice (Figure 45).

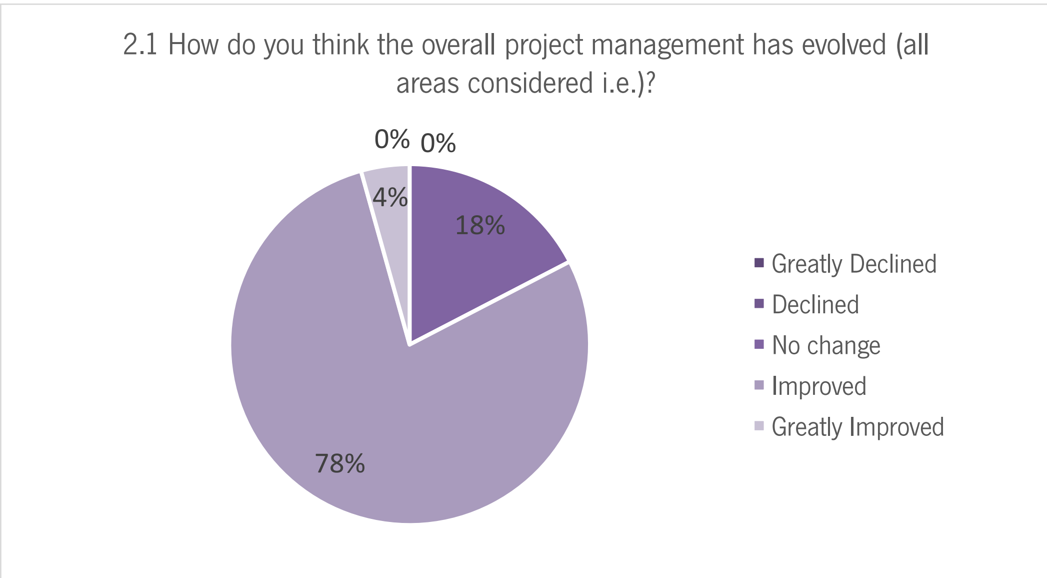

Figure 45 - PM evolution on SC.LiDAR recent past.

Although it is encouraging to find that there seems to be a positive result, for which this research and the work done through P00 can be credited for, the bias effects described in Chapter 3 (3.2 Data collection) may be at play here. To understand if it is so, the results for questions 2.2 "What project area(s) do you think changed the most?" and 2.3 "What project area(s) need(s) to be further improved?" must be looked at.

According to the team's feedback, the most mentioned project areas with perceivable change were communication (35%), integration (30%), and scope (26%) management (Figure 46).

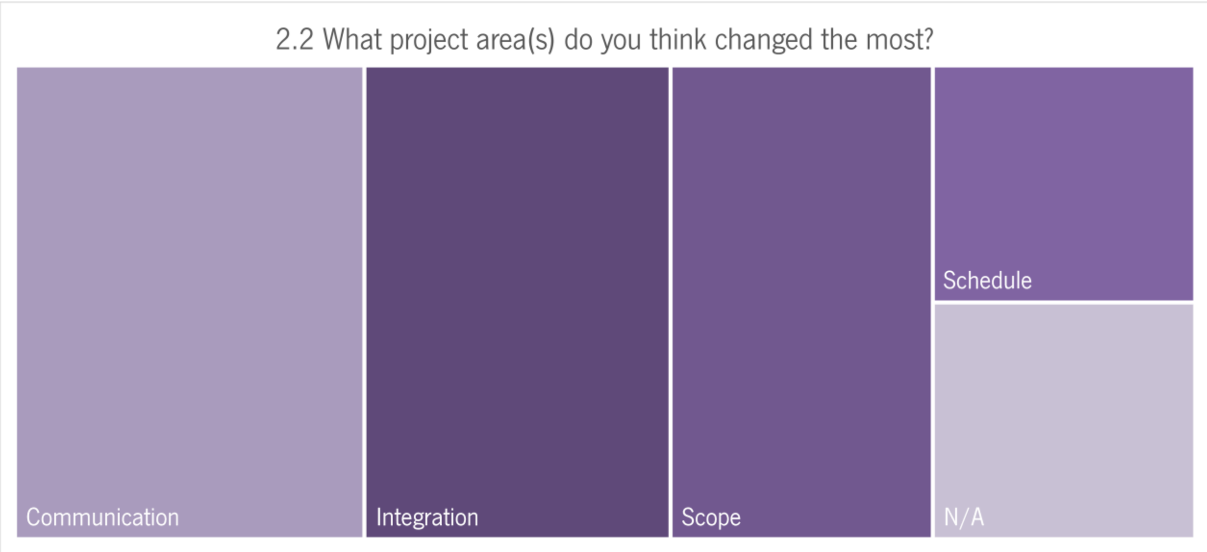

Figure 46 - Project areas which changed the most in SC.LiDAR recent past.

With many participants explicitly mentioning a communication and interaction improvement between SC project lines, others refer to how P00 has been pivotal to enhance coordination among them. It should be noted that P00 references were factored in as improvements to project integration. For instance:

- Respondent 6 says "*P00 started actually working*";
- Respondent 15 "*(...) would say the communication and interrelationship are two areas where this project changed the most(...)*";
- Respondent 20 says "*I think we saw a very good change in P00*";
- Respondents 11 and 23 more concisely see improvement on "*Integration*" and "*P00*";
- Respondent 9's answer, given in Portuguese, reflects how team interaction improved through P00's coordination meetings, although noticing that too many people attended them.

In continuity, participants are asked what could be additionally improved. Their answers reveal that, still, communication management offers room for improvement (30%), followed by project scope (17%). 26% did not provide an answer, said they do not know or are unsure about what to tackle next (Figure 47).

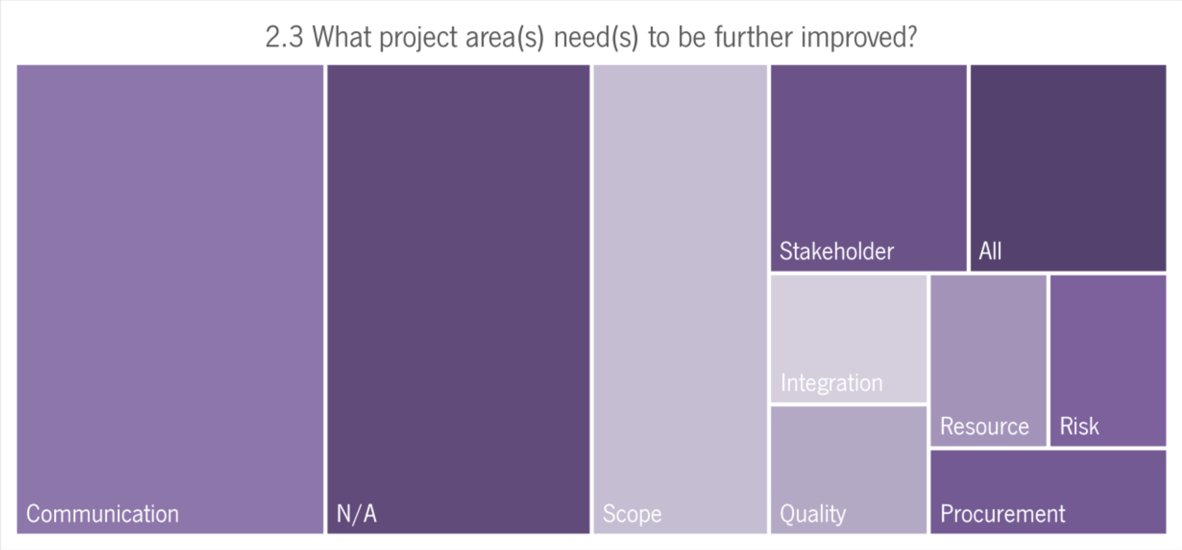

Figure 47 - SC.LiDAR management areas that need to be improved.

Section 3 – LiDAR Innovation integration

The third and last section of the survey has the purpose of probing different aspects of SC.LiDAR integration in the company's environment. Participants are asked to give their agreement level with twenty statements 3.1.1 – 3.1.20, which the researcher devised from the observed project reality during the January – April 2020 period. Some statements' link to traditional project management areas is relatively straightforward. For instance, statement 3.1.1 "I can easily access project information" has practical implications on communication management. Other statements, however, are bound to more nuanced phenomena, such as team cohesion, work focus or strategic alignment. Statements 3.1.6 "There are synergies between LiDAR Innovation and LiDAR ART" or 3.1.14 "My opinion and ideas matter to my project line coworkers" are some of such examples. Discrete results for this section are summarized in Appendix 6.

Like it was done for the first section, absolute values will be highlighted (the two highest) in order to interpret the team's response. I.e. statements, where the larger number of respondents coincide on the answer, are assumed to signal things that work well or that could be problematic. Table 11 summarizes answer typology for section 3 statements.

Table 12 - Answer typology for survey's 3rd section.

Statement	Affirmative % (Agrees or Strongly Agrees)	Neutral % (No Opinion)	Negative % (Disagrees or Strongly Disagrees)
3.1.1 I can easily access project information.	**83%**	4%	13%
3.1.2 The connection between LiDAR Innovation and the company's strategy is clear to me.	43%	26%	30%
3.1.3 The requirements for my project line deliverables are known.	70%	4%	26%
3.1.4 My manager deals with LiDAR Innovation with priority.	57%	30%	13%
3.1.5 I fulfill the established project workload (full-time or split-head).	78%	13%	9%
3.1.6 There are synergies between LiDAR Innovation and LiDAR ART.	43%	35%	22%
3.1.7 LiDAR Innovation goals are feasible/realistic.	39%	17%	**43%**
3.1.8 My work contributes to the overall success of the project.	**83%**	13%	4%
3.1.9 The project line has the development tools it needs.	52%	13%	**35%**
3.1.10 LiDAR Innovation is a priority to me.	70%	9%	22%
3.1.11 I am familiar with CC's mission and vision (roadmap).	57%	30%	13%
3.1.12 My project line adds value to LiDAR Innovation.	**96%**	4%	0%
3.1.16 There are conflicts of interest between Business Plan and Innovation.	35%	**61%**	4%
3.1.14 My opinion and ideas matter to my project line coworkers.	**83%**	4%	13%
3.1.15 I get in touch with other project lines when a concern arises.	**83%**	4%	13%
3.1.13 Exchange between my project line and P00 Coordination is adequate.	48%	**39%**	13%
3.1.17 There are high impending risks on the project.	70%	22%	9%
3.1.18 Authority within my project line is well defined.	78%	13%	9%
3.1.19 Authority within Sensible Car is well defined.	39%	**39%**	22%
3.1.20 I am confident of other project lines' technical decisions.	61%	17%	22%

The results show 96% of respondents are confident their project line positively contributes to project development (3.1.12). For 83% this is also a personal investment (3.1.8). Judging by these responses, team confidence in its capability seems quite high, particularly considering there is a greater number of people (43%) who believe SC.LiDAR goals are unrealistic (3.1.7). 35% of team members find they do not have the material resources they need to get the job done (3.1.9). By the time this questionnaire is filled, the project is one month shy of its second anniversary, so it is remarkable that demoralization has not taken a greater toll on the team. Still, it could be that people are not willing to admit it.

Inter and cross PL sharing seems prevailingly on the positive side, with 83% of people feeling integrated into their PL (3.1.14) and reaching out to other subproject teams when needed (3.1.15). The same percentage of respondents find easy access to information, so this is far from a concern (3.1.1).

Looking at where most people had "No Opinion", statement 3.1.16 stands out, with 61% of respondents unable to tell if there are conflicts of interest between SC.LiDAR and LiDAR ART. The questionnaire has some degree of redundancy; therefore, this result can be compared to that of statement 3.1.6, which states the contrary and has more polarized answers (Figure 48).

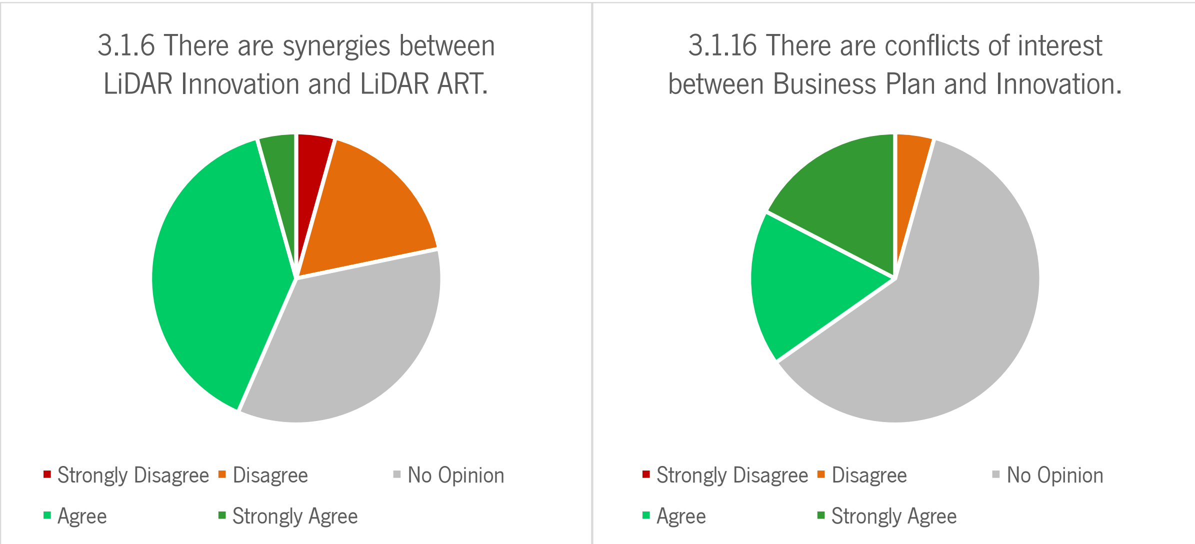

Figure 48 - Survey's 3rd section detail for statements 3.1.6 and 3.1.16.

