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Titel:

Achieving competitive advantage through standardization: a study of the effect of standardized operational procedures for the use of drones on the interoperability of the Danish outdoor drone industry

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Synopsis

The thesis examine whether the emerging Danish drone industry can achieve a competitive advantage in the global market of outdoor drone services by implementing international standards for the operational procedures for the use of drones. Standards in the drone industry are expected to gain the industry a competitive advantage on several operational and economic areas, thus the thesis has included a stepwise analysis of the relevance of standards in the drone industry and how they should be designed. The procedures is tested and found recommendable as the tests lead to the conclusion that even though following the procedures takes longer, the operation - measured on the safety during flight, the efficiency of the operation and the quality of the data collected - is more beneficial for the drone service company conducting it.

Christian Clemmensen Møller

Oplag: 1 stk.
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Achieving competitive advantage through standardization

A study of the effect of standardized operational procedures for the use of drones on the interoperability of the Danish outdoor drone industry.

Master of Science thesis
by Christian Clemmensen Møller

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Master of Science thesis
September 2017

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PREFACE

This Master’s Thesis has been conducted at Aalborg University during the period February 1st 2017 to September 2nd 2017 as a finalization of the Master's Degree program in Operations & Supply Chain Management at the Department of Mechanical and Manufacturing Engineering.

The thesis takes its theoretical foundation in selected elements from the subjects of the Master's program, including Total Quality Management and standardization regimes. Also an academic interest in the emerging Danish drone industry, which these years is growing increasingly market share at a global level, has laid the foundation for thesis. Danish drone service companies are well advanced in the development of components for drones, but especially in the use of drones as services for a wide range of industries such as agriculture, construction and media production, Danish drone service companies are currently among the world's leading in their field, thanks to ambitious national growth conditions.

The overall hypothesis of this Master’s Thesis is that the Danish drone industry can achieve a significant competitive advantage in the global market by implementing international standards for operational procedures for the use of drones. This is based on a hypothesis that international recognized operational procedures will partly increase the interoperability of the drone industry with foreign players, thereby strengthening its global growth conditions, partly enhancing safety in the use of drones while helping to streamline the operations of the Danish drone service companies and create better quality in their data collection.

READING GUIDE

The Master’s Thesis is structured with a mapping of the Danish drone industry in a global and national perspective followed by a examination of standardization regimes as a tool for companies to gain a competitive advantage in their market. Next, it is examined how the standardization of operational procedures for the use of drones can be designed to support the growth conditions of drone service companies as best as possible. The results are presented in the form of theoretically based operational procedures for the use of drones, which is subsequently tested by a Danish company engaged in drone services for infrastructure inspection, 3D mapping and agriculture analysis.

The sources of the Master’s Thesis are referred to with the author's last name as well as year for publication with a detailed bibliography at the end of the thesis. Figures as well is referred to with the author's last name as well as year for publication if not the figure is a product of this thesis. In that case no author is referred to.

PLEASE NOTICE

In this revised Master’s Thesis as of September 2nd 2017, all new sections and additional findings is marked with a green colour in agreement with the thesis supervisors in order to clarify for the reader where changes is located.

ABSTRACT

This thesis examine the emerging drone industry which is forecasted to solve current tasks more safely, efficiently and to a better quality. With Denmark as an active part of the global drone industry, the thesis examine whether the Danish drone industry can achieve a competitive advantage in the global market of outdoor drone services by implementing international standards for the operational procedures for the use of drones. The hypothesis for the research is that the Danish drone industry can gain significantly from such standards, as standards are expected to at the same time increase the interoperability with foreign companies, strengthen the Danish industry's global growth conditions, enhance safety issues in the use of drones, streamline the efficiency of drone operations and create better quality in the data collection.

The research has included a selected theoretical framework combined with thorough empirical sources and test data, which has been utilized in order to qualify the prerequisites and conclusions of the research. The thesis has examined which established standards there exist in the drone industry today. It is concluded that even though a lot of initiatives is going on, no applicable standards for the use of drones has yet been published. The thesis has also examined how related industries benefit from using standards and concludes that best practices from e.g. the wind and aviation industry. These could advantageously be implemented in the Danish drone industry in order to maintain the current competitive advantage, where Danish drone service companies holds a leading position. At last the thesis has examined how a standard for operational procedures for the use of drones could be designed, which subsequently has been designed specifically to the thesis' case company and tested in real drone service operations. The test has lead to a conclusion that even though following such procedures takes longer time before and after a drone operation, the operation itself - measured on the safety during flight, the efficiency of the operation and the quality of the data collected - is more beneficial for the drone service company conducting it, thus operational procedures is recommended and believed to contribute to the industry wide competitive advantage.

Based on the tests included, the major findings of this thesis is, that drone operations following the operational procedures makes a great potential for improving the Danish drone industry by positioning the industry as a leading part in the international standardization work. Such position would enable the industry to gain a competitive advantage globally. The findings in this thesis has not yet been implemented in the context of the Danish drone industry. Thus the thesis is intended to serve as an inspiration for future work regarding standardization in the Danish drone industry.

CONTENTS

CHAPTER 1: INTRODUCTION

The technological development of our globalized world is taking place at a increasing higher pace, where new technology with new applications is being created on a daily basis - such a technology as e.g. drones. In this race, it is relevant to question: how do we ensure that the emergence of new technology will actually be transformed into professional applications, that could form the basis for new business opportunities? According to the European Commission's Digital Agenda, one of the answers is standardization and interoperability (European Commission, 2010). The Danish Government (2016) is also dealing with these concepts focusing on increasing the export opportunities of Danish drone companies as well as companies in other industries by contributing to and applying a common set of international standards.

Across industries more and more new technology is emerging, becoming commercialized and widespread throughout the world. Often for the benefit of the people and businesses that are behind, the people and communities who use the technology on a daily basis - and in some cases also for the biggest worldwide challenges such as environmental pollution, humanitarian disasters and the overuse of natural resources. New technology has over time proved to be able to contribute to the solution to many challenges and make everyday life easier - no matter what part of the world and what level of challenges one consider. But new technology also creates new challenges for companies, people and communities who are to use it. Beginning is hard and often new technology is emerging from pioneering spirit instead of unified and quality assured international procedures that ensure an efficient, optimal use of the new opportunities. Thus new technology may be delayed in its dissemination if not completely forgotten in the race with other new emerging technologies - and no one will benefit. In other words, there is a need to handle the emergence of new technology with a unified and quality assured approach that at the same time validates technology's possible uses and provides a framework for using the technology in a way that enables global dissemination to benefit many businesses, people and societies as possible.

According to Hayden (2002) such a framework may be standardization. Through standardization, technology can be utilized globally across businesses, people and societies as it is applied in a unified and quality assured way around the world. It creates global growth potential as the road to global collaborations is more accessible. According to Hayden (2002) the keyword is interoperability across national borders, industries, branches and cultures which according to the European

Commission's Digital Agenda is a priority subject affecting Europe's overall economy (European Commission, 2010). Many technologies has already been standardized and thus the foundation for a global dissemination and application has been laid. Drone technology is one of the latest technologies on the market which undergo a rapid development, which has led to the creation of a whole new industry; the drone industry. Throughout the world, new applications emerge in relation to drone technology, which has already taken place in particular within media production, consulting, services, academic research and military use (Accenture, 2014). For companies around the world it means new business opportunities, but also global competition. Consequently it is a necessity to gain and maintain a competitive advantage that enables the company's service or product to achieve global dissemination - and one way of creating this is through standardized operational procedures (Danish Government, 2016). The Danish Government has taken into account the non-existing standardized procedures and has developed a national strategy for the use of drones, where one main focus area is participation in the ongoing cross-European work on standardization, which seeks to harmonize legislation and rules for the use of drones (ibid.).

1.1 MOTIVATION

The Master’s Thesis thus originate from a curiosity about how the rapidly growing Danish drone industry led by the Danish drone service companies can become interoperable with global players and thereby gain a competitive advantage in the global market. It is especially in the use of drones as services for a wide range of industries that the Danish drone industry is making its impact at the global level these years (ibid.). Thus the thesis will be based on the Danish drone industry and examine whether a standardized approach to operational procedures for the use of drones can help Danish drone service companies to gain and maintain a competitive advantage, and how such standardized operational procedures can be designed to support the Danish drone industry's growth conditions best possible.

The research and results of the thesis are intended to be sufficiently valid and qualified to be used by the thesis’ stakeholders such as drone industry organisations, privately held companies as well as academic researchers in the field of drones. This thesis serves as an inspiration for future work regarding standardization in the drone industry. Without the research conducted in this Master’s Thesis the Danish drone industry has no thorough academic knowledge of their opportunities in utilizing operational procedures as well as the potential competitive advantage gained by co-developing the standards for such procedures. Until now the Danish drone industry has experienced success without any procedures and it is difficult to estimate the consequences of not taking action towards using a standardized approach to operational procedures for the use of drones. To explore such consequences a fishbone diagram **(**American Society for Quality, July 16, 2017) is a suitable tool as it helps to clarify potential threats by identifying possible causes for an effect or problem - in this case related to operate without operational procedures as seen in Figure 1.1 below.

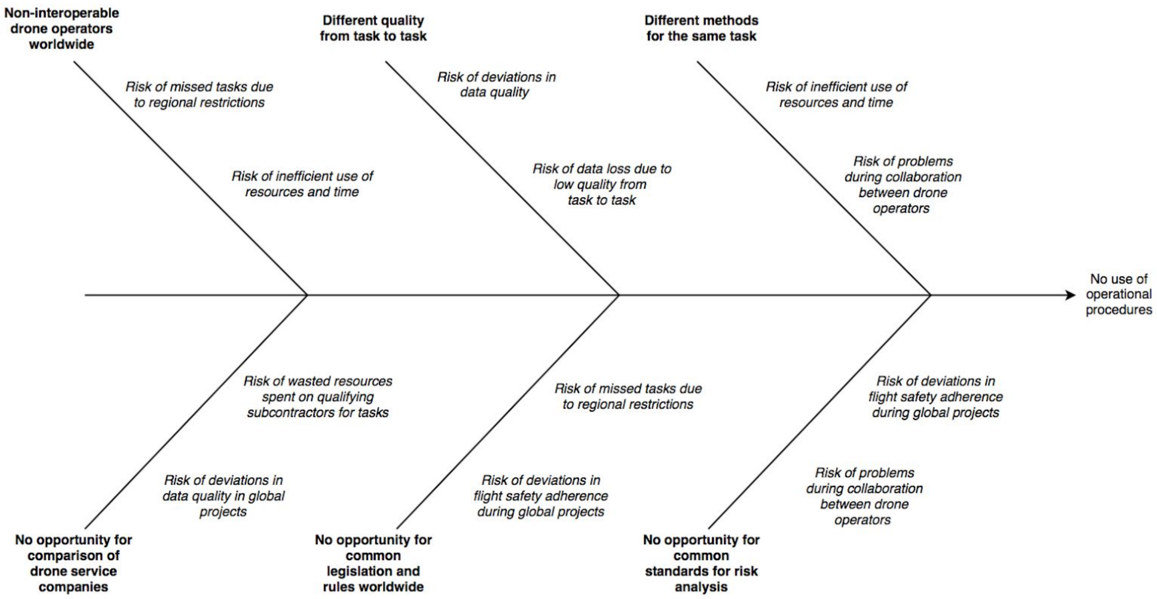


Figure 1.1: Fishbone diagram showing the risk of no use of operational procedures.

