LUISS Guido Carli

LIBERA UNIVERSITÀ INTERNAZIONALE DEGLI STUDI SOCIALI

Department of Business and Management

Chair of Strategic Management of Innovation

New market creation for technological breakthroughs: commercial drones and the disruption of the Emergency market

SUPERVISOR
Prof. Andrea Prencipe

CANDIDATE
Maria Elena Manzotti
662901

CO-SUPERVISOR
Prof. Luca Giustiniano

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Abstract

Although the technological development entailed by Breakthrough Innovations is a truly challenging one, the creation of markets in which to successfully commercialize and employ them can be arduous as well, even more when dealing with contexts of uncertainty concerning future developments of the underlying technology. This dissertation takes into account Remotely Piloted Aircraft Systems (RPAS) as a major Technological Breakthrough. While their inception is rooted in military research, their development and the technological convergence have recently opened up the chance for commercial applications. It is argued that the emergence of commercial drones has the potential to disrupt several industries, among which the emergency market is taken into consideration. Being able to efficiently collect data and images while requiring no human operator on-board, C-RPAS are on the verge of reshaping the emergency industry. However, several challenges are connected to the creation of new markets for BIs that can slow down their adoption rate, if not preventing their adoption at all. The obstacles to overcome include regulatory issues and ethical discussions revolving around privacy and safety. Moreover, the technological development is still fast-paced and adds to the total uncertainty of future scenarios. These unique challenges are addressed through a multi case study research involving three NGOs active in the Mediterranean Sea to save the lives of refugees (i.e. Migrant Offshore Aid Station, Sea-Watch and SOS Méditerranée) and an experiment made by DJI to train European rescuers to pilot C-RPAS. It is argued that if regulations to foster their adoption will be provided, the deployment of drones in humanitarian missions could potentially disrupt the emergency industry, a market for which they were not originally meant. The cross-case analysis eventually presents a framework for the integration of drones into emergency services.

1. Introduction

Remotely Piloted Aircraft Systems (RPAS) include an aircraft and its associated elements that are operated with no pilot on board from a nearby station (ICAO, 2011). Albeit their inception is rooted into the military industry where drones have disrupted warfare, their fast-paced technological development has led to the creation of new commercial applications. This dissertation aims to explore RPAS' penetration of civilian markets and, more specifically, of the emergency response field in order to gather whether another disruption is about to happen.

The innovation-related literature body is broad and, since scholars do not agree on a unique definition, it is drawn from the works of Dosi (1982 and 1988), Foster (1986) and Bower and Christensen (1995 and 2006) that are somehow connected and consistent between each other. The technological paradigm, S curves and performance trajectory theories are explored, providing that RPAS represent a major technological breakthrough from manned to unmanned aircrafts and from land to flying robots in military. Furthermore, the inception of commercial drones has brung along another breakthrough innovation by shifting the improvement trajectory from military to civilian. C-RPAS are smaller and cheaper, so they present new directions of technical change (Clarke, 2014). While the new product development process of technological breakthroughs is challenging, even more so is to create a market in which to commercialize them because of the uncertainty affecting both the underlying technology and the end market (Deszca et al., 1999). As argued by Zahra (2008), new market creation for breakthroughs is the result of a combination of experimentation and effectuation. Experimenting means to undertake a trial and error process (Lyinn et al., 1996), also drawing knowledge from the market through new market research techniques such as lead users analysis and empathic design (Leonard-Burton, 1998). Effectuation, instead, is the proactive interaction of stakeholders that ultimately shape the new product's features as well as the new market (Sarasvathy and Dew, 2005). Also thanks to their open source development, several commercial applications are now available for RPAS, including agriculture, delivery, hobby, photography, journalism, law enforcement and emergency services (Clarke, 2014 and Rao et al., 2016). The civilian market is broader than the military one, therefore it holds a huge and quite untapped potential (Antebi, 2014). Evidence of the latter fact is the global expenditure on commercial drones, which in 2014 amounted to $700 million and is expected to grow (Rao et al., 2016). While the emergency market seems to be the most distant one from military where drones were incepted, the valuable attributes of technology are actually the same across these two fields. According to Sandvik and Lohne (2014), in fact, C-RPAS' data provision and precision in targeting provide a great potential for humanitarian operations. However, the issue of drones' penetration of civilian markets is a controversial one due to discussions concerning the lack of a dedicated regulatory body and concerns about privacy, ethic and safety (Rao et al., 2016). Moreover, the peculiar nature of not for profit organizations adds to the uncertainty concerning the integration of commercial drones into emergency response.

The objective of this dissertation is to investigate the advantages and setbacks of C-RPAS' technology in order to gather if a disruption is likely to happen within the emergency market or not and how. More specifically, the first aim is to provide an in-depth picture of the way humanitarian operations are currently carried out by NGOs to understand their main needs. Subsequently, the potential profitability of emergency response as a market for drones is assessed in terms of their most beneficial deployment. Answers to the latter questions contribute in demonstrating that commercial drones will indeed spread into the emergency market through experimentations and effectuation.

This dissertation is basically divided into three main sections. The literature review commences by reviewing the critical contributions of scholars on breakthrough innovations and the relating new market creation techniques. More specifically, the second chapter presents an overview of technological paradigm, S curves and performance trajectory theories as well as the critical issues in the development process of radical innovations. Uncertainty connected to technology development and new market creation techniques is canvassed and analysed. The third chapter presents an in depth overview of RPAS' theory. Theoretical contributions are actually quite limited because of the novelty of the concerned topic. A background is firstly provided for the inception of M-RPAS and C-RPAS, then their technology and development process are described underlying challenges and development trends. An entire paragraph is dedicated to the reconciliation of breakthrough theory with drones' technology, explaining why drones are indeed a major technological breakthrough. The critical literature review ends with the presentation of new commercial application and the emergency market, defining the research objective and problem. The second section of this dissertation is the one dealing with the case study. Chapter four presents the methodology and the multi case research strategy that has been chosen to the latter extent as the best research strategy when collecting mostly qualitative data and no control is exercised on the involved actors. Chapter five illustrates four single case studies dealing with the selected three NGOs and one experiment. The three NGOs are all operating to save the lives of refugees within the Central Mediterranean Sea by deploying different technologies: Migrants Offshore Aid Station leases two camcopters, Sea-Watch is launching its aerial reconnaissance through the use of a microlight airplane and SOS Méditerranée relies on binoculars and human sight. The issue of migrants from Libya dying at sea represents a hot topic from a humanitarian and political point of view. Additionally, rescuers are end customers for drones offering as they could benefit a lot from their adoption. The experiment has been made to teach rescuers how to pilot C-RPAS for humanitarian operations by DJI, which is one of the leading drones' manufacturing companies. All cases are considered as single entities at first instance, notwithstanding the differences and similarities between them. The last section of the dissertation is the cross-case analysis. At this stage the case studies are compared and the first hypotheses are shaped. Afterword, they are related with similar and contrasting theory. Closure is eventually reached and conclusions are drawn through induction from the empirical evidences.

2. The challenge of creating new markets for Technological Breakthroughs: theoretical foundations

2.1. What is a Technological Breakthrough?

The first aim of this chapter is to define Breakthrough Innovations without giving any new contribution to that regard. For this reason and since the nature of the innovation-related literature body is varied and does not agree on a unique definition, the discussion is limited to three main theoretical concepts that are somehow related and consistent between each other: Technological Paradigms, Technology S curves and Performance Trajectories. The definition of Breakthrough Innovations is drawn from a macro perspective rather than from a firm specific one.

2.1.1. Technological Paradigms

According to Dosi (1988), an innovation is the solution to a problem that simultaneously satisfies a marketing test. Technological innovations come from the industrial arts, applied and pure science, and engineering (Garcia and Calantone, 2002). Each problem-solving activity takes place within a technological paradigm, which is *"a pattern of solution of selected techno economic problems based on highly selected principles derived from the natural science, jointly with specific rules aimed to acquire new knowledge and safeguard it, whenever possible, against rapid diffusion to the competitors"* (Dosi 1988, p. 1127). As Kuhn (1962) claims, a paradigm describes the questions that must be answered facing a determined subject matter, the structure of those inquiries and the framework used to interpret their results. Therefore, it essentially is a tool providing the boundaries and directions for technical change, within which innovations are incepted. Besides economic, institutional and social factors performing as an ex ante mechanism of selection (Dosi, 1982), the emergence of a paradigm is the result of its being more successful compared to other ones in solving a problem that the scientific community perceives as critical (Kuhn, 1962). The main characteristics of a paradigm are the specific product that has to be developed and the series of technological trajectories along which this development occurs (Dosi, 1988). A technological trajectory can be defined as *"a cluster of possible technological directions whose outer boundaries are defined by the nature of the paradigm itself"* (Dosi 1982, p. 154). Once a determined technological trajectory reaches its highest level within the relevant technological paradigm, this "ceiling" is called technological frontier (Dosi, 1982) (Figure 2.1.).

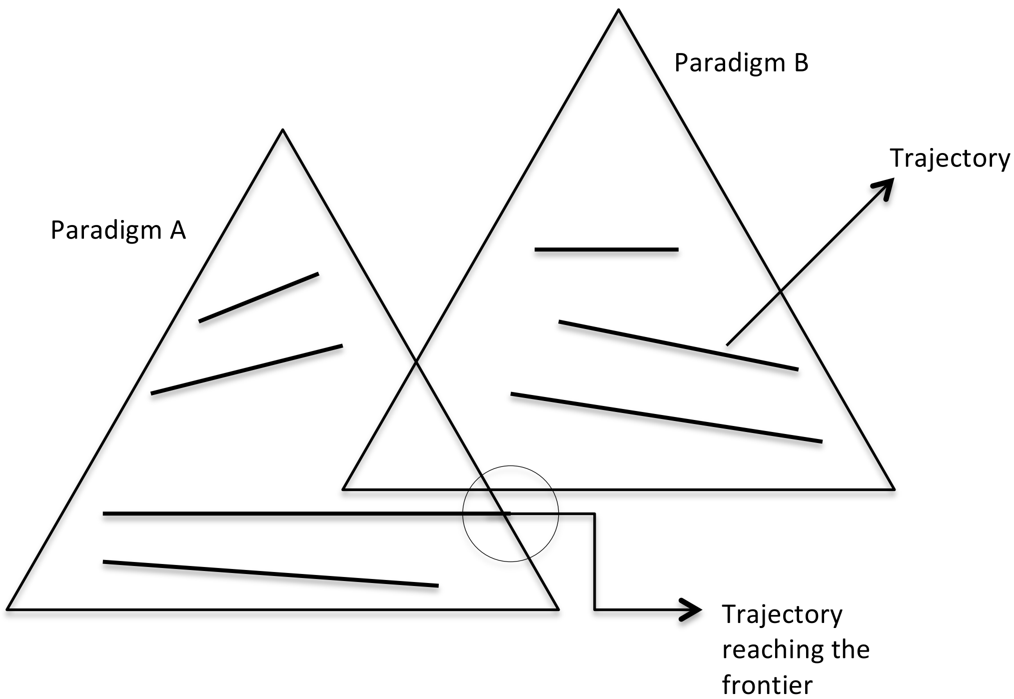

Figure 2.1.: Exemplification of the Technological Paradigm theory. Source: personal elaboration.

Dosi (1982) distinguishes between Incremental and Breakthrough innovations in terms of technical progress along one trajectory as opposed to the emergence of new technological paradigms.

The development of a product within a given technological paradigm evolves along a specific trajectory of improvement, typically building upon prior innovations (Christensen and Rosenbloom, 1995). Additionally, it is cumulative: the probabilities of further progressing along a trajectory are affected by the position one occupies facing the frontier (Dosi, 1982) since it is not possible to go beyond the boundaries set by a paradigm. Consequently, progress happening along each trajectory within one paradigm is said to be incremental, as it is the result of the inventor's knowledge - both scientific and technological - combined with the physical constraints of the underlying technology. When the paradigm's ceiling is reached and if the problem is still not solved, it is possible to either change trajectory or to shift to a new paradigm. Both are defined as technological breakthroughs. As proposed by Christensen and Rosenbloom (1995), new paradigms are discontinuities in trajectories pertaining to previous paradigms that entail a different set of problems. It is difficult to change trajectory, especially if the current one is powerful and since the new frontier might be far and thus leading to start anew with the research process (Dosi, 1982). Therefore, a paradigm shift coincides with the setting of new rules and boundaries because it derives from a new body of technological knowledge. Hence, it implies a new perspective on the problem and brings along a whole new set of questions.

2.1.2. Technology S curves

Foster (1986) claims that the performance of technologies follows an S-shaped path when plotted against the cumulative engineering effort involved in its development (Figure 2.2.).

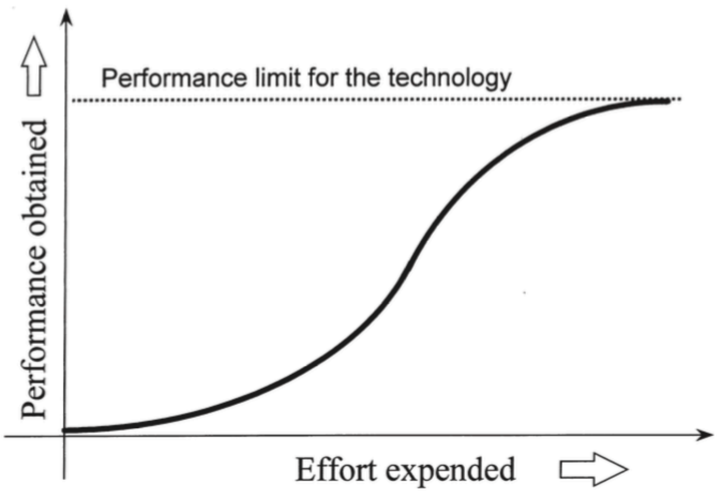

Figure 2.2.: the Technology S curve model. Source: Nieto et al., 1998.

Since the data concerning the investments made by different companies in terms of money, R&D hours, number of researcher etc. are difficult to find, it is customary to plot performance against time. Abernathy and Utterback (1978) have pinpointed the main stages of Foster's S curve, drawing the technology life cycle (Figure 2.3.).

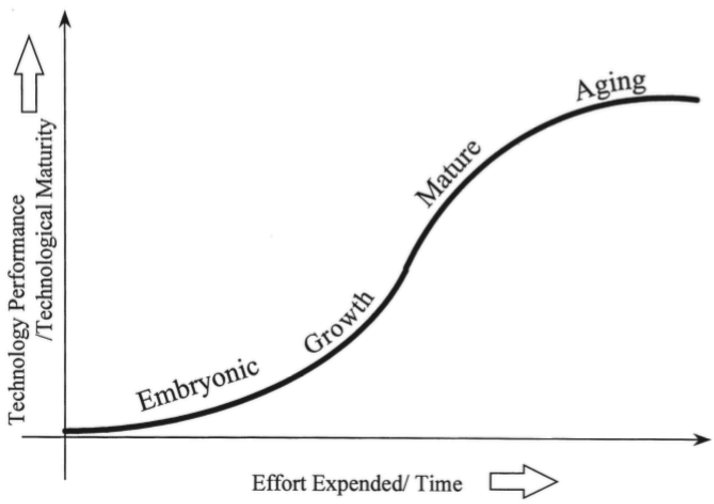

Figure 2.3.: the Technology S curve model and maturity. Source: Nieto et al., 1998.

The main stages are:

1. Introduction: a new technology is introduced and its performance increases slowly. This is due to its newness attracting few researchers and bringing along uncertainty about outcomes (Abernathy and Utterback, 1978).
2. Growth: incremental innovations increase the technology's performance rate in a short period of time. A dominant standard regarding product characteristics is affirmed and attracts more researchers (Utterback, 1974).
3. Maturity: progress slows down since the technology begins to be constrained by its limits, reaching its maximum when half of its technical potential has been realized (Foster, 1986).

From maturity onwards, the productivity of the engineering effort is decreasing and the performance rate is stabilized: after the point of inflection and into the aging phase, the returns from the technological investment will only increase by abandoning the current technology and adopting a new one (Nieto et al., 1998). When it comes to technological innovations and the ceiling is reached, a shift to another paradigm occurs, that is to say a new S curve is introduced. This shift from one curve to the other is not smooth, so that it is called discontinuity (van Wyk, 1987) (Figure 2.4.).

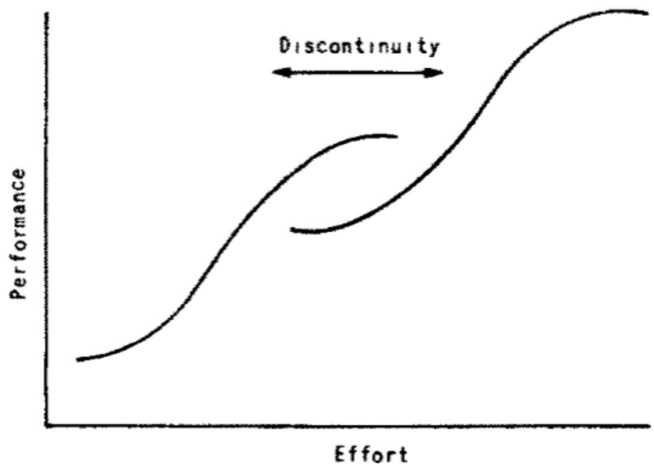

Figure 2.4.: successive S curves and discontinuity. Source: van Wyk, 1987.

At first, the performance of a technological breakthrough is inferior compared to the one of an already growing and stable technology (Foster, 1986). While the progress of the new technology is initially slower, it starts to improve rapidly afterwards and a time might come when it outpaces the older technology, crossing its performance and signalling the end of its efficient development (Figure 2.5.) (Sood and Tellis, 2005). If the new S curve crosses the old, the new paradigm will be superior (Adner and Kapoor, 2016).

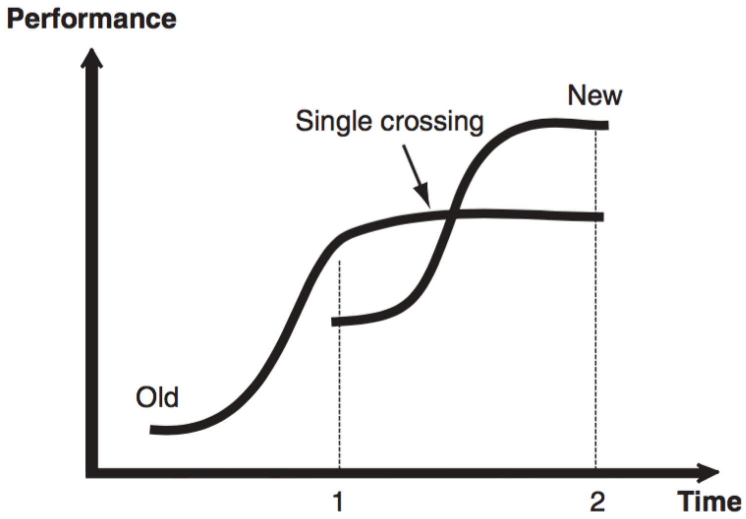

Figure 2.5.: Multiple S curves. Source: Sood and Tellis, 2005.

Hence, technological breakthroughs can be identified *"by the initiation of a new technology and new marketing S curve"* (Garcia and Calantone 2002, p. 122). In other words, technology disruption happens when a breakthrough overlaps with the performance of the older technology.

2.1.3. Performance Trajectory

In order to explain the different outcomes of different kinds of technological innovations, Bower and Christensen (1995) have developed the concept of performance trajectories as *"the rate at which the performance of a product has improved, and is expected to improve, over time"* (Bower and Christensen 1995, p. 45). Even though every industry has a critical performance trajectory on which to direct its investment efforts, they focused on the hard-disk-drive one. Since it has experienced major technological breakthroughs in cost and size of systems between 1976 and 1992, it is instrumental to demonstrate the performance trajectory theory concerning innovations (Figure 2.6.).

