A Process Model Integrated to Innovation Management Tools to Support Technology Entrepreneurship

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***Abstract*--Technology entrepreneurship (TE) has gaining increasing importance over the last decades. Therefore, a multidisciplinary research field was formed around research on technology-based innovation and entrepreneurship. However, despite the managerial and technological skills required in the challenge of new venture creation and development, little attention has been paid to the product/service and business levels of analysis of this phenomenon. An in-depth longitudinal study was conducted with four startups along 27 months. It was based on technology entrepreneurship, innovation management and new product development literatures. This research proposes a seven-step process model integrated to innovation management tools to support entrepreneurs in the context of startup creation and development. And then some theoretical and practical aspects of the proposed model are discussed. In particular the paper brings concerns on how the process and integrated tools helped TE management, how they were created and adapted to the startup context throughout the research, and which were the real contributions and limitations of well-known approaches, such as Lean Startup and other tools and processes.**

I. Introduction

Technology Entrepreneurship (TE) has gaining increasing worldwide importance due to its impact on the economic development [1, 2, 3, 4]. Consequently, a whole new field of research was born to support TE evolution and explore its implications. In great part, this new field has been built over two consolidated and inter-related fields of research: entrepreneurship and technology-based innovation [5, 6]. It is a new and unexplored field if compared to other older ones [3], however important and growing fast [7, 8].

Given the multidisciplinary nature of TE, one challenge was to seek for a clear definition of the phenomenon. So, TE was defined as the recognition, creation and exploration of gathered resources, integrating them around a technological solution regardless the organizational context [6]. The recognition is focused on discovery of entrepreneurial opportunities and validation of value propositions. Creation starts with concept development to reduce market uncertainties and then transformation of value propositions in products and services. Finally, exploration activities seek the value extraction from developed value propositions. It may also contain new technological developments and value propositions renewal.

It is also important to make clear the differences which makes technology entrepreneurship a unique field of research. There are various research topics in the landscape of TE, e.g., entrepreneurial product development, strategy and business model creation, product and service design, prototyping and testing in new ventures [2, 6]. However, despite the managerial and technological skills required in the challenge of new venture creation and development, little attention has been paid to methods with potential to help this endeavors at the product/service and business levels during recognition, creation and exploration phases. Studies on new product development (NPD) and innovation management tools/frameworks focusing the startup as unit of analysis are rare.

The use of well suited tools strengthens the innovation process in the context of technology-based innovation [9, 10, 11]. Once TE field deals with technological innovation in a multi-agent process, huge information asymmetry and great need for technological and managerial skills [8, 12, 13], tools successfully applied in the context of technology-based innovation in the past are opportunities to enrich the TE field, if well adapted.

So, building over literatures of entrepreneurship, new product development and technology-based innovation, this study proposes a managerial process model integrated to innovation management tools to support entrepreneurs in the context of startup creation and development. To achieve this goal, the need for adapting and developing tools in the context of TE [14] will be considered. The result is a framework intended to help managers and entrepreneurs in the TE management efforts, having the startup as the unit of analysis.

II. Literature Review

For this study, a startup is a human institution designed to recognize, create and explore technological entrepreneurship opportunities in an environment of extreme uncertainty. Its objective is to achieve a sustainable business model in line with the expectations of the founders. This definition was built on TE and startup classic definitions [15, 6] but with some changes, as the need of a technological solution and the substitution of the scalability principle by the satisfaction of founders' expectations.

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The concept of technology entrepreneurship opportunity born from definitions of entrepreneurial opportunity in general [16, 17]. Entrepreneurial opportunity is defined as a situation in which a person can create an approach of new means and ends by recombining resources to generate profit [16]. The use "value" instead of profit its preferable, once a venture can be created with non-financial purposes [17]. So, a technological entrepreneurship opportunity is defined as a situation in which a group of people can create an approach of new means and ends by recombining resources and using technology.

A. Technology Entrepreneurship: process-based perspectives

Entrepreneurship phenomenon is fundamentally based in action and involves a highly interrelated set of creative, strategic and organizational processes [17]. There is a need to deal with entrepreneurship in a process perspective, since change, action and newness are solid characteristics of entrepreneurship and process-based perspectives. There are evidences that a process-based view is useful in understanding technology entrepreneurship [2, 18].

So, this study will focus on TE as a process strongly marked by change, learning cycles, feedback and reorientation with the objective of generating a new startup. To do so and in order to design a useful process-representation, three fields of research strongly contributed to a TE process-based perspective: Technology Entrepreneurship, academic spinoff and other new technology-based ventures perspectives.

1) Technology Entrepreneurship field process-based perspectives

A three-step process of technology entrepreneurship is proposed (see Figure 1) [2].

Fig. 1. Main phases of TE process. Source: [2].

Formation activities are about seeking and recognizing opportunities as well as gathering resources. In exploration phase, entrepreneurs shall develop strategies to pursuit the opportunities of the first phase. In renewal phase, the focus must be on adapting to the changeable customer demands [2].

Each phase of TE process considers different levels of analysis, viz, product/service level, business/firm level and system level. In each of these levels there are some research topics of interest, as Figure 2 shows. Figure 2 is not intended to provide a full understanding of each possible topic in the TE context, but rather a map that could help the understanding of the vast and multidisciplinary TE field.

As Figure 2 shows, there are many issues and challenges in the levels of product/service and business/firm, such as strategy, business model creation, project management, product and service design, prototyping and testing. Despite of it, little attention has been given to these topics in academic literature.

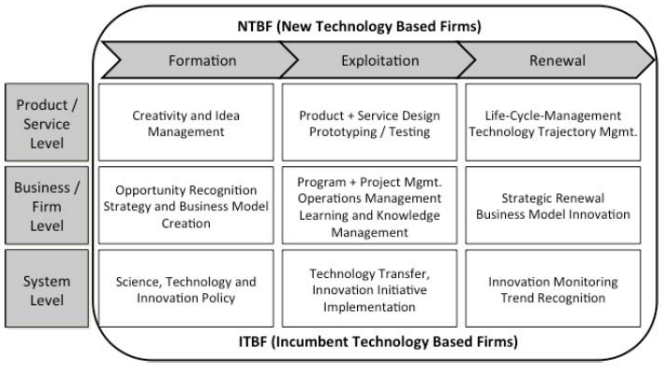

Fig. 2. Elements of TE framework with research topics. Source: [2].