Figure 1.1 presents a range of consequences for the Danish drone industry by keeping status quo with no standardized operational procedures for the use of drones, all of which the research in this Master's Thesis seeks to address. Amongst other is the lack of standardized methods for conducting any given drone operation as well as the difference in the quality of the data one gather using drones commercially. Without standardization all tasks are performed in individually ways leading to another consequence being the lack of interoperability amongst drone operators worldwide.

The deviation in methods and quality leads to a situation where there is less to no opportunity for comparing different drone service companies, as they in nature is incomparable due to their different ways of conducting their operations and gather data. The lack of comparison leads in turn to a non-unified market which is hard to apply common legislation and rules in for political decision makers, as the rules made to suit one part of the industry may harm another part unconsciously. Also this lack unable the opportunity for establishing some common standards for risk analysis for the most general types of drone operations, as drone operators may use different software, hardware and procedures besides having a diverse background which may or may not be within aviation.

1.2 LITERATURE SURVEY

A thorough literature survey has been conducted as a pre-analysis for this Master's Thesis to identify which literature regarding the area of research concerning the Danish drone industry may exist already. The aim has been to cover relevant literature for in case of similarities to be able to qualify the need for this specific Master's Thesis as well as exploring new perspectives in the field of research. This process has lead to formulating the problem statement of the thesis as many different sources has contributed with inspiration, perspectives and facts. Even though the initial literature survey has not found similar research as the research included in this thesis, there is some relevant literature that must be mentioned, even though it has not been conducted in the context of the Danish drone industry. This literature is found in the thesis' bibliography and the key readings are mentioned in this section.

Thomas Almdal of Danish Technological Institute (Dansk Standard, April 4, 2016) is quoted for stating that *"it would make sense to develop standards for operational procedures for drones like we know ISO 9001 for quality management. We lack some recognized procedures that allow cross-border guarantees that a company meets certain quality requirements in their work with drones"*. Also, the Danish Technological Institute (April 7, 2017) discusses standardization in a drone context including a mentioning of operational procedures - but without going into further detail on the topic. It is amongst other stated, that the varying legislation between countries inhibits the spread of drone services. Thus a future EU legislation lead by EASA requests standard scenarios to supplement risk assessments in which case Danish legislation is well developed, but has less or few standard scenarios at all.

Neither the Danish Government (2016) or Technology Council (2014) or the Danish Technological Institute (May 2016) present any specific details on what a standard for the operational procedure for use of drones could include or how the Danish drone industry could benefit from taking an active part in the development of such standard. It is stated that the Danish Government (2016) will strengthen the Danish participation in the international standardization work within the drone industry, but it is also stated that such work primarily will take place under the auspices of EASA and JARUS - still without mentioning the Danish approach to this international work. And the research conducted by Technology Council (2014) and the Danish Technological Institute (May 2016) concerns mainly a mapping of the Danish drone industry, but without including neither standardization nor operational procedures as a specific subject of interest.

In an international context the research conducted and covered in this thesis mainly concerns a mapping of the drone industry in general as presented by Bob Hazel and Georges Aoude (2015), without getting specific with how eventual operational procedures should be designed. It is stated that while the drone industry globally is undergoing a rapid development, the legislation and rules is not keeping up with especially the technology and the applications of drones commercially. That goes for the U.S. industry as well as the European industry, which all together is divergent in terms of specific rules from country to country. EASA covers in its *Introduction of a regulatory framework for the operation of unmanned aircraft* (2015) the need for establishment of standard scenarios for risk assessments conducted by drone operators, where - as stated - the majority is airspace users with less or no experience in performing safety risk assessments when using an unmanned aircraft to replace traditional equipment or dangerous activities like climbing on e.g. industrial inspections operations. Thus these operators need simple solutions for standard drone operations. Yet it is not covered how these solutions should be linked to a set of operational procedures - only that such procedures should be standardized in order to make common standard scenarios.

1.3 DELIMITATIONS

To ensure the necessary depth and detail in the research and results of the thesis, a number of delimitations have been made. These are expected to result in valid results, which subsequently can qualify to be brought to action by the thesis' stakeholders.

In order to qualify the results for use for the Danish drone industry the thesis has been limited to cover primarily the European drone industry controlled by the European Aviation Safety Agency (abbreviated *EASA*) and the International Civil Aviation Organization (abbreviated *ICAO*) whom the Danish drone industry is governed by. In Denmark, information and recommendations from EASA and ICAO are managed by the Danish Transport Agency, which is a board under the Ministry of Transportation.

The thesis is also limited to cover exclusively outdoor drone operations only, which differs from indoor drone operations on essential parameters such as the ability to use GPS during flight, consideration for safety measures and the current use of drones, which mostly is utilized in outdoor environments. Including indoor operations would mean doubling the area of research but without foundation for comparing the areas since indoor utilization of drones demands other and more advanced technology than the common Danish drone company in general utilizes due to e.g. special indoor GPS- and detect-and-avoid systems.

The thesis is limited to the civilian commercial applications of drones, and not the military, due to the special considerations for e.g. data encryption, security and confidentiality qualified information as well as the often extreme applications military usage include. A analysis of the military applications would require a comprehensive analysis by itself and has not been included in this thesis taken into consideration the resources that has been allocated to this thesis. The European Commission (Technology Council, 2014) limits the civilian commercial applications of drones to "drones for commercial and governmental use. This includes both state and military use of drones, but only unarmed drones as well as flying drones and thus unrelated technologies such as unmanned sailing, dredging or running vessels

1.4 DEFINITIONS

Drones are defined on the basis of the definition adopted by the international aviation agency ICAO (2011) as formulated: "*A (flying) drone is a fully or partially remote-controlled aircraft without a human person on board (...) which can be controlled with varying degrees of autonomy. Either by a degree of remote control from an external operator on the ground, in another vessel or fully autonomously through computers aboard the drone*." In the thesis a *autonomous flight operation* is defined as an operation during which a drone is operating itself without pilot intervention in the management of the flight (ICAO, 2011). There are more definitions on drones, as both drones may be moving through the air, through water or on the ground. Among the most common names for a drone the following is highlighted according to EASA (2015) and ICAO (2011) definitions:

- Unmanned Aircraft System (UAS)
- Unmanned Aerial Vehicle (UAV)
- Remotely Piloted Aerial Systems (RPAS)
- Remotely Piloted Vehicles (RPV)
- Remote Pilot Station (RPS)

EASA is an EU-organization established in 2003 that serves as a joint body maintaining, controlling and governing the civil aviation safety in the EU countries with powers to ban airlines within the EU. EASA seeks to standardize legislation and rules for aviation within EU member states.

ICAO is an agency of the United Nations (abbreviated UN) established in 1947, which works to create uniform standards for legislation and rules about civil aviation in its member countries. ICAO compiles documents that together form a template for how to align a country's aviation legislation. The aim is to ensure that the rules for flight are as uniform as possible from country to country. Each member state then implements this template in their own legislation, but no country has fully taken the ICAO template but has for the sake of local reasons added special rules or departed from existing ICAO rules.

JARUS ICAO is an association of 40 countries' air traffic agencies are broadly distributed worldwide. JARUS works to align and quality assure the rules for drone aviation. Both the European Commission and the European Parliament (EASA, 2015) have recognized JARUS as the focal point of establishing a unified set of rules. JARUS also contributes to the ICAO's work.

Drone categories has - on request by the European Commission and other stakeholders - been developed in the form of initial proposals by EASA (July 20, 2017). The proposals are based on a operation centric, proportionate, risk- and performance-based regulatory framework for all drones and established with three categories with different safety requirements proportionate to the risk (ibid.):

- *"Open" (low risk)* is a operation category that, considering the risks involved, does not require a prior authorisation by the competent authority before the operation takes place.
- *"Specific" (medium risk)* requires an authorisation by the competent authority before the operation takes place and takes into account the mitigation measures identified in an operational risk assessment, except for certain standard scenarios where a declaration by the operator is sufficient.
- *"Certified" (high risk)* requires the certification of the drone, a licensed remote pilot and an operator approved by the competent authority, in order to ensure an appropriate level of safety.

CHAPTER 2: INTRODUCTION TO THE DANISH DRONE INDUSTRY

The purpose of this chapter is to review the current status of the Danish drone industry - first in a global perspective, then in a national perspective. This spilt serves to discover the context which the Danish drone industry operates in as well as researching for usable best practises in foreign markets which could go into action in the Danish drone industry. Also in this chapter, the Danish drone industry's opportunities and conditions for future growth will be assessed and the thesis' case company will be presented, where all the tests of the thesis will be conducted.

2.1 A GLOBAL PERSPECTIVE

Commercially considered, the drone industry represents a relatively new global growth area both in terms of the development of drone technology and the use of drones for commercial services. This thesis focuses on the latter where many tasks, which today require helicopters, aircraft, cranes or scaffolding, in a few years can be solved with remotely controlled and programmed drones (Danish Government, 2016). Drones do not require space for a on board pilot nor large amounts of fuel, and they can be quickly adapted to the specific task (ibid.). Drones is expected to be able to take over and streamline a large number of complicated, dangerous or monotonous tasks, currently executed manually or not at all (ibid.). E.g. the Danish Technological Institute points out that drones will be able to streamline the work of inspections where drones can come close to previously difficult places, for example infrastructure, bridges and wind turbines, that previously would have required some kind of lift. There is also a great potential in agriculture, where farmers can use drones to monitor crops by giving the farmer a quick overview of the condition of the plants. Several industries are obvious areas for the use of drones and are already well under way (Dansk Standard, April 4, 2016).