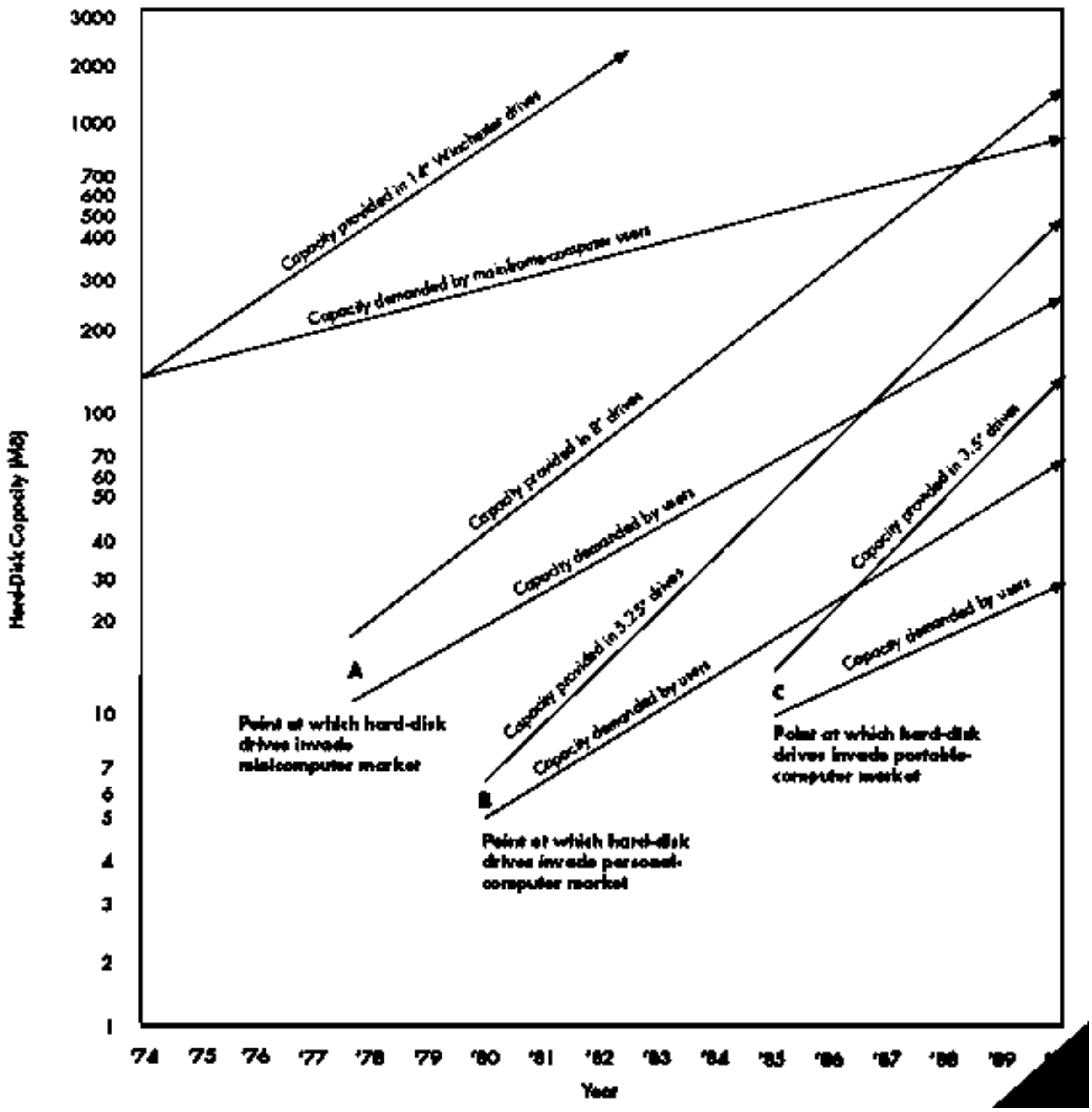

Figure 2.6.: How disk-drive performance met market needs. Source: Bower and Christensen, 1995.

The critical performance trajectory, that is to say the attribute that was valued the most by customers, was storage capacity. Subsequently, companies tried to innovate along this trajectory by compressing storage capacity. However, the gap between market demand and the performance trajectory increased over time as the industry was getting more than capable in satisfying this need (Bower and Christensen, 1995 and Christensen, 2006). The frontier has been reached so rapidly that the performance trajectories were steep (Bower and Christensen, 1995). Each time a disruption happened (i.e. smaller drives), each new architecture offered less storage capacity while creating other important attributes (i.e. smaller size and lower costs) and developing new markets (i.e. minicomputers, desktop PCs and portable computers) at the same time (Bower and Christensen, 1995). According to Bower and Christensen (1996), technological changes that have a sustaining impact on the development along performance trajectories are incremental innovations. They define technological breakthroughs as *"technologies that disrupt an established trajectory of performance improvement or redefine what performance means"* (Bower and Christensen 1996, p. 202) (Figure 2.7.).

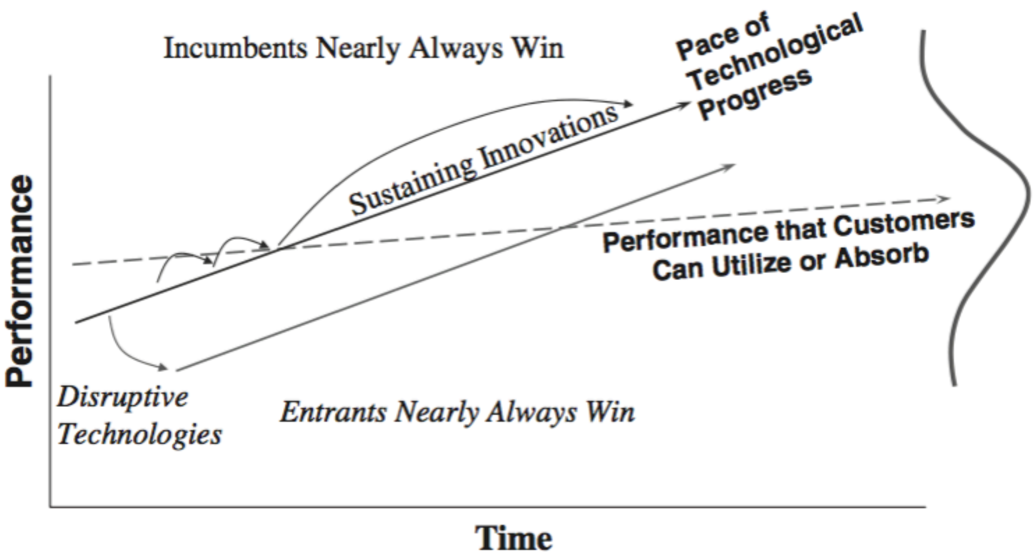

Figure 2.7.: The constructs of performance trajectories and the classification of incremental and disruptive innovations. Source: Christensen, 2006.

Drawing from the main theoretical contributions of Dosi (1982 and 1988), Foster (1986) and Bower and Christensen (1995 and 1996), it can be concluded that breakthrough innovations are:

- Paradigm (or trajectory) shifts entailing new perspectives on technological problems;
- Discontinuities when a new S curve crosses the older one's performance and outpaces its progress;
- Inventions that disrupt a performance trajectory and changes the valuable package of performance attributes.

2.2. New Product Development process for Breakthrough

Deszca et al. (1999) argue that the main reason for companies to struggle in bringing technological breakthroughs to market are the challenges connected to their development process (Figure 2.8.).

According to Leonard-Burton (1998), 63% of NPD projects are cancelled, 25% are commercial successes and 12% are commercial failures. Furthermore, the development process of breakthroughs is associated with greater risk compared to the one of less innovative products because of the uncertainty dealing with its underlying technology and end market (Dezsca et al., 1999, Leonard-Burton, 1998, McDermott, 1999) (Figure 2.9.). As a consequence, it is longer (5 to 10 + years) and expensive, providing few incentives for company to engage in it and leading them to focus their research efforts on more incremental technologies instead (Deszca et al., 1999).

At first instance, the uncertainty coming from the underlying technology and end market of breakthroughs are considered separately. According to the different stages of the NPD process, in fact, the unknowns on which to base further development vary.

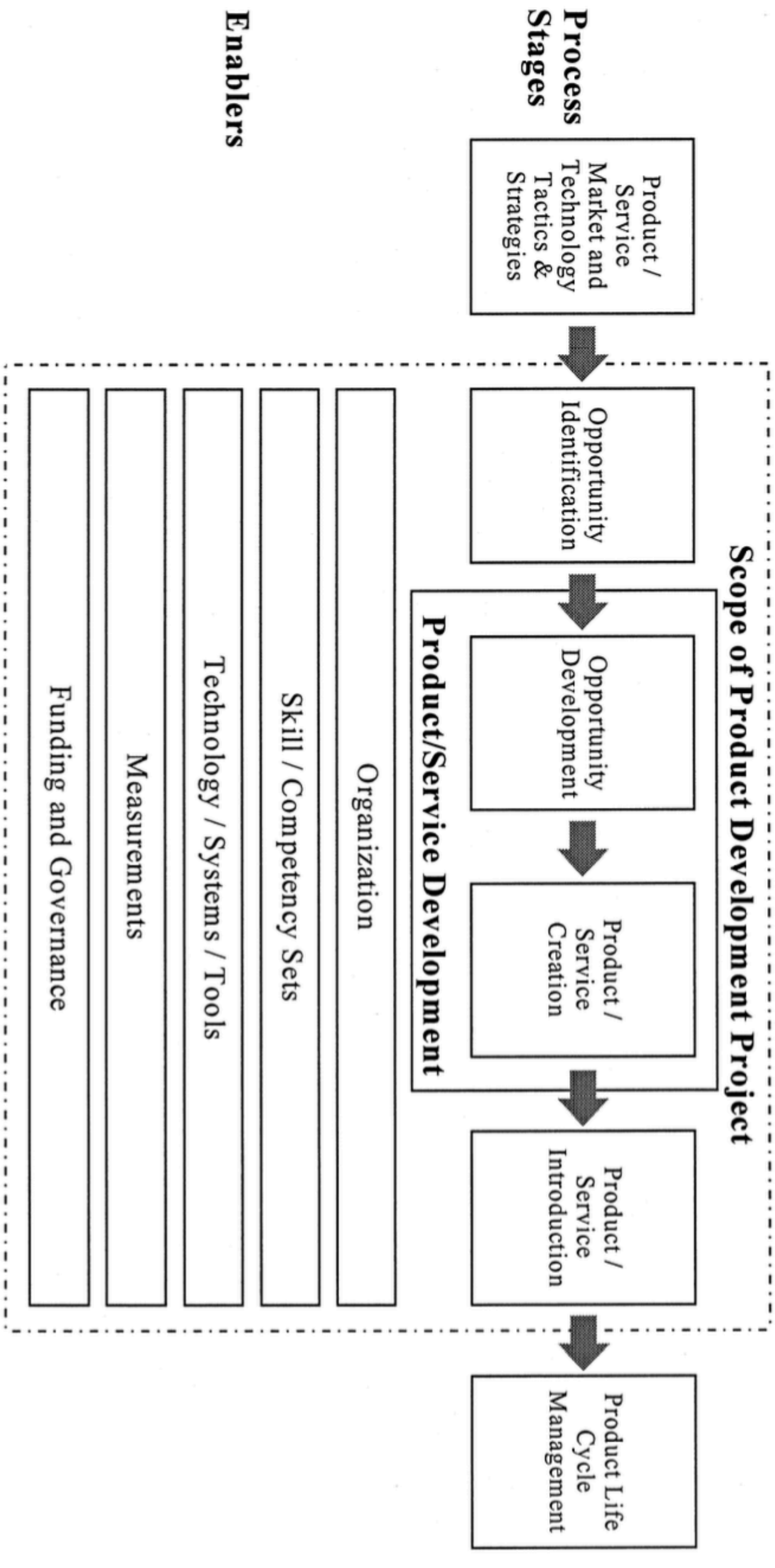

Figure 2.8.: Deterministic stage model of breakthroughs NPD. Source: Deszca et al., 1999.

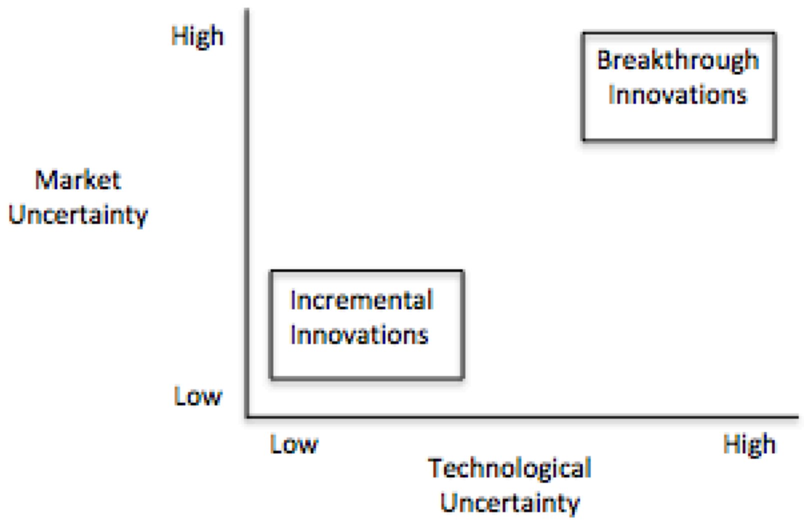

Figure 2.9.: Different levels of uncertainty in incremental and breakthrough innovation.

Source: personal elaboration.

2.2.1. Technology and Uncertainty

The challenges connected to the underlying technology's uncertainty of a breakthrough are at first faced at its embryonic stage (Deszca et al., 1999). It is difficult, indeed, to determine its market potential, that is to say whether it is an actual breakthrough, and which pattern to follow throughout its development. Because of the absence of a dominant design and the established attributes relating to it, to create a product and develop the opportunity is a major challenge as well, and an expensive one at that (Deszca et al., 1999). Moreover, as of today companies try to reduce the development cycle of breakthroughs as much as they can. This comes from the fear of the emergence of a new technology able to make the one under development obsolete. As a consequence, the trade-off between rushing the process, risking this way to fail in commercializing it, and slowing it down, risking this way to become a late mover and lose profit margins, is extremely acute.

Much attention has been put on NPD approaches such as Current Engineering, Quality Function Development, Design for Manufacturing and Stage Gate Model to avoid failures (Deszca et al. 1999), but they all implicitly deal with the development of incremental innovations (McDermott, 1999). As for what concerns breakthroughs, useful insights regarding NPD's best practices comes from a study by McDermott (1999) and include: using existing competencies to develop breakthroughs and reduce the entailed risk at the first stages, building alliances to diversify the risk and fill the gap in competencies without incurring in other costs, gaining deeper understanding of the market and the technology through informal networks and looking for the best fitting division within the company in which to develop the technological breakthrough. This should also reduce the time to market while reducing uncertainty and, ultimately, risk.

2.2.2. Market and Uncertainty

The challenges connected to the end market's uncertainty of a breakthrough mainly deal with the opportunity identification and the product creation and introduction stages (Deszca et al., 1999). This is due to the fact that they all entail drawing knowledge from the end customers regarding preferred attributes, distribution channels, pricing etc., narrowing down the different questions alongside the progress in the technology's development path. When it comes to breakthroughs, though, customers have no experience of the product. Throughout the whole development process, traditional marketing tools are indeed of poor use because the findings would be inaccurate and unreliable (Deszca et al., 1999). Moreover, the empirical study carried out by Bower and Christensen (1996) shows that the commercialization issue is clear: existing customers reject the technological breakthrough because of lack of interest in it. However, scholars have been providing alternative emerging methodologies of market research, among which are to be found:

- <u>Lead Users Analysis</u>. Lead Users are those who *"face needs that will be general in a marketplace, but they face them months or years before the bulk of that marketplace encounters them"* (Von Hippel 1989, p. 24). While drawing knowledge from them may miss some opportunities, it certainly helps in identifying earlier potential failures in the technology, anticipating market needs and making customers interact with the product (Deszca et al., 1999).

- Empathic Design. Empathic Design is *"the creation of product concepts based on a deep understanding of unarticulated user needs"* (Leonard-Burton 1998, p.194). It basically is a market research which differs from the others because of three unique attributes: actual observation of customer behaviour in situ, direct interactions between developers and potential users and exploitation of the developers' existing technological capabilities (Deszca et al., 1999).
- Visioning techniques. This method can be approached through Delphi techniques and going backwards in order to define future scenarios and anticipate trends (Deszca et al., 1999). The aim here is to think outside the box and picture nonobvious futures (Leonard-Burton, 1998).
- Market experimentation through prototypes. As models of the final product, prototypes are able to get users to familiarize with and understand it while stimulating the market demand at the same time (Leonard-Burton, 1998).

The development process of a breakthrough can be defined as *"successive approximation, probing and learning again and again, each time striving to take a step closer to a winning combination of product and market"* (Lynn et al. 1996, p. 19).

Leonard-Burton (1998) suggests that different NPD processes leading to new product definition situations result from combining uncertainty along the maturity of technological design and uncertainty along the degree of alignment of the technology with the current customer base (Figure 2.10. and 2.11.).

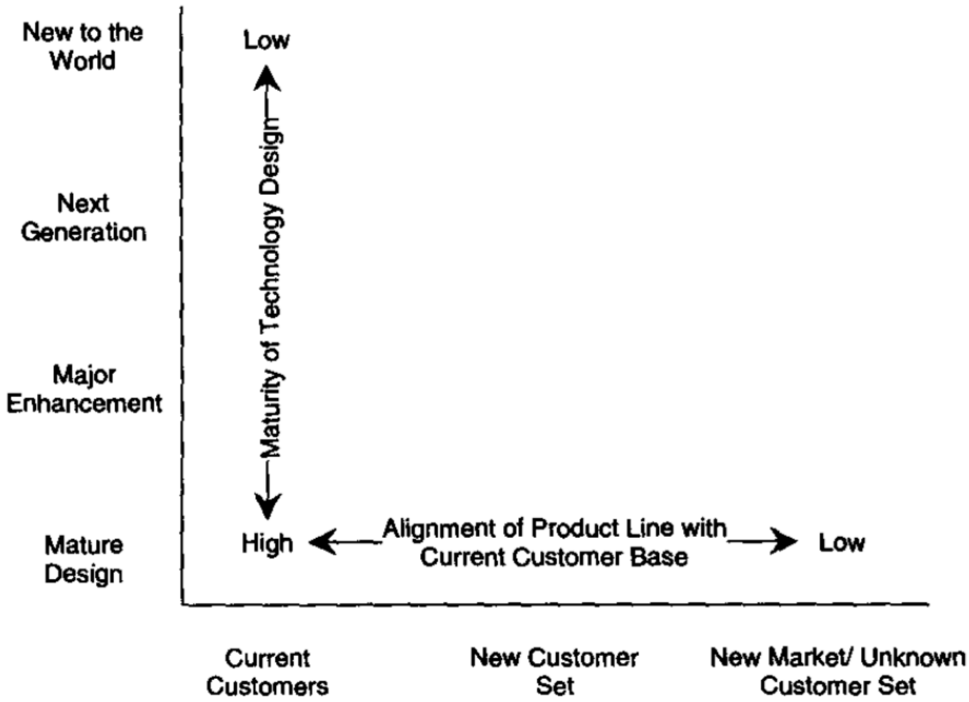

Figure 2.10.: Technology and market factors shaping the new-product definition situation. Source: Leonard-Burton, 1998.

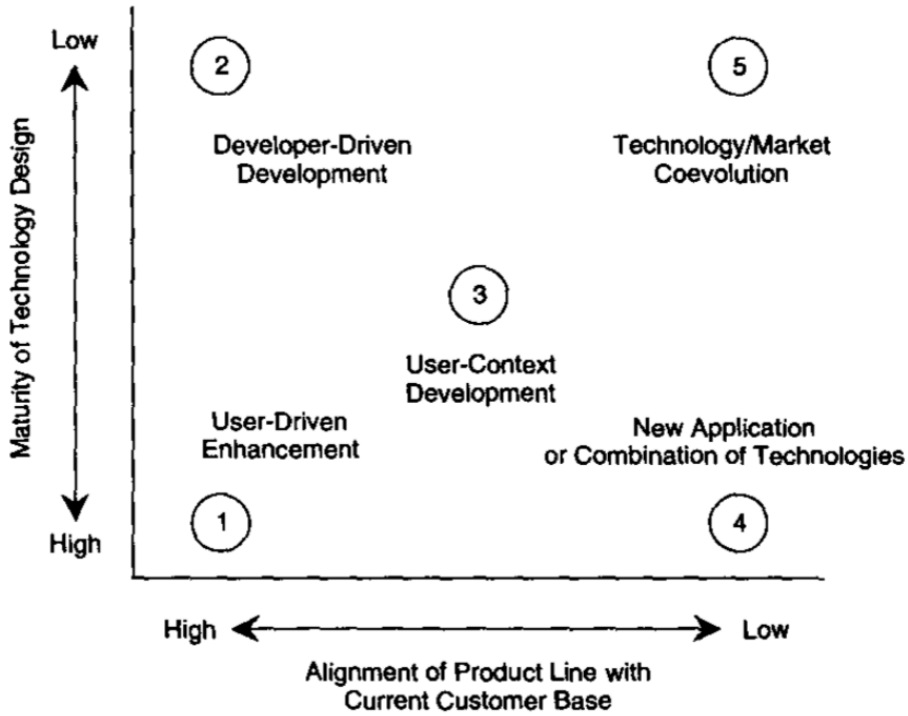

Figure 2.11.: New-product development processes at the extremes. Source: Leonard-Burton, 1998.