Another process-based representation of TE can be found [30]. The author represents the life cycle of an entrepreneurial firm in a four-stage phases: startup, transition, scaling and exit. It is also a nonlinear perspective, in which the "boundaries between adjacent stages are fuzzy and frequently overlapping" [30, p. 588].

In startup phase the challenges are to define and validate the business concept, with narrow focus and limited resources. The organization at this stage is typically informal and fluid. The transition period begins about the time when the new venture first gains traction in the marketplace and start to move towards a structured and disciplined form required for rapid scaling. The challenge is to complete the development of the value offering, establishing a solid foundation and preparing the product for rapid scaling. To do so, additional resources are required, and new capabilities must be developed [30].

In scaling phase, the goal is to enable rapid growth and starts to be required an organization with defined structure and processes. At some point, a successful *exit* can be required to harvest value for the benefit of entrepreneurs and investors [30].

Transition is the most critical period in the life cycle of a new venture and usually lasts between 18 and 36 months. Involves the transition from a nascent startup into a disciplined business. Transition implies in overcoming the challenges of laying foundation for rapid growth, acquiring resources and establishing credibility and legitimacy [30].

2) Academic spinoff process-based perspectives

Academic spinoffs (ASO) are new ventures created to explore intellectual property previously developed in universities and research centers [1, 19]. They are a specific kind of startups.

In the process of an ASO generation, there are two different periods: creation and development [1]. The creation starts with basic research, culminating in an invention. Then, the research group decides to register intellectual property (IP) and, eventually, to create a new venture from the IP. Hereafter the team starts looking for business opportunities to the early-stage technology [1].

Then, the development period begins. There are two parallel efforts in this moment, concerning to technical and market issues. The technical development process starts with

making a proof of the principle using the technology. Then, a prototype must be built. Finally, a product development process conducts the efforts until the technology turns into a commercially viable product. To do this, a market process runs alongside. It starts with actions to diminish market uncertainty. Then, one or more options concerning the application of technology are proposed to foster product development. Following product development, product sales begin [1].

In this study, the effort of generating a startup from idea to commercialization will be called creation and development, or generation process [1, 6]. In this process, the activities of recognizing, creating and exploring opportunities of technology entrepreneurship will take place.

Another process-based perspective was proposed by addition of milestones/critical junctures in the ASO generation process [19]. The authors offer a five-phase nonlinear process, which allows the ASO team to move backwards or forwards throughout the development process. The first step is the basic research, that presents the first critical juncture to be overcome: the opportunity recognition challenge. Then, in the second phase, opportunity framing take place, and its associated milestone is the need to gain commitment from an entrepreneurial team. The third phase deals with pre-organization. It is the moment to implement strategic plans and take decisions over the capabilities that must be developed and the resources and knowledge that must be obtained. If the team succeed in the third step, they will overcome the milestone of credibility and moves to the re-orientation phase. This phase focuses on delivering value to consumers by applying the technology in products and services. It is a moment of continuous efforts of identification, acquisition and integration of organizational assets with subsequent reconfiguration of them. If these activities are carried out successfully, the threshold of sustainability – the last critical milestone – will be overcome and the phase of sustainable returns can start.

3) Other New Technology-Based ventures perspectives

This topic will present three other perspectives: The Customer Development, Lean Startup and Customer-Oriented New Product Development Process (PDPOC, from the acronym in Portuguese).

The so called "Lean Startup method" was selected to this study not only due to its enormous diffusion, but also because of some scientific evidence that supports it [20]. The Lean Startup (LS) is a combination of agile practices with a process called Customer Development (CD) [14]. Its purpose is to help entrepreneurs increase their new ventures chance of success [15].

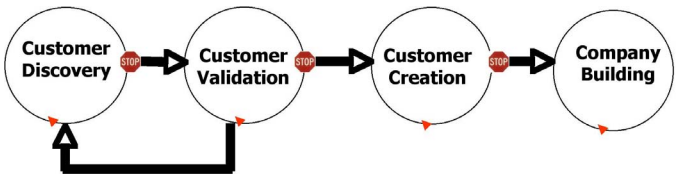

Fig. 3. Customer Development four steps. Source: [21].

CD is a four-step nonlinear approach (see Figure 3) that aims at offering guidance to hypothesis testing with emphasis on agility: new ventures quickly develop minimum viable products (MVPs) and get customer feedbacks. These feedbacks enable hypothesis revision, starting the cycle again, testing new value offerings and making small adjustments or more radical ones (pivoting) [21].

Usually associated to CD is the LS, created to help answering one question: how to develop and validate problems, product and assumptions about the consumer, laying the foundation for a successful new venture? To help get the answer, a rigorous and agile sequence of test and learning in contact with the reality is proposed [38].

The Lean Startup has four principles [15]:

- Validated learning.
- Build-measure-learn (B-M-L) cycle (see Fig. 4).
- Minimum Viable Product (MVP).
- Pivot or preserve.

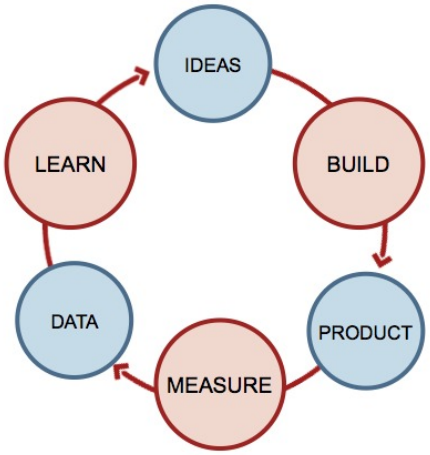

Fig. 4. The Build-Measure-Lean Cycle. Source: [15].

The last representation selected is not a new venture creation process itself, but a process of new product development called PDPOC. This process was chosen due to its potential to influence the results of this study by an approach closer to the practice and to the product/service level of a startup generation process. This potential -and this study itself- seeks to answer [17], who argued that just a few studies found in entrepreneurship are grounded in empirical evidence and can provide practical implications regarding to the "how" of entrepreneurship [17].