Despite the current restrictive legislation, requirements and rules, the industry for the use of drones for services is in strong growth. By 2020 the global market for the use of drones for services is expected to be worth around 6.7 billion USD (Blades, 2015) and expectations for growth are generally high (Danish Government, 2016). It is estimated that the global market for sales of drones will multiply by 2020 from annual sales of 140,000 drones in 2014 to about 1.6 million drones in 2020 (Danish Technological Institute, March 2016) as shown in Figure 2.1 below:

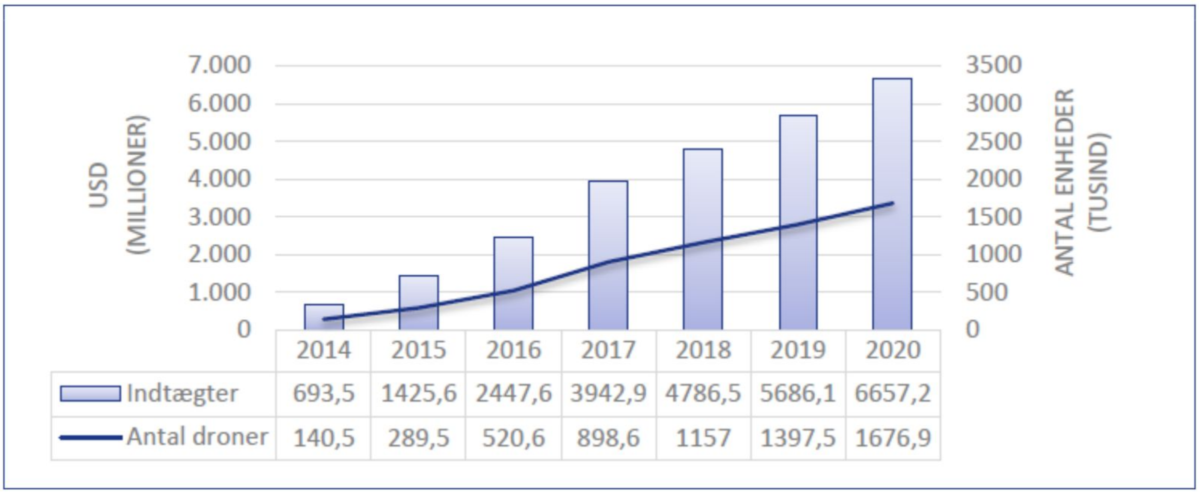


Figure 2.1: The market for the use of drones will increase tenfold in the coming years (Hazel & Aoude, 2015)

The European Commission (April 8, 2014) estimate that drones can amount to 10 % of the global aviation market in 2024. It is also estimated that by 2050, due to the increasing introduction of civilian drones in the airspace, around 150.000 jobs in Europe can be created - in which employment in the area of drone operator services is not included. Thus there is a need for investigating how the drone industry are to develop is these estimates should be realized. One growth area is the use of drones for services, another is within the development of drone technology, where significant growth can be noted. According to the Danish Technological Institute (May 2016), 4.313 unique patents in the field of drone technology were taken globally in the period 1994-2016 with an accelerating development. Thus, in 2014, there were twice as many patents as in 2013, which again had twice as many patents as in 2009, as shown in Figure 2.2 below:

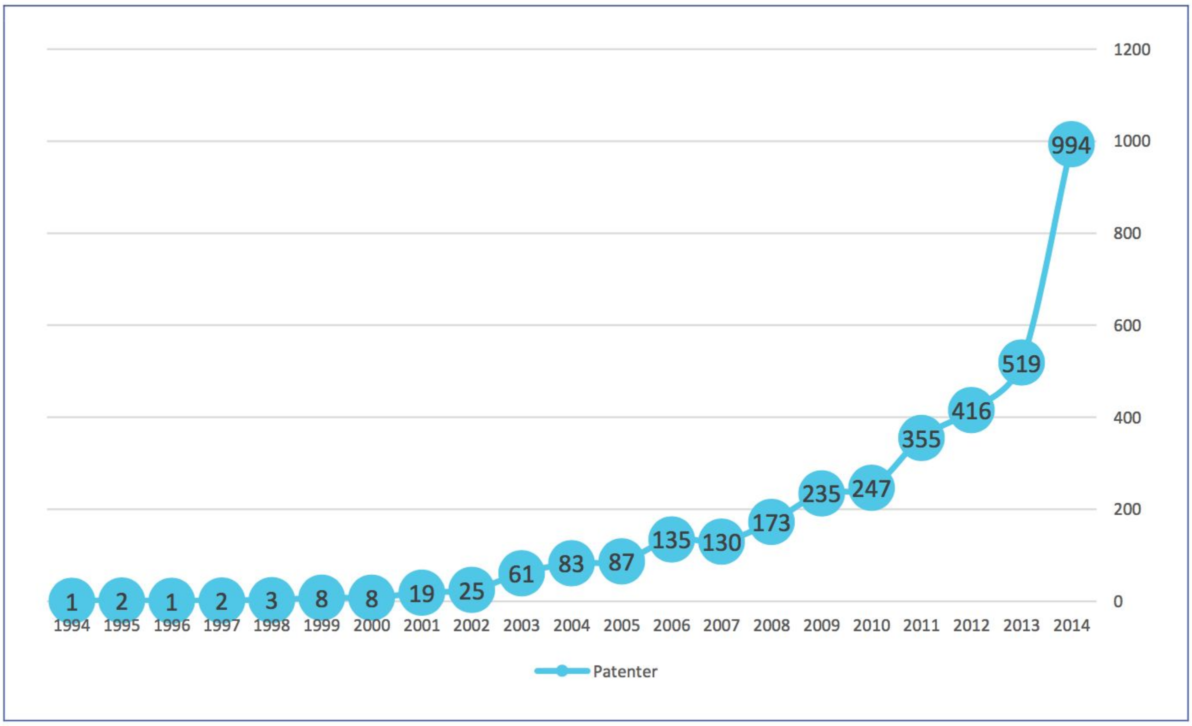


Figure 2.2: The global interest in drone technology is increasing (Hazel & Aoude, 2015)

Despite the rapid development of both drone technology and the use of drones for services, the industry at a global level still face challenges that limit the use of drones from its full potential. As far as technology is concerned, the development in microprocessors, GPS, sensors, motors, lightweight materials and advanced production is currently mature, thus contributing to the development of the drone industry. On the other hand, battery technology still limits the full potential of commercial drones due to limited flight time as well as carrying capacity (Danish Technological Institute, May 2016). As shown in Figure 2.3, many important technologies are still at an early stage of development, while associated technologies, that can be connected to a drone such as camera systems and sensors for a wide range of services typically are further advanced in the development. In larger often military drones, larger engines and energy sources can more easily be installed thus increasing flight time and carrying capacity, but it is usually not realistic for the smaller commercial drones where budget and civilian applications force some limitations. Moreover, drones are yet not fully autonomous thus still suffering from restrictive legislation, requirements and rules that limit the full potential for the drone technology (Danish Government, 2016). Therefore, in the vast majority of applications, there is still a need for human handling in the planning of drone flights as well as operational management of drones during flight operation and data collection.

As shown in Figure 2.3 there is a spread in the maturity of development stages regarding the technology and applications of drones. The application of drones for media production, agriculture and security authorities are among the industries that exploit the possibilities in the technology the most at the moment. Other industries such as construction and infrastructure monitoring are on its way using drones, while more demanding drone operations - such as package delivery - are still limited by strict legislation and regulations in most countries at a global level.

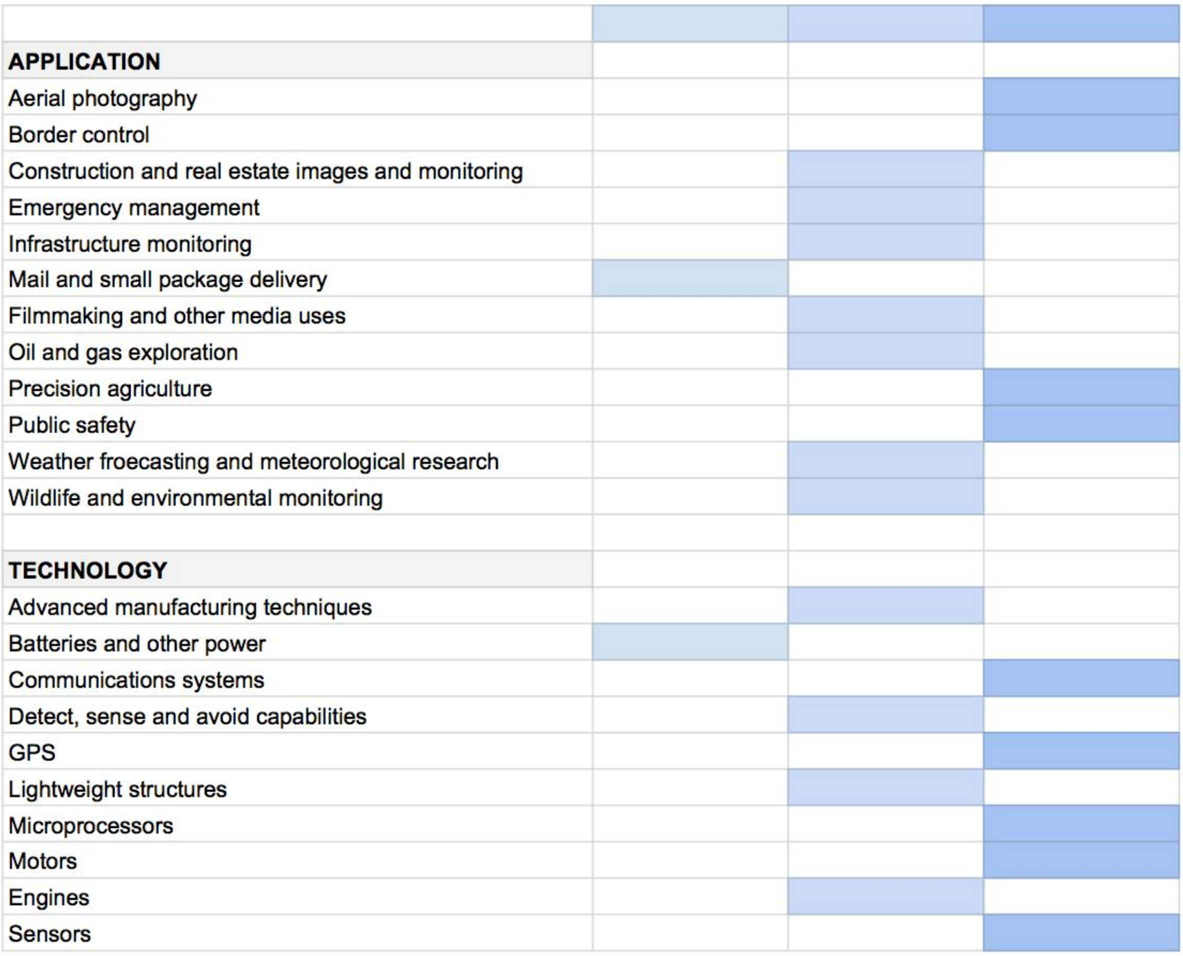


Figure 2.3: Maturity of drone-associated technology and applications (Hazel & Aoude, 2015)

2.2 A NATIONAL PERSPECTIVE

In Denmark, the drone industry is well advanced in the development of drone-associated technology and the use of drones for services in comparison to the global market. These years the Danish Government invests in research and development in the field of drones and has recently adopted new legislation that provides a solid framework for drone service companies and their use of commercial drones, taking into account e.g. flight safety and privacy in connection to drone flight. A national strategy for the Danish drone industry has also been published for the purpose of promoting the development and use of drone technology (Danish Government, 2016). The strategy focuses exclusively on the civilian use of drones, which is predicted to be the greatest growth potential for Danish companies. The growth potential is primarily attributable to the favorable national growth conditions that provide Danish drone service companies with good opportunities to position themselves in the global competition. The possibilities in drones in a national perspective are many and drones is expected to fulfill the potential for increased productivity and efficiency in both the private and public sectors (ibid.).