It could be interpreted that those 22% who "Disagree" or "Strongly Disagree" with 3.1.6 transferred to the 17%, "Strongly Agree" faction of 3.1.16. But factually, that is not so, because contrary to the researcher's initial intention, these statements are not mutually exclusive. Synergies and conflicts of interests always coexist, if not for real, at least potentially. And what Figure 48 shows is that respondents believe more in the potential for both projects to benefit each other, than they are aware of clashes between the two.

The second-highest “No Opinion” score goes to statement 3.1.13, which reveals 39% of respondents do not have an expectation towards P00 coordinative purpose. It backs observational findings that suggest this PL visibility and connection to SC.LiDAR structure is underdeveloped (see 5.1.5 January – April 2020 action route, p.80). The same number of respondents does not understand authority dynamics to the whole SC program (3.1.19). Contrastingly, within each PL, such authority is more clearly defined (3.1.18). It can be inferred that the further away from the team-level organization, the more ambiguous the project structure becomes to its team members. A sense of belonging and purpose is further compromised for nearly a third of the respondents, to whom the link between project foundation (them) and the company's higher strategic purposes is corrupted (3.1.2).

Section 3 delivers some results that strengthen the perceived problems surrounding the project's scope. Besides the already mentioned 43% who believe their PL objectives are unfeasible (3.1.7), 26% of respondents still do not know the requirements they should be working with (3.1.3). Although 70% of the responding team prioritizes SC.LiDAR, 22% openly admits doing the contrary (3.1.10). The percentage of people that fail to meet project workload is slightly less worrying, fixed at 9% (3.1.5). Some 70% find there are high impending risks on the project, whereby risk management assumes significant importance too.

Survey takeaway

The first section showed that the greatest dissatisfied portion of the team lies at the scope and communication management areas (1.1). Respondents see criticality in integration management (1.2). Scope and resource management issues take a significant proportion too, albeit being less mentioned. Scope concerns relate to the uncertainty that surrounds the prototype system's architecture. Team members, working on other projects, account for a resource management issue. More than 50% find that communication management offers room for improvement (1.4).

Section 2 reveals there is an overall improvement in PM practice for SC.LiDAR. This finding is backed by approximately 80% of the respondents (2.1). The team responses show improvement happened mostly with communication, integration, and scope management (2.2). Integration improvement is mostly associated with P00's agency on SC.LiDAR. Asked about what could be further improved, communication management turns up front again, with a 30% reference rate.

Section 3 provides more nuanced insights into project reality, with answers hinting at issues surrounding scope (goals and requirements) and resource management (tools and priorities). Integration challenges are present too, particularly aspects of interrelationship and familiarity with the project structure. In this regard, it is also important to mention the survey's adherence, which fell 39% short of full participation. Such absence can be rooted in a feeling of estrangement from the project's purpose or structure. Otherwise, some project personnel might effectively be working full-time on other projects. Among respondents, there is also a widespread perception of risks hovering SC.LiDAR. Considerations about these dimensions will be made on the observational periods following the survey.

Functional management and the TD will be approached to devise a new strategy to enhance communication management first and foremost. In time, the survey results will be presented to the team, and reform introduced afterward.

The survey's raw data is included in Appendix 7.

6. Discussion

To discuss research findings on SC.LiDAR management, it is important to put the project's existence into perspective. Therefore, this chapter starts by addressing SC.LiDAR scope and how project perception seems to have formed around it. Because this case study is itself a piece of the project narrative, communication and information management take prominent roles, something that has also been enforced by empirical findings alongside the project team. These abstract project management areas were referential for the survey's findings and have been taken from the PMBOK. A second subchapter summarizes the issues found to affect project line coordination within each area. It does not mean, however, that Agile or hybrid PM standards and concepts will be excluded from the discussion. Different aspects of project and innovation management, covered in the literature review, were also brought in for perspective. The third subchapter includes some considerations about the used research method.

6.1 The project in perspective

SC.LiDAR was approved into existence as part of the wider SC program, in June 2018. Such approval was based on the submission of the Technical Annex, which included some technical description of the program goals, and traditional project elements such as high-level planning for the program or some detail on its governing mechanisms. This was later broken down into seventeen subproject charters (Figure 23), which were signed by representatives of the cohort institutions, Bosch and U. Minho, as late as March 2019.

As a rule, the twelve LiDAR PC are signed by one responsible person and a proxy or co-responsible individual, from either side of the partnership. Supporting PMO structures exist on both sides too. From the onset, two functional managers (FM) from Bosch take prominence in the project structure, appearing as the main PL responsible in some cases, or having functional authority over a said person. This research's first observational period started in late 2019, early 2020, and evidence shows the project structure was polarized around two divisional silos, ENG41 and ENG42, headed by the referred FMs (Figure 49).

One of the core issues with SC.LiDAR comes from its design. Before the SC program scope was split into distinct project lines, plenty of the involved stakeholders were aware of interrelationship issues. However, these ended being poorly reflected on the PC. Task division is not clear, with some PL having been assigned activities that fall out of their competence area. In fact, one of the program's flagship purposes is to deliver two innovative LiDAR prototype sensors (A & B). But some of these prototype system specifications, namely the optical subsystem, have been left out of any of the twelve PL charters. This issue is seen as critical by the project team (Figures 42 and 43). The system architecture was also mentioned by ENG41 multiple times (*Research kick-off meeting*, p.57 and *SC.LiDAR requirements and P00 detraction*, p.72) and its impacts discussed with one of UM PM Officers (*The pandemic*, p.77). Furthermore, it means system design has been dependent on an informal commitment between parties.

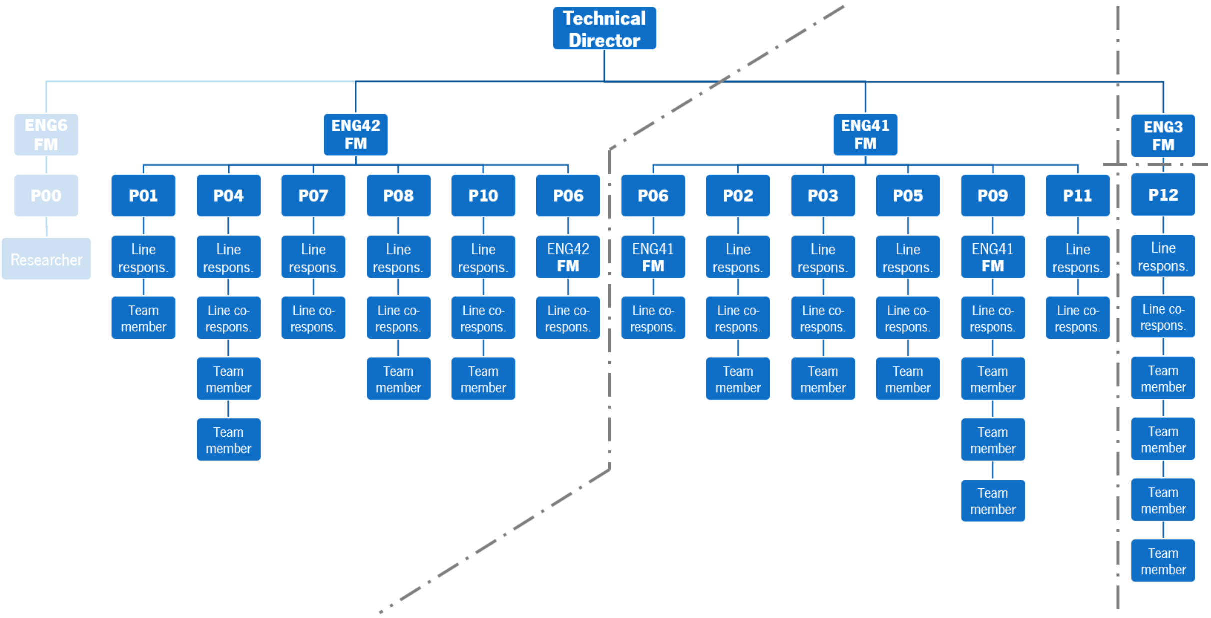

Figure 49 - Interpretation of SC.LiDAR perception partition before the research's onset.

To address this, a task force or system engineering team was assembled in early 2019, with the twofold purpose of conceiving the system's architecture and identifying dependencies among the twelve PL. Regardless of the delivered results, the project structure was insufficiently committed to such arrangement (*P00 Task Force*, p.71). To some extent, each manager failed to uphold that vision for the project.

In the absence of a clear, formal structure, monitored and controlled by a cohesive project management body, informal structures gained prominence. This drift from holistic stakeholder interests, as described by Swan and Scarbrough (2005), could have been undermining team cohesion and project identity from the start. Additional reflection of issues with project authority is patent in P12's organization. With ENG3 FM seemingly oblivious to SC.LiDAR's organization (Figure 49), leadership is effectively poured into a line responsible whose observed behavior is marked by insurrectional tendencies.

Another fragility of SC.LiDAR stems from the inbuilt ambiguity of its scope. This was deliberately done to give room for creative solutions, and in some instances, to remove the pressure of hard performance metrics from, otherwise, very ambitious technical goals. The tradeoff is an increased propensity for diverging interpretations of the project’s goals and the accompanying scope creep. Both sides of this double-edged sword have been observed on SC.LiDAR. Being a basic research project, it benefits from individual ingeniousness, as described by Satell (2017). The backup prototype concept, ideated by P01 line responsible (*Project transparency and clashes,* p.76), proves this, by affirming itself as the main development route towards the end of 2020. On the other hand, events involving some project lines (*Coordination with UM*, p.94) show that it is possible for a PL responsible to be proposing solutions that contradict the project’s “expected” results, just a few months away from its conclusion. Another instance of scope creep, which has not been previously mentioned, involves P10 – *Additive Manufacturing Technologies*. For much of its existence, this PL positioned itself as a hardware provider, without effectively trying to come up with innovative construction or material solutions for the prototypes. This omission in its results was realized by the researcher towards the end of the research (December 2020), upon re-reading P10’s PC. It stresses the need for management to regularly check adherence to the project’s scope. This is part of what leadership is meant to be, and as Chesbrough (2012) and Dias et al. (2014) argue, it is a crucial competence to lead the team into achieving a project’s full potential.

Considering the above, this research argues that interpreting such complex scope features cannot be left to the team’s sole discretion. It is one of the instances where project leaders ought to have a more directive kind of style and lead by example (Jung et al., 2003).

Leadership, authority and organizational structure

A directive kind of style was indeed adopted by the project’s technical director (TD) in the research early weeks. His push for a first optical concept and functional prototype (*Meeting the project lines*, p.56, *SC.LiDAR requirements and P00 detraction,* p.66) seems to have kickstarted P00’s coordinative purpose. His presence, however, became increasingly scant as the year progressed. It is unclear if it had always been like this. From what little feedback was sought on the matter, it appeared to be so. But, perhaps, his divergences with ENG41 FM had been more detrimental to his authority over the project structure. What is granted is that coordination and communication between the two had broken down several times, as directly witnessed or reported by third parties. Arguably, the failed setup of *LiDAR Management meetings* (p.74) illustrated an unwillingness to repair that link.

Lack of authority has also tormented the researcher’s role, as P00’s line lead. Adopting a mediator role was useful to bridge the polarized structure that had formed around functional management. This is in line with findings from Blindenbach-Driessen and Van Den Ende (2010), to whom project leaders must engage in coordinative and integrative efforts when working with functional organizations. When surveyed, the project team recognized significant improvements in communication and integration management, the latter being explicitly attributed to P00 (Figure 46). In hindsight, this might have worked because the team, itself, yearned for a neutral ground, where through dialogue, some PL were able to settle their differences. But with ENG41 FM's exit, the project structure converged in ENG42 FM, which assumed authority over almost all project lines (as reflected in Appendix 4). Although P00's purpose carried on as strategic and system integration, the researcher's role as line lead became somewhat redundant. As argued at the end of the last observational phase, ENG42 FM was now much better positioned to ensure monitoring and control processes. The team understood this intuitively. If they had to escalate an issue, for whatever reason, they had a direct, vertical line of reporting binding all PL together, which rendered the horizontal, projectized structure obsolete.

Ideation, innovation and project transparency

Innovation is dependent on ideation processes and the ability to combine new ideas into successful solutions. From a strategic standpoint, this requires the organization to be on the lookout for emergent solutions amidst its ranks. This is a challenging feat, in the sense that the wider a project structure is, the greater the number of voices to be listened to.