PDPOC, or Customer-Oriented New Product Development Process, was designed in the context of Quality Function Deployment (QFD) method [31] as a nine-step stage-gate-like [32] process, as detailed below:

- Identification of customer demands and needs.
- Concept development and testing.
- Basic project of the product.
- Detailed project of the product.
- Design of manufacturing process.

- Manufacturing preparation.
- Initial production.
- Market and customer service preparation.
- Analysis of customer satisfaction level.

B. Selected Management Tools

Multiple tools and approaches were used by this study (see figures 7 and 9) and by the startup accelerator (Acel) in which the research happened. Others were used by Acel in a first moment (first version of P-Start and before) and then were abandoned, as will be seen in section 4. However, this topic will describe five of them that played central role in the final proposal and results.

Lean Startup was built on Agile Methods context [14]. So, an agile method called SCRUM [33] has been used to strengthen tactical management of startup processes, marked by high uncertainty levels, complex problem solutions and cooperation [33, 39]. Although the focus of this study is not on Agile Methods or SCRUM, the Product Backlog tool [33] was central to all versions of P-Start.

Business Model Generation and Value Proposition Design were used because of:

- Theoretical and practical proximity with Lean Startup and Customer Development approaches [14].
- Potential to help in building technology management toolkits relevant to industry [34].

Two other methods (Roadmapping and QFD) were already been used systematically by Acel teams, including on startups generation processes. Roadmapping is a structured visual framework used to support definition of innovation and strategy processes. It is recognized by the potential for integration with other strategy and innovation tools [40] and is an integrator of different levels of the innovation management process, providing support at all of them [41]. QFD method was conceived in the late 1960s to ensure that customers' real needs were appropriately deployed throughout the design, construction and delivery of new products [42]. It is a management method capable of assisting the quality assurance during new product development [31]. This research sought to analyze if they could continue to be used in favor of the startup generation process. And, if so, to what extent and with which adaptations to the context of the?

C. Conclusion of literature review

So, the literature review sought to support the objective of this study: conceive a seven-step process model integrated to innovation management tools. First, it described some fundamental definitions. Next, it was necessary to present representations of processes that could help to structure the seven-step model conceived by this text. Two representations were found in the literature of technological entrepreneurship [2, 30], but presented low level of detail about their internal dynamics. So, two process representations of ASO generation were needed [1, 19], since ASO is a TE research stream more mature if compared to others. Then, a bigger level of detail and the milestones perspective were used to strengthen the construct made with the first two representations. But a bigger level of proximity to practice and the product/service and business levels were still needed.

Therefore, two process representations were added to the literature review: The Lean Startup along with the Customer Development four-step process and the PDPOC with its seven-step new product development process representation. These last ones were closer to the product/service and business levels of startup generation processes and could provide insights and structure to this study objectives.

These process representations were useful to conceive the final seven-step process of startup generation. And to help in specific challenges of these steps, innovation management tools would be integrated and applied. So, the literature review was finalized with a brief description of these tools.

III. METHODOLOGY

Building over this theoretical background, a 27-month action research program was held between an Brazilian startups accelerator and the engineering school of the top-ranked federal university in Brazil. This section will explain why action research was adopted and how it has been done.

A. Action research

Action research (AR) is a research method [24, 25] distinguished from others once it implies social change, or transformational action in one real issue [26].

Based on this, the researcher must participate of the real-world problem solution, in a system in which the researches actively participate of the action and the system members actively participate of the research process. They interact to search adequate contextual solutions for problems in no-controlled settings [29]. In this sense, AR is “research in action, rather than research about action” ([25], p. 222). The most distinctive characteristic of AR is this collaboration between researches, or problem outsiders, and the problem insiders (people directly affected by the problem) [27].

However, a common mistake is to reduce AR only to action, as if it was a kind of consultancy. Therefore, when AR is used by researchers, they intend to deepen theoretical understandings through the real problem-solving [25], with the commitment to produce scientific knowledge.

Thus, AR was considered appropriate to reach this research objective for many reasons, as follow:

- AR aims to address socio-technical real-world problems, as in the case of designing a process model integrated to innovation management tools. With the objective to help the management of the startup creation and development process in the context of a Brazilian accelerator of startups.
- The researchers were aware that unless they were strongly involved in the process, context and the challenges of startups creation and development, the problem would not be solved, and the objective would

not be reached. Reference [11] reinforces this view by stating that testing and refinements in practice are essential to design technology management approaches that are both useful to practice and robust from a theoretical point of view.

- Unless the researchers attempted to create and develop startups, they would be unable to devise a methodology to tackle this kind of problem.

B. The research project

This AR project was a collaboration between directors and startup teams from a Brazilian startup accelerator (Acel) and researchers from the innovation management group of the production engineer department of Federal University of Minas Gerais (NTQI/UFMG). The investors of the startup teams had participation too (associated with the startup teams), but with less proximity.

UFMG has achieved in the last years prominence by positioning itself among the third and fifth place in the ranking of the best universities in Brazil. It is particularly strong by its innovative capacity, as evidenced by being the larger Brazilian patent producer. NTQI research group has more than 15 years researching new technology-based ventures, and four new companies were founded as NTQI spinoffs in those years. All of them are still thriving. One of these spinoffs is Acel, an accelerator that works in the venture builder or startup factory model.

Through this study time, from October/2015 to December/2017, three startups participated of the research, and one derivative of one startup. Startup 1 (St1) was the first one, a B2B software startup designed to help in complex sales management, which process of creation and development started in Oct/2015 and was accompanied until Dec/2017. In this period, it received three rounds of angel investment and won SEED (seed.mg.gov.br) program at the end of 2017. SEED is one of the biggest Latin American acceleration programs.

Startup 2 (St2) project started in Dec/2016. It was a B2C software startup intended to reduce waiting/queue time to pay in establishments such as pubs, restaurants and nightclubs. It was accompanied through Apr/2017, when its investors, Acel and the startup team decided to end its generating endeavor.