The Danish Transport Agency (May 13, 2017) has registered over 830 approved Danish drone operators in 2017 compared to just 27 operators in 2014 as well as 1281 commercially approved drones in 2017 compared to 87 in 2014. The Danish Technological Institute (May 2016) estimates that at least 300 Danish companies develop drone-associated technology or use drones for services, of which almost half are drone operators and drone service companies engaged in media production. The number is rapidly growing, but most companies are still small sized businesses. In addition, a number of technology vendors and system integrators develop, assemble and implement technologies and software for drones. There is only one professional manufacturer of drones in Denmark, which may be due to the fact that Denmark has never had a major aviation industry. Hence the primary focus of the Danish drone companies is to develop or use drones as a platform for sensors, measuring equipment, data collection and other applications such as services, and not to design and construct the drone itself. This development is supported by the Danish academic strengths in research fields within sensors, robotics, computer science and IT (Danish Technological Institute, May 2016).

However, it is not only companies that use drones - researchers and authorities also benefit from the drone technology for usage within e.g. inspections, authority control tasks, research activities and public services. The usage is within industries such as energy, supply, offshore, agriculture, nature and environmental protection, geographic data etc. where drones can take over and streamline a range of tasks. However, the Danish Government (2016) estimates that there is limitations before the possibilities in drone technology can be fully utilized and translated into growth and job creation. That said, Denmark is considered to have the opportunity to become one of the countries leading the use of drones for services by efficiently and safely solve tasks that are currently resourceful and risky. Compared to the surrounding countries the Danish rules for drones are closely related to e.g. Norway and Sweden, but looking further in the near markets such as England and Germany, rules differs a lot thus hampers the freedom of movement between countries for those drone service companies looking to grow their businesses. An example of the differing rules is presented in Figure 2.4 below:

Rules applied	DK	NO	SE	GE	GB
Administration					
Operational	Yes	Yes	Yes	Yes	Yes
Categories	1A, 1B, 2	RO1, RO2, RO3	1A, 1B, 2, 3	TBD **	TBD
Governed by	Local CAA	Local CAA	Local CAA *	Local CAA	Local CAA
Licensed pilot	Required	Required	Required	TBD	Required
Logbook	Required	Required	Required	TBD	No
Police notice	Required	Required	Required	Required	TBD
Drone rules					
Max flight altitude	120 meters AGL	120 meters AGL	120 meters AGL	762 meters AGL	120 meters AGL
Visual requirement	VLOS	VLOS	VLOS	VLOS	VLOS
Restricted airspace	ATC permission	ATC permission	ATC permission	ATC permission	ATC permission
Safety zone	15-50 meters	50 meters	50 meters	TBD	150 meters
Fail safe system	Required	Required	Required	TBD	No

* As well as the Swedish authorities *County Administrative Board* and *Land Survey*

*** TBD = to be decided as German rules is subject to changes in the near future)*

Figure 2.4: Comparison of different drone rules (Dronelaw.in, 2017)

2.3 THE CASE COMPANY

The case company is the Danish drone service company Dronops, who utilize drones for services which they provide to a wide range of industries. Dronops specialize in e.g. inspection of critical infrastructure such as highways and traffic hubs, 3D mapping and agriculture analysis, where e.g. NDVI measurements of chlorophyll content in plants is analyzed. Established in 2015, the company is specialized in drone services with core competencies including managing the drone operation itself as well as the data collection, rather than carrying out the subsequent analysis and processing of data. Dronops is tasked to take care of the planning and operation of the drone flight, as well as collecting data during flight, and then transferring the collected data to the respective specialists. The need for a specialized drone service company consisting of professional drone operators has become increasingly relevant in recent years, as the task of collecting validated data safely and efficiently represents a full-time job, that is not necessarily possible for the specialists who will be analyzing the collected data.

As a professional operator of drones, Dronops manages up to 150 drone operations annually in a variety of services home and abroad. The tasks and methods of data collection itself range widely, but the core procedures for handling the drone and its operating system are generic across all types of drone services, as the platform used in drone operations itself is the same, with only the sensor package on the drone to be replaced depending on the given task. The delimitation to operating drones and collect data being a service provider within a wide range of drone services, makes Dronops an ideal case company for this thesis, which will examine the benefit of operational procedures for the use of drones in a wide range of different drone operations. In the case company, the requirements for safety, efficiency and quality in both the drone operation and the data collection is a first priority and at a high professional level.

The choice of Dronops as case company is believed to contribute with a valid foundation for conducting test of the thesis's operational procedures, which can provide new knowledge about future standards for operational procedures for the use of drones. A drone operator from the case company will assist the thesis with subject matter expertise as well as conducting the tests of operational procedures during the drone service operations elaborated in chapter 8.

2.4 SUMMARY

Both the global and Danish drone industry represent a relatively new commercial growth area when it comes to developing drone-associated technology as well as the use of drones as services. As rapid development in the field continues, drones are expected to be able to take over and streamline a wide range of tasks and solve them more safely, more efficiently and to a better quality than before (Danish Government, 2016). This development in the use of drones is expected to lead to a global market worth 6.7 billion USD (Blades, 2015) but there are still limitations on the way. Many vital technologies for drones such as batteries and autonomy during operation are still at an early stage of development, but associated technologies such as sensors, cameras and software are further advanced in their development. Applications such as media production, agriculture and authority control are among the most common in the global drone industry due to the relatively manual and simple use of drones with cameras. More demanding drone operations such as the delivery of packages and autonomous industrial use in production indoor or outdoor environments are not yet widespread and often restricted by legislation and rules. Furthermore, the European Commission (April, 2014) points out that drones can bring new challenges in terms of security and protection of citizens' rights, which must be taken into consideration before using the technology on a larger scale in a civilian application.

The Danish drone industry holds a leading position in the global development of technology associated with drones and especially within the use of drones for services. The research in this chapter has proved that Danish drone service companies currently enjoy a competitive advantage as the Danish rules for commercial use of drones are closely related to e.g. the surrounding countries such as Norway and Sweden. Thus Danish companies has easier access to expand their interests with only a few delimitations against them. In addition, the Danish Government (2016) currently invests in research and development as well as having published a national strategy for the Danish drone industry itself. The strategy places particular emphasis on the civilian use of drones, which is predicted to be the greatest growth potential for the Danish drone industry.

The major findings of this chapter is, that with the favorable national growth conditions, the political focus on an new emerging industry and the Danish strengths within drone-associated research fields such as sensor and robotic technology, computer science and IT (Technological Institute, May 2016), the Danish drone industry is forecasted to have good opportunities for future growth. The chapter concludes that Danish drone companies is well positioned in the global competition thus it is a question of to which extent the industry exploits the opportunities - one step will be to work with international standards, which will be examined in the next chapter.

CHAPTER 3: STANDARDIZATION

The purpose of this chapter is to establish the theoretical framework of the thesis by defining how selected theoretical concepts should be understood in the context of this thesis. The chapter will also examine the interrelationships of the concepts in relation to the problem's problem formulation. The theoretical framework of the thesis serves to form the basis for the following chapters, where theoretical concepts such as *standardization* and closely related concepts such as *interoperationality* and *competitive advantage* will form the basis for the thesis's research.

According to the Danish Technological Institute the three concepts mentioned above have proven to be closely related (Dansk Standard, April 4, 2016). Consequently, in order for a given company to gain a competitive edge on the global market, it must first ensure that its procedures are interoperable with other global players, with whom the company can immediately cooperate. This requires in turn the company's most important business-critical procedures to be uniform and quality assured in the form of a recognized standardization. This interrelation is illustrated in Figure 3.1 as seen below. The figure are to be interpreted as in order to gain the competitive advantage, one has to begin with standardization, from where the benefits vil develop step by step. This interrelation is what this chapter will investigate in relation to the Danish drone industry.

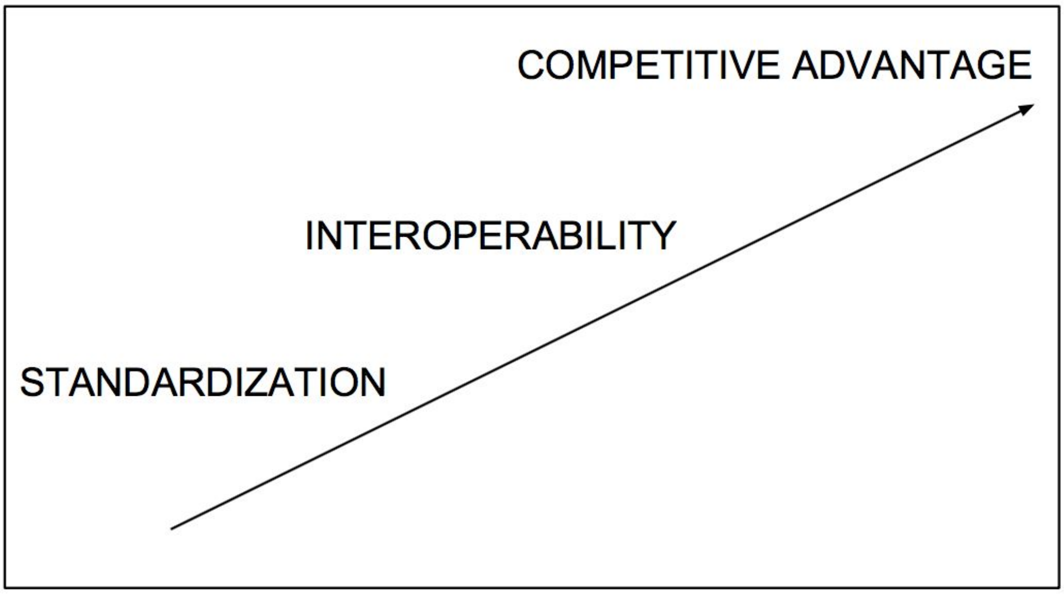


Figure 3.1: Development in benefits of working with standards (April 1, 2017)

As stated above it all starts with standardization. According to the Danish Business Authority (April 6, 2017), a standard may be defined as a specification that sets out technical or quality requirements for products, services and production methods. Standards are basically voluntary to use, but in some cases a standard can be made mandatory if it is politically decided to register the standard e.g. in European legislation. Most international standards embed "best practices" from around the world and support the development of compatible products and services across industry and national borders (Danish Government, 2015). The Danish Business Authority and Dansk Standard defines a standard as "*a common and repeatedly applicated document that sets out rules, guidelines or characteristics of activities or the results of these. The document is determined by consensus and approved by a recognized standardization authority. The aim of the document is to achieve optimal order in a given context* " (Danish Government, 2015). A standard can include demands for the labeling of a product or the quality of a given product or service. Standards also apply for methods and procedures, e.g. for the documentation of technologies and their application, as well as standards for terminology in different industries, e.g. the correct definition of a component or a subject term (ibid.). In connection with the performance of a given task, where there are specific and often stringent requirements for the procedure for reasons such as safety, so-called *standard operating procedures* are used (abbreviated SOP and in this thesis referred to as *operational procedures*). Operational procedures are a document consisting of a set of step-by-step instructions for how a given task is to be performed. Operational procedures thus act as a tool to ensure that a given task is performed correctly each time and meets current operating, quality, environmental and safety requirements (ISO Update, April 30, 2017). In the thesis' Chapter 7, the theoretical background for operational procedures will be further examined and operationalized in the form of a specific operational procedure for a specific drone operation related to the drone industry conducted by the case company.