When this research kicked-off, SC.LiDAR had nearly forty associates within Bosch (Appendix 3). While evidence suggested some people had been, if not completely, at least quite detached from the project structure (see *Resource management,* p.100), others showed an active interest in being part of a solution, judging, for instance, by the numbers joining P00 coordination meetings early on the research (see *P00 LiDAR coordination meeting from February 13,* p.66). As mentioned in the observational records, managing large assemblies can sometimes prove chaotic. Because, practically, there is no way to take in everyone's opinion, at any instant, management must come up with a plan to guarantee most individual inputs are considered, at all times. Reflections on project awareness, from late March 2020, showed that no information routes were linking P00's coordination, management, and individuals working at the PL ground level (*Project transparency and clashes*, p.78). In the absence of formal ideation and communication processes, this required keeping team members engaged through a culture of trust and transparency.

As Seeber et al. (2017) argue about the virtues of group brainstorming, its biggest accomplishment is teams' convergence and acceptance of an idea. Group ideation helps to develop team spirit (Furnham, 2000). And as other authors complement, management, or facilitators, have an arbitrational role to play in setting the rules for participation and birthing of project solutions (Litchfield, 2008; Rossiter & Lilien, 1994). When P01's line responsible came up with an alternate concept for a LiDAR prototype, the TD refused to make it a transparent process and, arguably, let it be scrutinized by capable peers (*Project transparency and clashes*, p.78). ENG42 FM was complacent with this. If found out, it could potentially damage management's relation with associates working under ENG41 FM leadership. Either conscientiously or not, keeping her in the dark, as had happened before (see *SC.LiDAR requirements and P00 detraction*, p.71), perpetuated a divisive example for the PL to reproduce amongst themselves.

Setting up a transparent project environment is not only beneficial to innovation as it is a *sine qua non*-enabler of agile PM frameworks. As described in subchapter 2.1.1, transparency is one of the three founding pillars of Scrum (Schwaber & Sutherland, 2017) and visual workflow processes are principal to Kanban (Tarne, 2011). Developing an off-the-record prototype went against this premise. One of SAFe's nine principles includes tapping into knowledge workers' personal drive. Once again, to ensure engagement, leaders have to promote an environment of mutual influence, where people voice their opinion, needs and concerns (Knaster & Leffingwell, 2019). Although de-emphasizing the project's formal hierarchy might promote ingenious ideas, like the described backup prototype concept, it is reasoned by Keum and See (2017) that more centrality and control during idea evaluation and selection processes, limit participant bias. Despite having a positive sign of the team's ability to innovate, it is questionable if, in this instance, management upheld the project's best interest, by judging, favoring and allowing the continuity of an idea that effectively sidelined part of SC.LiDAR's structure. It can be argued that, either unconsciously or not, management partiality was still present in the last observational period of this research, when ENG42 FM decided to temporarily exclude P09 and P11 from the core line leading team, assembled in *P00 Strategic and system integration* (p.97).

Feedback from the project team also revealed there were issues in sustaining an environment that favored idea creation and support within and among PL. Some project team members did not felt heard by their PL peers or distrusted other PL decisions (Appendix 6 – answers to 3.1.14 and 3.1.19).

Communication management

Naturally, amending SC.LiDAR's transparency issues would have to pass through reform of communication. The survey's findings revealed the project team was also sensible to the matter (Figure 44 and Figure 47). Literature both on project and innovation management preconizes this can be achieved by either formal or informal means, i.e. by setting up explicit formal monitoring and control processes or by tacit changes to work culture and in individual behavior (Barbosa et al., 2020; Ylinen & Gullkvist, 2014).

To address the perceivable and shared impression that SC.LiDAR had to improve its visibility and stakeholder engagement, the new meeting rationale (Appendix 4) was devised by the researcher and management (see *Communication strategy*, p.88). The relation between these formal meeting moments is meant to set the base for smoother information exchange and improved PL articulation. Table 13 shows how each meeting type relates to typical PM arrangements in established and hybrid frameworks:

Table 13 - Meeting rationale relation to PM frameworks.

External Follow-up	This meeting, involving both institutions PMOs, functional management (FM) and the TD, resembles a steering committee or a product portfolio management body (where the products would be different PL deliverables), as defined in SG hybrid solutions, such as the one proposed by Sommer et al. (2015) or in scaled agile frameworks like Large Solution or Portfolio SAFe® (Scaled Agile Inc., 2019c).
Strategic and System Integration	This meeting, organized by FM, includes a core or Product Owner team (all relevant PL responsible) like the one defined in the hybrid PM solution of Schuh et al. (2018), which in turn, is inspired by agile PM arrangements like Scrum (Schwaber & Sutherland, 2017), Scrum of Scrums (Larman & Vodde, 2010) or Essential SAFe® (Scaled Agile Inc., 2019a).
Project Status	*Project Status* is the widest-reaching meeting moment, which gathers the TD, FM, all PL responsible and team members. In a sense, it is similar to PI planning in SAFe®. However, its current purpose is not to plan, but to give everyone an overview of SC.LiDAR's progression. It is also meant to grant everyone a chance to speak up, raise issues or share ideas.
Line coordination	This is the PL or subproject team organization level. It could be that some PL could adopt AgPM methods, like Scrum or Kanban (Schwaber & Sutherland, 2017; Tarne, 2011), however, it is unlikely that, due to the different nature of their jobs, all PL could be synched into the same PMLC.

As mentioned, establishing a core specialist team in *Strategic and System Integration*, shares the same inherent logic of AgPM frameworks. It is equivalent to the Product Owner (PO) team in SAFe® or the team delegates' assembly predicted in Scrum of Scrums (Larman & Vodde, 2010). However, this research revealed SC.LiDAR is far from having a projectized structure and also that it has to deal with the limitations of poor role definition. In the absence of a PMg or conventional agile roles such as PO or Scrum Master (SM), a lot of pressure is put on each PL leading person. They may not have the competence or availability to coordinate the subproject team and simultaneously be part of a core specialist team. This might prove particularly stressful for those working on SC.LiDAR and BP at the same time. These Scrum roles or equivalent functions, which the researcher tapped into during his participation on SC.LiDAR, should be present across the project structure. Their exertion ensures there is a servant-leadership to translate the project's scope and instigate teammates towards its goals. There was an attempt to formalize participant responsibility and accountability, at least for meeting moments (Appendix 5), but the current management structure showed unfazed about it in the observed instances.

Project Status meetings include everyone enrolled in product development. In such a way, they are similar to PIPE occurrences in the BP LiDAR ART. During the last observational period, only a couple of these happened. However, they seemed to be characterized by the same social inhibition first observed in *Prologue - LiDAR ART* (p.55). When formal moments like this fail to serve their purpose, the organization ought to reconsider their usefulness, and also, to question if work culture aspects might be hindering individual participation in knowledge exchange.

Line coordination meetings have only been punctually observed, since the research's main purpose was to foster coordination between, and not within, PL. Anyhow, based on the observed reality, it is unlikely that traditional PM practices, heavily reliant on planning and controlling, will work for team-level coordination. In fast-changing environments, like that of SC.LiDAR, it is difficult to replan through Gantt charts and keep track of shifting requirements (Karlström & Runeson, 2005). This is not only because it would be unfeasible for a single PMg or project coordinator to keep track of twelve distinct timelines, but because, as witnessed, SC.LiDAR is heavily reliant on outsourcing (*Procurement management,* p.88), something that greatly compromised schedule adherence. It could be that some PL could operate in an agile-hybrid kind of manner, in which instance, it would involve a Product Owner team or a town hall coordinative space, as already set in *Strategic and System Integration*.

In summary, the emergent coordinative logic of the new meeting rationale began to take on the form of agile or hybrid PM configurations. Dissecting an established scaled agile framework, such as SAFe®, reveals that its solution is somewhat similar to what agile-SG hybrids have to offer, as described in subchapter 2.1.3. Such PM formats are Scrum-based at the team level but will put on more complex layers. As one moves higher up, or horizontally, in the organizational structure and the number of directly involved stakeholders increases, additional roles and ceremonies will have to be added in, with the risk of the arrived PM solution becoming as strict or willfully deterministic as classic PM methods (Hohl et al., 2018; Putta et al., 2018). Hopefully, this research has left SC.LiDAR one step closer to have a working hybrid PM solution. However, management should further work on clarifying role expectations alongside project staff, to fend off the effects of a potential unruly project environment (Nederveen Pieterse et al., 2019). This balance of formal process control is played against the need for agile (i.e. quick-reacting), self-manageable, and truly dedicated teams (Conforto & Amaral, 2016; Schuh et al., 2018). Such team composition is not compatible with some of the observed HR management practices observed. Despite steps taken towards their reduction, the existence of split-heads still persists. The diversion of expert personnel or key area specialists from SC.LiDAR to BP (see *Informal networks*, p.89) is likely to undermine Bosch's CC-PS innovative endeavors, particularly those of the studied Portuguese location. Communication management is just a subset of many interwoven PM areas. Therefore, fixed information channels and communicational arrangements should be beheld as transient and tailorable too. There are no steady solutions for cross-team coordination, consequently, SC.LiDAR's team members and management should continue to "experiment with multiple approaches and adapt" (Larman & Vodde, 2010, p. 199).

6.2 Main issues found and proposed solutions

The main issues found to afflict SC.LiDAR project line coordination have been summarized according to project knowledge areas, as considered in the PMBOK. Table 14 shows current practices listed alongside the identified PM shortcomings. It also points to solutions that have already been set in motion, or that could be tried in future project iterations.

Albeit some traditional project elements exist, such as the 12 PL Project Charters, there is no aggregate Project Management Plan nor an explicit project governance structure, with SC.LiDAR borrowing many of its procedures from organizational process assets or tacit agreements with external institutions. During this research, adaptability to AgPM solutions was also considered. Bosch's onboarding process provides the basics of Scrum and Kanban. Despite it being a good starting point for future work organization, most SC.LiDAR personnel was oblivious of such practices and did not apply them on a daily basis. Nonetheless, it is argued that the defining features of most common frameworks, such as project transparency and workflow visualization, could contribute to the betterment of project communications, yielding greater knowledge creation and exchange. Observation of BP LiDAR ART suggests that such Agile mindset has not taken root. Once it does, application of formal AgPM frameworks, such as team-level Scrum, and even scaled Agile, should be easier. Naturally, this would imply a different approach to project management, de-emphasizing the functional organization and selecting a hybrid PMLC. Such effort could be guided by the elements of CC-PS' divisional directive *CC-DD0301-2 Project Management.*

Table 14 - Identified SC.LiDAR PM practices, issues and possible solutions.

PM Knowledge Area	Observed practices	Observed issues	Suggested solutions and remarks
Integration management	• Project Charters are available.	• Underdeveloped project management plan elements (see other knowledge areas for detail). • Loose roles and responsibilities.	• Devise a responsibility assignment matrix, a stakeholder engagement plan or other less-traditional project artifacts to foster commitment and enforce accountability.
Scope management	• Requirements have been collected and are available.	• Scope design does not fully cover prototype system needs. • Scope creep. • Feasibility.	• Secure expert judgment during PC inception and check if subsystem features have clearly assigned PL teams to develop them. • Use PCs as living documents to monitor and control scope. Check if early presumptions still apply and negotiate project requirements with relevant stakeholders.
Schedule management	• Monthly high-level follow-up by the PMOs.	• Underdeveloped schedule without technical milestones (Annex 4).	• Preserve high-level program planning for reference. • Downplay microplanning in favor of working solutions (MVP). Focus on rapid, proof-of-concept prototyping.
Cost management	• Not applicable (N/A)	• N/A	• The SC program budget is managed through CC-PS PMO. Processes for cost management were not looked into within the scope of this research.
Quality management	• Various organizational process assets exist.	• Project deliverables' quality control.	• As reasoned before, quality control is entwined with the project's scope control, validation and, therefore, its accompanying issues (see above).
Resource management	• Resources are managed outside of the project.	• Clash over shared resources between SC.LiDAR and BP.	• Reduce split-head count across the organization. • Select key-project contributors fully dedicated to innovation projects, as in successful AgPM approaches.
Communication management	• Project follow-up is done separately by PMOs (cross institutional) and FM (within Bosch). • Scattered subsystem technical meetings.	• No defined communication routes exist linking the project team structure (other than functional bonds). • No project nor product documentation structure.	• Identify and enforce formal communication channels, aided by the proposed meeting rationale. Adapt meeting model if needed. • Consider using specialized project follow-up and documentation software (e.g., SuperOPL, MS Project Server, Jira, etc.). Resort to bills of materials (BOM), component file identification and versioning in SC.LiDAR.
Risk management	• Monthly high-level follow-up by the PMOs.	• Risk seemed to be downplayed during PMO follow-up meetings.	• Innovative project environments are easily mutable, which asks for more quick-reacting risk addressing strategies. Develop integration facets (interrelationship and communication) to address this.
Procurement management	• Organizational process asset for procurement.	• Procurement process is much centralized, bureaucratic, and slow.	• Consider developing a simplified, accessible procurement process for innovation projects that favors tighter order tracking and rapid prototyping.
Stakeholder management	• No holistic stakeholder view was identified.	• Lack of project team identity.	• Have a cohesive project management policy and body supporting all innovation's PL (invest on integration management).