Startup 3 (St3) was a B2C software startup which value proposition was built around providing organic food. St3 participated of the research by May/2017 to Dec/2017. It received two rounds of angel investment during this study, and the negotiation for the second was concluded in late Dec/2017.

The derivative (Dt1) started in Jul/2017 and was a new product of St1, adapted to a new market which would demand new features and new market strategy. Although it was not a new startup, some helpful insights came from its participation on the research.

The research partnership between Acel and NTQI/UFMG started due to an Acel demand: the need to design methods and processes which could help the managerial efforts and challenges present in the creation and development of its startups. This problem had a theoretical appeal as it was related to the technology entrepreneurship management and could be framed to a still unanswered research question about: how methods and techniques from innovation management and new product development literatures could be adapted and integrated to help TE management efforts with focus on product/service and business levels (see sections I and II)?

The research project was consciously guided by AR methodology according to [25, 26, 29] principles. E.g.:

- It was theoretically induced both in methods conception and execution, specially by technology entrepreneurship, innovation management and new product development literatures.
- The choices regarding to methodology were always made after understanding and agreement by Acel and research members, taking in consideration the recoverability criterion [29].
- At least monthly meetings were held between one researcher and the Acel team to foster collective reflection and keep tracking of the learning process on the managerial approaches that being built. The frequency of the meetings of this researcher with the other UFMG researchers was approximately every 45 days.

One of the researchers was the project manager and, then, CEO of St1 and Dt1, what allowed richness of data, exemplified by participation in 47 strategical meetings with the startup angel investors and approximately 110 formal meetings with St1's development team. Always using and perfecting the process and methods.

By the end of 2016, this researcher was invited to be the methodological coordinator of St2 project. After the end of St2, this function remained, but now with St3 case, what happened until Dec/2017.

The process model designed by this study changed radically at least three times (see IV. A. for more details). Each of these changes were made by the research team and Acel to evolve the research results. At each redesign of the approach all the startups were affected, because they were engaged in Acel managerial process. In other words, all the startups were following the results of this research as their managerial approach. This shows how the research shaped the course of action which, in turn, reshaped the research results.

The methodological choice of this study sought to fill a literature gap by providing a managerial approach adapted to TE practice and useful to provide help to startup teams and accelerators [14,17]. So, AR was chosen along with a longitudinal approach. These choices demanded in-depth analysis to avoid the risk of becoming a conceptualization of entrepreneurship process only based on theoretical perspectives, remaining far to the practice [17]. On the other hand, such an in-depth study could not be properly conducted with a high number of cases. So, rather than a weakness, this small number of cases shall be seen as a necessary step to build

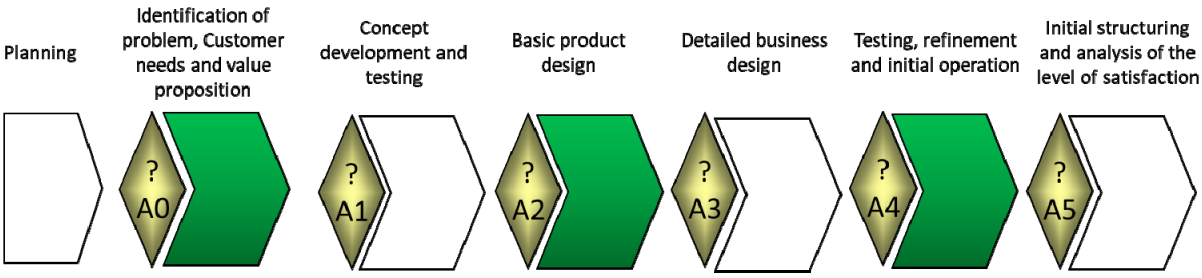

Fig. 5. P-Start 1. Source: Authors

a robust management approach to TE. The next step is to test the approach in other environments and contexts to ensure its stability and usefulness without significant changes [11].

Therefore, the results found by this research were helpful to build a construct that shall be improved by dissemination and testing in other contexts (e.g. by other accelerator programs and in other startup generation processes) [11]. A new project was started with this objective and will be led by the NTQI/UFMG research group in partnership with SEED acceleration program.

IV. Results

The AR program generated a seven-step process model integrated to some innovation management tools with the objective of support technology entrepreneurship efforts. This section will present the process model, called P-Start, and the tools associated with it. Will also present how the literature review elements were used in the research design, that is, in the AR cycles that shaped the process model representation and the management tools adapted and integrated with it.

A. The P-Start process

The final version of P-Start consists of a framework structured on seven steps and two milestones. Each step represents activities aimed at solving problems and overcoming challenges throughout the startup creation and development process. Thus, within each stage there are sub-stages containing tools or activities geared to overcome such challenges.

Two intermediate versions of P-Start, called P-Start 1 (see figure 5) and P-Start 2 (see figure 7) were built before the final version, or P-Start 3. The evolution between versions occurred along the cycles of AR, seeking to obtain a more suitable model to TE reality.

P-Start construction was based on the integration of tools and aimed to strengthen the generation process of startups. At each point in the research, especially when the P-Start versions were redesigned, three guiding questions were asked as drivers of the AR:

- Is the present P-Start model representative of startup's creation and development reality?
- Are the stages and sub-stages suitable to TE reality and well used? Are there activities being done still not present on P-Start?
- The framework has consonance with the literature review?

Thus, only the methods that had the two items below remained on final P-Start version:

- Had been applied in one or more cases, with a perception of success from the perspective of those involved in AR, showing practical applicability.
- Helped or were closely related to at least one of the TE items proposed by figure 2.

First P-Start version (figure 5) was deeply influenced by PDPOC's structure, however associated with some concepts of Lean Startup and Customer Development, as can be seen by the name and contents of its second stage. In each sub-stage there were tools to help in specific challenges (see figure 6). After 18 months of AR based on st1 and st2 cases, a reformulation of P-Start 1 was proposed, generating P-Start 2.