The second aim of this chapter is to explore new market creation techniques for technological breakthroughs. The new market creation frontier is where developers cannot be certain whether they have identified the right market and ask themselves who actually the customer is (Leonard-Burton, 1998). As a consequence, the discussion concerns a low degree of alignment with the current customer base. Thus, only new application or combination of technologies and technology/market coevolution situations are taken into account. While the former provide a novel solution to a new set of customers, the latter entails serendipity in creating a new market for an entirely new product (Leonard-Burton, 1998). It can be said that both solutions are technology-push rather than market-pull because it is the technology potential and not the customers' demand driving the NPD process (Leonard-Burton, 1998).

2.3. Technological Breakthroughs and New Market Creation

Dew et al. (2008) assert that to commercialize a technological breakthrough means to create a new market that will destroy the existing one: it is not a matter of just predicting the progress of technological trajectories in view of substituting technologies into an existing market. "Market" is defined as the coming together and contingent interaction of demand, supply and institutions (Sarasvathy and Dew, 2005). Even though new markets and new technologies tend to develop simultaneously (Deszca, Munro and Noori, 1999), new market creation entails the creation of new customers, that is to say the breakthrough development will not lead to a new market automatically (Dew et al., 2008). Subsequently, to create a new market for technological breakthroughs *"may require as much time and investment as their technical development"* (O'Connor and Price 2013, p. 225).

A major insight dealing with the attempt at creating opportunities for technological breakthroughs comes from Lynn et al. (1996) and their "probe and learn" method, which brings along the introduction of an early version of the product into an initial market. Through subsequent modification affecting both the prototype and the initial market and basing on previous learning in a reiterative process, uncertainty is reduced by a good measure (Lynn et al., 1996). Being an expensive and resource-consuming method, though, experimentation must take place within opportunities that are worth probing (Lynn et al., 1996). Since the probe and learn method entails *"things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery and innovation"* (March 1991, p. 71), it can be included in the exploration category. But exploration's returns are uncertain and often negative (March, 1991).

Alternatively to market exploration, Sarasvathy and Dew (2005) developed the effectuation theory drawing from empirical studies on entrepreneurship: it is *"who comes on board to determine what the new market will look like, rather than let predicted visions of the new market drive the search for and selection of new members"* (Sarasvathy and Dew 2005, p. 558). Reversing the logic, the starting point here is the creation of a network of stakeholders that increase resources while adding constraints to future goals, this way shaping the product's features and, eventually, the new market (Sarasvathy and Dew, 2005) (Figure 2.12.). While developers look for an already existing "right" market through exploration, through effectuation they create the new market from scratch by interacting with other players. The rational behind effectuation is to shift the breakthrough commercialization problem from pre-existing market exploration to new market building, from probation to creation, as entrepreneurs do (Dew et al., 2008).

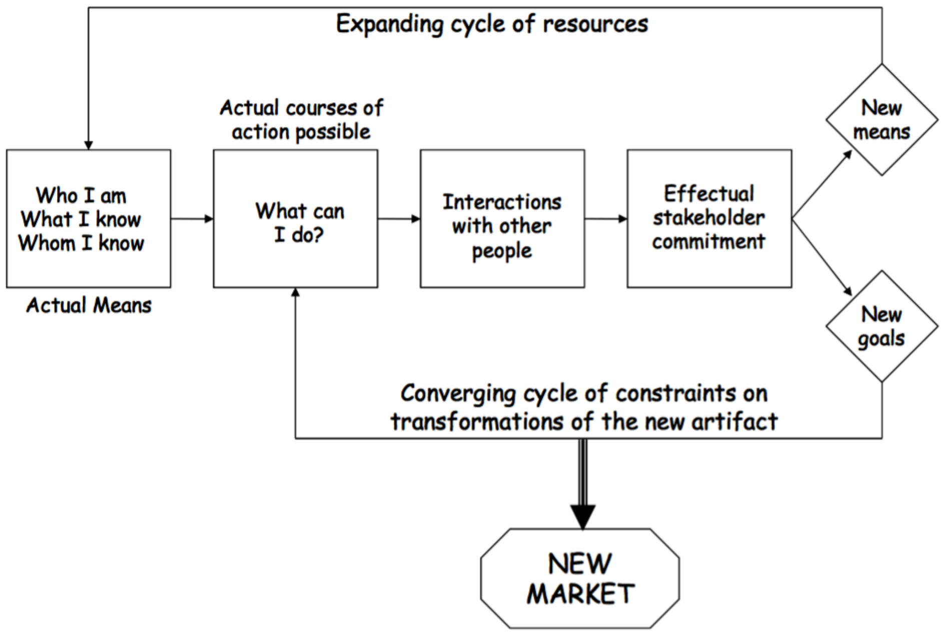

Figure 2.12.: New market resulting from the effectual network. Source: Sarasvathy and Dew, 2005.

Zahra (2008) reconciles exploration and effectuation into a virtuous cycle (Figure 2.13.). As to create an opportunity it is necessary to experiment about technological trajectories and the way their disruption might affect the industry, in fact, effectuation substantially involves exploration (Zahra, 2008). In turn, exploration could lead to creation of new opportunities (Zahra, 2008).

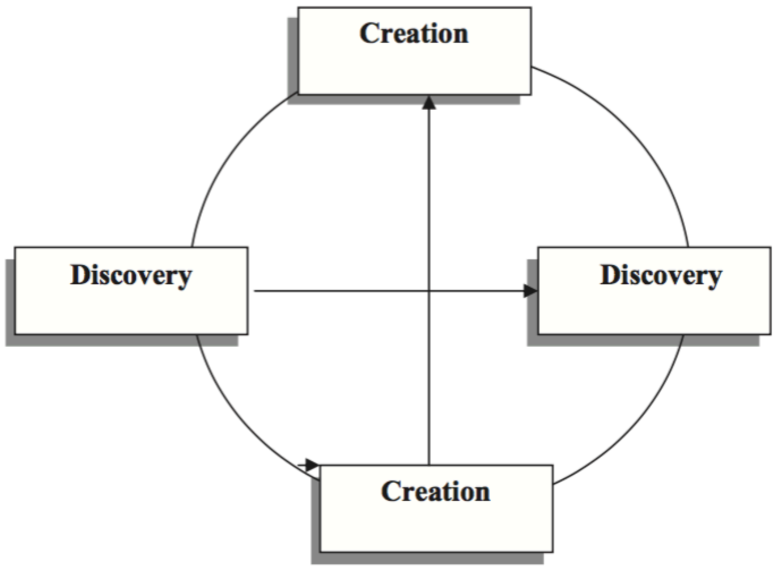

Figure 2.13.: the discovery-creation virtuous cycle of opportunity recognition. Source: Zahra, 2008.

According to Adner (2002), customer needs influence the breakthrough development in that they adopt a new technology when their current needs are satisfied because they start to value other attributes that were not a priority before (Adner, 2002 and Bower and Christensen, 2005). Thus, as the technology develop and becomes able to satisfy its market demand, its attributes may become relevant to other markets (Adner, 2002). But why should users suddenly start to value new attributes and give up the current preferred ones for them? Adner (2002) argues that the reason behind the substitution and consequent disruption is that customers do not actually care about the new attributes, but rather about their absolute price. When current needs are satisfied, in fact, the marginal utility from performance improvements is decreasing, which in turn makes the willingness to pay for incremental innovation decreasing as well (Adner, 2002). As claimed by Deszca et al. (1999), the main problems faced in selecting a market for technological breakthroughs relate to which stage of their development process they are to be found in. This is also Adner's point (2002), who suggest that price is irrelevant at the embryonic phase of the breakthrough NPD because the performance is not yet able to fully satisfy users. Hence, disruptions are more likely to happen during the later stages of the development, when customers care about lower absolute prices more than about a worse price/performance offering (Adner, 2002). *"While disruption is enabled by sufficient performance, it is enacted by price."* (Adner 2002, p. 686).

The work of O'Connor and Price (2013) serves as an ultimate complement to the new market creation theory for technological breakthroughs. They observed twelve projects and extrapolated six activities that must be undertaken in order to create a new market and fully leverage the breakthrough at the same time (Figure 2.14):

1. Generation of application ideas to pursue early in the technology development;
2. Choice of the new market basing on which might benefit the most from the breakthrough, even if it is an unfamiliar one;
3. Choice of the business model through exploration as it might evolve alongside the technology;
4. Stimulate the value chain, as it might evolve alongside the market;
5. Pre-education of the market through attendance at professional conferences, advertising in technical journals, use of prototypes and niches penetration as market tests;
6. Appropriate market entry strategy according to the development stage (niche market and low price) and internal expectations (market-based rather than performance-based KPIs).

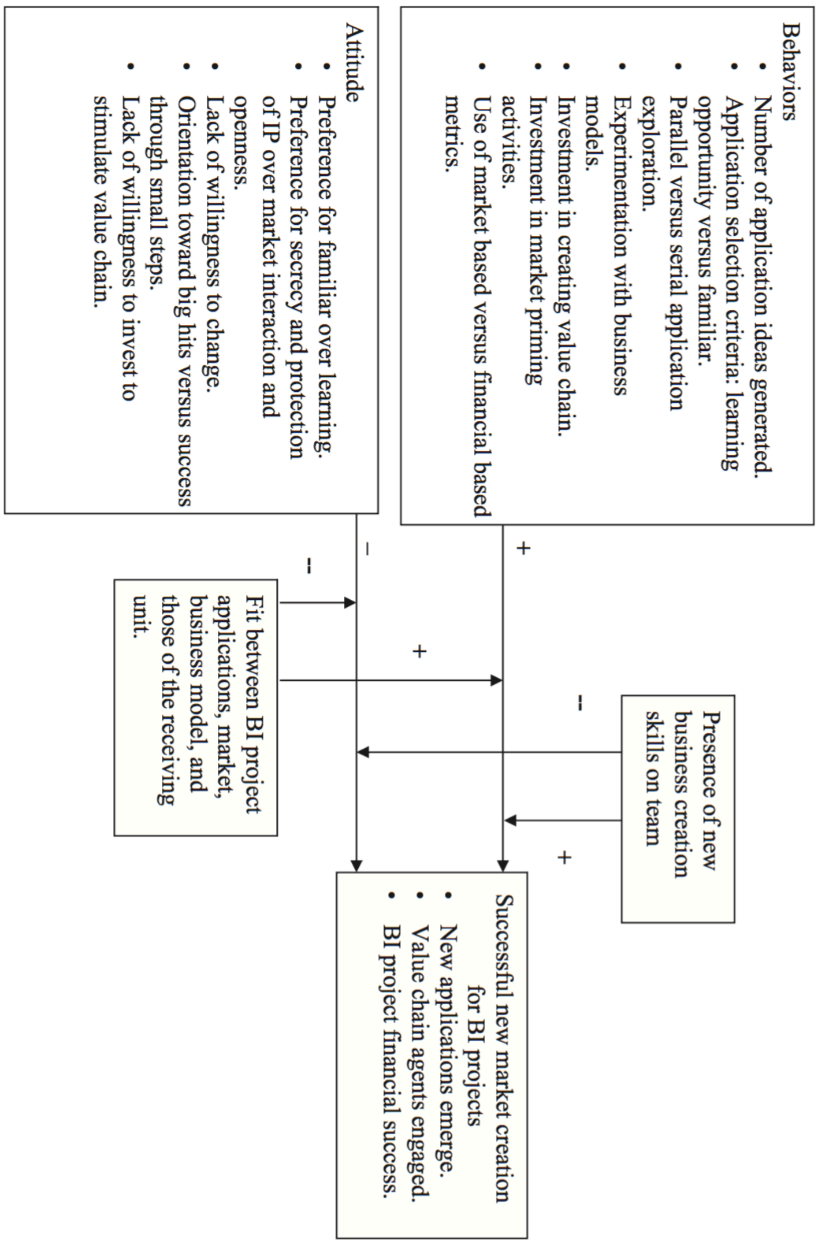

Figure 2. 14: Model of enablers and constraints associated with new market creation for breakthroughs. Source: O'Connor and Price, 2013.

3. Remotely Piloted Aircraft Systems (RPAS) and the Emergency Market

3.1. Drones

According to the International Civil Aviation Organization (Cir. 328, 2011):

An Unmanned Aerial Vehicle (UAV) is *"a pilotless aircraft, which is flown without a pilot-in-command on-board and is either remotely and fully controlled from another place (ground, another aircraft, space) or programmed and fully autonomous"* (ICAO 2011, p. 3).

Unmanned Aircraft System (UAS) refers to *"an aircraft and its associated elements which are operated with no pilot on board"* (ICAO 2011, p. (x)).

A Remotely-Piloted Aircraft (RPA) is *"an aircraft piloted by a licensed remote pilot situated at a remote pilot station who monitors the aircraft at all times. RPA is a subset of Unmanned Aircraft"* (ICAO 2011, p. 7).

The Remotely-Piloted Aircraft System (RPAS) *"comprises a set of configurable elements including an RPA, its associated remote pilot station(s), the required C2 links and any other system elements as may be required, at any point during flight operation"* (ICAO 2011, p. 8).

Hence, the term UAS includes both autonomous and remotely controlled UAVs (or UAs) while RPAS, on which the dissertation is focused, refer to remotely controlled UAVs only, that is to say RPAs.

UAVs are also called Quadcopters, which more specifically are *"multirotor helicopters that are lifted and propelled by four rotors"* (Parihar et al. 2016, p. 2128).

The term "drone", which stands for Dynamic Remotely Operated Navigation Equipment (Parihar et al., 2016) and is commonly used to broadly address RPAS, will be used as well throughout the discussion.

3.1.1. Background

The inception of drones is rooted into the military industry since R&D activities started during World Wars Ⅰ and Ⅱ. Larynx and Ram, two major UK drone programs developed for air war in response to German radio-controlled bombing, allowed longer-range attacks and flying at night and in poor weather conditions while reducing the costs connected to manned aircraft (Farquharson, 2006). Due to major technical and funding problems (i.e. low reliability and inability to actually reduce the costs), though, they never reached mass production (Farquharson, 2006). In the US, during the Cold War, drone NPD was restored for intelligence, surveillance and reconnaissance activities since it allowed larger geographical range and better technological performances (Kindervater, 2016). However, the development was halted again because the low public visibility of drones caused for them to be overshadowed by the satellite technology, on which funding efforts were actually allocated at the time (Kindervater, 2016). It was during the Kosovo War that the deployment of UAVs really took off through the development of Predator and Global Hawk drone programs (Kindervater, 2016). Although NATO's use of drones reduced both costs and the risk for human lives, further improvement were needed in the geographic data provided by drones and their interoperability between systems (Kindervater, 2016). Afterwards, UAVs were used in the Afghanistan, Iraq and Yemen's strikes, at which point surveillance and targeting activities started to converge with a strive for making drones more automated (i.e. "lethal surveillance") (Kindervater, 2016). While UAVs have been used in Japan for agriculture since 1990s (Marketline, 2014), the true shift to civilian applications actually occurred in 2005, when the rescue effort following Hurricane Katrina saw the deployment of military drones in the US to look for survivors (Rao et al, 2016). A year later, the Federal Aviation Administration (FAA) authorized Predators military drones to fly over civilian skies and, from then on, commercial drones have started emerging worldwide (Rao et al, 2016) (Figure 3.1.). Although military applications for drones (M-RPAS) are perhaps still more visible, many others have been identified for civilian use (C-RPAS) and they are expected to foster innovation in military as well (Boucher, 2014). C-RPAS are the subject matter of this discussion.

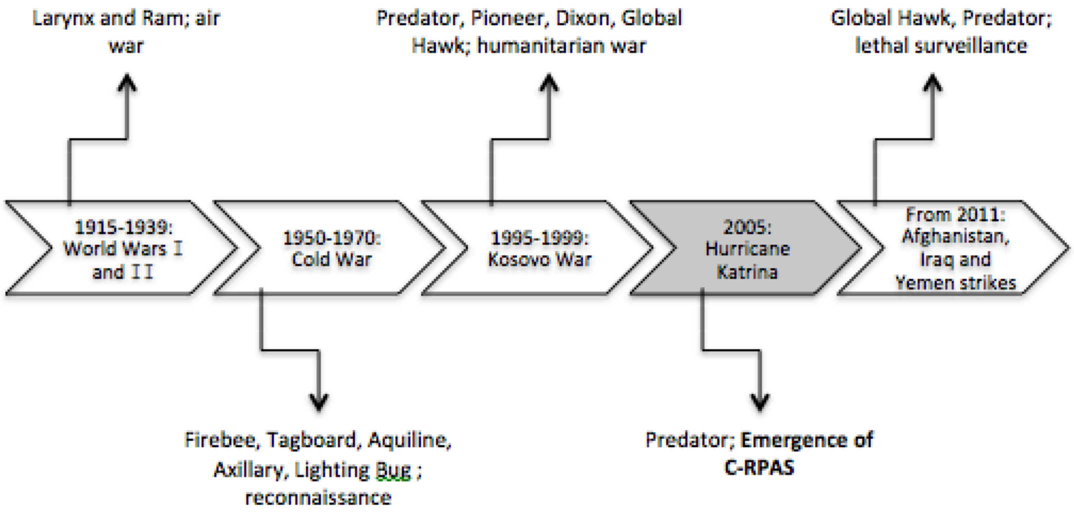

Figure 3.1.: Milestones of the development of RPAS. Source: personal elaboration.

3.1.2. Technology

Size is the base on which to pinpoint different categories of drones (Clarke, 2014):

- Large drones: 150 kg or more;
- Mini-drones: between 20 and 150 kg;
- Micro-drones: between 0,1 and 7 kg;
- Nano-drones: less than 0,1 kg.

Depending on size, other two important attributes of RPAS vary: the range of flight (from few feet around the operator to over 17,000 miles) and the flight altitude (from few feet to a maximum of 65,000 feet) (Rao et al., 2016).

Rao et al. (2016) claim that the majority of commercial drones' designs do not look like their larger and more expensive military counterparts since they are built on small platform with cheap components. As of today, most commercial drones have a similar design (Figure 3.2.) including *"a microcontroller with four to eight motors and propellers, a radio receiver, electronic speed control and a battery built on a light plastic or metal frame"* (Rao et al. 2016, p. 84). Additionally, GPS devices can be used to navigate and sensors, cameras and gimbals can be added to increase stability, for aerial imagery and for image stability (Rao et al., 2016).

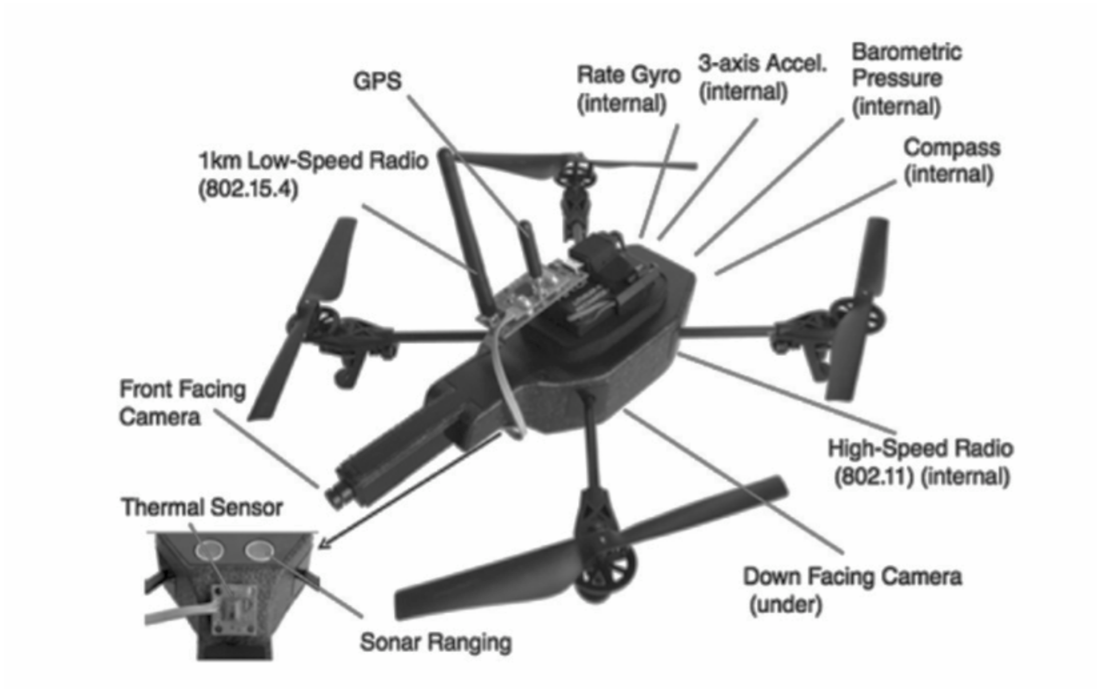

Figure 3.2.: Structure of a commercial drone. Source: Rao et al., 2016.