6.3 Research method and bias

In hindsight, the researcher found some limitations in the main data collection method. Saunders et al. (2016, p. 361) argue that participant observation is much reliant on relationship building with relevant stakeholders. Understandably, trust is key to information access and a participant observer, actively involved in the project's processes, must be "all things to all people". This required some personal exertion to silence the researcher's own interpretation of what was going on and what would be best for the work organization. This suppression of personal belief had two perceivable side effects, in public and private traits.

- Public - For one, transmitting a coherent leadership style was difficult at times, because taking a stance could be perceived as favoritism towards a certain project interpretation. Alternatively, assuming no stance at all could be seen as a lack of personal drive or commitment to the project's solutions. If the objective was winning everyone's confidence, establishing oneself as a new project character and P00 as a neutral, brokering ground was paramount. For the observational researcher, being impartial seemed a reasonable approach at first. However, merely mediating project meetings became, more and more, at odds with the impulse to drive the discussion towards a favored conclusion, as would be expected of a PMg or someone in a leading role.
- Private - Sometimes, when privately conferencing with project stakeholders the researcher would stop midway through discourse. Briefly, the line of thought was lost to the implications of what was being said. In retrospect, it is as if the reflective nature that comes with observation was getting in the way of conversation. Observation as a data collection technique should be done systematically, rather than at random occasions, and cannot be practically used all the time. The experienced cognitive dissonance was likely amplified by the researcher's own analytical personality. Saunders et al. (2016) warn that not everyone is suited to observational research. Coming across as someone conflicted, scheming or generally put, unreliable, undermines the researcher's ability to advise and, at the same time, the ability to lead as a project coordinator.

Considering this, a structured observation approach, with a specific observation schedule could have delivered clearer research results. Presential, semi-structured interviews could have been an interesting way of deepening the research findings, if it was not for the working conditions instability brought on by the pandemic. They could also have been used to validate observational findings, as in other narrative-based case studies (Melo, Salerno, Freitas, Bagno, & Brasil, 2020). The distribution of a questionnaire to SC.LiDAR teams, as well the enrollment of FM and other project stakeholders in interpreting its results, was complemented with the analysis of project documents and records. Additionally, it is hoped that the questionnaire's anonymity might have yielded less skewed accounts. Although the derived themes and issues still result from interpretation, this allowed to reduce observational bias to some extent (Norris, 1997; Saunders et al., 2016).

7. Conclusion and Further Suggestions

This research's main purpose has been to facilitate inter-team coordination amongst SC.LiDAR's project lines, subordinate to the research question "*What issues affect SC.LiDAR project lines coordination and how to address them?*".

Before proceeding to reflect on its success, a remark goes to the misleading dichotomy still present in literature and PM culture, which often presents agile and traditional PM as polar opposites. If anything, this work's literature revision served to change the researcher's long-held belief that the emergent nature of innovation projects could only be answered through agility. In fact, what holds true and adequate, for all kinds of projects, is that there is an ever-changing, tailorable PM solution to serve each project's reality.

To get to the core of the issues affecting PL coordination a participant-observation role was adopted. Observational findings of the first two observational periods, December 2019, and January – April 2020, revealed project shortcomings associated with scope management, resource management and communication management. Document analysis of the program PCs revealed loosely defined PL scopes and underdeveloped integration detail for a combined product build and delivery. To address scope management issues, it is suggested to alternate a directive and servant leadership kind of style. For future innovation projects, as complex as SC.LiDAR, it is recommended that more detail is put into system and interface definition, ahead of the project start or early on after kick-off. Area experts and even future working team members should be enrolled in such preparations. Project perception was split between functional silos and communication channels were lacking. This was partially countered through the establishment of a virtual project line with a coordinative purpose, P00. The researcher brought in servant leadership aspects, embodying attitudes like those of a SM in AgPM frameworks, brokering divergencies across the multiple PL.

To check and confirm existing project issues, this was followed by the application of a questionnaire to program associates working at the team level within Bosch, in May 2020. According to the surveyed project's team response, this research's early phase was successful in increasing project integration and communication. The survey confirmed communication management as an area for potential improvement. Later on, a new communication strategy was devised, mimicking scaled-agile-hybrid solutions' by establishing a centralized or core team of PL-leading individuals. During this period, integration management gained prominence as insufficient role definition across SC.LiDAR became ever more evident. In this regard, alternate project organization solutions are proposed. Either develop a strong-matrix structure with the creation of the PMg role to lead the project or preserve the current FM ownership by developing Agile-like roles in its PL-leading personnel. This could be achieved by taking PMLC examples already included in an existing divisional guideline for PM.

Towards the last observational phase of September – December 2020, the organization started to curb concerns with HR assignment and mobility, as some dissociation between SC.LiDAR and Business Plan teams took place. This is seen as beneficial, given that dedicated teams are a *sine qua non*-enabler of fast-reacting, agile solutions. It will not only benefit SC.LiDAR and other innovation projects, but also make for a smoother transition to AgPM. Since SAFe applies to Bosch CC-PS' BP projects, future research could particularly focus on the success of its adoption.

A remark about the difficulty that teams showed in making their progress palpable and visible must be made. To address it, a shift from a requirements-centered development process to a fast-prototyping culture could prove advantageous. One of innovation management's greatest challenges is to set up its teams to fail fast and fail often. Incremental test runs will also avoid propagation of errors during long time-periods. Because innovation is an empirical, exploratory process, where project learning drives the enterprise's value-function, PM has to alleviate its deterministic facets and pave the way for project teams to thrive and progress towards tomorrow's knowledge.

The results from this case study might not be directly transposable to other R&D departments in the automotive industry sector. Nevertheless, its insights are thought to be useful in championing innovation amidst large cross-functional teams, by means of tailorable PM solutions.

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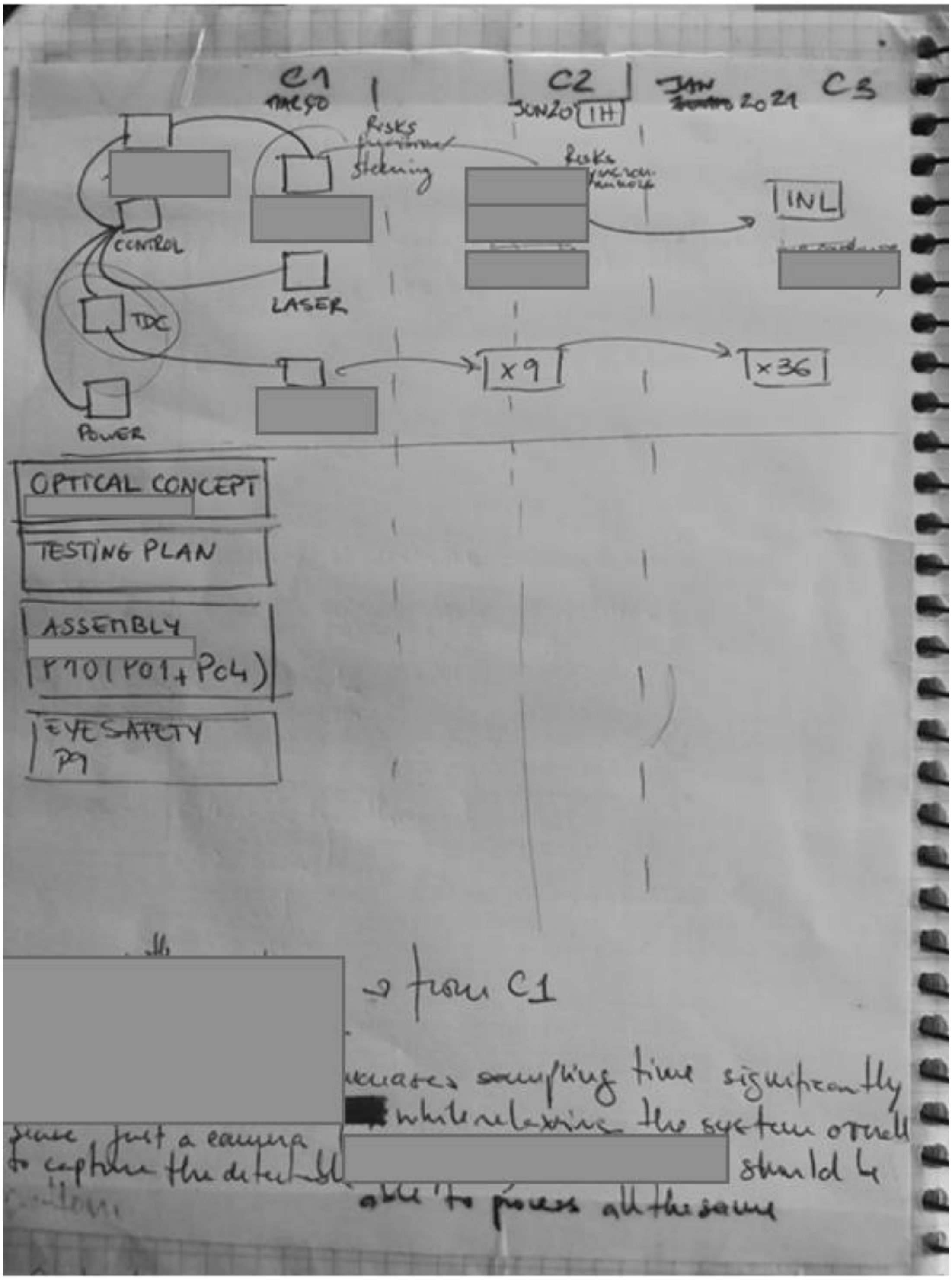
APPENDIX 1

Schematics on SC.LiDAR prototypes as noted down by the researcher.



APPENDIX 2

Classical vs. Agile Project Management in Innovation Projects - SC LiDAR status

INTRODUCTION

The following survey is part of an ongoing research regarding Project Management practice and its outcomes in an innovation context. Its main purpose is to characterize the current state of affairs regarding management practices within LiDAR Innovation and identify room for improvement.

It comprises 3 different sections and will take roughly 15 minutes of your time to cover.

Other than demographics, its contents will be de-characterized so that your answers remain essentially anonymous and confidential.

Please confirm you have read and agreed to this.

Yes

Gender

Age

Nationality

(optional)

Function

(optional)

1. LIDAR INNOVATION PROJECT AREAS

Each project is a unique endeavor with the purpose of delivering new products, technologies, services or processes. Projects may be managed within several frameworks or standards. The PMBOK® – the Project Management Body of Knowledge – is one of such references, renowned across businesses the world over.

1.1 In this section, you are asked to give your satisfaction level in relation to multiple project areas of LiDAR Innovation, as they have been identified by the PMBOK®.

Please, select your satisfaction level for each project area (below is a short description of each, if needed):

1.1.1 Integration Management

"In the project management context, integration includes characteristics of unification, consolidation, communication, and interrelationship."

1.1.2 Scope Management

"Managing the project scope is primarily concerned with defining and controlling what is and is not included in the project."

1.1.3 Schedule Management

"Project Schedule Management includes the processes required to manage the timely completion of the project."

1.1.4 Cost Management

"Project Cost Management includes the processes involved in planning, estimating, budgeting, financing, funding, managing, and controlling costs so that the project can be completed within the approved budget."

1.1.5 Quality Management

"Project Quality Management includes the processes for incorporating the organization's quality policy regarding planning, managing, and controlling project and product quality requirements in order to meet stakeholders' objectives."

1.1.6 Resource Management

"Project Resource Management includes the processes to identify, acquire, and manage the resources needed for the successful completion of the project."

1.1.7 Communications Management

"Project Communications Management includes the processes necessary to ensure that the information needs of the project and its stakeholders are met through development of artifacts and implementation of activities designed to achieve effective information exchange."

1.1.8 Risk Management

"Project Risk Management includes the processes of conducting risk management planning, identification, analysis, response planning, response implementation, and monitoring risk on a project."

1.1.9 Procurement Management

"Project Procurement Management includes the processes necessary to purchase or acquire products, services, or results needed from outside the project team."

1.1.10 Stakeholder Management

"Project Stakeholder Management includes the processes required to identify the people, groups, or organizations that could impact or be impacted by the project, to analyze stakeholder expectations and their impact on the project, and to develop appropriate management strategies for effectively engaging stakeholders in project decisions and execution."

1.2 What area of LiDAR Innovation do you find most critical?

1.3 Do you think it jeopardizes work efficiency?

1.3.1 If yes, can you explain how?

1.4 In your opinion, what could be improved about LiDAR Innovation?

2. LIDAR INNOVATION RECENT PAST

For this section, please consider the last couple of months working on LiDAR Innovation.

2.1 How do you think the overall project management has evolved (all areas considered i.e.)?

2.2 What project area(s) do you think changed the most?

2.3 What project area(s) need(s) to be further improved?

3. LIDAR INNOVATION INTEGRATION

Projects and Programs, such as Sensible Car, make up a company's strategy and map its business development for the future. Simultaneously, a company's strategy success will be dependent on how well the organizational mission and vision transfer across different hierarchical levels.

3.1 Over this next section, you are asked to give your agreement level with statements which reflect LiDAR Innovation integration within the Chassis System Control context, and that of Bosch, as a whole.

Mind that LiDAR Innovation and your own project line might be used interchangeably.