STAGES	SUB-STAGES
Planning	Financial analysis
	Analysis of competitors, benchmarks and substitutes
	Value chain and business environment analysis
	Roadmapping
Identification of problem, Customer needs and value proposition	Business model generation canvas
	Problem testing
	Elicitations
	Initial product functionalities
	Customer needs identification
Concept development and testing	Concept development
	Brand and URL creation
	Concept testing
	Competitive analysis
Basic product design	Web and app product requirements
	Web and app product backlog
	Quality matrix
	Testing with potential customers
Detailed business design	Beta version (web and app) for testing
	Distribution strategy
	Business plan for client creation
	Metrics plan
	Mapping of operational processes
	Mixed Brand Development
Testing, refinement and initial operation	Beta version with adjustments and improvements
	Development of material for advertisement
	Testes de vendas reais e otimização dos canais
Initial structuring and analysis of the level of satisfaction	Initial sales and channel optimization
	Initial operation tests

Fig. 6. Sub-stages of P-Start 1. Source: Authors

P-Start 1 assisted in organization and structuring of technology, product, and market information throughout the evolution of startups. It was also useful to guide and prioritize

the actions of the startups team, facilitating group consensus and indicating possible approaches and methods for the challenges perceived by the team at each stage. Finally, the sub-stages helped communication between startup teams, Acel and investors. These benefits remained to the other P-Start versions.

So, the team perceived P-Start1's potential to be consolidated as a representative process of technological entrepreneurship. However, adaptations would have to be made for this potential to be realized, especially with respect to the linearity, rigid presence of gates with go/kill criteria at the end of each stage, and the almost obligatory walk through all steps and sub-stages of the framework.

So, P-Start 2 (figure 7) was designed to:

- Simplify stages, sub-stages and activities that had been little used or used with low value perception by AR team.
- Reduce process linearity, adding cyclical and iterative aspects.
- Move towards a contingency approach in which the decision on the use of methods in each sub-step was guided by the practice and the desire of the participants involved. Thus, P-Start would become a flexible reference model containing possible methods, tools and approaches. And not an overly prescriptive process.
- Decrease the number of stages and, consequently, milestones in the process. Search for flexible criteria for each gate (go / kill decision).

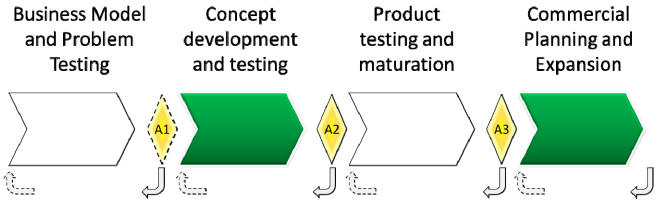

Fig. 7. P-Start 2. Source: Authors

To do this P-Start 1 redesign, the literature of Lean Startup and Customer Development [14, 15, 21] were broadly used to make the model more fluid and iterative. The perspective of milestones associated to a fluid process with possibility to move forward and backward between steps were incorporated from TE literature [19]. Finally, some P-Start 1 stages were suppressed once they were not theoretically close to the TE process representations found in literature review.

P-Start 2 model was used for only three months and soon demanded a new reformulation. Although some significant advances were found in this model, it showed a large gap: adaptation only to the first startup creation and development stages. And difficulties to help more mature startups. In other words, adapted only to startup stage, not to transition stage [30] of the generation process. For example, it was not adapted to st1 that, at this moment, had approximately one and a half year. So, P-Start 3 were designed.

P-Start 3 (see figure 9, below) sought to incorporate P-Start 1 and 2 learning. It was also added to the model the approximate separation between the stages of recognition, creation and exploration of entrepreneurial opportunities, typical of TE definition adopted by this study and influenced by TE literature. The stage 7: consolidation and renewal were influenced by figure 1 [2] and by customer development process (see figure 3). Technical and market separation in a cyclical and iterative process were deeply influenced by the development phase in ASO development [1] and shaped the fourth and fifth stages of P-Start 3. The milestones were revised and redesigned with influence of Lean Startup, PDPOC and ASO representations [15, 19, 32].

1	Planning and organization
1.1	Financial analysis
1.2	Roadmapping
1.3	Planning and team structuration
1.4	Preparing for investment
2	Problem identification and testing
2.1	Business Model Generation Canvas - hypothesis
2.2	Problem testing
2.3	Customer profile and journey
2.4	Analysis of competitors, benchmarks and substitutes
2.5	Value map
2.6	Environmental and value chain analysis
3	Concept development and testing
3.1	Concept creation
3.2	Concept testing
3.3	Competitive analysis and market positioning
4	Sales preparation and testing
4.1	Choice and project of initial sales model
4.2	Customer journey (shopping experience)
4.3	Channel testing
4.4	Monetization decision
4.5	Branding and support material production
5	Product testing and maturation
5.1	Product Backlog and technical documentation
5.2	Supply chain management
5.3	Technichal and customer support
5.4	Quality assurance
5.5	Intellectual Property
6	Commercial Expansion
6.1	Sales model refinement
6.2	Metrics design
6.3	Marketing actions
6.4	Sales actions
6.5	Customer succes actions
7	Consolidation and renewal
7.1	Design and maturation of metric systems
7.2	New markets/opportunities mapping
7.3	Derivatives and platform planning
7.4	Tendencies monitoring