More specifically, following the model by Parihar et al. (2016): four arms are attached to the main body and connected to each other, four motors are attached to each arm and to four electronic speed controllers (that are connected to each other as well), four propellers are attached to each motor, a remote controller is used to control the rotation of propellers and four rotors are used to lift the body and payload. Sensors are located into the flight controller, which basically is the brain of the quadcopter and controls the motors and, through them, the propellers (Parihar et al., 2016). The electronic speed controller acts on the motors to control speed and directions while transmitters and receivers control the radio to change settings (for instance from day to night) (Parihar et al., 2016).

On the quality of sensors and data and control feeds depend the primary functions of drones: control, navigation and operation (Clarke, 2014). Remote feeds, in turn, depend on the communication facilities (like the GPS device) that are to be found on board and that affect the drone's usability (Clarke, 2014). As a consequence, the distance *"the signals have to travel may negatively affect control, navigation and/or operational quality"* (Clarke 2014, p. 234).

Commercial drones can be controlled remotely through radio signals by a human pilot or through the autopilot control mode (Chao et al., 2010).
According to Clarke (2014), effective remote human control of a drone can be exerted only if the pilot has sufficient data-feeds in sufficient time to make decisions, adequate communication of data, availability of a sufficient instruction-set, adequate communication of instructions and if the drone responds to the instructions given by the pilot in a reasonable amount of time. The operational functions such as load carrying primarily depend on the available payload (affected in turn by size and engineering power), the duration of the flight (related to the available power-source) and the environment (for instance altitude) (Clarke, 2014). Because of their dimension, C-RPAS can lift a maximum of 4 pounds (Rao et al., 2016). Dealing with the majority of RPAS technology, control, navigation and operations are performed by different people (Clarke, 2014), so that to fly one drone at least three people are required.

When it comes to the development of C-RPAS, leading companies such as DJI, 3DRobotics and Parrot invite communities of enthusiast to participate in the development process of their open source hardware and software projects (Rao et. al, 2016). This sharing of ideas across open platforms brings along an open source attitude to innovation (Boucher, 2014). Moreover, the NPD process of drones is parallel to the one of other emerging technologies, like 3D printers (Rao et al., 2016), computing, sensors and robotics (Clarke, 2014), from which they inherit both opportunities and setbacks. This feature of RPAS' technology is called technological convergence and has recently lead small drones to reach the performance standards of manned aircraft in an even more efficient way. C-RPAS, in fact, are able to carry payloads, be aware of their own location thanks to the GPS device and communicate and process data thanks to their miniaturised computers (Clarke, 2014). Furthermore, DJI and Parrot have recently released custom software applications that are specifically designed to operate on mobile computing devices like smartphones and tablets and, when combined with on board sensors, support drones operations (Vincenzi et al., 2015).

While large M-RPAS are still expensive to maintain and control, the emergence of high power density batteries, miniaturized equipment, wireless network devices and the consequent increasing production volumes have lead to lower costs for C-RPAS (Chao et al., 2010). Their purchase price is between $100 and $10,000 and the average cost per hour of flight is about $25 (Clarke, 2014).

3.1.3. Challenges

Several challenges are connected to the technology of drones (Marketline, 2014).
At first instance, in fact, while drones depend heavily on data and control feeds, *"signals between drones and remote pilots and between drones and GPS satellites are subject to a considerable amount of interference – variously environmental, accidental and intentional."* (Clarke 2014, p. 233). This may alter communications and lead the drone not to behave accordingly to its pilot's instructions (Clarke, 2014). The behaviour of drones might also be unpredictable due to the ambiguity of computing procedures: low quality software makes for low quality decision-making by the computers embedded within drones (Clarke, 2014). As drones are essentially robots, their behaviour must be constrained and their autonomy must be subjected to human supervision, which can be achieved only if manual control can be restored quickly (Clarke, 2014). Autonomy regards the ability of the drone to fly back and forth with

minimal human interaction, so that it may result in vigilance and complacency issues (Vincenzi et al., 2015). Additionally, besides the limitations inherited from computer, data communication and robots through technological convergence, C-RPAS face technical limitations such as load capacity, flight duration (15-30 min) geographical range and speed (Clarke, 2014). The remote pilot needs a supporting infrastructure and for it to be sophisticated might mean to undermine the cost-savings coming from having no pilot on board (Clarke, 2014). Other limitations deal with poor display designs, as the remote pilot often lacks visual and auditory clues from the flying environment (Vincenzi et al, 2015). Lastly, bad weather conditions, smoke, fire and heat represent major challenges for drones as well.

3.1.4. Development Trends

ICAO recognizes many categories of aircraft and states that each one of them may potentially become unmanned in the near future (ICAO 2011, p. 4).

At least for what concerns the military, the main attributes along which progress is currently made are size and stealth. The drones under development are in fact designed to replicate the flight mechanics of birds and insects (Bumiller and Shanker, 2011). Another critical improvement trajectory is the one in software aiming at making drones more and more autonomous since to provide them with artificial intelligences will make them easier to fly (Rao et al., 2016). The development of sensors' technology has the same purpose of making human intervention as marginal as possible (Karpowicz, 2016). Subsequently, developers are looking forward to the commercialization of micro UAVs and self-learning UAVs (Wolf, 2016). Finally, development efforts are currently focusing on the battery life span and power of C-RPAS (Clarke, 2014).

3.2. Why RPAS are a major Technological Breakthrough?

The technological progress in aircraft technology follows two main trajectories - civil and military - with major improvements in power, range and speed along both (Dosi, 1988). Concerning the military trajectory, it is approaching a ceiling because of its paradigm boundaries. On the one hand, in fact, no matter how many improvements are made, human limitations hinder the technological performance (like night view or longer-range precision in attacks). On the other hand, going beyond the paradigm to further improve the technology puts pilots' safety in jeopardy. Back to the years of Ram and Larynx, the problem was to provide the Royal Air Force with longer-range attacks while reducing human casualties and limitations like poor night view (Farquharson, 2006). Afterwards, the US Department of Defence during the Cold War needed longer geographical range and better technological performances for its intelligence activities (Kindervater, 2016). Continuous improvements in the military aircraft technology could not wholly satisfy these exigencies because of its intrinsic drawbacks. Consequently, taking a different approach on the problems at hand lead to the inception of UAV programs. Therefore, drones are a major technological breakthrough in that they entail a paradigm shift from having a pilot on board the aircraft to flying without one.

In addition to this, as defined by the Oxford Dictionary, Robotics is the branch of technology (engineering and computer science) that deals with the design, construction, operation and application of robots. Since drones essentially are flying robots (Clarke, 2014), it can be said that they represent a major technological breakthrough in Robotics as well, shifting paradigm from land robots to flying ones.

The shift implies new perspectives and progress path to follow basing on an entirely new body of knowledge. UAVs are indeed disrupting warfare in that they alter who fights wars from humans to machines. While reducing human casualties and military costs, the new UAVs paradigm brought also along an entirely new series of problems that mainly deals with reliability and control of the aircrafts (Kindervater, 2016).

The technology S curve theory provides further evidence of the fact that UAVs' technology is disrupting the military industry (Figure 3.3.).

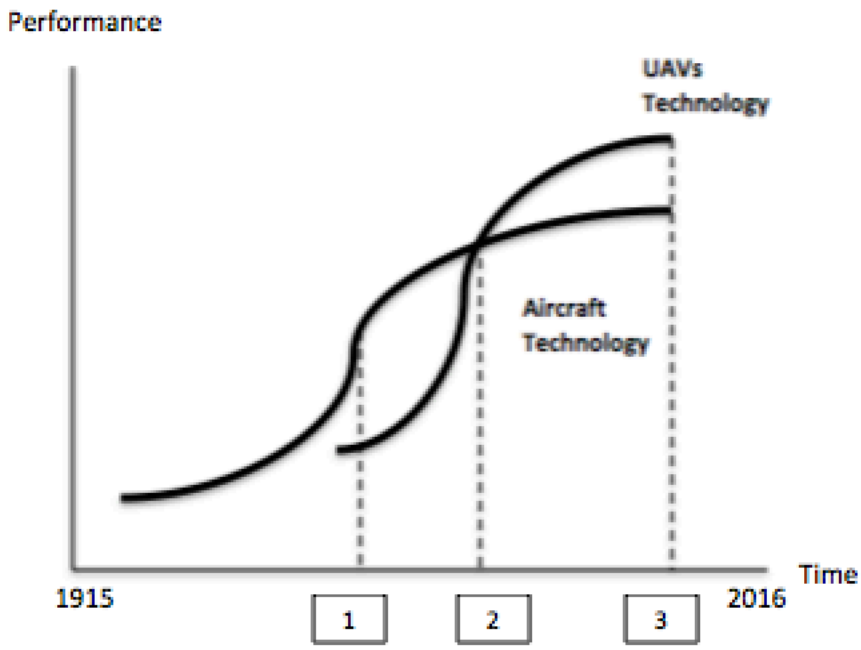

Figure 3.3.: Aircraft and UAVs technology S curves. Source: personal elaboration.

During the years of World Wars I and II the performance of RPAS was still below the one of aircrafts (point 1). Drones were, in fact, difficult to control, imprecise in navigation routes and attacks and expensive to develop (Farquharson, 2006). Their technological progress started to take off in the years of the Cold War, more specifically after the fall of CIA's U-2 aircraft (1960), and continued its improvement throughout the Kosovo War when NATO preferably deployed drones instead of manned aircraft for its strikes (point 2) (Kindervater, 2016). The superiority of UAV's technology was first established in Afghanistan and Iraq when the US Army killed several Al-Qaeda leaders through the use of armed drones (point 3) (Kindervater, 2016). As argued by Antebi (2014) and concerning the effort dimension, in US the growing use of RPAS has lead to an increase in the allocated budget: from $3.9 billion in the period 1988-2000 to $26 billion in the period 2001-2013. Incremental progress is still fast-paced concerning drones in warfare and the technological trajectories are far from reaching their frontier (Clarke, 2014). This growth is expected to balance the decreasing demand for manned aircraft (Boyle, 2015). Subsequently, RPAS are to be considered as technological breakthrough because while they initially lagged behind in the critical attributes valued by military like precision and control, they eventually redefined performance trajectories by creating new valuable attributes like stealth, longer geographical range of flight and lower risk to personnel, as well as new markets.

Commercial drones are to be considered as another technological breakthrough coming from a shift in trajectory from military to civil within the new UAS paradigm. The reduction in size, in fact, leads to the creation of new markets beside the military one and to new directions of technical change (Clarke, 2014).

3.3. New Applications for RPAS

Boucher (2014) distinguishes four major applications of RPAS: military, non-military governmental, commercial and personal/recreational. Besides military RPAS, the others are subsets of the C-RPAS category. Thanks to the open source development allowing for a core technological base that can be altered and the subsequent lower costs, several niche applications for UAVs are indeed now financially viable worldwide (Boucher, 2014). As of 2014, more than 70 countries have adopted drones for both military and commercial scopes (Marketline, 2014) with Israel being the number one supplier (Boyle, 2015) (Figure 3.4., 3.5. and 3.6.).

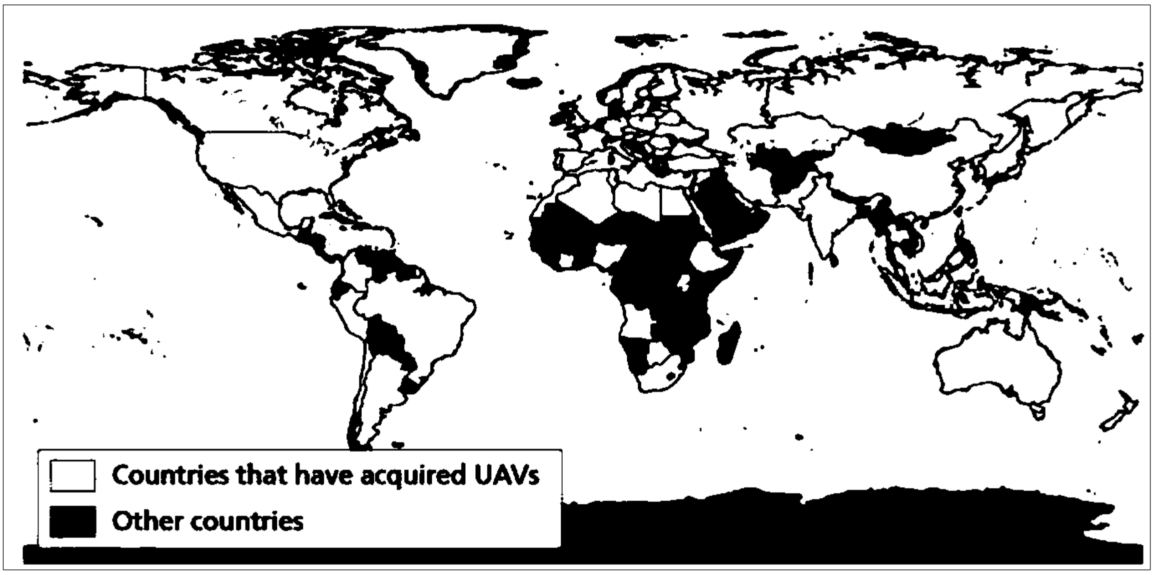

Figure 3.4.: Countries that have adopted UAVs. Source: Marketline, 2014.

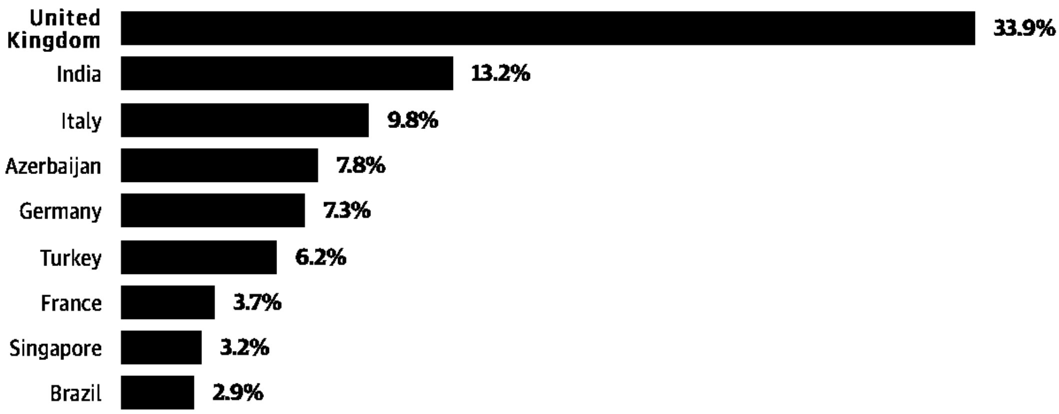

Figure 3.5.: Percentage of total UAVs (2010-2014) received by country. Source: The Guardian, 2015.

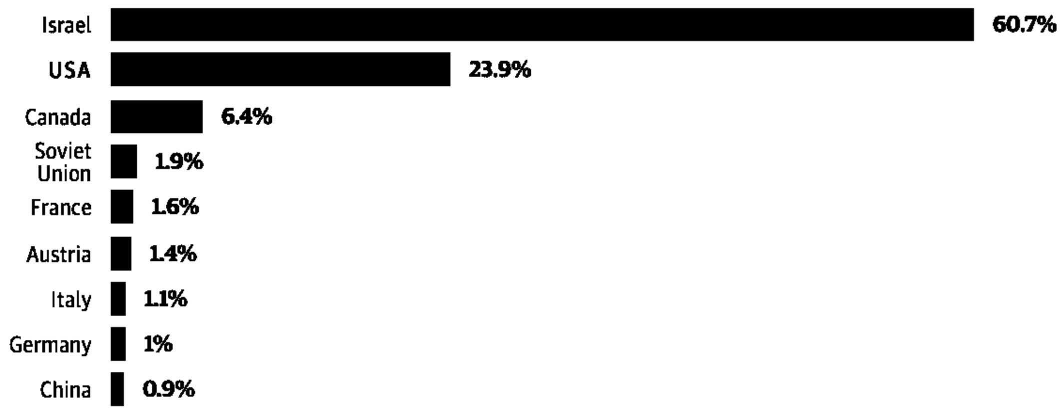

Figure 3.6.: Percentage of total UAVs (1985-2014) supplied by exporting country. Source: The Guardian, 2015.

The Association of Unmanned Vehicle Systems International predicts in its report that UAVs could have an economic impact of $82.1 billion in the period 2015-2025 (Marketline, 2014) (Figure 3.7.). Another estimate by the Teal Group predicts for annual sales of drones *"to double from $5.2 billions to $11.6 by 2023"* (Boyle 2015, p. 79). R&D expenditure and procurement will reach $89 billion in the next ten years, the majority of which coming from the US (Boyle, 2015).

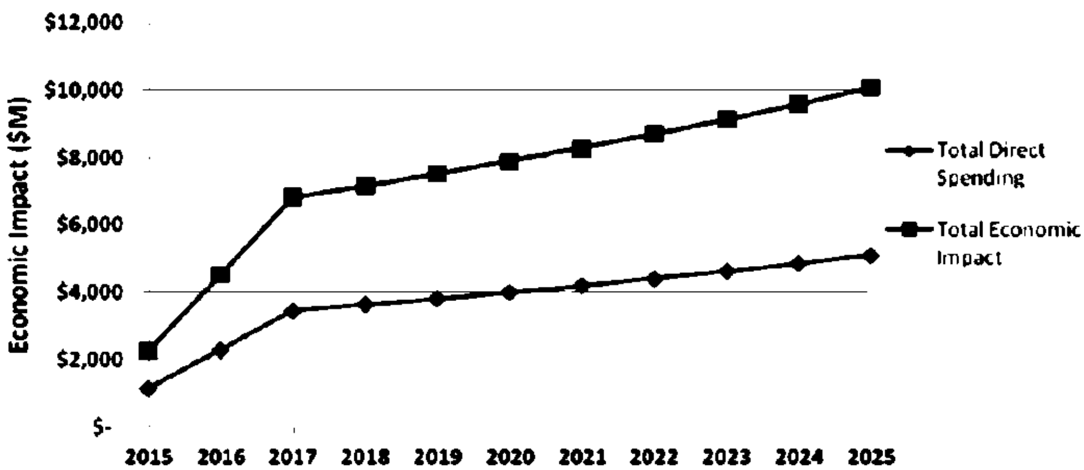

Figure 3.7.: Estimated economic impact of UAVs integration. Source: Marketline, 2014

Thus the global estimated investments in in drone hardware will have an overall increasing trend, but according to Business Insider (2016) it will be sharper for consumers and mostly enterprises compared to the government (Figure 3.8.).

The global expenditure on commercial drones has been $700 million in 2014 and the market size for their related services such as drone rentals and 3D printers is expected to equal the one of hardware sales within the next three years (Rao et al., 2016).