The recent decades of technological development of e.g. IT and robotics has emphasized the need for international standards in order to enable technology such as a TV or USB connector to be used in all over the world and to be compatible with the existing technology of consumers and companies (ibid.). When using standards, one can easily document that a product or service meet specific requirements and conditions, e.g. making trade within the EU easier. Standards can also help companies and authorities when working together, they can expand companies' market shares and help consumers and governments save money. Standards are important for a well-functioning internal market as well as the international competition and trade. Standards are also important to consumers, authorities and industry because they ensure interoperability and a minimum level of safety and quality (Danish Business Authority, April 6, 2017). Investigations conducted by the Danish Business Authority's Internal Market Center (Danish Business Authority, April 6, 2017) demonstrate a positive correlation between companies' application of international standards and their productivity, export and growth. Compared to companies that do not apply standards, companies that do enjoy up to 25 % higher growth rates, up to 15 % higher productivity and up to 50 % higher export rates. There may be several factors that affect this difference, but the connection can be said to reflect that standards can play an important role in international trade. In Denmark, standardization are being controlled by Dansk Standard, which is the official Danish standardization organisation governed by ISO. According to the Danish Business Authority (April 6, 2017), the Danish Government and state is another important player within standardization who co-finances annual activities in Dansk Standard with almost 22 million DKK in the form of performance contract funds and contingent payments. National Partnership for Standardization, which consists of a wide range of business leaders from Danish companies and organizations, is also an active player in Denmark. At European level, tasks associated with standardization is carried out by the three major European standardization organizations CEN, CENELEC and ETSI. Globally, the tasks are carried out by the standardization organizations ISO, IEC and ITU. Common to the global, European and national level is, that stakeholders like consumers, workers, authorities and industry all are tasked with developing new standards in their respective field of work.

Thus there exists many languages within the field of standardization and often the different standards target specific industries, while others are more generic. An industry can not easily follow all the branches of existing standardization regimes, and therefore a few must be prioritized. Thus the Danish Technological Institute points out that the Danish drone industry should find inspiration in the ISO 9001 standardization arising out of quality management, where internationally recognized standardized procedures allow the companies using them to collaborate across borders regardless of their respective industries and thereby grow faster (Dansk Standard, April 4, 2016).

3.1 ISO 9001

In order to be able to gain inspiration from ISO 9001, one must first understand the background and reasons for what we today know as the *ISO 9000 family* (ISO, April 8, 2017). The specific requirements of ISO 9000 are evident in the latest ISO 9001 (latest update arrived in 2015). ISO 9001 is a standard of quality management - commonly referred to as a *quality management system* - used as a management tool for business development and optimization of over a million companies and organizations in more than 170 countries (Dansk Standard, April 1, 2017). ISO 9001 defines a number of specific standards for management of the enterprise, that companies must comply with in order to be certified according to ISO 9001. ISO 9001 requires companies to have documentation for all its processes that affect quality (Evans et al, 2011) and is based on the assumption that certain generic characteristics of management can be standardized and that a properly designed and implemented quality management system can provide a given company with well established definitions of their processes. Furthermore, ISO 9001 ensures that certified companies can be sure that other certified companies comply with the company's own standards and quality requirements (ISO, April 8, 2017). Thus ISO 9001 becomes a competitive parameter in connection with offerings from other companies that are not certified. The standard means that companies have a recognized and basic management tool - regardless of the size and scope of the organization (Evans et al, 2011). ISO 9001 has gradually become synonymous with quality and efficient management (ibid.).

The ISO standardization regime was established to meet five goals, as shown in Figure 3.2 (Evans et al, 2011):

1. Achieve, maintain and seek to continuously improve the quality of the company's product or service in relation to the given requirements.
2. Improve the quality of the company's operations so that they continually meet customer's stated and implied needs.
3. Create trust in company management and other employees to ensure that quality requirements are met and continuous improvements are made.
4. Create trust with customers and other stakeholders that quality requirements are met in the company's delivered product or service.
5. Establish trust in that the requirements of the company's quality management system are met.

Figure 3.2: Objectives of the ISO standardization regime (Evans et al, 2011) (rephrased)

ISO 9001 is founded on a number of prior and recognized - yet diverse - theoretical paradigms, all of which were developed and practiced throughout the period 1900-1985. A number of prominent profiles within research on *quality* became particularly noted including Deming, Juran, Taguchi, Crosby, Feigenbaum, Ishikawa and others (Evans et al., 2011). Two key perspectives that these profiles shared were that they regarded quality as crucial for the future competitiveness of the global market, and maintained the statement that quality would save - and not cost - companies money. With the emergence and application of quality thinking through the period 1900-1985 (ibid.), more companies throughout the world began to develop their own standards and management tools to enhance quality - primarily in their production. Over time, the quality thinking became widespread to cover the whole company and not only its production, with also service companies taking on the quality thinking (Evans et al, 2011). Concepts such as quality management, quality control, quality system and quality assurance were widely applied, but often in conflicting terms from country to country, but also within a country and even within the same industry. With the signing of the Treaty of the European Union in 1992, when free trade between member states became the norm, quality became an important strategic goal now. In order to standardize quality requirements for member countries - and the countries that wanted to do business with them - an organization for standardization was established in 1946 - the International Organization for Standardization (IOS) - with representatives of the Member States' national standardization bodies, which adopted a set of written quality standards that has been updated continuously (Evans et al, 2011). Later on IOS was renamed ISO (which is a scientific term for *the same*) and ISO 9001 became the replacement for a range of more or less established quality systems, all related to the term *Total Quality Management* - often shortened *TQM* - which had sought to define and conceptualize the concept of *quality* without major impact (Evans et al, 2011).

3.2 STANDARDS & INTEROPERATIONALITY

Danish companies are increasingly met by demands on using international standards when delivering their products or services to major Danish export companies and when they export directly by themselves. By using international standards, these companies ensure that their products or services can interact and is interoperational with other companies - even across borders. International standards make it easier for Danish companies to enter global value chains and sell their products or services abroad (Ministry of Business, 6th May, 2015). Standards thereby become the means for making the company's' products or services interoperable - hence in this context, the key theoretical term is *interoperability*. According to Hayden (2002), international standardization helps to create interoperability across national borders, industries, industries and cultures. This means that new technology can be applied globally across businesses, people and societies as it is applied in a quality-assured way around the globe, which creates a global growth potential for the involved companies, as the road to global collaborations become more accessible. Among other things this is the main reason why the European Commission's Digital Agenda has made interoperability a priority area affecting Europe's overall economy (European Commission, 2010). In Denmark, the Danish Government (2015) also focuses on interoperability and seeks with their strategy "Growth through increased use of international standards" to make it easier and cheaper for small and medium-sized enterprises to apply international standards, thereby increasing the use of international standards by Danish companies to make it easier to enter into global value chains (Ministry of Business, May 6 2015).

3.3 STANDARDS & COMPETITIVE ADVANTAGE

One thing is to ensure interoperability with foreign companies, another is to exploit it for one’s business’ competitive advantage, which is defined by circumstances that allow a company to produce products or services for a better profit margin or in a more desirable quality for its customers, than its competitors are able to (Investopedia, April 8, 2017). Competitive advantage can be attributed to a number of factors such as the company's cost structure, the quality of its product or service, its distribution network, its customer service etc. Generally speaking, competitive advantage allow for greater value for a company and its shareholders. The more sustainable the competitive advantage is, the harder it is for competitors to neutralize it (ibid.)

According to the Danish Government (2015) companies’ application of international standards can positively affect their productivity as standards are often based on international best practices, thus usable as a tool for systematically review of e.g. the company's internal procedures compared to the operations of similar companies (ibid.). The standards’ contribution to increased productivity has lead to the Danish Government's efforts to ensure that more small to medium-sized companies apply international standards strategically (ibid.). Increased productivity, however, is only one example on how standards can positively affect companies' competitive advantage positively. In line with the emergence of international standards, more and more companies have begun to use international standards to create a competitive advantage (Gill, 2009). Studies have shown that companies that have won awards for their use of standards generally gain a higher market value and revenue than other companies. This is often due to the fact that applying standards leads to fewer errors and better utilization of resources, which ultimately leads to a significant reduction in the company's costs of producing its product or service - and thus higher productivity (ibid.).

In other words, there can be made a clear connection between standards and competitive advantage which e.g. thinkers including Powell (1995) and Zentner (2011) has done, even though investment in standardization may seem less measurable compared to the need to produce more in order to meet the ever-increasing competition and demand from the market (Gill, 2009). According to Gill (ibid.) the rationale is quite simple, as uniform and quality assured standards ensure the company's procedures are free of errors and waste of resources, thus enabling more output in the form of products or services for the same amount of input used. Zentner (2011) points out that globalization has forced companies to find new ways to increase their competitiveness, which has led companies to work with standards in relation to their operational procedures, which in turn has proved necessary to create and maintain a solid competitive advantage.

3.4 SUMMARY

In this chapter, the theoretical framework of the thesis has been presented. Selected theoretical concepts such as standardization, interoperability and competitive advantage has been examined and their interrelationship have been studied and highlighted. The major findings in this chapter is that the interrelationship between the theoretical concepts must start with standardization from where benefits such as closer cooperation with contractors and clients in both ends of the supply chain will develop step by step. Then true competitive advantage can be achieved. The findings of this chapter is backed by the Danish Technological Institute who recognizes the interrelationship as a mean for success when working with standardization (Dansk Standard, April 4, 2016).