Please, select your agreement level with each statement:

3.1.1 I can easily access project information.

3.1.2 The connection between LiDAR Innovation and the company's strategy is clear to me.

3.1.3 The requirements for my project line deliverables are known.

3.1.4 My manager deals LiDAR Innovation with priority.

3.1.5 I fulfill the established project workload (full time or split-head).

3.1.6 There are synergies between LiDAR Innovation and LiDAR ART.

3.1.7 LiDAR Innovation goals are feasible/realistic.

3.1.8 My work contributes to the overall success of the project.

3.1.9 The project line has the development tools it needs.

3.1.10 LiDAR Innovation is priority to me.

3.1.11 I am familiar with CC mission and vision (roadmap).

3.1.12 My project line adds value to LiDAR Innovation.

3.1.13 Exchange between my project line and P00 Coordination is adequate.

3.1.14 My opinion and ideas matter to my project line coworkers.

3.1.15 I get in touch with other project lines when a concern arises.

3.1.16 There are conflicts of interest between Business Plan and Innovation.

3.1.17 There are high impending risks on the project.

3.1.18 Authority within my project line is well defined.

3.1.19 Authority within Sensible Car is well defined.

3.1.20 I am confident of other project lines technical decisions.

Thank you for your time!

Renato Pinto
BES-Innovation
Materials Eng. MSc.

If you have any questions you can reach
fixed-term.Renato.deMatosPinto@pt.bosch.com or pg27645@alunos.uminho.pt

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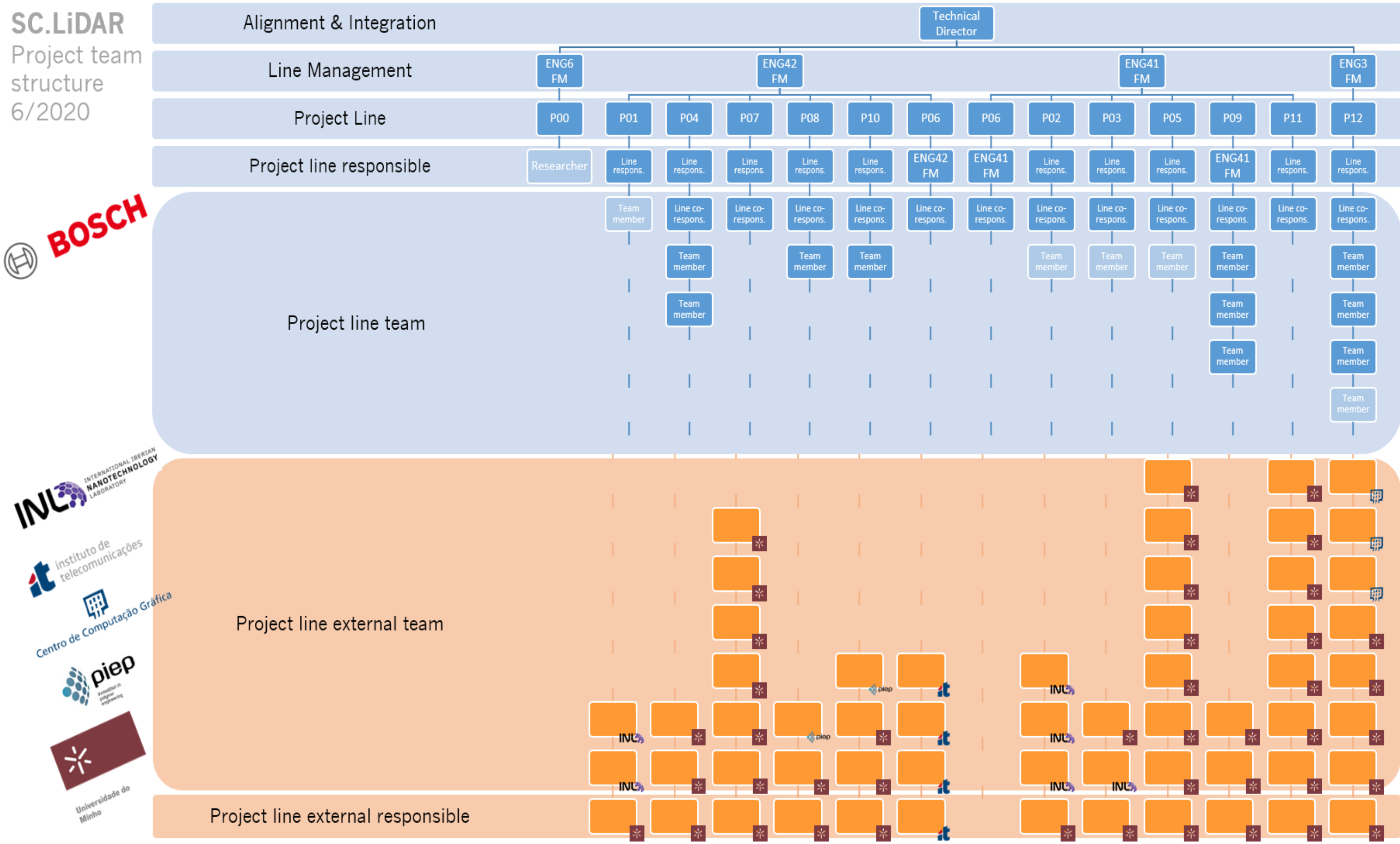
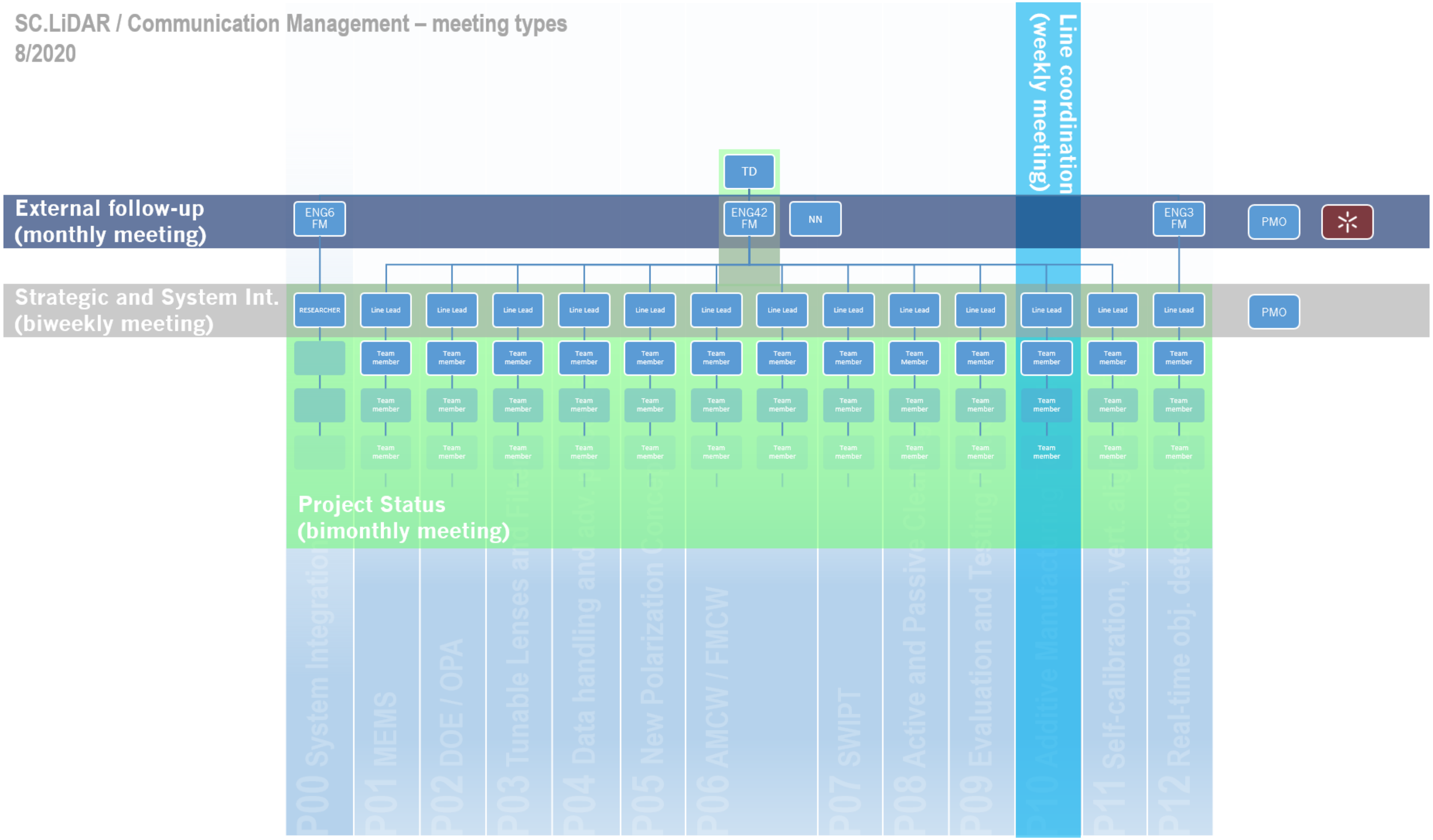
APPENDIX 3


SC.LiDAR
Project team structure 6/2020
Alignment & Integration
Technical Director
Line Management
ENG6 FM
ENG42 FM
ENG41 FM
ENG3 FM
Project Line
P00
P01
P04
P07
P08
P10
P06
P06
P02
P03
P05
P09
P11
P12
Project line responsible
Researcher
Line respons.
ENG42 FM
ENG41 FM
Project line team
Line co-respons.
Team member
Project line external team
Project line external responsible
BOSCH
INL International Iberian Nanotechnology Laboratory
instituto de telecomunicações
Centro de Computação Gráfica
piep
Universidade do Minho

Appendix 4


SC.LiDAR / Communication Management – meeting types
8/2020
Line coordination
(weekly meeting)
TD
External follow-up
(monthly meeting)
ENG6 FM
ENG42 FM
NN
ENG3 FM
PMO
Strategic and System Int.
(biweekly meeting)
RESEARCHER
Line Lead
Team member
PMO
Project Status
(bimonthly meeting)
P00 System Integration
P01 MEMS
P02 DOE / OPA
P03 Tunable Lenses
P04 Data handling and
P05 New Polarization
P06 AMCW / FMCW
P07 SWIPT
P08 Active and Passive
P09 Evaluation and Te
P11 Self-calibration, ver
P12 Real-time obj. dete

APPENDIX 5

Responsibility Assignment Matrix (RAM) for Communication Management – meeting types

	Strategic and System Integration			Project Status			Line Coordination			External Follow-up		
Occurrence every	2 weeks			2 months			Week			Month		
Roles	Organizer	Input	Output	Organizer	Input	Output	Organizer	Input	Output	Organizer	Input	Output
ENG4 PM			I / C		S						S / C	I
ENG42 Team Lead		S			S				I	-	R	A
ENG6 Team Lead			I			I				R	-	A
PMO		S	C			I					S / C	I
P00 Line Lead	R	-	A	R	-	A			I			I
PXX Line Lead		R	R		R	R	R	A	R			
PXX Team Member			I		S			R	A			

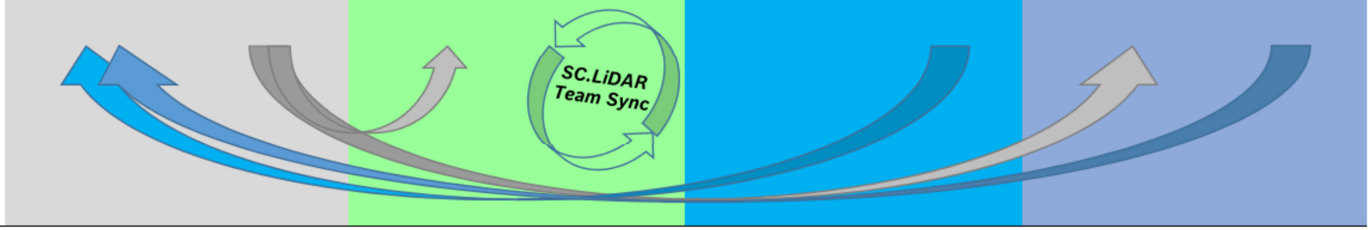
RASIC – R = Responsible, does the work / A = Accountable, ultimate answerer / S = Supportive, should attend / I = Informed, kept to date / C = Consulted

	Strategic and System Integration	Project Status	Line Coordination	External Follow-up
Communication Medium	Face-to-face / Skype meeting E-mail (for distribution) MS Teams	Skype meeting E-mail (for announcements)* MS Teams	Face-to-face / Skype meeting MS Teams	Face-to-face / Skype meeting E-mail (for distribution)