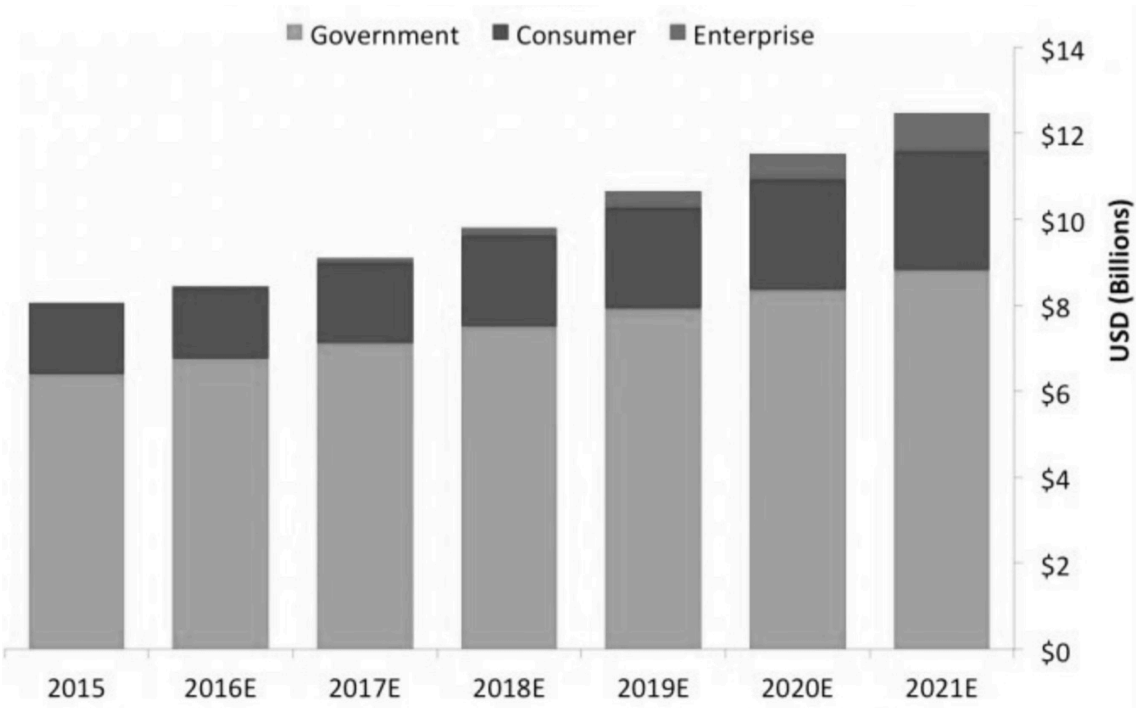

Figure 3.8.: Estimated Global Investment in Drone hardware. Source: Business Insider, 2016

Antebi (2014) claims that the above mentioned changing trends are facilitated by rapid technological development, reduced costs of technology, globalization, availability of technology coming from both globalization and lower costs, and lack of regulation limiting the use and development of drones. Moreover, the civilian market is broader compared to the military one, so that it holds a huge potential which is still quite untapped (Antebi, 2014). As of today, the primary commercial application areas for

RPAS are agriculture, delivery, hobby, photography, journalism, law enforcement and emergency services (Clarke, 2014 and Rao et al., 2016). While agriculture is currently the largest and more profitable one (Marketline, 2014), a lot of attention has been recently put over delivery since Amazon, DHL and Google are pioneers within this market (Marketline, 2014).

3.3.1. Challenges

Despite the different applications that are still popping up for C-RPAS, several factors are hampering the adoption of drones. The most relevant one is perhaps regulation as it differs between M-RPAS and C-RPAS and, concerning the latter, technology has definitely outpaced the regulatory process since there is no clear regulatory process to follow (Rao et al., 2016). In Europe, C-RPAS above 150 kg are controlled by the EASA, while smaller ones are under national rules (Papppot and de Boer, 2015). As both Europe and US are trying to integrate regulations on commercial drones, the diffusion of UAVs may be constrained or fostered depending on the outcomes (Marketline, 2014). Safety and privacy are also major concerns. While the privacy issue is linked to the regulatory one, Rao et al. (2016) claim that small mistakes in flying drones could lead to great damage and harm civilians' health. Besides the risk connected to poor communications channels of UAVs and the chance that they could be hijacked by fake GPS signals, there is also the issue of carrying payload concerning the logistical challenges of drone delivery (Rao et al., 2016). If for instance a hot burrito lands on some pedestrian, the damage could possibly oughtweight its potential benefits. Lastly, the connection of RPAS to warfare attracts tough opposition on their spreading to commercial markets (Marketline, 2014).

3.4. The Emergency Market

"The term humanitarian assistance refers to aid and action designed to save lives, alleviate suffering, and maintain and protect human dignity during and in the aftermath of emergencies" (Sandvik and Lohne 2014, p. 146).

The global emergency response market is expected to grow from $80.10 billion in 2015 to $101.33 billion by 2020, with a compound annual growth rate of 4,8% during the period 2015-2020 (Figure 3.9.) (PRNewswire, 2016). This is due for the largest part to the advancement in technology connected to this field.

Although the emergency market can be seen as diametrically opposite to the one in which UAVs were incepted, that is to say for war, they are actually strictly entangled. In fact, the most valuable attributes of drones in military are essentially the same for emergency activities. According to Sandvik and Lohne (2014), the attributes in question deal with the hardware component of RPAS and are surveillance, load carrying and targeting. Drones might in fact be deployed for providing data about emergencies and for humanitarian relief, thus participating directly in human relief operations (Sandvik and Lohne, 2014). Additionally, their precision in delivering attacks can be used for human targeting, again helping in saving lives (Sandvik and Lohne, 2014).

This technology transfer from military to emergency is due to the development process of drones, but also to the interaction of different stakeholders, namely developers and politicians aiming to gain legitimacy for the UAVs industry against oppositions (Sandvik and Lohne, 2014). In other words, it is the result of both exploration and effectuation.

Mosterman et al. (2014) argue that the deployment of C-RPAS into humanitarian activities is difficult due to the peculiar nature of emergencies' needs such as availability, responsiveness, agility, transparency and interactivity. Planning and executing a mission is indeed a problem of optimization between the supporting infrastructure, the fleet of vehicles and the help request basing on the choice of routing trajectories for the drones and the continuous communication and interaction between humans and robots (Mosterman et al., 2014). However, new developments in communication networks and wireless and crash-avoidance technology are helping in better exercising guidance and control tasks (Mosterman et al., 2014). Rao et al. (2016) claim that another major development in drones' technology regarding humanitarian applications is the Openpilot project, which has the purpose of creating free universal autopilot software for flying commercial drones (Openpilot website). Openpilot is flexible in both hardware and software components, so that researchers can modify it basing on their needs and thus eliminating the necessity for a human operator (Chao et al., 2010). It also improves autonomy and navigation accuracy (Chao et al., 2010).

As a consequence, it can be said that although the technology of C-RPAS is not mature, its development paths may be a premise for *"more efficient and less costly emergency response and relief"* (Mosterman et al. 2014, p. 260).

Yet, it is still unclear if the deployment of C-RPAS in this field will be an actual disruption or just a fade (Sandvik and Lohne, 2014). Notwithstanding the several advantages like speed, efficiency and safety, regulation, ethical and privacy issue are still barriers to the adoption of drones (Sandvik and Lohne, 2014). Furthermore, the underlying technology of UAVs still need improvements and thus represents a barrier in itself (Scott, 2016).

4. Methodology

4.1. Objective of the Research

The literature review showed that although there is plenty of evidence on the disruption of the military industry by RPAS, very few is provided for drones' commercial application and least of all for the emergency market. Albeit having established the breakthrough nature of both M-RPAS and C-RPAS, in fact, the novelty connected to the penetration of civilian markets currently prevents from assessing its actual impact, that is to say whether a disruption is likely to happen or not and how. Dealing with C-RPAS, field such as delivery and agriculture are under the spotlight because their size and potential are huge. Humanitarian activities, instead, are still quite untapped from an empirical point of view and developers are not sure whether emergency actually represents a profitable market for drones' integration. The use of drones in this field is indeed at its embryonic stage, both technologically speaking and as a concept (Sandvik and Lohne, 2014). Subsequently, the objective of this research is to create knowledge to the latter concern through induction, which means to build new theory starting from specific observations (Stake, 2013). In other words, the aim is to explore and compare emergency activities among different NGOs to gather the likelihood of drones' adoption and consequent disruption of the emergency industry.

4.2. The Multiple Case Study Research Method

The case study research aims at understanding unknown dynamics within real life settings (Eisenhardt, 1989) and thus is particularly suitable when research and theory are at their early stages (Darke et al., 1998). As argued at the beginning of this chapter, the theory connected to C-RPAS and their potential disruption of the emergency market is close to be totally lacking. Moreover, there is no control over the involved actors' behaviour and little prior empirical evidence is available, so that an experiment would be unsuitable as a research strategy. Besides, the resources to effectively experiment with drones and emergency activities are not available to the researcher. It would also be impossible to gather satisfying insights from a quantitative analysis because there are few companies that deploy drones for saving lives. Subsequently, the case study research has been chosen as a research strategy. Given that no single case is representative or relevant enough to formulate a general theory, a multiple case study approach has been used. The interest in the single cases is instrumental to understand the broad theory (Stake, 2013). Each case study is analysed as a stand-alone entity at first instance and afterwards related to the others in order to gather the relating differences and similarities. This method makes it possible to investigate a phenomenon within different settings that have been selected to produce contrasting results (Darke et al., 1998). The underlying assumption provided by the literature review is that C-RPAS are a technological breakthrough and that civilian markets provide several opportunities for disruption. The research is interpretive in that the methodology is mainly qualitative (Darke et al., 1998).

4.2.1. The Research Questions

Stake (2013) defines the multiple case study research as the study of multiple cases within a larger phenomenon, which is called the quintain or research problem. The quintain of this research is the deployment of drones by NGOs in their surveillance, rescue and first aid activities. The foreshadow problem is that few companies within the emergency market actually deploy C-RPAS, therefore it is uncertain if they will cause a disruption or if their commercialization will be a failure instead. The research questions are meant to ask what is relevant to understand the quintain (Stake, 2013). They are, in other words, the research focus (Eisenhardt, 1989). The following research questions have been addressed:

- How emergency activities are currently carried out by each NGO?
- What are the similarities in their needs?
- Is emergency a potentially profitable market for C-RPAS?
- How can C-RPAS be actually deployed within the emergency market?

4.2.2 Case Studies Selection

According to Stake (2013), the cases within a multi case research strategy need to be somehow similar between each other but contributing differently to the building of the general theory at the same time. Since humanitarian activities are broad in nature and geographic scope, the research focuses on surveillance, rescue and first aid at sea in the Central Mediterranean area.

Nowadays, Libya and Syria are among the most violent places in the world, so that migrants undertake journeys on small vessels to escape poverty, violence and wars. Illegal immigration is prohibited and sanctioned by the European Directive 2001/51/CET, which underlines the obligation for migrants to possess the mandatory documents and visas to enter the Member States (European Union Law website). However, it is nearly impossible for most people living in those countries to obtain the required documentation. Therefore, since no legal transportation is available to them, they try to make the crossing from Libya or Syria to Italy on small boats. The latter issue has raised public awareness in recent years due to the ethical and political discussions revolving around it as well as the several deaths caused by shipwrecks. According to the archives of La Stampa (2015), more than 10,000 people have died in the last ten years, of which 2015 has been the year with more deaths as 3,771 migrants have perished in the Central Mediterranean Sea. Hence, the government and several NGOs are acting to fill the absence of large-scale humanitarian operations and save the lives of refugees (Figure 4.1.). Moreover, NGOs are end customers for drones offering because they may benefit exponentially from its critical attributes and are currently experiencing limitations in their ships' technology for surveillance and rescue activities. Among the others, Migrant Offshore Aid Station, Sea-Watch and SOS Méditerranée have been chosen to develop the case studies. Despite the similarities that are to be found in their activities and geographical scope (i.e. rescues of migrants within the Central Mediterranean Sea), several differences are to be found among the way they carry out their humanitarian operations. While the former deploys drones for its missions, in fact, the latters do not. They also differ in size and thus provide for a complete and representative sample. Besides the multiple case studies, evidences have been gathered from an experiment held in Europe by the Chinese company DIJ starting in May 2016 to train European emergency workers to pilot C-RPAS for rescue missions (Bhattacharya, 2016). The experiment has the purpose of promoting the integration of drones into humanitarian operations (Scott, 2016).

Figure 4.1.: Maritime Asset Info graphic. Source: Migrant Report, 2015

4.2.3. Data collection

Eisenhardt (1989) argues that case study research can involve qualitative or quantitative data or both. In this case, mainly qualitative data are concerned.

Prior to collecting the data, background information about the companies involved in the sample have been gathered from documentary sources such as newspapers, newsletters and their websites, blogs and Social Media channels. Additionally, European regulatory frameworks as well as country news media relating to refugees issue have been reviewed to gain further understanding of the environment of the research. For what concerns the DJI experiment, technical journals, YouTube videos, annual reports and local newspapers are the main sources of data collection. A first challenge has been to initiate a contact with the companies, since volunteers are occupied with surveillance and rescue tasks and consequently enjoy little free time for interviews, which are the primary source of data collection for this study. Interviews were conducted via Skype Call with single individuals following a set of questions that were prepared in advance and ranged from fifteen to twenty minutes (Figure 4.2.). The conversation mode has been rather informal throughout all of them. The aim of the interviews was to provide an in-depth picture of the humanitarian activities carried out by the three NGOs, the challenges they face on a daily basis and the prospect of integrating drones within their operations to overcome them. One out of three NGOs has not been reachable, consequently the case on Sea-Watch has been developed basing solely on documentary sources.

4.2.4. Data Analysis

In order to provide a reliable and effective cross-case comparison, notes regarding interviews and documentary sources have been rigorously collected and stored within a dedicated database. The process of analysing the insights has actually started during the data collection phase, as similarities and differences were pinpointed immediately. Further comparative analysis has been performed afterwards through triangulation of the data. The cases have been compared in pairs looking for differences within the most similar ones and for similarities within the most distant ones. Additionally, different dimensions along which to compare the data have been chosen in order to look at them from a different perspective. The dimensions are: technology deployment, limitations connected to technology, limitations connected to the market and current needs. Conclusions were lastly drawn basing on this analysis and on the literature review.

	Company	**Migrant Offshore Aid Station**	**Sea-Watch**	**SOS Méditerranée**
Background	Home Country	Malta	Germany	Germany
	Active Since	2014	2015	2015
	Drone	X	n.a.	n.a.
Secondary Data	Newsletter	X	X	n.a.
	Website	X	X	X
	Facebook	X	X	X
	Twitter	X	X	X
	YouTube	X	X	n.a.
	Newspapers	X	X	X
Primary Data	Contact Mode	Email and Skype Call	n.a.	Skype Call
	Duration of the Interview	15 min.	n.a.	20 min.

Figure 4.2.: Sample Overview. Source: personal elaboration

5. Case Study

At this stage of the research, each case study is analysed as a single entity notwithstanding the differences and similarities between them. At first instance, a company profile is provided for each NGO in order to present a background for the cases. The resources used to the latter extent are mainly documentary. Both information coming from the interviews and documentary sources have been instead employed to describe their search-and-rescue activities.

5.1. The Case of Migrant Offshore Aid Station

5.1.1. Company Profile

Figure 5.1.: MOAS Logo. Source: MOAS website

Christopher Catrambone, an American entrepreneur, founded Malta-based Migrant Offshore Aid Station (MOAS) by the end of 2013 with his Italian wife Regina (MOAS website). They were moved by the strong belief that *"No one deserves to die at sea"* (MOAS website). Mr Catrambone was already running the Tangiers Group, which provides insurance services in conflict zones (Tremlett, 2015). With private funds they purchased the Phoenix, a 40-metre expedition vessel amounting to $5.2 millions after reparations (Tremlett, 2015). Two rigid-hulled inflatable speedboats were also purchased to bring migrants on the Phoenix (MOAS website). In addition to this, they hired the rescue crew and leased two C-RPAS from the Austrian company Schiebel (MOAS website). Setting up MOAS had monthly operating costs up to €600,000 (Tremlett, 2015). The first mission was carried out in the period August-October 2014 along the Libyan coast and it turned out to be successful since they performed ten rescues and saved about 13,000 people (MOAS website). This made MOAS the first private rescue ship within the central Mediterranean (Il Fatto Quotidiano, 2014). While the issue of children dying in the attempt to reach the European coasts was becoming more pressing, public funding allowed the NGO to became global in 2015 and extend its operations to South-East Asia and the Aegean Sea (MOAS website). As of today, the core team is made of nine people and the whole organization includes security professionals, medical staff and maritime operators (MOAS website). So far, they have rescued about 25,000 people at sea and never lost a life (MOAS Facebook Page).

5.1.2. Search-and-rescue Activities

MOAS' operations are coordinated from Malta, which is located close to the North Africa coast in the Central Mediterranean Sea and thus lies within the migratory route from Africa to Italy (MOAS website). MOAS works in cooperation with the Maritime Rescue Coordination Centre (MRCC) of Rome, the Doctors Without Borders Switzerland-based organization and recently with Emergency and its 52-metres boat Responder (MOAS website). The Catrambones believe that cooperation is the future of humanitarian activities. The Phoenix sails on predetermined routes (Figure 5.2.) with a 20-person crew on board and the capacity to host about 300 migrants (MOAS website). Search-and-rescue operations are generally performed as follows:

- The MRCC transmits to the Phoenix the location of the call for help;
- The drones pinpoint the exact location of the vessel in distress and the conditions of migrants;
- The speedboats ferry refugees to the Phoenix giving priority to women and children;
- The medical staff from Doctor Without Borders provides first aid;
- Migrants are transported to Italy.

Alternatively, the drones locate a vessel in distress during recognition and transmit the data to MOAS and the MRCC. Afterwards, either the call is passed by the MRCC to other emergency boats or MOAS itself take off to rescue the migrants (Figure 5.3.).

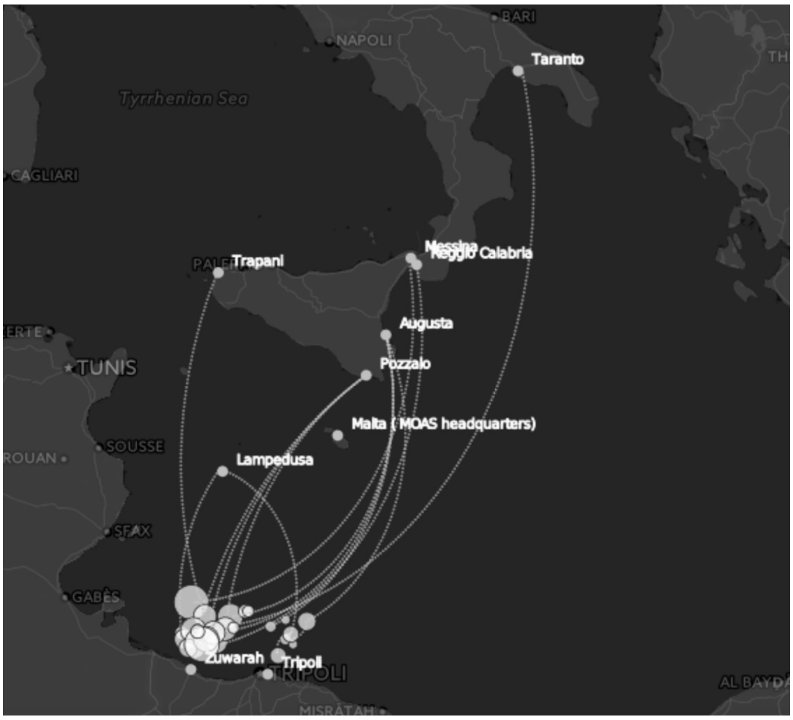

Figure 5.2.: 2015 MOAS's Operations. Source: MOAS website

Figure 5.3.: 2015 Phoenix rescuing refugees. Source: MOAS website

5.1.3. C-RPAS deployment

The Phoenix is equipped with two Schiebel drones. More specifically, they are Camcopter S-100s weighting about 100 kg and having a range of 200 km, maximum speed of 200-km/h and flight time of six hours (Schiebel website) (Figure 5.4.). They take off from the deck and feed sonar, thermal and night high-resolution images to the crew through a software application. MOAS uses drones to locate the position and direction of migrants' vessels. Since the Camcopters take off vertically, they are particularly suitable for the sea environment. There are three members on board the Phoenix liable for controlling and navigating the drones (Figure 5.5). Ian Ruggier is the Head of Operations at MOAS. He says that having the drones transmitting images helps in focusing the rescue effort because to know in advance what is actually going on makes the decision-making process informed and thus happening faster. Likewise, the rescue itself becomes quicker and, given that time is precious in emergency activities, they can make the difference between life and death. Furthermore, camcopters can cover huge amount of sea faster than any boat. Subsequently, they allow spotting boats that are beyond the navigation route of the Phoenix and would have been missed otherwise. Being the Earth essentially a ball, in fact, it is not possible to see very far at sea. Other advantages of drones' deployment that have proved to be invaluable to MOAS are their ability to fly at night, in bad weather conditions and within dangerous areas of the journey such as the Libyan coast. Since the pilots are on station, their lives are not at risk and human limitations like the need to rest do not affect the mission. It would be impossible to patrol the dead-zone running few miles from Libya without drones, so that they end up expanding MOAS's geographic scope. Additionally, using C-RPAS is expected to drive down the costs in the long run.