The theoretical framework in this chapter will form the basis of the studies in the following chapters in relation to the Danish drone industry, where the above mentioned theoretical concepts *standardization*, *interoperability* and *competitive advantage* will be the key parts in the research for answering the thesis' problem formulation. In the following sections 4.2 and 4.3 the theoretical framework will be linked to the thesis' field of research and operationalized in the following chapters 5 to 8, that constitute the examinations of the thesis' problem formulation.

CHAPTER 4: PROBLEM FORMULATION & METHODOLOGY

This chapter presents the problem formulation of the thesis with the purpose of establishing the framework for the research in the field of interest of the thesis. Next, the problem formulation is operationalized in specific work questions which later will be linked with the theoretical framework of the thesis, as the two frameworks is examined and presented in separate chapters. Finally, this chapter presents the methodological considerations for the thesis, including significant decisions in the methodological approach, as well as a critical look at the sources and data utilized.

4.1 PROBLEM FORMULATION

The overall hypothesis of the thesis is:

“The Danish drone industry can achieve a significant competitive advantage in the global market by implementing and following international standards for operational procedures for the use of drones.”

The hypothesis is based on an expectation that such operational procedures will increase the interoperability of the Danish drone industry with foreign companies and stakeholders, thereby strengthening its global growth conditions and gaining the industry an international competitive advantage. Thus the thesis will be based on the Danish drone industry and address the following problem statement as the framework for the following research and studies:

"This thesis will examine how the Danish drone industry can achieve a competitive edge by implementing and following international standards for operational procedures for the use of drones.

The thesis will also examine and then test how such operational procedures can be specifically designed to support the growth conditions of the Danish drones service companies while at one and the same time; 1) increases safety during flight operation with the use of drones 2) streamline drone service operations and 3) creates better quality in the data collection during flight operation.”

4.2 OPERATIONALIZATION OF PROBLEM FORMULATION

The thesis' problem formulation will be examined through a number of separate chapters, each of which will be based on the theoretical framework of the thesis as each of them examine and answer a specific work question originating from the overall problem formulation. Thus it is the intention that the results from these chapters together will provide a basis for a qualified conclusion on the thesis' examinations. In order to do this, each chapter will contain a theoretically based analysis of the question before presenting the main findings and considerations in the end of each chapter.

The specific work questions will be discussed in the following separate chapters:

Chapter 5: Established industry standards

"Which established standards can be identified in the international drone industry and in industries related to the drone industry?"

Chapter 6: Importance of an implementation

"What is the importance of a implementation of international standards for the Danish drone industry's competitiveness and potential competitive advantage?"

Chapter 7: Designing new operational procedures

"With the knowledge of best practices and established standards in industries related to the drone industry and within the drone industry, how can operational procedures for the use of drones be designed, so that they support the Danish drones service companies' growth conditions?"

Chapter 8: Results of new operational procedures

"Which effect do the new operational procedures have for the drone service companies measured at the following measurement points?

a. *The degree of safety during the use of drones*
b. *The degree of efficiency in operations*
c. *The degree of quality in the data collection"*

4.3 METHODOLOGY

This section will present the methodological considerations of the thesis, including the most important decisions made regarding the method as well as an assessment of the sources and data used in the thesis.

The research areas of the thesis can be divided into two steps, each contributing to the dissemination of knowledge and results derived from the problem formulation and the thesis' theoretical framework. Chapters 5 and 6 constitute the first step in which the purpose is to identify and assess the possible significance of drone industry related standards for the Danish drone industry's competitiveness and potential for gaining a competitive advantage. In Chapter 5, the thesis seeks to identify existing standards in the drone industry as well as in related industries, including an analysis of whether relevant best practices from other industries could be identified. Chapter 6 evaluates the effect of a potential implementation of international standards and best practices for the Danish drone industry's competitiveness and assess whether a competitive advantage can be gained by utilizing such standards. This first step is prerequisite to assess the relevance of the research conducted in the thesis and ultimately qualify the results of the thesis. As the drone industry still is relatively new thus to some extent powered by pioneering spirit rather than standardized procedures, the thesis seeks to find inspiration in existing standards from related industries. Many industries has themselves experienced the same progressive growth as the drone industry currently applies do either it is the IT- or wind industry which e.g. is considered related to the drone industry at least in this thesis.

Chapter 7 and 8 make up the second step of the research in the thesis. Based on the results from Chapters 5 and 6, Chapter 7 aims to design new operational procedures for the use of drones based on a theoretical framework and inspired by best practices from related industries. The chapter takes into account that these procedures must be applicable to the drone service companies which in the future will follow the procedures as well as the procedures is to support the growth conditions of the Danish drone service companies. With the design of new procedures, Chapter 8 will test these at a number of measurement points at the thesis' case company, which is chosen due to the widely span of the company's services within the drone industry. Thus, it is ensured that the operational procedures designed in the thesis are generic in order to create value across the drone industry. The purpose of these tests is to qualify the relevance of such procedures in the Danish drone industry and ultimately qualify the results of the thesis.

The selection of empirical and theoretical sources for the thesis has initially been focused on the tension between the concepts of standardization, interoperability, competitive advantage. Significant amounts of empirical sources have been found concerning these concepts - yet not directly related to the drone industry - e.g. the European Commission's Digital Agenda (2010) which reviews standardization and interoperability as a priority area affecting Europe's overall economy (European Commission, 2010). Other empirical sources has been the Danish Government's own publications in relation to standardization (2015), partly their strategy for the Danish drone industry (Danish Government, 2016) partly an in-depth analysis of the global drone industry conducted by the Danish Technological Institute (March, 2016).

The data sources used for test purposes in Chapter 8 are extracted directly from the drone operating system and the associated software. The data includes e.g. an overview of safety conditions in relation to the drone operation such as flight altitude, battery condition during flight, the effect of weather- and wind conditions on the drone as well as compliance with safety distances. Data sources also counts inputs from the drone flight computer such as flight time and actual flight path versus scheduled flight path. The data quality is generally of high quality and without interference from external factors due to all data is extracted directly from either the drones' operating system or the associated software.

CHAPTER 5: ESTABLISHED INDUSTRY STANDARDS

This chapter will cover the first working question of the thesis' problem formulation:

Which established standards can be identified in the international drone industry and in industries related to the drone industry?

Since the 1960s, the number of standards in Denmark has increased from 1,000 to about 25,000. The development must be seen in the light of the establishment of the European internal market and the increased international trade in general, which has necessitated a common reference base for e.g. procedures, methods and requirements for quality and safety. Such reference base and use of international standards will enable products and services to be more easily developed, produced and used across borders, making it easier for businesses to innovate and produce across borders and thus participate in global value chains (Government, 2015). In this chapter it is considered relevant to investigate which standards exist today in the drone industry as well as industries related to the drone industry due to the fact that standards according to the Danish Technological Institute (Dansk Standard, April 4, 2016) and Dansk Standard (April 1, 2017) can be a step towards establishing common guidelines for e.g. security- and operational procedures for the use of drones.

The chapter contains a survey of standards in the drone industry - in this case widely considered at an European level. The purpose is to identify which standards already exist and what other actions regarding standardization regimes are being developed in relation to harmonize and quality assure rules for drone aviation as well as procedures for e.g. the operational use of drones. It is examined whether there are best practices or existing standards from relevant industries related to the drone industry that could be the foundation for future standards in the drone industry. In this case related industries means industries that share the same characteristics as the drone industry meaning that they all have been at an early stage of technological development at the time they have been sought commercialized, thus already have experienced the progressive growth currently happening in the drone industry. The shared characteristics makes these related industries relevant to include in the research.

5.1 STANDARDS IN THE DRONE INDUSTRY

In order to map established standards in the drone industry, research has been widely sought in the European and national organizations responsible for developing and publishing existing standards - both in general business as e.g. ISO and Danish Standard and in more specific aviation areas such as EASA and ICAO. The investigations of established standards in the drone industry have led to a number of discoveries of ongoing initiatives in the field of standardization, all of which relate to two areas: rules/legislation and standards. In the following, these areas will be mapped with a geographical delimitation to the European drone industry as mentioned in section 1.1.

The *rules and legislation* for drone flight vary according to the Ministry of Education (April 2, 2017) and the Danish Technological Institute (April 7, 2017) across EU countries. It impedes the use and the mobility of drone services thus work should be done to develop common rules and legislation (Danish Standard, April 4, 2016). According to the Ministry of Education (April 15, 2017) the varying rules and legislations in the area of drones may also affect the allocation of R&D investments, as the legislation is currently determined nationally limiting the opportunities for researchers and businesses to cooperate internationally. The Ministry of Education (ibid.) points out that a set of common international rules and legislations will strengthen international R&D cooperation in the global industry.

While rules and legislations vary across EU countries, there are several actions in relation to common *standards*. Common to these efforts is that they seek to align the way in which work is done with drones on a general level. Amongst other EASA (2015) has with its publication Technical Opinion presented its overall guidelines for the development of common standards. EASA's instructions include 27 specific proposals for a general set of rules for drone aviation, but according to EASA itself (ibid.), it is only a minor step on the road. The organization believes that it is urgent to develop and publish standards that the different national requirements can refer to and thereby creating interoperability across countries. EASA emphasizes that there are ongoing initiatives at national level in many European countries hence the need for standardization at European and international level is necessary as soon as possible, so that consensus is reached on standards for the most vital requirements for e.g. drone operators' level of competence, training and documentation as well as their operational procedures. Even though the focus is solid there are still no published and applicable standards in the field of drones (EASA, 2015). EASA (2015) emphasizes that the need for international standards for operational procedures for the use of drones is also pointed out by the drone operators themselves, who find that they are unable to exploit global market opportunities as they are limited by the varying rules and authorizations from country to country. Accordingly, ICAO has established a panel of drone operators (called Remotely Piloted Aircraft Systems Panel or *RPASP*) to come up with proposals for such standardized procedures and best practices in their respective field of competence. The panel will play a decisive role in developing the future rules for drone flight. Initially, the ICAO's expectation (EASA, 2015) allows panel recommendations to be used as a baseline for those countries that have not yet defined their own legislation or for countries that wish to revise and align their existing legislation with applicable international standards.

EASA (2015) notes that the vast majority of European drone operators do not have a background in aviation, but rather are owners of smaller companies that have taken drone technology into their business. Consequently, the drone operators have little or no experience of producing risk assessments in connection with their drone operations. EASA points out that common standards for risk scenarios do not yet exist on a international level - but if they did, they could be expected to provide the foundation for general risk assessments which in turn could be expected to align the way in which all countries consider risk of drone flight (Technological Institute, April 7, 2017). Thus it is EASA's proposal that a number of standard risk scenarios are established in order to enable drone operators to plan their operations thus increase safety during the drone flight. EASA (2015) highlights a number of drone services where this is particularly relevant, including media production, inspections and agriculture being among the currently most developed applications of drone services (Hazel & Aoude, 2015). According to EASA, it is a job for the respective national standardization organizations e.g. ISO (Danish Standard in a Danish context) to provide drone operators with such standard risk scenarios for the most common uses of drones as an addition to the other operational procedures for the use of drones. This is in line with the Danish Institute of Technology's suggestion that the Danish drone industry should find inspiration in ISO 9001 for quality management, where international standards and procedures allow for cross-border cooperation (Dansk Standard, April 4, 2016) which according to the Danish Technological Institute will make it easier and safer to use drones across national borders (ibid.).