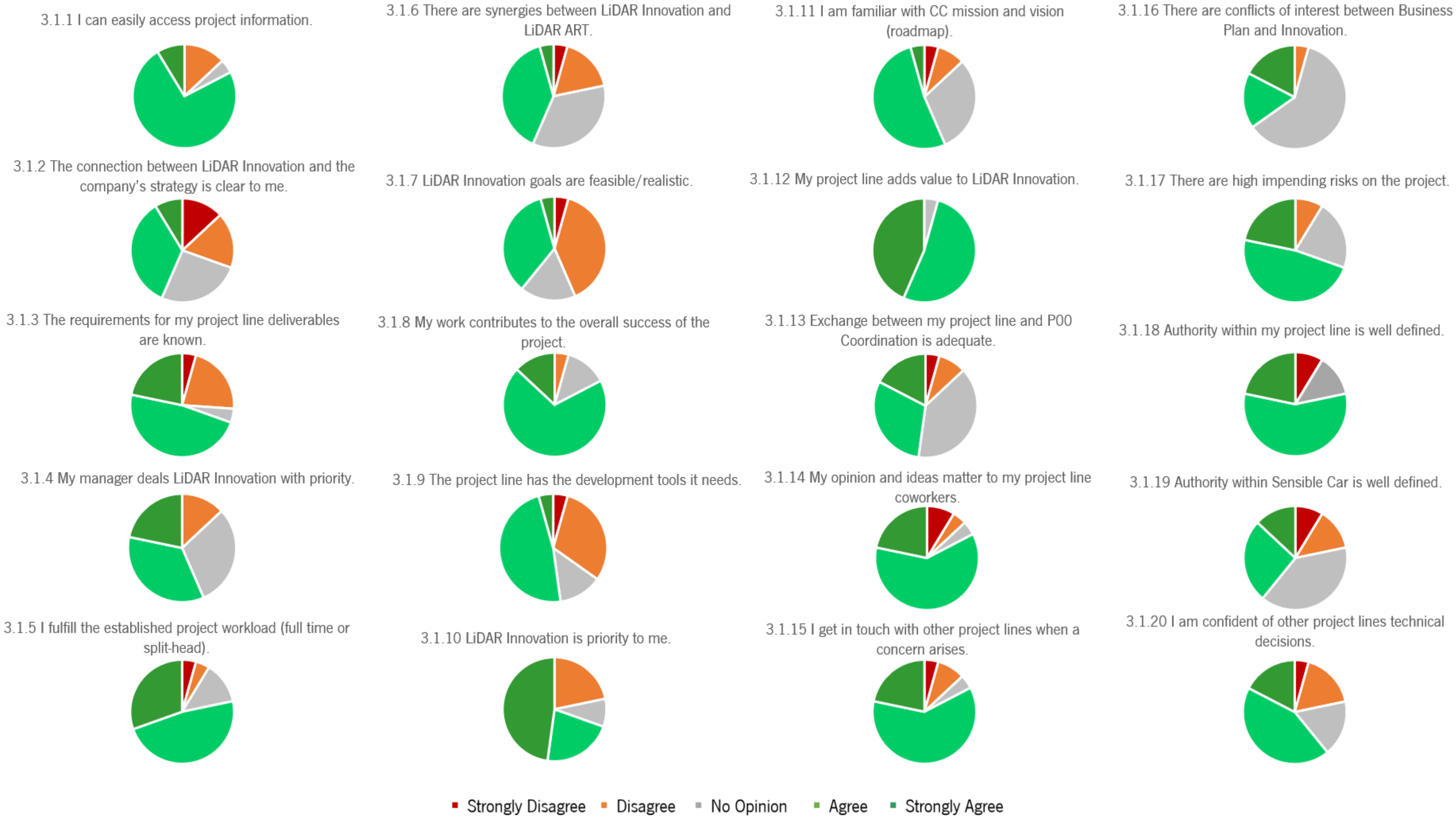
	Input	Output	Input	Output	Input	Output	Input	Output
Communication Tools	Updated PXX Status .xls 	Meeting minutes Updated SC.LiDAR Status .xls 	PXX Pitch.pptx	Meeting minutes Project highlights Project lowlights .pptx	PXX Status .xls 	Updated OneNote* Updated PXX Status .xls 	*	*

Information Flow

Input	Output	Input	Output	Input	Output	Input	Output



Appendix 6



3.1.1 I can easily access project information.
3.1.2 The connection between LiDAR Innovation and the company's strategy is clear to me.
3.1.3 The requirements for my project line deliverables are known.
3.1.4 My manager deals LiDAR Innovation with priority.
3.1.5 I fulfill the established project workload (full time or split-head).
3.1.6 There are synergies between LiDAR Innovation and LiDAR ART.
3.1.7 LiDAR Innovation goals are feasible/realistic.
3.1.8 My work contributes to the overall success of the project.
3.1.9 The project line has the development tools it needs.
3.1.10 LiDAR Innovation is priority to me.
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3.1.14 My opinion and ideas matter to my project line coworkers.
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3.1.16 There are conflicts of interest between Business Plan and Innovation.
3.1.17 There are high impending risks on the project.
3.1.18 Authority within my project line is well defined.
3.1.19 Authority within Sensible Car is well defined.
3.1.20 I am confident of other project lines technical decisions.
Strongly Disagree
Disagree
No Opinion
Agree
Strongly Agree

APPENDIX 7

Survey's raw data

Respondent	Gender	Age	1.1.1 Integration Management	1.1.2 Scope Management	1.1.3 Schedule Management	1.1.4 Cost Management	1.1.5 Quality Management	1.1.6 Resource Management	1.1.7 Communications Management	1.1.8 Risk Management	1.1.9 Procurement Management	1.1.10 Stakeholder Management
1	Male	25	Satisfied	No opinion	Satisfied	Satisfied	Satisfied	Satisfied	No opinion	Satisfied	Satisfied	Satisfied
2	Female	35	Satisfied	Dissatisfied	Dissatisfied	Dissatisfied	Satisfied	Satisfied	No opinion	Dissatisfied	Satisfied	No opinion
3	Male	36	Satisfied	Dissatisfied	No opinion	No opinion	Satisfied	Satisfied	Satisfied	No opinion	No opinion	No opinion
4	Male	34	Dissatisfied	Dissatisfied	Dissatisfied	No opinion	Very Dissatisfied	Dissatisfied	Dissatisfied	No opinion	Dissatisfied	Very Dissatisfied
5	Male	32	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied
6	Male	25	Satisfied	Satisfied	Satisfied	Satisfied	No opinion	Satisfied	Satisfied	No opinion	No opinion	No opinion
7	Male	27	Satisfied	Very Satisfied	Very Satisfied	Satisfied	Very Satisfied	Very Satisfied	Very Satisfied	Satisfied	Satisfied	Satisfied
8	Female	27	Satisfied	No opinion	Satisfied	Very Satisfied	No opinion	Satisfied	Satisfied	Dissatisfied	Satisfied	Satisfied
9	Male	22	Very Satisfied	Very Satisfied	Very Satisfied	Very Satisfied	No opinion	No opinion	Very Dissatisfied	Very Satisfied	Very Satisfied	Very Satisfied
10	Male	25	Satisfied	Satisfied	Satisfied	Very Satisfied	Satisfied	Satisfied	Dissatisfied	Satisfied	Very Satisfied	Satisfied
11	Male	26	Satisfied	Dissatisfied	Satisfied	Very Satisfied	Satisfied	No opinion	Satisfied	Satisfied	Satisfied	Dissatisfied
12	Male	24	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	No opinion
13	Male	28	Dissatisfied	Dissatisfied	Dissatisfied	No opinion	No opinion	Dissatisfied	Dissatisfied	No opinion	No opinion	Dissatisfied
14	Male	25	Very Satisfied	Very Satisfied	Very Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Very Satisfied	Satisfied	Satisfied
15	Male	31	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied
16	Male	28	Satisfied	No opinion	Satisfied	No opinion	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied	Satisfied
17	Male	25	Satisfied	Satisfied	Very Satisfied	Very Satisfied	Satisfied	No opinion	Satisfied	Satisfied	Satisfied	Satisfied
18	Male	28	Satisfied	Satisfied	Satisfied	Satisfied	No opinion	Satisfied	Satisfied	No opinion	No opinion	No opinion
19	Male	33	Satisfied	No opinion	No opinion	No opinion	No opinion	No opinion	Satisfied	No opinion	No opinion	No opinion
20	Female	29	Satisfied	Satisfied	Satisfied	Satisfied	No opinion	Satisfied	Satisfied	No opinion	No opinion	Satisfied
21	Male	32	Dissatisfied	Satisfied	Satisfied	No opinion	Dissatisfied	Satisfied	Dissatisfied	Dissatisfied	No opinion	Dissatisfied
22	Male	24	Dissatisfied	Dissatisfied	Dissatisfied	Dissatisfied	Dissatisfied	Dissatisfied	Dissatisfied	Dissatisfied	Dissatisfied	Dissatisfied
23	Male	32	No opinion	Satisfied	No opinion	Satisfied	Satisfied	Satisfied	No opinion	No opinion	Satisfied	No opinion

Respondent	1.2 What area of LiDAR Innovation do you find most critical?	1.3 Do you think it jeopardizes work efficiency?	1.3.1 If yes, can you explain how?	1.4 In your opinion, what could be improved about LiDAR Innovation?
1	The optical path.	No		I improve the coordination with different teams involved.
2	Resources	Yes	no one is dedicated 100% to Innovation tasks. Or even 20%. People that shoulfd be workling 100% into Innovation are working as weel in BP activities.	Innovation resources working full time.
3	Defining exactly what are the responsabilities of each line. Mainly because on the beginning of the project there was no strategy to get the big picture of the overall project and to get each line working together knowing exactly what are their tasks to contribute to the project.	Yes	The fact that some tasks are not cleary atributted to a specific line (or more) origins that the task may not be correctly addressed.	Regular meetings like the ones that we'r having right now.
4	Clash over resources with the product development.	Yes	If people are working a bit on several different things it's hard to be concentrated and efficient.	It's a bit late now. But the project could be much better if it had a much better startup, with a clear aim, scope, stakeholders, well aligned with the product development. Also and a clear, well thought through team structure.
5	Interconnection between different lines for a single prototype. Most of the single project lines where not defined with an overall system in mind.	No		I do not have a strong opinion on the matter.
6	Combining all areas and deliver something that works and matches specifications requirements	No		Communication between the different areas, share of knowledge
7	Anything related to optics	No		the communication between teams
8	umirror controller and driver e detection	No		não sei muito bem..pq são bastantes coisas a inumerar.. Primeiro acho que P00 deveria ser diminuido a quantidade de pessoas naquela reunião. Depois deveria ser mostrado a todas as pessoas a missão da P00, e importancia de todas as linhas. POderia haver uma especie de apresentação mensal dos pontos que foram evoluindo naquele mes. OU seja, linha a linha ir apresentar as suas coisas. Não se sabe por exemplo nada de P05. P06 - FMCW. na reunião doP00, porque nem sempre há coisas a revesitar, deveria-se poder apostar numa reunião deste tipo. de forma por exemplo aos membros pensarem em possiveis hipoteses de incorporação.
9	Communication	Yes	If there is no communication, there might not be functional final product.	Communication
10	Integration.	No		Don't know.
11	The coordination between innovation lines, where goals and requirements should be exchanged effortlessly.	Yes	With the lack of necessary requirements, some innovation lines have two options: they must either follow outdated data that can be altered in the future, with the risk of re-doing work; or wait for information that may come too late, leaving little time for improvement iterations and testing.	One extra layer should exist above the innovation responsibles, e.g Mechanical, Electrical, Optical Responsibles. The setting of goals and tasks would be organized at this level, with the information then being passed down to the teams. This would allow team members to focus on the technical issues, while enabling a more streamlined decision-making process for the team leaders.
12	Once LiDAR is an optical sensor and a technical product. Optical is the most sensitive area to care about. Nevertheless, integration of all technical areas is classified, by me, as a critical area too.	No		Acquire some people with high technical knowledge and experience on critical fields in order to better exposed the problems and solutions, and most important, share knowledge with young developers.

13	Resource management & Integration. The project is highly ambitious and attempts advancements in many areas, however the structure and interrelations seem underprioritised and not quite sufficient for an advanced R&D project. The main issue is lack of more experienced team-members to guide & advice the many young colleges.	Yes	While young engineers are often good at solving problems, experience is very helpful in predicting what will be useful and what might give problems later.	More clear responsibilities & planning Communication between lines Better follow up of colleagues, both for short and long term development
14	Here I have to address 2 areas: workforce and resources. P00 is (was) facing a major problem regarding the defined timeline. Mainly because it had too few people previously working in critical areas of the project (e.g. the optical design), and most of the people are not working full time on this. About the resources and its management, the idea that I have is that every project had a mindset of individual spending and only for project specific related goods, which might not have a cost-final usabilty ratio that justifies the expense. There was a third one - communication and common guidelines - which I think is now well taken care , owing to the solidification of P00.	Yes	Less people working/thinking, less work done and ideas given. At this point, I think that the workload is quite soft considering the people involved, but it was not the case in the beginning, and that might happen again in the future (Proto. B development). The now limited resources also jeopardize work efficiency when having a direct influence in the suitability of materials to the development we are doing.	In my opinion, tackle it as a more important and relevant project. Why not having PI meeting relating all projects or a similar approach? I'm not saying to use a Scrum strategy on the overall project (not only P00) but something that might be closer to that.
15	Detection	Yes	Not easy to design a prototype without knowing what is the detector	Communication with the partners
16	Integration Management	Yes	If the integration management doesn't work properly, there is no connection between the different areas involved in a project which will lead the project to a failure in timeline, cost or any other area.	Definition
17	All of them are very important	No		More headcounts working only for the Innovation
18	The areas that I found more critical are the hardware/components and system related areas.	Yes	Affecting negatively the efficiency is unaviodable as some concepts are new and are being tested and combined for the first time.	I have one opinion for future inovation projects applications: bring more universities to participate increases competition.
19	I have no clue.	No		I think the overall interaction among different lines could be improved. Sometimes, I feel I don't know what people doing in the other lines.
20	No opinion	No		No opinion
21	Lack of communication between the Bosch and Bosch-UM teams	Yes	Because it is not clear or the role of each stakeholder in each stage of the project, as well as the interactions between	The teams management. Adjust people and experiences to roles.
22	The RX devellopment.	Yes	At the moment the high dificulty it to achieve the comitted field of view within the reduced APD areas that are available in the market.	Comit to realistic goals in the beginning of the project. Have a transparent project road map shared with all the elements of the project.
23	The interconnection between different lines is not ideal, although it has improved in the last months with the creation of P00.	Yes	Each line is working on their own topics and there is a lack of general view of the system to be built. This means that if there is an important change on the system, the work of each individual line could be jeopardized.	In my opinion, the creation of line P00 helped overcoming many problems. I would continue to invest and strengthen the role of P00.