Figure 5.4.: MOAS's camcopter. Source: MOAS website

Figure 5.5.: Crew operating the camcopters. Source: MOAS website

5.1.4. Challenges

The use of drones in search-and-rescue activities has proved to be beneficial, nonetheless several obstacles still exist. First of all, it is challenging to make national authorities see the above-mentioned advantages. The lack of harmonized regulations on C-RPAS does not help to this regard. Since regulation on commercial drones is currently up to the national level, it has been difficult for MOAS to fly its camcopters on territorial waters that are close to the international ones in which the Phoenix journeys. Moreover, some European governments claim that the rescue operations within the Mediterranean Sea are multiplying migrants' attempts to escape their own countries and are consequently leading to more deaths, notwithstanding the fact that among refugees are to be found criminals and fanatics. The issue is actually controversial, since to separate political and ethical discussion from emergency activities has proved to be nearly impossible. Also, the cost of the vehicles is problematic. The market price of the two Schiebel camcopters is $5.5 millions. MOAS rents them for $300,000 per months and despite Schiebel having donated two months' worth of use it still affects heavily the NGO's financials. Within these circumstances the need for cooperation between NGOs and public donations is more than ever acute in order for MOAS to keep using C-RPAS. This in turn makes the need for raising public awareness even more acute.

5.2. The Case of Sea-Watch

5.2.1. Company Profile

Figure 5.6.: SW Logo.
Source: SW website

Following the end of Mare Nostrum initiative by the European Union, a group of private citizen from Germany founded Sea-Watch (SW) in 2014 with the mission of *"saving lives, create publicity to question the European border policy and find imitators that will take action as well"* (SW website). Harald Höppner is the main supporter of the project and invested about $70,000 to buy the 21-meter MS Sea-Watch from Netherlands, which he renovated with the help of the crew (Mennitti, 2015). The whole investment made by Höppner amounts to about $135,000 (Cafebabel, 2015). On board the ship were eight people and on July 2015 they took off for their first mission in which they operated as a support for other organizations helping in rescuing a hundred migrants (Mediterranean Hope, 2015). During the first year of activity they were able to save 5,000 people (SW website). The need for a bigger and more efficient vessel led the founders in 2016 to buy 33-meters Sea-Watch 2, an English vessel allowing medical care offering and a larger crew on-board (i.e. 15 people, 250 migrants) (SW website). On April 2016 Sea-Watch 2 took off for its first mission and carried out six rescues saving about 600 lives (Mediterranean Hope, 2015). Besides the purchase of the ships and the initial investments, SW relies completely on donations (SW website). The crew is made of professionals in the medical, security and navigation fields (SW website). They use the hash tag #SafePassage to raise public awareness.

5.2.2. Search-and-rescue Activities

SW's operations are headquartered in Berlin but based in Lampedusa, which is located near Sicily and is thus close to the Libyan shores (SW website). SW cooperates with Watch the Med (WTM) for surveillance and Human Rights at Sea to ensure the complacency with the law (SW website). The rescue missions are generally carried out as follows (Cafebabel, 2015):

- WTM receives emergency calls and transmits the coordinates of the vessels in distress to SW;
- Sea-Watch 2 sails towards the pinpointed location;
- Two Sea-Watch's speed boats carry the migrants on board the ship;
- Life jackets, medical assistance and refreshments are offered to the refugees;
- Refugees spend some time aboard – often the entire night - while SW waits for bigger vessels to pick them up and bring them to European shores (Figure 5.5.).

Alternatively, it is possible for SW to locate migrants' small boats through the Sea-Watch 2 radar or through the use of binoculars (Cafebabel, 2015). Because it does not transport immigrants to the European coast, it can be said that SW is at sea for the majority of time. The NGO focuses its patrolling efforts on Libyan territorial waters (SW website). The improved technology of Sea-Watch 2, compared to the one of MS Sea-Watch, allows better surveillance activities and the ability to sail also with rough sea conditions (SW website). However, when the weather conditions became risky for the crew, the mission is paused or terminated (SW website).

Figure 5.7.: Sea-Watch 2. Source: SW websit

5.2.3. Challenges

The main challenge faced by all NGOs operating within the Central Mediterranean Sea is without a doubt to spot migrants' vessels in a reasonable amount of time and with reasonably precise coordinates. With the aim of becoming more efficient in doing so, SW will deploy an airplane in the near future for its surveillance tasks (SW website). The project is carried out in cooperation with Switzerland-based Humanitarian Pilots Initiative (HPI) under the name Sea-Watch Air (Figure 5.8.) (SW website). HPI was incepted as a supporting organization for NGOs active in saving the lives of refugees within the Mediterranean Sea (HPI website). HPI's founders claim that with an aircraft it is possible to patrol a wider area in a shorter amount of time compared to ships and consequently saving costs, efforts and time (HPI website). Sea-Watch Air will provide aerial reconnaissance and thus a broader scan when patrolling the Libyan coast, as well as more efficient rescue operations (SW website). Once the aircraft will locate a vessel in distress, it will report its coordinates to the MRCC, which in turn will transmit them to nearby rescue boats (SW website). A preparation period in which to train pilots and perform flying tests was needed prior to the launch of Sea-Watch Air project (SW website).

Figure 5.8.: Sea-Watch Air. Source: SW website

During one of theses tests, the microlight airplane was able to spot two vessels whose position was immediately transmitted to the MRCC so that people were promptly rescued (SW blog). Microlight aircrafts such as the one deployed by SW and HPI fly at a low speed and usually have fixed wings, one seat and weight about 300kg (British Microlight Aircraft Association website). The market price of fixed wings microlight aircrafts range from $35,000 to $100,000 (Microlight Flying website). If the weather conditions are expected to be dangerous for the pilots, the mission will be paused or interrupted (SW website).

5.3. The Case of SOS Méditerranée

5.3.1. Company Profile

Figure 5.9.: SOS Mediterranee Logo. Source: SOS Mediterranee website

Captain Klaus Vogel co-founded SOS Méditerranée in May 2015 with the aim of *"saving human lives, protecting and assisting the refugees and raising public awareness on the migrants issue in the Mediterranean Sea"* (SOS Méditerranée website). He was working on commercial ships since the age of eighteen and has experience himself in rescues at sea (The Huffington Post, 2015). The other co-founders are private European citizens, making this way SOS Méditerranée the first expression of a collective civil European will (SOS Méditerranée website). The NGO has now branches also in France and Italy respectively run by Sophie Beau (who is also co-founder of SOS Méditerranée alongside Vogel) and Valeria Calandra (SOS Méditerranée website). Thanks to public donations, the NGO was able to lease the 77-meters MS Aquarius, which has a market price of $1,7 millions and a maximum capacity of 500 refugees (The Huffington Post, 2015). The crew is made of 27 people including technical and maritime personnel and professional rescuers and doctors (SOS Méditerranée website). On February 2016 SOS Méditerranée launched its first (and so far only) mission performing 25 rescues and saving more than 5,600 people at sea (SOS Méditerranée reports). The cost of searching and rescuing the refugees at sea is estimated to be about $12,000 per day (SOS Méditerranée reports). They use the hash tag #TogetherForRescue to raise public awareness.

5.3.2. Search-and-rescue Activities

Aquarius is active on the Italian part of the Mediterranean Sea between Sicily, Lampedusa and the Libyan coast, sailing along predetermined routes to spot vessels in distress (SOS Méditerranée reports (Figure 5.10.). SOS Méditerranée has established partnerships with Doctors Without Borders and Doctors of the World to provide refugees with medical care after the rescue, the MRCC and Human Rights at Sea organization (SOS Méditerranée reports).

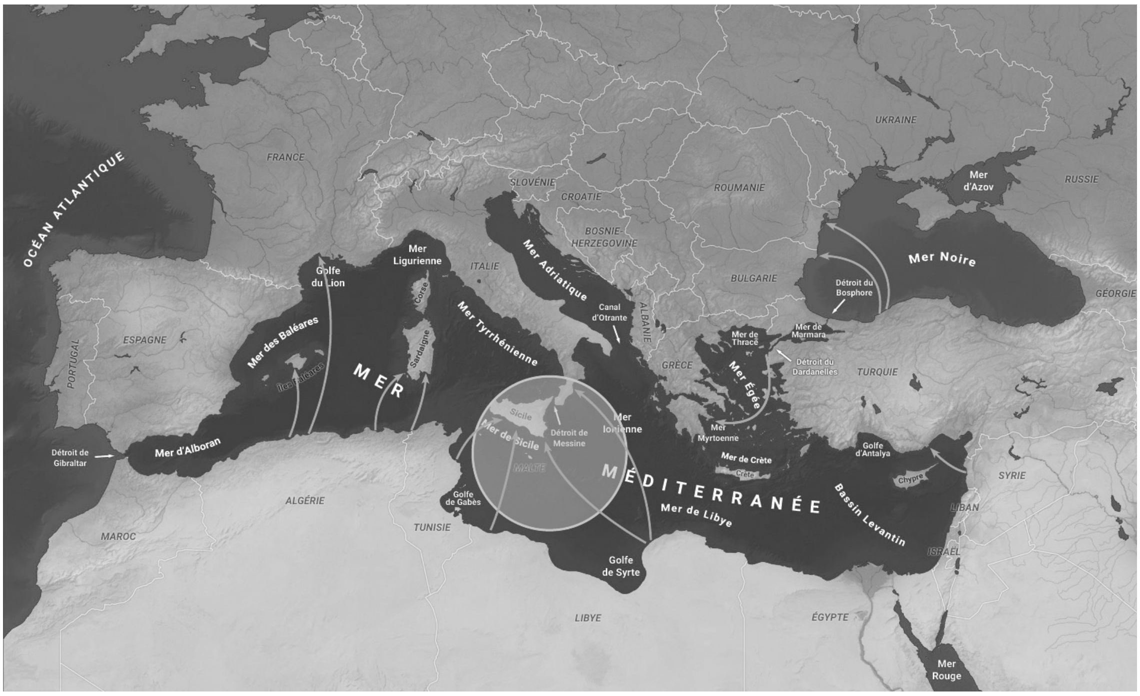

Figure 5.10.: AQUARIUS's Routes. Source: SOS Méditerranée website

The SOS Méditerranée operations are generally carried out as follows:

- The people on guard duty on the Aquarius receive the emergency calls transmitted by the MRCC;
- The Aquarius takes off towards the location indicated by the MRCC;
- Migrants in distress at sea are transferred on board the Aquarius and medical care is provided to them;
- The Aquarius brings refugees to the European shores.

If the crew is not able to spot the exact location of the vessels in distress, they deploy binoculars and sail around until it is possible to pinpoint them. In other words, they rely on sight. Within only 6 months of activity, the Aquarius crew has already dealt with the deaths of several migrants during more than one mission. People were either died before the arrival of the Aquarius or they perished in the attempt to reach it. The protocol in these circumstances is to retrieve the bodies and bring them on board alongside the survivors. Afterwards, the ship takes off and carries dead and alive refugees to the European shores.

Figure 5.11.: The AQUARIUS. Source: SOS Méditerranée website

5.3.3. Challenges

One of the most challenging tasks for rescuers is to fight their physical limits. They need, in fact, to stay awake at night and to bring migrants who have jumped off their boats on board, often doing so by grabbing their hands. Also the psychological component is not easy to manage because the crew has seen people drowning in front of them as well as the bodies of the ones already perished before their arrival. To retrieve the dead bodies of women and children who have not made it to the rescuing ship takes a lot of physical work and several hours with the knowledge that the crew cannot do anything for them. This has a heavy impact on state of minds. There are moments of joy arising from the gratitude of the rescued, but still the memory of the dead never fades. In addition to this, most rescuers feel that if the European management of migrants will not improve, their efforts will became pointless as there are too many refugees for them to handle. Weather conditions provide a constraint in that the life of the crew is a priority and thus is not put at jeopardy, even for a mission. Another constraint to efficiency comes from the limited sight that the rescuers have on the Aquarius, especially at night. The major challenge, however, is the one dealing with funding. Since, as an NGO, SOS Méditerranée survives on donations, the future of its missions is constantly affected by uncertainty. If on the one hand they look forward to inspire the inception of other NGOs operating within the Central Mediterranean area, on the other hand a sort of competition arise in raising public funds.

The latter issue is the main reason behind the fact that the company is not planning on purchasing C-RPAS in the near future. While they recognize the several advantages of drones' technology, they are in fact already facing challenges in financing their core activities. Nevertheless, if they were given the chance to deploy a camcopter for their missions, they would use it for real-time intelligence and surveillance activities. To have images in advance picturing the situation they will have to face would be certainly useful, both to shorten the decision-making process and to raise awareness. Footage fed by drones could be indeed publicly shared with the objective of gaining financial help by raising public awareness on their tragic conditions. However, this could also represent a privacy issue since to escape from countries like Syria is considered treason and thus sharing pictures in which they are portrayed would put at risk several migrants' lives. Furthermore, aside from the economical issue, there would also be the need for people able to pilot the drone on board the Aquarius and that represents another obstacle. Consequently, as of today SOS Méditerranée is not giving any thoughts on buying a C-RPAS, nor to use other aircrafts. Being preoccupied with building a network of rescuers and ships across Europe, they are currently not concerned about improving their activities. Even more, they would be if public donations were larger but that is not the case.

5.4. The DJI Experiment

In addition to the multiple case studies, evidences have been gathered from the trial held by DJI in Europe to teach rescuers how to pilot commercial drones. This is the world's largest experiment with C-RPAS to potentially save lives (Scott, 2016).

Figure 5.12.: DJI Logo.
Source: DJI website

When it comes to C-RPAS, DJI is one of the leading manufacturing companies. Founded in 2006, it is headquartered in China and currently employs more than 3,000 people (DJI website). *"Today DJI products are redefining industries. Professionals in filmmaking, agriculture, conservation, search and rescue, energy infrastructure and more trust DJI to bring new perspectives to their work and help them accomplish feats safer, faster and with greater efficiency than ever before."* (DJI website). On April 2016, the company announced its official partnership with the European Emergency Number Association (EENA) (DJI website). EENA is a Brussels-based NGO founded in 1999 and promoting high-quality emergency services across Europe with the aim to improve emergency response in accordance with citizen requirements (EENA website). It does so through the provision of a platform including all stakeholders involved in the European emergency field (i.e. more than 1,200 emergency services representatives) (EENA website). Although the one with EENA is its first official partnership, DJI is not new to the emergency services as several American NGOs have already purchased and deployed its C-RPAS (Reagan, 2016).

Together, DJI and EENA started a one-year experiment on May 2016 with the purpose of seeking ways to integrate the deployment of drones into humanitarian missions and understand how their technology could benefit rescuers within different scenarios, environment and conditions (DJI website). The project has provided selected teams of pilots in Europe with the most up to date aircraft technology equipment, including DJI's ready-to-fly Phantom and Inspire drones, its M100 platform and Zenmuse XT thermal-imaging system (DJI website). The Phantom drone can fly for 28 minutes, has 5km of flight range and a market price of $1,199.00 (Figure 5.13.) (DJI website). The

Inspire drone can fly for 22 minutes, has 4,5km of flight range and a market price of $1,999.00 (Figure 5.14.) (DJI website). M100 is a customizable and programmable flight platform with a market price of $3,299.00 (DJI website).

Figure 5.13.: The Phantom drone. Source: DJI website

Figure 5.14.: The Inspire drone. Source: DJI website

The first two selected pilot sites are the Greater Copenhagen Fire Department in Denmark and the Donegal Mountain Rescue Team in Ireland (EENA website). Since rescuers in Ireland are already deploying advanced software applications to coordinate search-and-rescue missions in remote areas, the focus within the latter site is on improving real-time networking capabilities and crowd-sourcing techniques (DJI website). Instead, the focus in Copenhagen is on drone applications for fire fighting, chemical accidents and larger car accidents (DJI website). Prior to the beginning of the on site test operations, DJI has provided a 3-days workshop to train pilots on the most important features of drones' technology such as the hardware components, flying instructions and safety provisions (EENA website). After this specialized training, the companies are keeping in constant touch to oversee the deployment of drones in rescue missions and share the relating best practices (EENA website). Throughout the experiment, teams additionally receive instructions, support and guidance on an on-going basis concerning the development of applications through the DJI's software development kit (DJI website). The latter fact relates to the open innovation attitude towards technological progress of DJI. At the end of the experiment, DJI and EENA will share their gatherings with the whole international emergency-response community to provide evidence that drones can be deployed safely and effectively within humanitarian missions (DJI website). Mr Durscher from DJI's staff said: *"Drones are transforming the way first response operate by not only helping commanders make faster, smarter and better informed decisions, but also by providing first responders with more detailed information from an aerial perspective. The technology is easy to deploy and can be used in dangerous situations without risking pilots' lives"* (DJI website).

After the first months of experimentation, though, some challenges have arisen. First of all, rescuers are not professional developers so that to fly a drone is not easy for most of them and thus they have to practice it a lot (Scott, 2016). Secondly, DJI's C-RPAS are affected by limitations in their technology such as the battery life, the ability to fly in bad weather conditions and the struggles in communicating with the emergency services' IT systems, which is actually harder than controlling a drone (Scott, 2016). On its part, EENA looks forward to overcome the challenges in data analysis and integration to fully benefit from the deployment of drones into emergency (Reagan, 2016). Lastly, people at the management levels of NGOs are sceptical towards the use of C-RPAS (Scott, 2016). However, while first responders learn how to pilot quadcopters, DJI becomes more likely to penetrate the emergency market (Meola, 2016).

6. Cross-Case Analysis

The cross-case analysis is performed discussing at first instance similarities and differences between the single cases. Data have been compared a second time along the dimensions of technology, uncertainty and needs. The purpose is to shape the first hypotheses. Comparisons are made afterwards with regard to conflicting and similar literature. Lastly, closure is reached concerning the quintain by drawing from the answers to the research questions.

6.1. Shaping Hypotheses

The companies selected for the research are all European-based NGOs founded within the last three years and operating within the Central Mediterranean Sea to save the lives of refugees escaping violence and poverty at their home countries on small vessels. By comparing the companies' fundamental data (Figure 6.1.) it is possible to make some preliminary observations:

- The relative size of the concerned NGOs ranges from small to large and the largest one is also the one with less months of activity;
- All companies aim at saving lives, but the core ambitions of SW and SOS Méditerranée also include raising public awareness through the testimony of their daily activities;
- While all deploy a ship, MOAS also leases two camcopters and SW is about to launch its aerial surveillance with a microlight airplane;
- On average and notwithstanding neither the number of missions nor the months of inactivity, MOAS and SOS Méditerranée have saved so far a number of lives per month that is close, with MOAS currently ahead by about 100 lives per month. SW have averagely saved half of the refugees of the other two on a monthly basis;
- Sea-Watch 2 has half the capacity of crewmembers and refugees of the Aquarius and can host 5 crewmembers and 50 migrants less than the Phoenix. The Phoenix can host 200 less migrants and 7 less crewmembers on board than the Aquarius;

- Both MOAS and SOS Méditerranée cooperate with Doctors Without Borders and the MRCC, while Human Rights at sea is in partnership with both SW and SOS Méditerranée. All NGOs have currently four cooperation's;
- The estimated monthly operating costs of MOAS are almost twice as much the ones of SOS Méditerranée.