Fig. 8. P-Start 3 sub-stages. Source: Authors

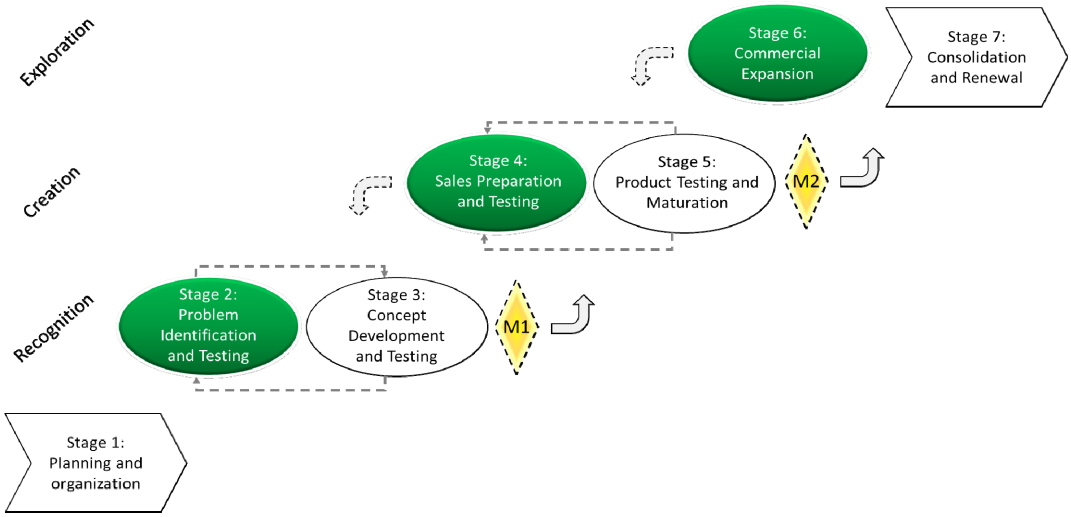

Fig. 9. P-Start 3. Source: Authors

So, P-Start 3 was built with less linearity, seeking to become more cyclical and suitable to TE reality. Definitive choice for a contingency approach was made, so that each step and sub-stages (see figure 8) of P-Start were seen as a possible tool in a toolkit, analogous to the work of [43] with the objective of help to deal with information asymmetry and guide effort prioritization and decision making.

Each P-Start Stage has its own objective, for instance:

- Planning and organization: Assemble activities related to planning and organization that will occur throughout the P-Start stages.
- Problem Identification and Testing: Obtain and consolidate knowledge regarding the original problem addressed by the startup, delving deeply into the reality regarding customers and possible solutions.
- Concept Development and Testing: Create, develop and test the startup concept to achieve a product-market fit that justifies greater investment.
- Sales Preparation and Testing: By testing and interacting in a small-scale reality, create an initial version of the sales strategy and model that has potential to expand the sales operation as required by the business model assumptions.
- Product Testing and Maturation: Product testing in real customers to mature its concept and reach a version capable of being marketed in real scale.
- Commercial Expansion: Apply the conceptual model obtained in the fourth stage to expand the operation of sales in real scale, according to the assumptions of the business model.
- Consolidation and Renewal: Assemble the activities related to consolidation and renewal of the startup, aiming to keep it competitive in the market.

Finally, P-start 3 also presented milestones associated with each macro-stage transition. The macro-stage were the recognition, creation and exploration phases. The M1 milestone was positioned between the recognition and creation. And milestone M2 between creation and exploration. M1 aimed to verify if the startup reached its product-market fit and, at this maturity level, found a minimum viable prototype/product that has been approved in terms of the value proposition and price. Here, early users should be satisfied to use the solution.

M2 aims to verify if the startup product and marketing model are ready to start a significant gain of scale. The product shall be ready to support commercialization on a larger scale and the marketing/sales model shall be ready to receive resources investment and generate gain of scale in startup's sales.

B. Other Tools

Roadmapping, located in first stage of P-Start, were used in two levels. The first level use was to make a long-term planning in the TE context. This larger roadmap (figure 10, below) had one-year time horizon and four layers: market drivers, market, product/service and technology/resources. It was used in st1, st3 and dt1 to communicate the vision and strategy of the startup to investors, potential investors, acceleration programs and internal team.

The second level had smaller time horizons (figure 10) and has been integrated to SCRUM (see figure 11) to help in startup management. This approach was used in st1 and dt1 when the team started to grow, and an embryonic functional division began to happen, demanding management adaptations. The time horizon was the exact time of four SCRUM sprints. The layers were: market goals, process, product/service and resources. The market goals layer differs from market layer in the bigger roadmap due to an association of goals to each roadmap action (visible deliverables, as SCRUM states). And the process layer was created due to startup need of establish more solid processes in the transition phase [30].

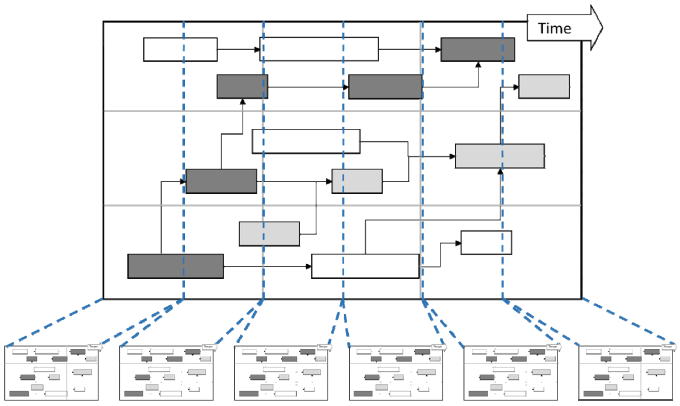

Fig. 10. Two-level application of roadmapping. Source: Authors

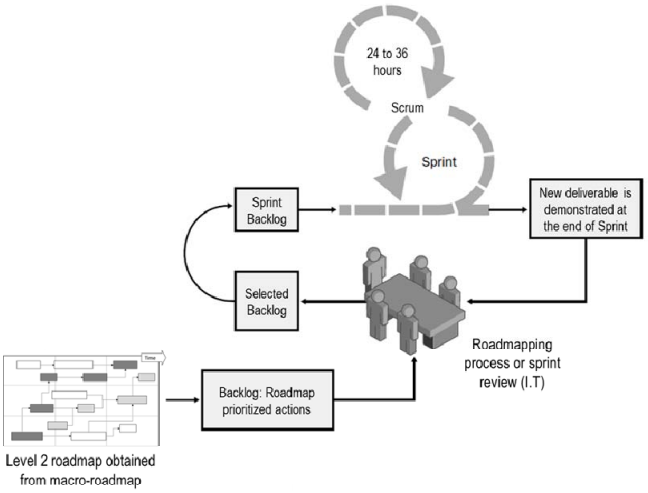

Fig. 11. Roadmapping-SCRUM integration. Source: Authors

Figure 11 demonstrate roadmapping-SCRUM integration. Its use begins with the level-2 roadmap obtained from the level-1 macro-roadmap. Then, one backlog is made to each team (e.g.: sales team and product teams) and a repriorization of level-2 roadmap can be done. Some level-2 roadmap layers are for responsibility of specific teams and the layer' content is a pre-prioritized backlog for this team.