Respondent	2.1 How do you think the overall project management has evolved (all areas considered i.e.)?	2.2 What project area(s) do you think changed the most?	2.3 What project area(s) need(s) to be further improved?
1	Improved	The area about mechanics	The area about optics.
2	No change	na	na
3	Improved	The one related with the development of the prototype.	It's difficult to answer because some lines are dependente of the sucess of the prototype development so I would say, maybe its early to say.
4	Greatly Improved	Communication between different groups. Schedule management for the lidar prototype.	Work quality.
5	Improved	P00 started actually working.	Not sure.
6	Improved	Defining and managing all the necessary tasks	Not really a specific area, but communication between them
7	Improved	The optical concept	All project areas
8	Improved	a interação entre teams. Embora ache que a equipa foi demasiado alargada. A reunião de coordenação tem muitas	communications management
9	No change	None	Communication
10	Improved	Integration.	Don't know.
11	Improved	Communication between innovation lines has improved, and the overall goal of the project is more clear.	Decision-making process needs to be streamlined. As it stands, it relies too much on meetings with all stakeholders, including several people from each innovation line. With such a large group attempting to find the correct direction to go, the process is very slow and inefficient.
12	Improved	Communications and integration between technical areas, even UMinho-Bosch relationship improved.	Technical - Knowledge is never enough; Project disclosure - at some point we will need to show and promote the project for outside bosch view.

13	No change	I think there might have been some changes in schedule management?	There is always room for improvement.
14	Improved	I only have a slight idea of what the project was before, but I would say the communication and interrelationship are two areas where this project changed the most during the last months. Schedule management, in my opinion, also changed for the best.	Resource management and probably, but in another scale, Procurement management.
15	Improved	MEMs and DOEs	Lens and Filters
16	Improved	Communication between lines has improved	Risk Management
17	Improved	N/A	Optical
18	Improved	Communication clearly improved.	There is still a relative big internal unknowledge among people from diferent project lines of what everyone is doing and aims to achieve. This is totally against the spirit of a
19	Improved	I think we saw a very good change in P00.	Not sure.
20	No change	No opinion	No opinion
21	Improved	The Bosch Teams/lines/projects interface	Bosch-UM temas interface and teams roles.
22	Improved	P00	P05
23	Improved	Coordination between lines was what changed the most.	Better link between components, system and testing areas.

Respondent	3.1.1 I can easily access project information.	3.1.2 The connection between LiDAR Innovation and the company's strategy is clear to me.	3.1.3 The requirements for my project line deliverables are known.	3.1.4 My manager deals LiDAR Innovation with priority.	3.1.5 I fulfill the established project workload (full time or split-head).	3.1.6 There are synergies between LiDAR Innovation and LiDAR ART.	3.1.7 LiDAR Innovation goals are feasible/realistic.	3.1.8 My work contributes to the overall success of the project.	3.1.9 The project line has the development tools it needs.	3.1.10 LiDAR Innovation is priority to me.	3.1.11 I am familiar with CC mission and vision (roadmap).	3.1.12 My project line adds value to LiDAR Innovation.	3.1.16 There are conflicts of interest between Business Plan and Innovation.	3.1.14 My opinion and ideas matter to my project line coworkers.	3.1.15 I get in touch with other project lines when a concern arises.	3.1.13 Exchange between my project line and P00 Coordination is adequate.	3.1.17 There are high impending risks on the project.	3.1.18 Authority within my project line is well defined.	3.1.19 Authority within Sensible Car is well defined.	3.1.20 I am confident of other project lines technical decisions.
1	Agree	No Opinion	Agree	Agree	No Opinion	No Opinion	No Opinion	Agree	Agree	Agree	Agree	Strongly	No Opinion	Agree	No Opinion	No Opinion	Agree	Agree	No Opinion	Strongly
2	Agree	Agree	Disagree	Disagree	Strongly Disagree	Agree	Disagree	No Opinion	Agree	Disagree	Agree	Strongly Agree	Agree	No Opinion	Agree	No Opinion	Agree	Agree	No Opinion	Agree
3	Agree	Agree	Disagree	Agree	Strongly Agree	Agree	Disagree	Agree	Disagree	Strongly Agree	Agree	Agree	No Opinion	Agree	Agree	Agree	Agree	Agree	No Opinion	Agree
4	No Opinion	Strongly Disagree	Agree	Agree	No Opinion	Agree	Strongly Disagree	Agree	Disagree	Agree	No Opinion	Agree	Strongly Agree	Strongly Agree	Agree	Agree	Strongly Agree	Agree	Strongly Disagree	Disagree
5	Agree	No Opinion	Agree	Agree	Agree	Disagree	Disagree	No Opinion	No Opinion	Agree	No Opinion	Agree	No Opinion	Agree	Agree	Agree	Agree	No Opinion	Agree	Agree
6	Agree	Agree	Agree	Agree	Agree	No Opinion	Agree	Agree	Agree	Agree	Agree	Agree	No Opinion	Agree	Agree	Agree	Disagree	Agree	Agree	Agree
7	Agree	Agree	Disagree	Strongly	Agree	Agree	Agree	Agree	Agree	Strongly	Agree	Strongly	Agree	Agree	Agree	Strongly	No Opinion	Strongly	Agree	Agree
8	Strongly Agree	Disagree	Agree	Agree	Agree	No Opinion	Agree	Agree	Agree	Strongly Agree	Agree	Strongly Agree	No Opinion	Agree	Agree	Strongly Agree	Agree	Agree	No Opinion	Agree
9	Agree	No Opinion	Strongly Agree	Strongly Agree	Strongly Agree	No Opinion	Agree	Strongly Agree	No Opinion	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Disagree	Strongly Agree	Strongly Disagree	Strongly Agree	No Opinion	Strongly Agree	Strongly Agree
10	Agree	Disagree	Strongly	Disagree	Strongly	Disagree	Disagree	Agree	Disagree	Strongly	Agree	Strongly	No Opinion	Strongly	Agree	Strongly	Agree	Agree	Agree	Agree
11	Agree	Strongly Agree	Agree	No Opinion	Strongly Agree	Disagree	Agree	Agree	Agree	Strongly Agree	Disagree	Agree	No Opinion	Agree	Disagree	Disagree	Agree	Strongly Agree	Disagree	Disagree
12	Agree	Disagree	Agree	Agree	Agree	Strongly Agree	Agree	Agree	Disagree	Disagree	No Opinion	Agree	No Opinion	Agree	Agree	No Opinion	No Opinion	No Opinion	No Opinion	Agree
13	Agree	Agree	Disagree	No Opinion	Agree	Agree	Disagree	Agree	Disagree	Strongly Agree	Agree	Agree	Agree	Disagree	Agree	No Opinion	Strongly Agree	Strongly Disagree	Disagree	Disagree
14	Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Agree	Agree	Strongly Agree	Agree	Strongly Agree	Agree	Strongly Agree	Disagree	Strongly Agree	Strongly Agree	Strongly Agree	Disagree	Strongly Agree	Strongly Agree	Strongly Agree
15	Agree	Agree	Agree	No Opinion	Agree	No Opinion	Disagree	Agree	Agree	Disagree	No Opinion	Agree	No Opinion	Agree	Agree	No Opinion	No Opinion	Agree	Agree	Agree
16	Agree	No Opinion	No Opinion	No Opinion	Disagree	Agree	No Opinion	Agree	Disagree	No Opinion	No Opinion	Agree	No Opinion	Agree	Agree	Agree	No Opinion	Agree	No Opinion	No Opinion
17	Strongly	Agree	Strongly	No Opinion	Agree	Agree	Agree	Agree	Agree	Agree	No Opinion	Agree	Agree	Strongly	Strongly	Agree	Agree	Agree	Agree	Agree
18	Agree	Disagree	Disagree	No Opinion	Agree	Agree	Disagree	No Opinion	Disagree	Disagree	No Opinion	No Opinion	No Opinion	Agree	Disagree	No Opinion	Agree	Agree	Disagree	No Opinion
19	Agree	No Opinion	Agree	Agree	Agree	No Opinion	No Opinion	Agree	No Opinion	Strongly Agree	Disagree	Agree	No Opinion	Agree	Agree	No Opinion	No Opinion	Agree	No Opinion	Disagree
20	Agree	Agree	Agree	Strongly	Strongly	No Opinion	Strongly	Strongly	Strongly	Strongly	Agree	Strongly	No Opinion	Agree	Strongly	No Opinion	Agree	Strongly	Strongly	Strongly
21	Disagree	Strongly Disagree	Strongly Disagree	Disagree	Agree	Strongly Disagree	Disagree	Agree	Strongly Disagree	Strongly Agree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Disagree	Strongly Disagree	Agree	Strongly Agree	Strongly Disagree	Strongly Disagree	Strongly Disagree
22	Disagree	Strongly Disagree	Strongly Agree	Strongly Agree	Strongly Agree	No Opinion	Disagree	Disagree	Agree	No Opinion	Agree	Strongly Agree	Strongly Agree	Strongly Agree	Strongly Agree	Disagree	Strongly Agree	Strongly Agree	No Opinion	No Opinion
23	Disagree	No Opinion	Agree	No Opinion	No Opinion	Disagree	No Opinion	Agree	Agree	Disagree	Agree	Agree	No Opinion	Agree	Agree	No Opinion	Agree	Agree	No Opinion	No Opinion

Annex 1

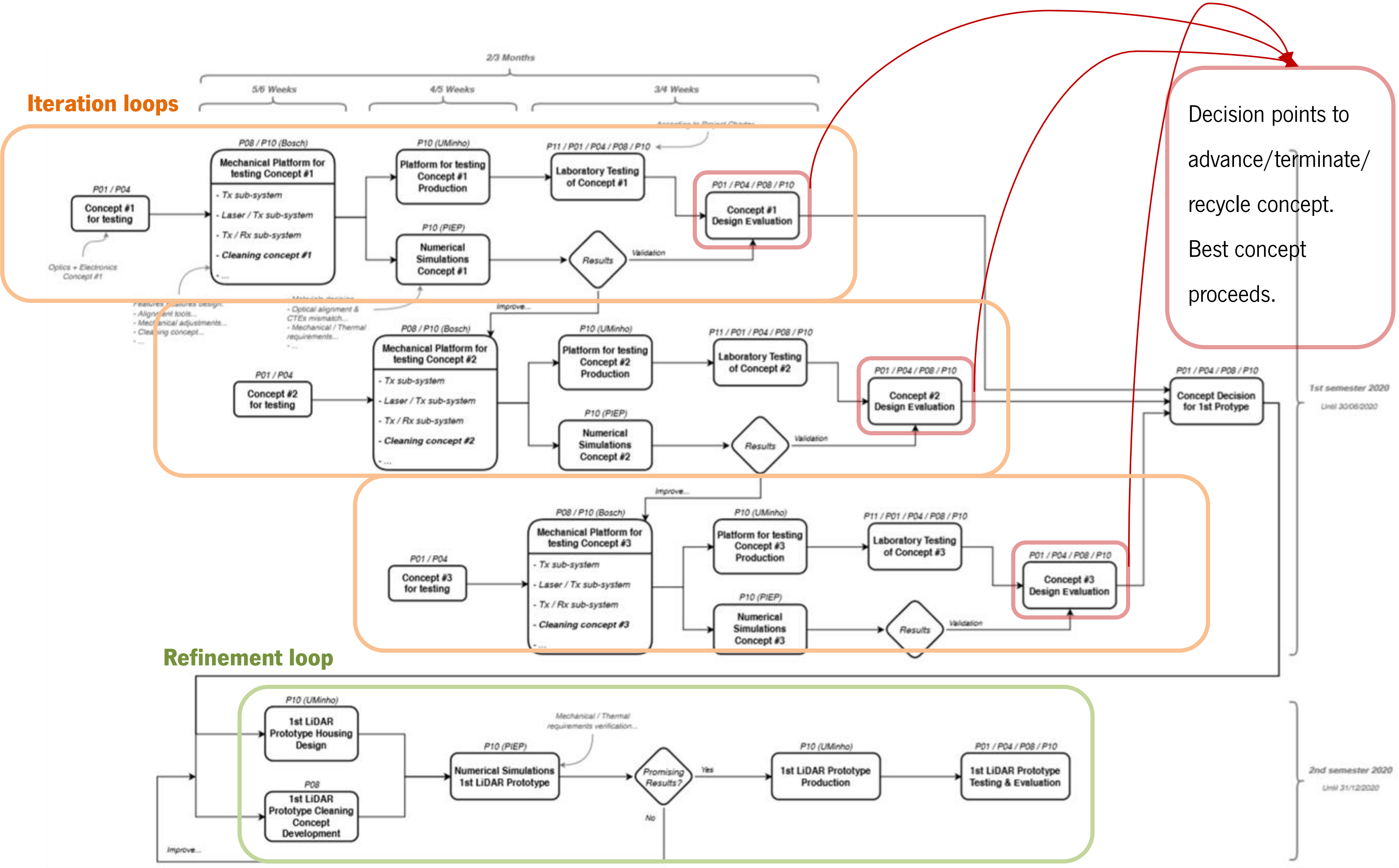
Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	**Planning Process Group**	**Executing Process Group**	**Monitoring and Controlling Process Group**	**Closing Process Group**
4. Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Work 4.4 Manage Project Knowledge	4.5 Monitor and Control Project Work 4.6 Perform Integrated Change Control	4.7 Close Project or Phase
5. Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
6. Project Schedule Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Durations 6.5 Develop Schedule		6.6 Control Schedule	
7. Project Cost Management		7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget		7.4 Control Costs	
8. Project Quality Management		8.1 Plan Quality Management	8.2 Manage Quality	8.3 Control Quality	
9. Project Resource Management		9.1 Plan Resource Management 9.2 Estimate Activity Resources	9.3 Acquire Resources 9.4 Develop Team 9.5 Manage Team	9.6 Control Resources	
10. Project Communications Management		10.1 Plan Communications Management	10.2 Manage Communications	10.3 Monitor Communications	
11. Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses	11.6 Implement Risk Responses	11.7 Monitor Risks	
12. Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	
13. Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Engagement	13.3 Manage Stakeholder Engagement	13.4 Monitor Stakeholder Engagement	