Company	**MOAS**	**SW**	**SOS Méditerranée**
Relative Size	Medium	Small	Large
Mission	"No one deserves to die at sea"	"Saving lives, testify ad find imitators"	"Saving human lives, protecting and assisting, raising public awareness"
Months of activity	23	12	6
Number of lives saved	25,000	5,600	5,600
Equipment	One ship, two speedboats, two drones	One ship, two speedboats, one aircraft	One ship
Ship	Phoenix (40 metres)	Sea Watch 2 (33 meters)	MS Aquarius (77 meters)
Capacity	20 crew people, 300 migrants	15 crew people, 250 migrants	27 crew people, 500 migrants
Cooperation	MRCC, Doctors Without Borders, Schiebel, Emergency	Watch The Med, Human Rights at Sea, HPI, MRCC	MRCC, Doctors Without Borders, Doctors of the World, Human Rights at Sea
Operative base	Malta	Lampedusa	Palermo
Estimated monthly operating costs	$600,000	n.a.	$372,000

Figure 6.1.: Fundamental Data. Source: personal elaboration

For what concerns the search-and-rescue activities, all three companies carry them out in a similar manner: they receive the coordinates of the vessel in distress at sea, reach its location, carry the migrants on board and provide them with medical care. It is also possible for them to spot some vessel at sea, in which case they either transmit the coordinates to other emergency boats or perform the rescue themselves. While MOAS and SOS Méditerranée bring the rescued to Europe, though, SW waits for other ships to perform the task. Nonetheless, the greatest differences are to be found in how they spot the small boats of refugees and their locations. Notwithstanding funding, surveillance tasks are the most challenging according to the NGOs since they involve limitations in human capabilities and technology when attempting at pinpointing the exact location of a call for help or patrolling a determined area. Indeed, saving as much time as possible in doing so is vital when it comes to emergency response. As SOS Méditerranée's crew still relies on sight and binoculars, MOAS and SW have tried to make the surveillance process more efficient and less time-consuming. SW has in fact established a partnership with HPI, which provides a microlight airplane for surveillance. Being able to cover a wider area of sea in less time than any ship and thus also saving costs and efforts, Sea-Watch Air is expected to overall quicken their rescue operations. Furthermore, the aircraft will not be affected by challenges such as the limited sight at sea that instead is heavy on SOS Méditerranée rescuers. As of today, SW has saved half the lives per month compared to SOS Méditerranée, which makes sense because its ship holds half the capacity and crewmembers. Sea-Watch Air is expected to improve SW's performances in terms of lives saved on a monthly basis. Despite the above-mentioned advantages, though, both SW and SOS Méditerranée's activities are paused or even terminated in cases of bad weather or dangerous situations in order to prevent the lives of crewmembers from being put at jeopardy. The latters do not stop MOAS instead. Its deployment of camcopters is in fact dependent neither on weather nor on other external factors because the pilots are on station and consequently safe all of the time. The absence of a pilot aboard also removes other human limitations such as poor night view, which still concerns the pilot of an aircraft. Moreover, C-RPAS bring along the same advantages as SW's microlight airplane in that they allow speed and broader geographical scope and consequent savings in time and efforts (Figure 6.2.). The same evidence is presented by the DJI experiment, which demonstrates drones' potential of helping commanders in accelerating the decision-making process by providing detailed information in advance dealing with the situation they are about to face.

		Microlight Airplane	**Camcopter**
SIMILARITIES	Time to patrol the area	Less	Less
	Patrolling area	Wider	Wider
	Precision in pinpointing locations	Enhanced	Enhanced
	Communication	With MRCC	With MRCC
DIFFERENCES	Pilot	One	Three
	Termination due to weather	Yes	No
	Human limitations	Yes	No
	Cost	$35,000-$100,000	$2,75 millions

Figure 6.2.: Comparison between aircraft and drones technologies in emergency. Source: personal elaboration

The disrupting attributes of C-RPAS are even more emphasised if the performance of MOAS is compared to the one of SOS Méditerranée. The former has indeed saved more lives per month with less capacity to host migrants and seven less crewmembers than the latter. Hence, it can be presumed that MOAS is more efficient in its operations *ceteris paribus* and that its enhanced efficiency comes from its better technology, that is to say from the two camcopters. Furthermore, while MOAS holds a no deaths record, the crew of SOS Méditerranée does not. Albeit the fact that specific circumstances have to be taken into account and for this reason it is not possible to state that it is entirely due to the deployment of drones, it can be assumed that at least part of the difference in their deaths record might come from the deployment of drones. The psychological challenges faced by the Aquarius crew could also be overcome by using UAVs, which are estranged from emotional components and the need to rest. As a consequence, the first hypothesis is:

The integration of C-RPAS into emergency response is able to improve the NGOs' performance along the dimensions of efficiency, efforts and speed. This improvement is expected to be superior compared to the one coming from aircraft technology due to the lack of entailed human limitations.

MOAS deploys drones in surveillance and communication tasks because their technology fits with the sea environment and responds to their most acute need of going beyond human limitations. The same use is currently being experimented by DJI and EENA within their selected pilot sites in Denmark and Ireland. SOS Méditerranée would deploy C-RPAS for the same tasks, given the same perceived needs. Subsequently, a second hypothesis is:

The most beneficial deployment of drones into rescue operations is to perform surveillance and real-time intelligence tasks.

One could argue that drones have their setbacks and major ones at that. According to the insights from MOAS and DJI, pitfalls and potential hampering factors to their adoption are to be found mainly in costs and regulations. The monthly operating costs of MOAS almost double the ones of SOS Méditerranée despite the fact that the

Phoenix is smaller than the Aquarius. This cannot obviously be entirely related to camcopters, but still it underlines the trade-off between better technology and increasing need for funding. While a microlight airplane has a market price of $100,000 at most, MOAS's camcopters together costs $5,5 millions. If on the one hand for many organizations it would be a worthy investment because of its long-term expected benefits and returns, on the other hand NGOs survive on donations representing a volatile source of income. The uncertainty that companies such as MOAS, SW and SOS Méditerranée face deal with the future of their activities as periods of low donations' volumes correspond to periods of inactivity. As a consequence, they might not be willing or even able to stretch their finances by leasing C-RPAS. This is a great limitation to the adoption of drones into the emergency market. The DJI's Phantom and Inspire drones are far cheaper: together with the M100 platform they cost averagely $5,000 each, which is less than the minimum market price for microlight airplanes (i.e. $35,000). However, alongside the difference in price comes the difference in performances. While Schiebel camcopters can fly for six hours and have a flight range of 200 km, DJI's ones have a flight time of half an hour and a flight range of 5 km. Furthermore, Schiebel drones have no reported difficulties neither in communicating with the emergency IT systems nor in flying in bad weather conditions as DJI's ones. In addition to this, only one pilot is needed for flying the microlight airplane, while to control the camcopters at least three people are required, which further increases the overall costs of deployment. A first solution to drive down the costs connected to UAVs' technology is cooperation, as claimed by the founders of MOAS. SW has not indeed bought or leased the aircraft since its partner HPI provides it. Partnering organizations on all the concerned emergency boats provides medical care. Likewise, if companies like DJI partner with NGOs to provide C-RPAS, the savings would be remarkable and game changer in the short-term from an adoption rates point of view. In addition to this, in the long-term drones are expected to drive down costs themselves through their operations. Thus, another assumption is:

The higher market price of C-RPAS will not be sufficient to hinder their adoption into this field, even though it might be slowed down because of them.

Dealing with regulation, the need for a harmonized European law on drones' usage is definitely acute. Nonetheless, MOAS has been able to deploy C-RPAS without incurring in any lawsuit so far. Again, the lack of dedicated regulation might slow down the adoption rate but not completely halt it. The true point is in fact not the lack of harmonized laws, but rather the risk of inception of a restricting one that would limit the deployment of quadcopters within all fields. Oppositions coming from scepticism towards privacy and safety issues exist worldwide when it comes to drones, especially since they are commonly associated to warfare. Experiments such as the one made by DJI in partnership with EENA that has large visibility may help in weakening oppositions by shifting drones' association from killings to humanitarian operations. Furthermore, the experiment will also provide evidences of their most valuable attributes and how they cannot be substituted with other technologies to the latter extent. On the one side, rescuers are trained in controlling C-RPAS for free. On the other, manufacturers become more likely to penetrate the emergency market. Although it might not be the most profitable one given the prospect of not for profit partnerships, in fact, it would certainly help with their brand image and in fostering the spreading of drones' deployment into other industries. Positive brand associations would reduce scepticism and oppositions by giving C-RPAS legitimacy, which in turn would subsidize the need for restricting regulations. The last hypothesis is:

Regulation might prevent the adoption of drones but that will become more and more unlikely as their attributes are enhanced in connection to humanitarian operations spreading their usage to other fields.

6.2. Revolving to Literature

It has been already established that C-RPAS represent a trajectory shift within the new drone paradigm shifting the path of improvement from military to civilian markets. Alongside the penetration of civilian markets, new attributes have been created like the degree of autonomy, ability to fly in bad weather conditions, communication efficiency and small size. In short, commercial drones are a technological breakthrough. As such, they are introducing a new S curve whose performance is expected to cross the aircraft's one by outpacing its progress and ultimately bringing along a disruption (Sood and Tellis, 2005). C-RPAS are indeed superior to microlight airplanes in performance, as they do not suffer from human limitations like the need to rest or bad night view. To this extent the first hypothesis is consistent with the theory: camcopters provide NGOs with invaluable attributes that make them superior to aircrafts with regard to emergency response.

The nature of commercial drones' technological progress is nowadays incremental rather than radical, so that the uncertainty connected to technology is medium-low and there is still room for major improvements. In fact, their development is currently fast-paced and undertaken according to an open innovation attitude. Throughout its experiment, DJI does indeed stimulate rescuers in developing features that will better serve their needs, which in turn serves two different purposes: fill the gap in competencies without incurring in additional costs (Mc Dermott, 1999) and gaining deeper understanding of the market and the technology through informal networks (Mc Dermott, 1999). This will ultimately reduce uncertainty in technological development (Mc Dermott, 1999). When it comes to the customer base, the alignment with the current one is definitely low since the shift is from soldiers to rescuers. Combining it with a rather high maturity in technological design, the situation at hand is of "New application or Combination of technologies", where a novel solution is provided to an identified need (Leonard-burton, 1998). In other words, the situation is one of technology transfer from military to emergency (Leonard-burton, 1998). While RPAS are well understood in warfare, NGOs have little experience of them. Yet, their need for more efficient and less time-consuming surveillance activities is well known.

This confirms the second hypothesis of drones being best deployed into emergency services for surveillance and real-time intelligence tasks. Facts are consistent with the theory also dealing with the commercialization issue as for instance SOS Méditerranée is rejecting the new technology due to lack of interest despite the reduced technological uncertainty (Bower and Christensen, 1996). On its part, DJI is deploying new market research techniques like lead user analysis, empathic design and market experimentation to overcome the latter issue. Pilots in Denmark and Ireland are currently getting familiar with C-RPAS while developers observe and interact with them, thus making sure of understanding the market and developing the "right" product for them. Complementing exploration, effectuation is the proactive creation of a new market through the interaction between the involved stakeholders (Sarasvathy and Dew, 2005). The involved stakeholders in this case are NGOs and rescuers who aims at carrying out their humanitarian operations more efficiently, developers who seeks new application for drones' technology, manufacturing companies aiming at gaining legitimacy for their products and make profit and governments who are favourable to the spreading of drones into civilian markets. Given the relevance of these ambitions and the close interactions between the latter players, it can be presumed that C-RPAS will penetrate and disrupt the emergency market. Evidence is provided also by the expected growth of the market by 4,8% compound annual rate (PRNewswire, 2016). However, dealing with the NGOs involved in this case study, the adoption rate is slow and the case can be replicated across the field. It has been previously stated that this is mainly due to regulations and costs. The main advantages in deploying C-RPAS for rescue operations gathered from MOAS, DJI and EENA and the expected ones gathered from SOS Méditerranée are the same presented by the literature: data provision and precision in targeting. However, while DJI's drones' limitations are the same as the ones gathered from the theory including communication, flight duration and range and bad weather conditions, this is not true for MOAS. The company deploys in fact commercial camcopters weighting 100kg and thus pertaining to the mini-drones category, which is not meant for recreational purposes also because of its costs. Adner (2002) claims that technology substitution happens when the customers' current needs are satisfied because they start to value other attributes and more specifically the absolute price. Moreover, disruptions are likely to occur at later stage of the breakthrough's development, when customers care about lower absolute prices more than about worse price/performance offerings (Adner, 2002). Bower and Christensen (1995 and 2006) additionally argue that technological breakthroughs can be identified by their lower prices compared to the existing offering. Yet, the empirical evidences of the case study seem to suggest that the reverse is true: the existing aircraft technology is cheaper compared to the new one of camcopters, whose performance is actually more than able to satisfy NGOs. Additionally, companies seem to value more the lower prices of binoculars and microlight airplanes than the superior performance of C-RPAS. Even more, they do not care about incremental improvements in neither technology. Albeit the fact that C-RPAS are a technological breakthrough, that DJI and EENA are testing the market with the aim of penetrating it, that the involved stakeholders are interacting to commercialize them and that forecasts about market growth lead to presume that a disruption is about to occur, scholars contradict the latter assumption. A possible explanation reconciling the literature with the case is to be found within the peculiar nature of the emergency market. NGOs are indeed bounded to donations in order to survive and survival is not dependent on performance. More specifically, MOAS is the one currently saving more lives but if people stop funding its operations due to lack of interest, the company would face failure and inactivity notwithstanding its successes. The prospect of driving down the costs on a long-term horizon is not game changer for drones' adoption rates since the uncertainty connected to the cash inflows of NGOs might not guarantee a long-term horizon at all. Their priority is saving lives, but it is somehow overshadowed by the need to survive in order to do so. There is no literature dealing with the disruption of not for profit markets by technological breakthroughs like drones. Hence, drawing from the empirical evidences gathered from this research it is possible to state that the penetration of the emergency market might follow different patterns concerning prices and performances. The assumption is that further technological development will reduce market prices for C-RPAS in the near future, which will enable the actual disruption. For instance, the increased autonomy of UAVs will make it easier to fly them and reduce the amount of training needed as well as the number of people required to control one vehicle (Rao et al., 2016). In the meantime, partnerships and experiments will continue educating the market and the lead customers.

6.3. Reaching Closure

Going back to the research questions is instrumental to sum up the points that have been made throughout the cross-case analysis and to address the quintain and the research objective.

1. *How emergency activities are currently carried out by each NGO?* MOAS, SW and SOS Méditerranée carry out their emergency activities following the same schedule but deploying different technologies when it comes to surveillance tasks. More specifically, MOAS leases two drones, SW has partnered with HPI to launch its aerial surveillance through the use of a microlight airplane and SOS Méditerranée relies on binoculars and human sight. The deployment of different technologies has led to different performances. If the number of lives saved per month is taken into account as a fundamental key performance indicator, as of today MOAS is the better performing company. Although Sea-Watch Air is expected to increase the performance of SW, the disrupting attributes of MOAS's camcopters are likely to outpace the ones of the microlight airplane. In other words, MOAS is expected to maintain the best performance because its emergency activities are not paused or terminated due to bad weather or dangerous conditions thanks to the absence of a pilot on board its vehicles.
2. *What are the similarities in the NGOs' needs?* Recurring needs within the three organizations are raising public awareness with regard to the dying migrants' issue in order to increase their donations' volume and be ultimately able to save more lives and being more efficient in their rescue operations. With the

shared main objective of saving lives, donations and technology are the two enabling factors concerning a better performance. To be more efficient, in fact, NGOs need to save time, efforts and costs. The deployment of drones has proved to serve the latter need as it allow less time-consuming operations, more precise data to be obtained in advance and the ability to patrol a wider area of sea. However, efficiency is somehow conflicting with the need for increasing availability of funds because the cost of drones' deployment is rather high when compared to the one of other less efficient technologies like binoculars or airplanes. This is due to the technology's components, the fact that more than one person has to fly the C-RPAS and the time required for training. As the technology development goes further, increased autonomy and easiness in control are expected to reduce both the number of pilots and the need for training. Cooperation with C-RPAS' manufacturers aiming at gaining legitimacy will drive down the costs of deployment and increase interest towards the emerging technology as well. Experimentations with the objective of integrating drones into humanitarian operations will both educate rescuers and raise awareness towards the potentially invaluable benefits of deployment, this way possibly increasing also the volume of donations to lead users NGOs. In turn, incremental innovations and increased deployment will drive down the production costs and thus the market price of camcopters. Eventually, C-RPAS will drive down NGOs' operating costs in the long term thanks to the increase in efficiency that they bring along.

3. *Is emergency a potentially profitable market for C-RPAS?* Emergency is indeed a potentially profitable field for the deployment of drones, even though it might not be the most profitable one amongst all civilian markets. The interests in saving more lives, gaining legitimacy thanks to the positive associations with humanitarian operations and spreading the overall use of drones by overcoming oppositions are motivating stakeholders to contribute in the development of drones and penetration of the emergency market. The expected growth rate indeed equals 4,8% per year. However, the prospect of

cooperating with NGOs hinders the potential profit. The gaining are thus mostly in the long run than in the short run profits and probably more strategically than monetary. Furthermore, the uncertainty connected to regulations may represent a great limitation to profitability and success in commercialization and deployment of C-RPAS. Again, experimentation aiming at showing the benefits of drones' integration into rescue activities and technological development can reduce oppositions by reducing the concerns over privacy and safety. Reducing opposition will in turn reduce the need for a restricting regulation, this way eliminating uncertainty to the latter extent.

4. *How can C-RPAS be deployed within the emergency market?* As claimed by MOAS, SOS Méditerranée and pilots involved in the DJI experiment, the most beneficial deployment of drones into emergency response is surveillance and real-time intelligence thanks to the attribute of precision in targeting and data gathering. Moreover, as the technological development progress, commercial drones may be able to lift heavier payloads in the near future, thus performing relief as well.

The objective of this research was to explore and compare emergency practices to gather if C-RPAS are likely to be adopted and disrupt this field and how. So far it has been assessed that the likelihood of adoption is high due to their breakthrough nature, the valuable benefits that they bring along, the involved stakeholders' interest and the forecasts of growth. It is also expected that regulation and costs issues will not halt the adoption rates, but possibly slow them down. Nonetheless, scholars' contributions are contrasting with the prospect of drones' disruption when it comes to prices of breakthroughs, and lacking concerning the disruption of not for profit markets like emergency response. Since C-RPAS are expensive compared to aircraft and NGOs care more about prices than about new attributes and performances, the disruption is not likely to happen, this way making drones more like a fade into the emergency field. However, the very nature of NGOs' financials is different from the ones of other organizations. Additionally, the market price of drones is expected to decrease alongside further development and increases in experimentation and partnerships. MOAS's case and the DJI experiment are positive evidences dealing with the likelihood of disruption. As a conclusion, it can be said that C-RPAS will spread as a paradigm through the penetration of the emergency market involving NGOs and not only governments.

7. Conclusions

This dissertation is about the potential disruption of the emergency response market by C-RPAS. It arises from the increasing worldwide spreading of commercial drones, which is indeed a much controversial topic due to the discussions revolving around regulation, privacy, ethic and safety concerns. As of today, several commercial applications within civilian markets are available for drones' technology, among which the emergency field is the least explored one. The latter is due to the peculiar nature of not for profit organization as end customers, which undoubtedly hinders the potential for profits. However, several strategic benefits come alongside its penetration, such as legitimacy for RPAS that are traditionally associated with warfare. Furthermore, the attributes making drones valuable in military are the same that prove to be beneficial into humanitarian operations and include enhanced efficiency and reductions in long-term costs and efforts. In other words, military and emergency markets are indeed close to each other, this way enabling technology transfers. The little empirical and theoretical contributes as well as the sharpness of discussions concerning drones within emergency are the main reasons for investigating this topic. Even more, the branch of emergency on which the research is focused is subject to political and ethical discussions as well. Migrants trying to make the crossing from Libya to Europe in order to escape violence and poverty in their home countries on small illegal vessels and consequently dying at sea in the attempt are in fact a major concern from multiple points of view. NGOs that operate to save their lives are end customers for drone offerings and thus fit perfectly with the purpose of the study, which basically deals with two of the most controversial topics nowadays. The ultimate goal is to assess whether drones are actually about to spread into the emergency field and if their adoption is going to bring along a disruption or be only a fade. In order to gather the likelihood of disruption, the main questions to be answered by literature and empirical case studies deal at first instance with how humanitarian operations are actually carried out by NGOs. Through the provision of a framework for rescue activities, it is in fact possible to understand the main needs of the market and how C-RPAS could fit and solve them. Afterward, the investigation turns to the challenges that may halt the adoption of drones to assess the potential of the emergency market in view of penetrating it. This dissertation is to be framed within the innovation literature dealing with breakthrough innovations and new market creation techniques. Albeit several contributions by scholars provide definitions and strategies for technological breakthroughs, few of them regards new application of radical innovations and even less turn to commercial drones as a main topic. Subsequently, the discussion aims at adding some clarifications on C-RPAS and their technology as well as building a new theory concerning their disruption of the emergency market, this way also providing an insight about not for profit markets' disruption patterns. The methodology that has been adopted in order to achieve the above-mentioned objectives is the one of multicase study research. After having set the research questions and selected the cases, each of them has been analysed as a stand-alone entity through documentary sources and interviews. Data have been rigorously collected and then compared pairing the cases and along the dimensions of technology deployment, limitations connected to technology, limitations connected to the market and current needs. Additionally, comparisons with the existing similar and conflicting literature have been performed through a cross-case analysis. This methodology has been chosen because of the mainly qualitative nature of data and the lack of control over the involved actors' behaviour. More than one case has been selected since none of them is relevant or representative enough to induct a reliable theory basing on it. Furthermore, the cases provide a replicable sample that can be extended to all emergency fields as it varies in size of NGOs, adopted technologies and performances. The results have been quite striking in that the literature review led to the assumption that adopting C-RPAS for surveillance and real-intelligence tasks would have been cheaper compared to other technologies like airplanes. However, that has not been the case and, consequently, the need to reconcile empirical evidences with theory has pushed the assumptions further. The premises in terms of performance enhancement, long-term costs reductions and market profitability seem to indicate an imminent disruption of the market despite the challenges regarding technology development, scepticism and regulations. Nonetheless, the higher market price of C-RPAS is conflicting with scholars' assumption that breakthroughs are to be recognized because they are cheaper. One explanation for the contrasting results is that the peculiar nature of not for profit markets provides for a different pattern of disruption. Solutions like partnering with commercial drones manufacturers are presented as a mean to save costs and the technological development is assumed to reduce production costs and ultimately prices, this way enabling the actual disruption. The cross-case analysis confirms that emergency response is indeed a profitable market for C-RPAS, at least from a strategically perspective. Even more, it might be instrumental to legitimize their use within other industries, thus decreasing the likelihood of restrictive regulations. C-RPAS will in turn increase awareness toward emergency issues like dying refugees in the Mediterranean Sea, this way increasing also the flow of donations for NGOs in a positively reiterative cycle. As a conclusion, commercial drones are a paradigm that will spread across civilian market bringing along several disruptions among which emergency is to be found, that is to say a market at first glance far from the one in which they were incepted.