In product teams, the sprint review meetings were made to select backlog and evaluate the last sprint [33] according to the product layer of the level-2 roadmap. And the scrum meetings were made daily. In non-product teams, the sprint review meetings were made using a fast roadmapping-process and the scrum meetings occurred at intervals between 24 and 36 hours.

Other method used was the QFD. In second and third P-Start stages, the method were used to help in VPD prioritization efforts. Due to the high volume of information generated with the VPD method in st1, the startup team had difficulties to prioritize it and find an adequate product-market fit. The VPD method, while suggesting prioritization, does not provide adequate tools to support such prioritization when there is a high volume of data to be processed and prioritized. The QFD method helped in this effort, and the detailed application can be found in [45]. Other authors used a similar approach to help VPD prioritization efforts using QFD [44].

V. Discussion and Implications

This section discusses the main inferences and considerations that can be drawn from the study. And their implications for related theories and practices.

A. Implications of methods and tools in TE context

Given the multidisciplinary and specificity of TE, AR proved to be important for adapting the methods and guiding their application. The results of this study were perceived as useful to help complex problem solving, improve communication, help in collective decision making and integrating strategic decisions to operation activities. The impact of this last benefit was realized when the startups began to present more than 5 people in the team.

The benefits of P-Start model associated with other methods is also seen because it helps to solve, in different intensity levels, seven of the eight hurdles [30] that a startup faces in transition phase (see figure 12).

	Hurdle	Aid intensity of P-Start
1	Setting a direction and mantaining focus	High
2	Positioning products/services in na expanded market	High
3	Maintaining a cutomer/market focus	High
4	Building an organization and management team	Low
5	Developing effective processes and infrastructures	High
6	Building financial capability	Low
7	Developing and nurturing a culture	No aid
8	Managing risks and vulnerabilities	High

Fig. 12. P-Start helping to solve the eight startup hurdles. Source: [30], adapted by authors

P-Start help in first hurdle by representing the creation and development efforts in a process way which stimulate to focus in small objectives at each stage. Besides that, in each stage there is a strategic reflection focused in one subject and finally, the roadmapping approach also helps in this hurdle. The second hurdle is the only focus and objective of P-Start's sixth stage and begins to be planned and prepared in the fourth stage, once that the market positioning in lower scales is done on recognition macro-phase and, in some extent, in the fourth stage of P-Start.

The whole P-Start framework, e.g. steps 2, 3, 4, 5 and 6, is oriented by "get out of the building" principle [23], emphasizing the need for customer focus, the issue of third hurdle. Steps 2 and 3 of P-Start are 100% oriented to this principle, but since the hurdle is more focused on the post M1 juncture, can be mentioned that sub-stages 4.2, 4.3, 5.3, 6.3, 6.4, 6.5, 7.2 and 7.4 are oriented to help overcoming this

hurdle. It can also be mentioned that PDPOC and QFD were chosen, respectively, as a reference model for P-Start 1 and a useful method due to their customer focus.

The fifth hurdle is the central contribution of a process-oriented approach such as P-Start. For instance, roadmapping, SCRUM, stage 6 and sub-stages 5.4, 5.5 and 1.3 help in this challenge. All risks posed by the eighth hurdle are consistently addressed by specific P-Start stages. For instance, the cycle between steps 4 and 6 for market risks; step 7 and sub-stages 2.4 and 3.4 for competitiveness risks; execution risks in sub-steps 1.3, 4.3, 4.5, 5.1, 5.2, 5.3, 5.4, 6.3, 6.4, 6.5 and 7.1. Finally, technical risks in step 5.

P-Start also helped, but with less intensity, the fourth hurdle (by means of roadmapping and sub-stages 1.2 and 6.2) and the sixth one (by means of sub-stages 1.2 and 1.4).

B. Stages, milestones and linearity in TE context

It could be said that linear representations with milestones and stages are not helpful to the context of innovation or TE [46]. However, this study shows that TE field can benefit of these characteristics if they can be well adapted.

P-Start 3 was a framework that preserved some linear characteristics associated with the flow perspective. And with two milestones between its macro-phases. The linearity has been diminished if compared to more classical GDP representations [31, 32] but preserved some aspects to help in the challenge of keeping the focus of the team. The milestones were also relaxed, acting not as criteria of decision to go/kill [31, 32], but as systems of for decision making aid.

The milestone M2 helped in decision making in critical st1 and st3 moments, for instance. After stages 2 and 3, the good results of these startups generated excitement on its investors. Soon after the first concept testing, they wanted to direct all startup's resources to start sales in bigger scale (stage 6), without overcoming M2. But at that moment the startups could not be able to sustain gains of scale once the products were almost artisanal and teams were still working on a little efficient way. At that time, P-Start helped to keep focus on 4 and 5 stages before investing in big scale commercialization.

Only after approximately one-year st1 became able to overcome M2 milestone, and st3 did not reached this moment during this research. At the end of the research, all the investors and startup teams said that moving to 4 and 5 stages before overcoming M2 would have been a wrong choice with high probability to lead st1 and st3 to failure. The reason: many unexpected and complex challenges arose while dealing with stages 4 and 5. And the startup teams would not have been able to solve these problems in a larger scale environment before overcoming M2 milestone.

M1 also helped, especially in st2 case. This startup had a particularity when started to be accelerated by Acel. The team, composed mainly by technical members, wished to gain scale on sales with an already functional prototype and scarce market knowledge. But value propositions had not been properly tested, and customer needs were not known enough by the team. This prototype development was done based on non-validated hypotheses about the client's desires and pains. In other words, they had not reached product-market fit before investing resources in product development. Using P-Start, Acel convinced them to focus on stages 2 and 3. During this time dealing with stages 2 and 3, st2 team realized that some hypothesis and premises of the business model would generate an unsustainable startup. So, they decided to finish st2 operations. P-Start, in this case, helped to reduce risks and waste of resources in an early stage of the startup generation.

C. Considerations about the Lean Startup theory and practice

The Lean startup provide benefits to TE field by diverse ways [14, 15, 20], which is in line with the findings of this study. However, to enlarge its reach and strength, some implications should be highlighted.