Such work is initiated under the standardization organization ISO, where the first international working group meetings regarding standardization in the drone industry were held in 2016 with several member countries such as Kina, France, Germany, Japan, Russia and USA indicating that they would actively participate in the work (Dansk Standard, April 4, 2016). The ISO working groups takes place concurrently at international and national level. Internationally, ISO is working in ISO / TC 20 / SC 16 (ISO, April 15 2017), where work is conducted in so-called working groups (Technological Institute, April 7 2017). The ISO Technical Committee is engaged in drones and contains representatives from 13 countries as is apparent from Figure 5.1.

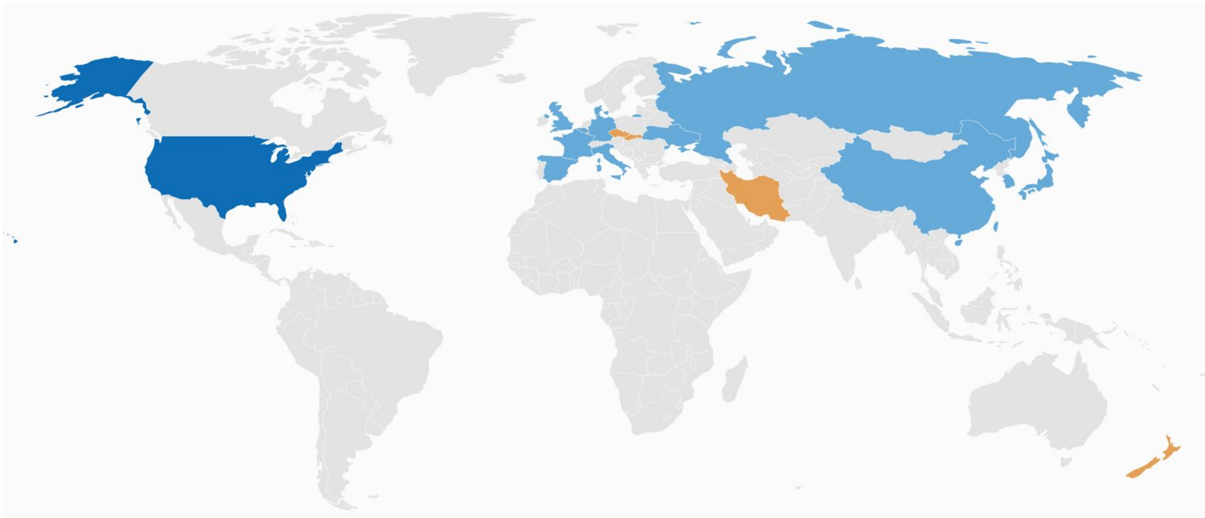


Figure 5.1: Member countries in ISO Technical Committee ISO/TC 20/SC 16 (ISO, April 15 2017)

ISO operate with 3 working groups (abbreviated WG 1, 2 and 3) in relation to the drone industry. WG1 deals with general specification such as vocational terminology for the drone industry as well as general instructions on categorization and classification of drones. WG1 has published a draft standard for industry specific terminology, which is currently gathering international consensus, but with various conflicts with EASA and JARUS on categorization and classification of drones (ISO, April 15, 2017). WG2 is engaged in product systems such as battery technology in relation to drone technology and has not yet published any standards. WG3 deals with operational procedures for the use of drones, but no standards have yet been published. However, a large overlap has been observed with instructions given by EASA and JARUS.

In a Danish context, Dansk Standard (Danish Technological Institute, April 7, 2017) is heading the Danish work regarding standardization in the drone industry in form of working group S-831 of Dansk Standard (April 15, 2017) consisting of representatives from among others Danish drone producent Sky-Watch A/S and the

Danish Technological Institute. The working group is focusing primarily on the classification of drones as well as operational procedures for the use of drones. Among the activities of the working group are participation in the ISO Technical Committee ISO / TC 20 / SC 16, preparation of Gap analysis for existing standards and mapping of stakeholders for future standardization work in Denmark. However, the working group S-831, as well as the ISO Technical Committee ISO / TC 20 / SC 16, has not yet published any draft or applicable standards for the operational procedures for the use of drones.

5.2 STANDARDS IN RELATED INDUSTRIES

In the absence of applicable standards in the drone industry, it is relevant to distinguish existing standards found in relevant industries related to the drone industry, as explained in section 4.3. The purpose with this section is to investigate and map whether there are best practices or experiences that the drone industry can benefit from. Such mapping will make it possible in Chapter 6 to assess the importance of implementing standards in the drone industry, including the impact on the Danish drone industry's competitive advantage. The selected industries in this section - the aviation-, health- and IT industry - each share certain common characteristics with the drone industry as explained in Chapter 5.

5.2.1 AVIATION INDUSTRY

EASA (2015) mentions in its Technical Opinion that the drone industry should find inspiration in the aviation industry, with whom there - naturally - are many similarities and, in part, also common legislation. Aviation, by its very nature, is a border crossing industry crossing many different airspace areas thus dealing with lots of different areas of governmental jurisdiction (The Danish Transport Agency, April 16 2017). In line with the prevalence of aviation after World War II, international cooperation expanded on flight safety and common rules. Over time, it has evolved into a cooperation under the auspices of ICAO between all the world's nations about virtually all civil aviation activities. As a basis for cooperation, the expectation was that after the end of World War II, international civil aviation would increase significantly. At the time it would happen, there would be a need for common international standards for civil aviation for the sake of aviation security and flight safety. Also at a European and Nordic level close collaborations was established,e.g. in the form of a single European airspace - called Single European Sky - which was the result of efforts in the EU to provide better aviation safety, increased capacity and higher efficiency for air traffic control between countries. The single sky replaces the carpet of different national solutions for airspace and air traffic control, and at the same time helps reduce flight time by aligning and quality assure the way airspace is controlled (ibid.).

EASA points out that implementing similar standards in the drone industry can lead to an appropriate situation as known from the aviation industry where national rules and legislations refer to common international standards, which in turn provides a common starting point for e.g. radio communications in specific airspace and what kind of equipment and education should be required in order to communicate (EASA, 2015). Today, all ICAO standards are incorporated into Danish aviation legislation, and the Danish Transport Agency supervises the compliance. The Danish Transport Agency (April 16, 2017) is the main authority in Denmark within civil aviation and is therefore responsible for the ongoing monitoring and supervision of aviation security in Denmark and Danish aviation abroad. The Board's work on aviation safety consists of transforming international standards into Danish legislation, approving flight schools and other educational establishments, and overseeing quality systems, including only approved components in aviation. According to the Danish Transport Agency (ibid.) all rules and procedures, from the layout of airports to the flight itself, follow international standards, which are the same everywhere in the world. The common standards are established under the auspices of ICAO and include requirements for training and procedures, as well as for the layout of airports and airspace. Furthermore, all personnel working in aviation in jobs with possible effect on the flight safety must be certified. This means that the national aviation authorities issue a certificate to the personal as proof of that they have completed and passed an approved education to perform their safety related duties. Thus, all pilots, flight mechanics, air traffic controllers and cabin crew are certified (ibid.).

However, in the aviation industry, it is not only people who are certified. All components included in aviation must also be certified and approved before being used. This applies, for example, to all parts of the aircraft - from the seat cover to the electronic components of the cockpit - and to the advanced computer systems used for navigation and air traffic management. This is governed by a quality assurance system that is a requirement for all airlines, airports and other aviation companies that help monitor and fine-tune on matters that affect flight safety. Specifically, it means that internal inspections are carried out regularly in the company with the aim to correct possible sources of error before they risk having a safety significance, in addition to the external control performed by the Danish Transport Agency (ibid.).

5.2.2 WIND INDUSTRY

Like the aviation industry, the wind industry is subject to strict requirements and quality assurance systems in order to ensure safe operations and counteract machine downtime, which both in a worst case scenario can have major consequences for all involved in the value chain. The wind industry is becoming increasingly standardized according to the industry organization Vindindustrien (April 16, 2017) thus facing a need for standards that can not be misunderstood by suppliers on the one hand and manufacturers on the other. A modern wind turbine has over 50 times more operating hours than an average car, and is often exposed to extreme climate impacts on the sea, in arctic areas and in deserts. As one of the world's largest series of manufactured machines, the modern wind turbine must therefore be able to handle such impacts without breaking down. At the same time, the wind industry is under a massive pressure for industrial development to make wind energy less expensive than competitive energy technologies. The international focus on the transition to renewable energy is expected to lead to increased demand for green solutions - including wind energy. In this area, Denmark has global players, which have a unique position to exploit the increasing demand for wind energy. Developments are also moving towards increasingly global value chains and demand for socalled *system deliveries*, where solutions is sold as a interconnected package. These changes in the industry forces turbine manufacturers and their subcontractors to consider a new and reinforced way of handling knowledge sharing and documentation in an effective way. Companies in the wind industry are becoming increasingly in need of formulating technical specifications, test methods, service agreements and quality assurance requirements in a highly quality assured environment, which should be widely used throughout the international wind industry (Danish Government, 2015). Standardization is thus, according to the Vindindustrien (April 16, 2017) one of the keys to ensure a world-leading, cheap wind technology in the future and standards thus plays a central role for the future of the industry.

However, the industry organization Vindindustrien experiences that requirements for specifications from wind turbine manufacturers may contain requirements for documentation of conditions that subcontractors either can not interpret or not know how to test (Megavind, April 16, 2017). The wind turbine industry (April 16, 2017) and Dansk Standard (April 16, 2017) have therefore launched a common standardization project - called *New Standards in the Wind Industry* - which brings together the wind industry and the research community to create common standards for product design and quality management in the production process. The areas of competence that are united and standardized in the project are areas where the participating companies are not in direct competition with each other, which makes it possible to make individual knowledge common knowledge. The aim is to accelerate the maturation of a number of areas of strategic importance to the Danish wind industry, in particular to ensure competitiveness and reduce costs. The project will lead to the development of applicable standards for both testing and documentation of design and quality assurance in production. Dansk Standard will be part of the working groups as collaborator in order to assist with the anchoring of the standards that the working groups find and to provide the international secretariat for standards in the wind turbine area. The project is expected to give the Danish wind industry a unique opportunity to influence international standardization work (ibid .). The Danish government (2015) also supports the project and works to ensure that increased use of standards becomes a focus area as a tool to improve interaction between companies in the industry and to strengthen Danish companies' ability to enter global value chains. Thus, the Government's stated goal is to increase the application of existing international standards and contribute to the development of new relevant standards to spread them globally (ibid.).