Annex 2

Organizational Structure Type	Project Characteristics					
	Work Groups Arranged by:	**Project Manager's Authority**	**Project Manager's Role**	**Resource Availability**	**Who Manages the Project Budget?**	**Project Management Administrative Staff**
Organic or Simple	Flexible; people working side-by-side	Little or none	Part-time; may or may not be a designated job role like coordinator	Little or none	Owner or operator	Little or none
Functional (centralized)	Job being done (e.g., engineering, manufacturing)	Little or none	Part-time; may or may not be a designated job role like coordinator	Little or none	Functional manager	Part-time
Multi-divisional (may replicate functions for each division with little centralization)	One of: product; production processes; portfolio; program; geographic region; customer type	Little or none	Part-time; may or may not be a designated job role like coordinator	Little or none	Functional manager	Part-time
Matrix – strong	By job function, with project manager as a function	Moderate to high	Full-time designated job role	Moderate to high	Project manager	Full-time
Matrix – weak	Job function	Low	Part-time; done as part of another job and not a designated job role like coordinator	Low	Functional manager	Part-time
Matrix – balanced	Job function	Low to moderate	Part-time; embedded in the functions as a skill and may not be a designated job role like coordinator	Low to moderate	Mixed	Part-time
Project-oriented (composite, hybrid)	Project	High to almost total	Full-time designated job role	High to almost total	Project manager	Full-time
Virtual	Network structure with nodes at points of contact with other people	Low to moderate	Full-time or part-time	Low to moderate	Mixed	Could be full-time or part-time
Hybrid	Mix of other types	Mixed	Mixed	Mixed	Mixed	Mixed
PMO*	Mix of other types	High to almost total	Full-time designated job role	High to almost total	Project manager	Full-time

*PMO refers to a portfolio, program, or project management office or organization.

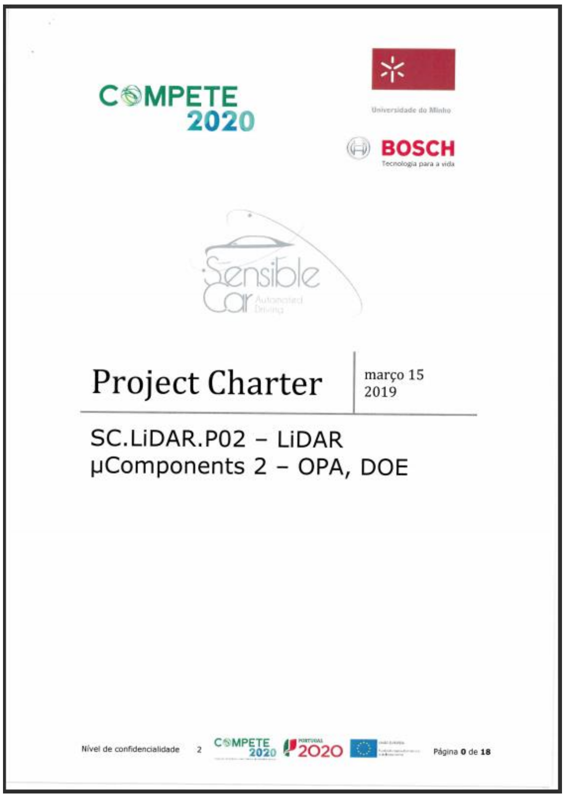
ANNEX 3



Iteration loops
2/3 Months
5/6 Weeks
4/5 Weeks
3/4 Weeks
P01 / P04
Concept #1 for testing
Optics + Electronics Concept #1
P08 / P10 (Bosch)
Mechanical Platform for testing Concept #1
- Tx sub-system
- Laser / Tx sub-system
- Tx / Rx sub-system
- Cleaning concept #1
P10 (UMinho)
Platform for testing Concept #1 Production
P10 (PIEP)
Numerical Simulations Concept #1
P11 / P01 / P04 / P08 / P10
Laboratory Testing of Concept #1
Results
Validation
P01 / P04 / P08 / P10
Concept #1 Design Evaluation
Improve...
P01 / P04
Concept #2 for testing
P08 / P10 (Bosch)
Mechanical Platform for testing Concept #2
- Tx sub-system
- Laser / Tx sub-system
- Tx / Rx sub-system
- Cleaning concept #2
P10 (UMinho)
Platform for testing Concept #2 Production
P10 (PIEP)
Numerical Simulations Concept #2
P11 / P01 / P04 / P08 / P10
Laboratory Testing of Concept #2
P01 / P04 / P08 / P10
Concept #2 Design Evaluation
P01 / P04
Concept #3 for testing
P08 / P10 (Bosch)
Mechanical Platform for testing Concept #3
- Tx sub-system
- Laser / Tx sub-system
- Tx / Rx sub-system
- Cleaning concept #3
P10 (UMinho)
Platform for testing Concept #3 Production
P10 (PIEP)
Numerical Simulations Concept #3
P11 / P01 / P04 / P08 / P10
Laboratory Testing of Concept #3
P01 / P04 / P08 / P10
Concept #3 Design Evaluation
P01 / P04 / P08 / P10
Concept Decision for 1st Protype
1st semester 2020
Until 30/06/2020
Decision points to advance/terminate/ recycle concept. Best concept proceeds.
Refinement loop
P10 (UMinho)
1st LiDAR Prototype Housing Design
P08
1st LiDAR Prototype Cleaning Concept Development
P10 (PIEP)
Numerical Simulations 1st LiDAR Prototype
Mechanical / Thermal requirements verification...
Promising Results?
Yes
No
P10 (UMinho)
1st LiDAR Prototype Production
P01 / P04 / P08 / P10
1st LiDAR Prototype Testing & Evaluation
Improve...
2nd semester 2020
Until 31/12/2020

ANNEX 4

Project Charters for SC.LiDAR P02, P04, P09 & P11 and details.


Project Charter

março 15
2019

SC.LiDAR.P02 – LiDAR
µComponents 2 – OPA, DOE

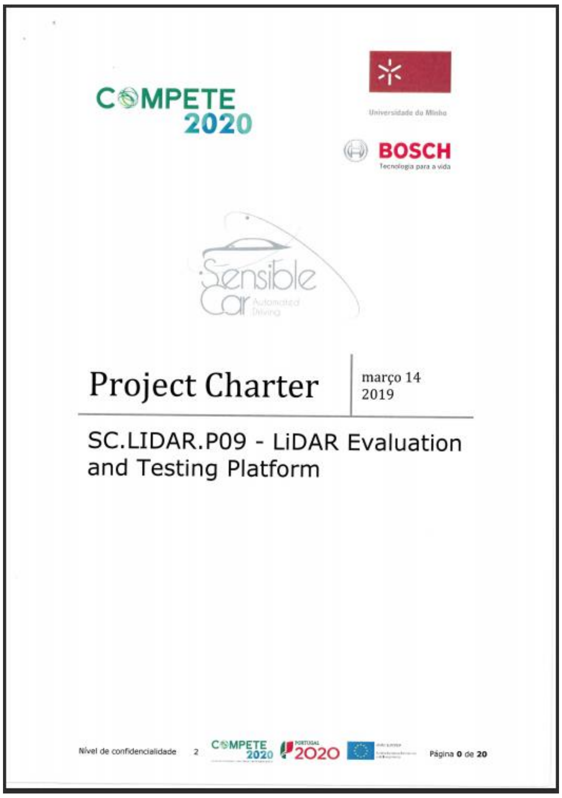
Nível de confidencialidade 2 Página 0 de 18


Project Charter

março 15
2019

SC.LIDAR.P04 – Data handling
and advanced processing for
LiDAR

Nível de confidencialidade 2


Project Charter

março 14
2019

SC.LIDAR.P09 - LiDAR Evaluation
and Testing Platform

Nível de confidencialidade 2 Página 0 de 20


Project Charter

março 14
2019

SC.LIDAR.P11 - Self-Calibration
and vertical alignment and end
of line testing system

Nível de confidencialidade 2 Página 0 de 18

SC.LIDAR.P02 – LIDAR µComponents 2 – OPA, DOE

Contents

SC.LIDAR.P02 – LIDAR µComponents 2 – OPA, DOE

8.2 Technical Milestones

Tabela 5– Marcos Técnicos do Projeto

ID	Marco Técnico	Meio de Verificação	Responsável	Data
#01				
#02				
#03				
#04				

Publicações:

- Todas as publicações devem ser comunicadas aos Responsáveis do outro parceiro para aprovação, antes de serem submetidas.
- Todas as publicações devem ter como *acknowledgements* a referência do Programa de Financiamento, para que possam ser oficialmente aceites pela Entidade Financiadora. A frase de *acknowledgements* a ser usada é a seguinte:
  "..."
- É incentivado ter autores de todos os parceiros, desde que cada autor tenha participado suficientemente no trabalho para assumir responsabilidade por

All Project Charters have English Indexes, but most of the contents are written in Portuguese.
The PL names were not translated, as seen in the previous page.

Most of the PC have left the Technical Milestones chart in blank.

The Annex 5. Management Policies entry, with instructions for publishing acknowledgment of the Program, was left incomplete in all PC.

Annex 4. Project Deliverables Expected Content

ID	Descrição do conteúdo do entregável
E1.2.1	- Aquisição de conhecimento e informação crítica sobre OPA (LCOS) e DOEs. Estudo das [redacted]
E2.2.1	- Consolidação das especificações iniciais para os OPA (LCOS) e para os DOEs tendo em [redacted] tendo em consideração as especificações finais do sistema de varrimento. Definição das metodologias de testes, tendo em conta a validação dos componentes e do sistema.
E2.3.2	- Consolidação das especificações para o sistema de varrimento híbrido para o protótipo LiDAR (protótipo B).
E3.2.1	- Desenvolvimento e teste de protótipos ao nível dos componentes DOE e LCOS (neste caso [redacted]
E4.2.1	- Desenho detalhado do sistema de varrimento para o protótipo LiDAR B e ao seu [redacted]
E5.2.1	- Realização de testes aos LCOS e aos DOEs fabricados ao nível do componente e testes ao protótipo de sensor LiDAR com o sistema de varrimento híbrido.
E6.2.1	- Definição das estratégias de proteção e valorização da propriedade intelectual resultante do projeto.
E6.2.4	- Definição das estratégias de proteção e valorização da propriedade intelectual resultante do projeto.
E6.3.1	- Trabalhos relacionados com a produção, submissão e apresentação de todas as publicações técnico-científicas submetidas no âmbito dos trabalhos desenvolvidos neste projeto.

ANNEX 5

Sensible Car program - Anexo Técnico front page.

PORTUGAL 2020

UNIÃO EUROPEIA

Fundos Europeus Estruturais e de Investimento

PROPOSTA DE CANDIDATURA

PARTE B

(ANEXO TÉCNICO)

SISTEMA DE INCENTIVOS À INVESTIGAÇÃO E DESENVOLVIMENTO TECNOLÓGICO (SI I&DT)

AVISO Nº 26/SI/2016

REGIME CONTRATUAL DE INVESTIMENTO (RCI)

PROJETOS DE INTERESSE ESPECIAL E DE INTERESSE ESTRATÉGICO DE I&D

PROJETOS EM CO-PROMOÇÃO

Sensible Car / Anexo Técnico – Aviso 26/SI/2016 Página 1 de 257