1) Minimum Viable Product (MVP)

The so-called Minimum Viable Product (MVP) is one of the fundamental principles of the Lean Startup [15, 20, 11]. MVP is the minimum in-development product version that allows a full B-M-L cycle with least effort and development time [15]. The "build" step produces MVPs [20].

However, MVP definition presents fragilities. Scott Cook, Intuit founder, were in charge of a team that had received strong training on LS. Nevertheless, he said that "engineers naturally focus on the word *product*. So, they soon want to build a product" [47], a robust product, going against the other principles of LS. This confusion with the term product, or viable product, were presented in st1 and st3 cases. Initially, acel team struggled to convince investors of these startups to accept the B-M-L cycle in contact with customers by using as testing mechanism simple artifacts, distant from the common product conception.

In theory field, the fragility of the concept led to the dissemination of several versions of the MVP as smoke MVP, Oz wizard MVP, concierge MVP and even prototype MVP (note: prototype minimum viable product). According to this, smoke MVP can be a landing page and MVP prototype can be a functional prototype.

In fact, the concepts viability and product become difficult to apply together in a startup reality. A smoke MVP can be a product, but is it a viable product? No. A viable prototype? Yes, but only if viability is associated with the ability to run the build-measure-learn cycle. These concepts caused misunderstandings and conflicts in st1 and st3 cases, as shown above.

On the one hand, "validity of the MVP concept becomes considerably important so that the entire Lean Startup theory remains viable [20, p. 178]", and on the other hand there are problems with the concept of MVP and its meaning.

So, this study proposes a solution building over classical GDP literature [48] of prototypes as analytical/real and focused/embracing. The MVP should be called Minimum Viable Prototype instead of Minimum Viable Product. The "viable" term in this sense will be associated with the minimal resources to run a build-measure-learn cycle. So, building over existing most famous MVP definition [15], MVP would now be the prototype version during development that allows for a

complete build-measure-learn cycle with least effort and development time.

As a result, the strength of the MVP term and the stability of the LS theory would be preserved without, however, preserving the term confusions associated.

2) Prototypes, interindustry range and fail fast

The software complexity of st1 were far bigger from st3. This fact made the use of Lean Startup slightly more difficult in st1 than in st3, due to prototype cost and speed needed to run B-M-L cycle. This issue raised some questions about prototypes and interindustry range of LS.

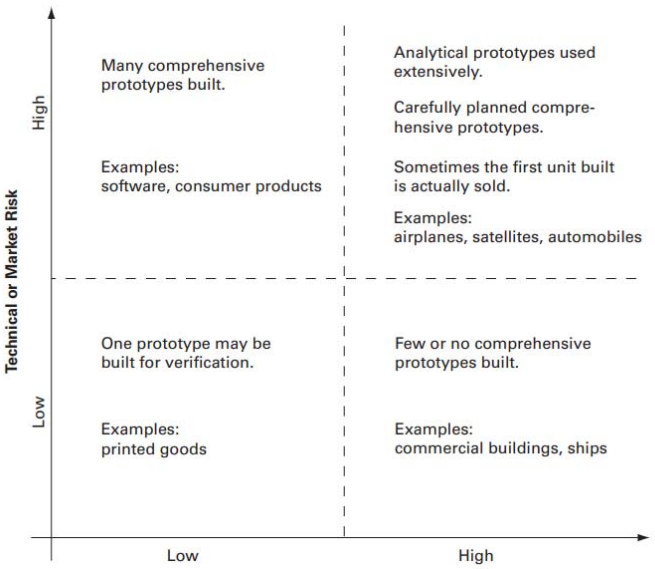

Fig. 13. Influence of risk factors and cost of construction on the number of prototypes in different industrial sectors. Source: [48]

As figure 13 shows, in software market the risks are high and prototype costs are low, enabling Lean Startup fast approach of fast running B-M-L cycles. But how to use LS approach in other sectors with higher prototype cost? Due to time and resources needed in these other industrial sectors, they seem to be more adherent to iterative new product development [49]. And more, taking apart the cost and time for prototyping, these approaches can become virtually the same. So, more attention to prototyping and design of experiments theory shall be given to enable LS use on multiple industrial contexts.

Another LS and Silicon Valley principle is the fail fast one. It is well-suited to realities in which the failure cost is low (e.g. software industry). But is the principle equally valid in situations where the cost of failure is higher?

Perhaps the fail fast principle is not useful when the prototypes cost is high. And even in software startups' environment it can have limitations. At the end of this research, st1 had more than 2 years of operations, and a huge amount of resources have been employed to build the startup. It was almost overcoming M2 milestone. The cost of failure in this scenario would be bigger than the failure cost in st3, that had less than a half development time. So, it is reasonable that st1 team would be more attentive to avoid radical failures than st3 team.

So, the affordable loss and acceptable risk principles [28] should be used instead of the fail fast one to make better decisions in entrepreneurial context. And prototype and failure costs should be always considered.

VI. Conclusions

The AR approach reached the goal of designing a process-based representation of TE associated with managerial methods and techniques. This result contributed by addressing the need for startups' teams of practical orientation in early and late life cycle stages, unlike approaches Lean Startup, focused only on the early stages of startups [30].

This work results were based on the balance between the perspective of excessive planning of traditional business schools [14] and the perspective of not carrying out any planning.

Aspects and implications of different methods usage in TE context were presented. For instance, considerations about some Lean Startup aspects that are not well addressed by theory has been made.

As recommendation for future research studies on Design of Experiments could help to understand how to use LS or LS-based approaches to foster innovation in non-software industries and even in software industry innovation when dealing with higher prototype and failure costs. Also, studies on mature startups, positioned in the transition stage [30], could help to understand their challenges and propose solutions, since LS does not serve well these "high maturity" startups. One limitation of this study was in this sense, since only one analyzed startup managed to reach the seventh P-Start stage.

Finally, studies with the objective of testing P-Start and its integrated tools in other environments, startups and accelerators are needed to strengthen them and ensure their usefulness and stability in a variety of contexts.

Acknowledgments

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