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Department of Business and Management

Chair of Strategic Management of Innovation

New market creation for technological breakthroughs: commercial drones and the disruption of the Emergency market (Summary)

SUPERVISOR
Prof. Andrea Prencipe

CANDIDATE
Maria Elena Manzotti
662901

CO-SUPERVISOR
Prof. Luca Giustiniano

Academic Year 2015-2016

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1. Introduction

The purpose of this study is to provide an in depth picture of commercial drones as a breakthrough innovation and to gather whether they are to disrupt the emergency market as a new application for their technology. From a literature review's perspective, lots of contributions concern radical innovations and new researches have been made on new market creation techniques. However, almost any of them regards drones and the disruption patterns of not for profit markets. Moreover, heated discussions revolving around ethical, privacy and safety concerns deal with the deployment of drones into civilian market nowadays. The objective of this dissertation is to provide a framework for drones' penetration of the emergency field and to gather if they will represent an actual disruption or only a fade. In order to achieve the latter, a literature review is provided at first instance defining breakthroughs and new market creation techniques as well as an overall picture of C-RPAS and their technological development and of the emergency market as a potentially profitable field. Afterward, the case study and relating methodology are presented. The selected cases focus on three NGOs operating within the Mediterranean Sea to save the lives of migrants trying to make the crossing from Libya and Syria to Europe. While Migrants Offshore Aid Station deploys two camcopters into its humanitarian operations, Sea-Watch and SOS Méditerranée do not. Additionally, the experiment made by the leading drones manufacturing company Dji to tech European rescuers how to pilot C-RPAS is analysed. Lastly, a cross-case analysis is performed to provide reconciliation between literature and empirical results and ultimately uncover the future of commercial drones into the emergency market.

2. C-RPAS as Technological Breakthroughs, New Market Creation Techniques and the Emergency Market: a Literature Review

2.1. Technological Breakthroughs and Uncertainty

This dissertation aims at defining breakthrough innovations without giving any new contributions to the latter extent. Consequently, three theories are taken into account as somehow related and consistent between each other: Technological Paradigms, Technology S curves and Performance Trajectories. A technological paradigm is *"a pattern of solution of selected techno economic problems based on highly selected principles derived from the natural science, jointly with specific rules aimed to acquire new knowledge and safeguard it, whenever possible, against rapid diffusion to the competitors"* (Dosi 1988, p. 1127). Therefore, it can be said that it is a tool providing the boundaries and directions for technical change, within which innovations are incepted. A technological trajectory can be defined as *"a cluster of possible technological directions whose outer boundaries are defined by the nature of the paradigm itself"* (Dosi 1982, p. 154). Once a determined technological trajectory reaches its highest level within the relevant technological paradigm, this "ceiling" is called technological frontier (Dosi, 1982). When the frontier is reached and a technological problem is still not solved, it is possible to either change trajectory or to shift to a new paradigm. Both are defined as technological breakthroughs. Foster (1986) claims that the performance of technologies follows an S-shaped path when plotted against the cumulative engineering effort involved in its development. At first, the performance of a technological breakthrough is inferior compared to the one of an already growing and stable technology (Foster, 1986). If over time the new S curve crosses the old, the new paradigm will be superior and a technology disruption occurs (Adner and Kapoor, 2016). Lastly, performance trajectories are *"the rate at which the performance of a product has improved, and is expected to improve, over time"* (Bower and Christensen 1995, p. 45). Technological breakthroughs are eventually defined as *"technologies that disrupt an established trajectory of performance improvement or redefine what performance means"* (Bower and Christensen 1996, p. 202).

The development process of a breakthrough is associated with greater risk compared to the one of less innovative products because of the uncertainty dealing with its underlying technology and end market (Deszca et al., 1999). Technologically speaking, it is in fact difficult to determine its market potential, that is to say whether it is an actual breakthrough, and which pattern to follow throughout its development (Deszca et al., 1999). From an end market point of view, instead, customers have no experience of the product so that it is difficult to exert knowledge from them regarding for instance preferred products' features (Leonard-Burton, 1998). New market research techniques such as lead users analysis, empathic design and experimentation with prototypes help to the latter extent (Leonard-Burton, 1998). Combining uncertainty along the maturity of technological design and uncertainty along the degree of alignment of the technology with the current customer base, it is possible to identify the new market creation frontier as where developers cannot be certain whether they have identified the right market and ask themselves who actually the customer is (Leonard-Burton, 1998).

2.2. New Market Creation Techniques

A major insight dealing with the attempt to create opportunities for technological breakthroughs comes from Lynn et al. (1996) and their "probe and learn" method, which brings along the introduction of an early version of the product into an initial market. Through subsequent modification affecting both the prototype and the initial market and basing on previous learning in a reiterative process, uncertainty is reduced by a good measure (Lynn et al., 1996). However, it is an expensive and resource-consuming method. Alternatively to market exploration, Sarasvathy and Dew (2005) developed the effectuation theory where, reversing the logic, the starting point is the creation of a network of stakeholders that increase resources while adding constraints to future goals, this way shaping the product's features and, eventually, the new market. While developers look for an already existing "right" market through exploration, through effectuation they create the new market from scratch by interacting with other players. Aiming at assessing why customers should suddenly start to value new attributes and give up the current preferred ones for them, Adner (2002) argues that the reason behind the substitution and consequent disruption is that customers do not actually care about the new attributes but rather about their absolute price. When current needs are satisfied, in fact, the marginal utility from performance improvements is decreasing, which in turn makes the willingness to pay for incremental innovation decreasing as well (Adner, 2002). Price is irrelevant at the embryonic phase of the breakthrough NPD process because the performance is not yet able to fully satisfy users. Hence, disruptions are more likely to happen during the later stages of the development, when customers care about lower absolute prices more than about a worse price/performance offering (Adner, 2002).

2.3. Drones as Technological Breakthroughs and their new Commercial Applications

According to the International Civil Aviation Organization, a Remotely-Piloted Aircraft (RPA) is *"an aircraft piloted by a licensed remote pilot situated at a remote pilot station who monitors the aircraft at all times. RPA is a subset of Unmanned Aircraft"* (ICAO 2011, p. 7). The Remotely-Piloted Aircraft System (RPAS) *"comprises a set of configurable elements including an RPA, its associated remote pilot station(s), the required C2 links and any other system elements as may be required, at any point during flight operation"* (ICAO 2011, p. 8). The inception of drones is rooted into the military industry since R&D activities started during World Wars Ⅰ and Ⅱ with two major UK drone programs: Larynx and Ram. Their first civilian applications occurred in 2005, when the rescue effort following Hurricane Katrina saw the deployment of military drones in the US to look for survivors (Rao et al, 2016). Size is the base on which to pinpoint different categories of drones with 150 kg being the threshold to distinguish between M-RPAS and their smaller commercial counterparts, C-RPAS (Clarke, 2014). Depending on size, other two important attributes of RPAS vary: the range of flight (from few feet around the operator to over 17,000 miles) and the flight altitude (from few feet to a maximum of 65,000 feet) (Rao et al., 2016). As of today, most commercial drones have a similar design (Figure 3.2.) including "*a microcontroller* *with four to eight motors and propellers, a radio receiver, electronic speed control and a battery built on a light plastic or metal frame"* (Rao et al. 2016, p. 84). When it comes to the development of C-RPAS, leading companies such as DJI, invite communities of enthusiast to participate in the development process of their open source hardware and software projects (Rao et. al, 2016). Moreover, the NPD process of drones is parallel to the one of computing, sensors and robotics (Clarke, 2014), from which they inherit both opportunities and setbacks. Several challenges are connected to C-RPAS' technology, including: communication, unpredictable behaviour, load capacity, flight duration, geographical range and speed and bad weather conditions, on which development trends are focusing (Clarke, 2014). Drones are a major technological breakthrough in that they entail a paradigm shift from having a pilot on board the aircraft to flying without one. In addition to this, it can be said that they represent a major technological breakthrough in Robotics as well, shifting paradigm from land robots to flying ones. They redefined performance trajectories as compared to manned aircrafts by creating new valuable attributes like stealth, longer geographical range of flight and lower risk to personnel, as well as new markets. Commercial drones are to be considered as another technological breakthrough coming from a shift in trajectory from military to civilian within the new UAS paradigm. The reduction in size, in fact, leads to the creation of new markets beside the military one and to new directions of technical change (Clarke, 2014). The global expenditure on commercial drones has been $700 million in 2014 and the market size for their related services is expected to equal the one of hardware sales within the next three years (Rao et al., 2016). As of today, the primary commercial application areas for RPAS are agriculture, delivery, hobby, photography, journalism, law enforcement and emergency services (Clarke, 2014 and Rao et al., 2016). However, several factors are hampering the adoption of commercial drones, including the lack of a dedicated regulation and safety and privacy issues (Rao et al., 2016).

2.4. The Emergency Market

Dealing with the hardware component of RPAS, their most valuable attributes in military are essentially the same as for emergency activities: surveillance, load carrying and targeting (Sandvik and Lohne, 2014). This technology transfer from military to emergency is due to the development process of drones, but also to the interaction of different stakeholders, namely developers and politicians aiming to gain legitimacy for the UAVs industry against oppositions (Sandvik and Lohne, 2014). Subsequently, it is the result of a mix of experimentation and effectuation. It can be said that although the technology of C-RPAS is not mature, its development paths may be a premise for *"more efficient and less costly emergency response and relief"* (Mosterman et al. 2014, p. 260). Yet, it is still unclear if the deployment of C-RPAS in this field will be an actual disruption or just a fade (Sandvik and Lohne, 2014). Notwithstanding the several advantages like speed, efficiency and safety, there are still barriers to the adoption of drones such as lack of regulations and ethical, safety and privacy issues (Sandvik and Lohne, 2014).

3. The Case Study Research

Dealing with C-RPAS, field such as delivery and agriculture are under the spotlight because their size and potential are huge. Humanitarian activities, instead, are still quite untapped from an empirical point of view and developers are not sure whether emergency actually represents a profitable market for drones' integration. The use of drones in this field is indeed at its embryonic stage, both technologically speaking and as a concept (Sandvik and Lohne, 2014). Subsequently, the aim of this research is to explore and compare emergency activities among different NGOs to gather the likelihood of drones' adoption and consequent disruption of the emergency industry. The case study research aims at understanding unknown dynamics within real life settings (Eisenhardt, 1989) and thus is particularly suitable when research and theory are at their early stages (Darke et al., 1998). Moreover, there is no control over the involved actors' behaviour and little prior empirical evidence is available, so that an experiment would be unsuitable as a research strategy. Therefore, the case study research has been chosen as a research strategy. Given that no single case is representative or relevant enough to formulate a general theory, a multiple case study approach has been used. The interest in the single cases is instrumental to understand the broad theory (Stake, 2013). Each case study is analysed as a stand-alone entity at first instance and afterwards related to the others in order to gather the relating differences and similarities. The underlying assumption provided by the literature review is that C-RPAS are a technological breakthrough and that civilian markets provide several opportunities for disruption. The quintain of this research is the deployment of drones by NGOs in their surveillance, rescue and first aid activities. The foreshadow problem is that few companies within the emergency market actually deploy C-RPAS, therefore it is uncertain if they will cause a disruption or if their commercialization will be a failure instead. The following research questions have been addressed:

- How emergency activities are currently carried out by each NGO?
- What are the similarities in their needs?
- Is emergency a potentially profitable market for C-RPAS?
- How can C-RPAS be actually deployed within the emergency market?

Since humanitarian activities are broad in nature and geographic scope, the research focuses on surveillance, rescue and first aid at sea in the Central Mediterranean area.

Nowadays, Libya and Syria are among the most violent places in the world, so that migrants undertake journeys on small vessels to escape poverty, violence and wars. The latter issue has raised public awareness in recent years due to the ethical and political discussions revolving around it as well as the several deaths caused by shipwrecks. Hence, the government and several NGOs are acting to fill the absence of large-scale humanitarian operations and save the lives of refugees. Moreover, NGOs are end customers for drones offering because they may benefit exponentially from its critical attributes and are currently experiencing limitations in their ships' technology for surveillance and rescue activities. Among the others, Migrant Offshore Aid Station, Sea-Watch and SOS Méditerranée have been chosen to develop the case studies.

Christopher Catrambone founded Malta-based Migrant Offshore Aid Station (MOAS) by the end of 2013 (MOAS website). Following the end of Mare Nostrum initiative by the European Union, a group of private citizen from Germany founded Sea-Watch (SW) in 2014 (SW website). Captain Klaus Vogel co-founded SOS Méditerranée in May 2015 (SOS Méditerranée website). Despite the similarities that are to be found in their activities and geographical scope (i.e. rescues of migrants within the Central Mediterranean Sea), several differences are to be found among the way they carry out their humanitarian operations. While the former deploys two camcopters for its missions, in fact, the latters respectively use a microlight airplane and binoculars. They also differ in size and thus provide for a complete and representative sample.

Besides the multiple case studies, evidences have been gathered from an experiment held in Europe by the Chinese company DIJ starting in May 2016 to train European emergency workers to pilot C-RPAS for rescue missions. The experiment has the purpose of promoting the integration of drones into humanitarian operations (DJI website). Prior to collecting the data, background information about the companies involved in the sample have been gathered from documentary sources such as newspapers, newsletters and their websites, blogs and Social Media channels. Additionally, European regulatory frameworks as well as country news media relating to refugees issue have been reviewed to gain further understanding of the environment of the research. For what concerns the DJI experiment, technical journals, YouTube videos, annual reports and local newspapers are the main sources of data collection. Interviews were conducted via Skype Call with single individuals following a set of questions that were prepared in advance and ranged from fifteen to twenty minutes. The aim of the interviews was to provide an in-depth picture of the humanitarian activities carried out by the three NGOs, the challenges they face on a daily basis and the prospect of integrating drones within their operations to overcome them. One out of three NGOs has not been reachable, consequently the case on Sea-Watch has been developed basing solely on documentary sources. In order to provide a reliable and effective cross-case comparison, notes regarding interviews and documentary sources have been rigorously collected and stored within a dedicated database The cases have been compared in pairs looking for differences within the most similar ones and for similarities within the most distant ones. Additionally, different dimensions along which to compare the data have been chosen in order to look at them from a different perspective. The dimensions are: technology deployment, limitations connected to technology, limitations connected to the market and current needs. Conclusions were lastly drawn basing on this analysis and on the literature review.

3. The Cross-Case Analysis

For what concerns the search-and-rescue activities, all three companies carry them out in a similar manner: they receive the coordinates of the vessel in distress at sea, reach its location, carry the migrants on board and provide them with medical care. It is also possible for them to spot some vessel at sea, in which case they either transmit the coordinates to other emergency boats or perform the rescue themselves. The greatest differences are to be found in how they spot the small boats of refugees and their locations. As SOS Méditerranée's crew still relies on sight and binoculars, MOAS and SW have tried to make the surveillance process more efficient and less time-consuming. SW has in fact established a partnership with HPI, which provides them with a microlight airplane for surveillance. Being able to cover a wider area of sea in less time than any ship and thus also saving costs and efforts, Sea-Watch Air is expected to overall quicken their rescue operations. Furthermore, the aircraft will not be affected by challenges such as the limited sight at sea that instead is heavy on SOS Méditerranée rescuers. Despite the above-mentioned advantages, though, both SW and SOS Méditerranée's activities are paused or even terminated in cases of bad weather or dangerous situations in order to prevent the lives of crewmembers from being put at jeopardy. The latters do not stop MOAS instead. Its deployment of camcopters is in fact dependent neither on weather nor on other external factors because the pilots are on station and consequently safe all of the time. The absence of a pilot aboard also removes other human limitations such as poor night view, which still concerns the pilot of an aircraft. Moreover, C-RPAS bring along the same advantages as SW's microlight airplane in that they allow speed and broader geographical scope and consequent savings in time and efforts. The same evidence is presented by the DJI experiment, which demonstrates drones' potential of helping commanders in accelerating the decision-making process by providing detailed information in advance dealing with the situation they are about to face. MOAS deploys drones in surveillance and communication tasks because their technology fits with the sea environment and responds to their most acute need of going beyond human limitations. The same use is currently being experimented by DJI within the selected pilot sites in Denmark and Ireland. SOS Méditerranée would deploy C-RPAS for the same tasks, given the same perceived needs. Emergency is indeed a potentially profitable field for the deployment of drones, even though it might not be the most profitable one amongst all civilian markets. The interests in saving more lives, gaining legitimacy thanks to the positive associations with humanitarian operations and spreading the overall use of drones by overcoming oppositions are motivating stakeholders to contribute in the development of drones and penetration of the emergency market.

One could argue that drones have their setbacks and major ones at that. According to the insights from MOAS and DJI, pitfalls and potential hampering factors to their adoption are to be found mainly in costs and regulations. The higher market price of commercial drones as compared to other technologies provides a limitation. However, partnerships with drones' manufacturers and reduction in production costs over time will reduce it. The lack of a dedicated regulation is less worrisome than the possible inception of one restricting the use of commercial drones. Again, partnerships between manufacturers and NGOs will reduce oppositions. And decreasing oppositions will in turn reduce the need for a restricting regulation. Nonetheless, scholars' contributions are contrasting with the prospect of drones' disruption when it comes to prices of breakthroughs and lacking concerning the disruption of not for profit markets like emergency response. Since C-RPAS are expensive compared to aircraft and NGOs care more about prices than about new attributes and performances, the disruption is not likely to happen, this way making drones more like a fade into the emergency field.

Yet, the empirical evidences of the case study seem to suggest that the reverse is true. Moreover, the very nature of NGOs' financials is different from the ones of other organizations. There is no literature dealing with the disruption of not for profit markets by technological breakthroughs like drones. Hence, drawing from the empirical evidences gathered from this research it is possible to state that the penetration of the emergency market might follow different patterns concerning prices and performances. MOAS's case and the DJI experiment are positive evidences dealing with the likelihood of disruption. As a conclusion, it can be said that C-RPAS will spread as a paradigm through the penetration of the emergency market involving NGOs.

5. Conclusions

This dissertation is about new commercial applications for drones, which were incepted in military. More specifically, the research focuses on the emergency response market that at first glance is considered as the most far from warfare. In recent days, discussions revolving around privacy, regulatory and safety concerns on commercial drones are as acute as ever. Since there is a lack of literature concerning this topic, the study aims at building a theory to the latter regard: are commercial drones actually about to disrupt civilian markets? Is emergency among them? The multicase study research strategy has been selected as a methodology because the data are mostly qualitative and there is no control over the involved actors' behaviour. Three NGOs operating to save the lives of migrants in distress at sea in the Mediterranean are have been selected as a sample because heating discussions are affecting also this issue and rescuers might be lead users for drones' technology. Additionally, contributions were drawn from an experiment made by DJI to teach them how to fly drones. The empirical results coming from the cross-case analysis showed that emergency is indeed a market suitable for disruption. Moreover, being a not for profit field, the disruption by commercial drones follows a different path than other civilian markets. It can be concluded that commercial drones will spread among civilian markets and disrupt several of them, including emergency.

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