Specifically, the project must redefine the areas of cooperation between several stages of the value chain (Vindmølleindustrien, April 16 2017). The project deals with new standards for testing and documentation of design and developing common concepts and standards for components of a wind turbine. The motivation behind the project is that wind turbine producers work closer and closer together with their suppliers and subcontractors, who are increasingly involved in the development, design and testing of new wind turbine models. In order to develop strong partnerships, there is a need for a common terminology and a documentation tool that minimizes errors and misunderstandings between the companies (ibid.). The project also deals with new standards for quality assurance in production e.g. by increasing the communication regarding quality assurance across the value chain, by creating significant cost reductions through fewer errors, by creating higher quality in production and by accelerating launch of new products. The project develops an industry-adapted version of the American Quality Management Tool APQP, which is a preventive quality assurance standard and a recognized tool focusing on production processes and quality standards - originally developed for the US automotive industry to systematically reduce production-related errors in a finished product. APQP can be used to systematically reduce production-related defects in the final product (e.g. wind turbines), even before components, subsystems and finished products leave the plant (Vindmølleindustrien, April 16, 2017).

5.2.3 OTHER RELATED INDUSTRIES

Also in other industries, standards are used as a tool for identifying best practices, which the drone industry could benefit from of adapting. These include the industries health and IT, both sharing certain characteristics with the drone industry, as explained in chapter 5. Within the Danish and European health industry, one of the major challenges is the lack of common standards for information and communication (ZealandDenmark, April 17, 2017). Thus, different systems from EU countries to EU countries, and even from region to region within national borders, are often used, which is paradoxically taking into consideration the ongoing development of electronic patient records, health portals, telemedicine services and other ICT tools that constantly creates more focus on the cooperation between hospital, the private doctors, the home care and the patient. Horizon 2020, which is the EU's Research and Innovation Program (Ministry of Education, April 17, 2017) will accordingly seek to develop common standards for IT systems to avoid competing systems that are not interoperable with the ICT solutions that Is already on the market. The goal is to save costly resources to develop new IT systems as well as increased interoperability in cross-border healthcare. In addition, the standards must create better opportunities for companies to develop innovative ICT products and to deploy it in a larger European market. Horizon 2020 calls SC1-HCO-14-2016, DS-03-2016 and SC1-HCO-16-2016 (ZealandDenmark, April 17, 2017) especially focus on ensuring interoperability whereby a product or service can be integrated and used with others systems. The calls also focus on creating standardized ICT solutions as well as standards for the health and welfare services delivered to the citizens via ICT. For example, it may be an international standard for patient records that will require interoperability in communications, which will contribute to increased collaboration in healthcare.

In the IT industry, interoperability and standardization are key concepts as technology changes very quickly (Hayden, 2002). A system or service developed and commercialized one day may be outdated shortly thereafter. Thus interoperability in the development of new technology and new services is crucial for companies' ability to future-proof their product or service. In the IT industry, the international working group - the Internet Engineering Task Force (abbreviated IETF) - is working with standardization with the purpose of making the internet work better (IETF, April 17, 2017) by producing unidirectional and quality assured technical documents that set the standard for how IT systems are designed, used and managed on the internet. The working group is not an official authority but rather an open source network consisting of network designers, researchers and users of the internet. The work is carried out in so-called working groups (abbreviated WG) organized within various areas such as data security, routing etc. The IETF publishes a document called the Internet Standards Process, which is the basic definition of how IETF compiles standards (ibid.). In essence, the process of creating an IETF standard means that a given new specification undergoes a period of development and multiple iterations by review from the group's open source network. Once the standard is complete, it is recorded in the IETF Catalog of Standards and published.

The objectives of the standards is amongst other to ensure technical expertise, easy-to-understand documentation and timeliness in the IT systems and the use of the internet. In practice, the process of making standards is complicated as today's rapid development of IT technology poses high standards for efficient and timely development of standards without compromising the creation of high-tech specifications and without slowing down the emergence of new IT related technology. At the same time, consideration must be given to the need for accommodate all parties involved and the need to establish consensus among users of the internet, which includes everything from citizens to authorities and businesses (ibid.). The IETF standards are available to all manufacturers who wish to apply them in their development of new technology, but without forcing manufacturers to use or comply with the standards. It is rather understood in the IT industry that products complying with these standards are interoperational (Hayden, 2002). In a time of identity theft, hacker attacks and cyber crime, IT security is becoming increasingly important for both citizens, authorities and businesses (ibid.). Here too, standards play a role, including to define the way a company wants its employees to act online. This applies e.g. the way they should use and handle company data (ibid.)

In Denmark, as part of its standardization strategy, the Danish Government will work to increase the influence on the development of new European IT standards, so that the international standards for public digitalization are based on the standards that are already widely used in Denmark. The purpose is to ensure the best possible coherence in IT solutions for the public sector while providing Danish developers and suppliers of IT solutions an optimal starting point for export through the management of Danish interests in the preparation of European standards (Government, 2015).

5.3 SUMMARY

This chapter has covered the first working question of the thesis' problem formulation by examining which established standards there can be identified in the drone industry and in related industries. The chapter has sought to provide the foundation for Chapter 6 where the importance of such standards and best practices for the Danish drone industry's competitive advantage will be assessed.

In recent decades, the number of standards in Denmark has increased significantly due to increased cross-border trade and cooperation. This development has made it necessary to establish a common reference base for e.g. procedures, methods and requirements for e.g. quality and safety to facilitate the development and trade across industries, borders and technologies. Several industry stakeholders and experts estimate that standardization and commonly acknowledged international standards will be an important step towards establishing common guidelines. The Danish Technological Institute (Dansk Standard, April 4, 2016) assess that standards could lead the way in establishing operational procedures for the use of drones. Thus this chapter has examined the drone industry for existing and ongoing initiatives in relation to standardization. In order to qualify the results, the studies have been expanded to also map standards and initiatives from related industries, which are currently more mature in the development than the drone industry, but have went through the same early development stage as the drone industry is today.

The examination of established standards in the drone industry have led to a number of discoveries, all of which are linked to two areas: rules/legislation and standards. The status of the drone industry is that the legislation and rules for drone aviation vary across EU countries, but is more or less well established in the majority of countries where commercial drone flights are conducted on a daily basis. However, the varying legislation impedes the trading and the mobility of drone services, which according to Dansk Standard is the reason for work should be done to develop common rules and legislation. The responsible authorities EASA and ICAO are also aware of the need to develop some standard risk scenarios for the most common uses of drones as most of the drone operators do not have a background in aviation thus lacking experience in producing risk assessments in connection with their drone flight - this often prevents drone operators from getting permission for drone flights internationally. According to the Danish Technological Institute, the Danish drone industry should therefore find inspiration in the ISO 9001 for quality management, where international standards and procedures allow for cooperation, which in turn could be expected to make it more safe to use drones - also across national borders.

However, despite many ongoing initiatives regarding standardization on a European and national level in Denmark, according to EASA neither a draft or applicable standards for operational procedures for the use of drones have yet been published. That said many initiatives are underway among the responsible authorities in order to counter the need for a common reference base for e.g. operational procedures for the use of drones. The need is expressed not least by the drone operators themselves who experience being restricted in their global competitiveness as they can not operate outside their own country due to different rules, procedures and requirements for education. Consequently, this chapter has examined existing standards in relevant industries related to the drone industry to investigate whether there are best practices that the drone industry can benefit from. The investigations have concerned the aviation-, health- and the IT industry, each sharing certain common characteristics with the drone industry. In these industries, there is currently a common reference base for the most critical areas of cooperation, trade and security. The chapter has mapped relevant standards and best practices and it is clear that the Danish drone industry will be able to find inspiration in many of the experiences that the related industries have made - this will be investigated further in Chapter 6.

CHAPTER 6: THE IMPORTANCE OF AN IMPLEMENTATION

This chapter will cover the second working question of the thesis' problem formulation:

What is the importance of a implementation of international standards for the Danish drone industry's competitiveness and potential competitive advantage?

According to the Danish Technological Institute (Dansk Standard, April 4, 2016) and Dansk Standard (April 1, 2017) standards can contribute to the establishment of common guidelines in the drone industry, including for the operational procedures for the use of drones. As argued in Chapter 3 by Erhvervsstyrelsen, a positive correlation has been established between a company's application of international standards and an increased productivity, export and valuation (April 6, 2017). Consequently, it is relevant to investigate the importance of a future implementation of international standards for the Danish drone industry's competitiveness and consider whether the industry can create a competitive advantage by for example take the lead in the international standardization work.

The chapter contains an analysis of the current competitiveness of the Danish drone industry in relation to the ongoing standardization work with common international standards and best practices. Chapter 2 of the thesis charted the current status of the Danish drone industry in respectively a global and national perspective, and Chapter 5 identified and mapped existing and related standards in the drone industry at a European level. Based on these chapters, the purpose of this chapter is to link this knowledge and investigate the importance of a future implementation of international standards and best practices for the Danish drone industry's competitiveness. Subsequently, in chapter 7, specific suggestions will be presented on how a standard for operational procedures for the use of drones could be designed to best support the growth conditions of Danish drone services companies.

6.1 IMPORTANCE OF STANDARDS TO COMPETITIVENESS

As explained in section 2.2, the Danish drone industry is considered to be well-placed in the international industry for the use of drones for service tasks. According to the Danish Government (2016), Denmark with its leading drone service companies are assessed to become one of the leading countries in the use of drones to efficiently and safely solve tasks that are currently resourceful and risky. This is despite a significant variation in legislation and rules for commercial drones across EU countries (Danish Technological Institute, April 7, 2017 and Ministry of Education, April 2, 2017), which according to Dansk Standard (April 4, 2016) inhibits the use and mobility of drone services. The current Danish competitive position of strength in the market is due amongst other to the quality of Danish legislation and rules for drone flight, as compared to other European countries has been implemented with inputs from all relevant authorities and consolidated into pragmatic rules for commercial drone flights. In addition, as stated in figure 2.4, the Danish legislation on drones is very similar to the legislation of the surrounding countries, enabling merit for Danish drone service companies in e.g. Norway and Sweden. According to the Ministry of Education (April 15, 2017), the varying rules and legislation may limit the possibility for academic researchers and companies to collaborate internationally, which is supported by the European drone operators who perceives themselves being hampered by their international growth opportunities (EASA, 2015). Danish drone service companies, however, benefit from favorable national growth conditions due to partly the Danish Government's (2015 & 2016) political focus on contributing to growth in the Danish drone industry, and partly to the use of international standards as a driving force for increased growth for Danish companies across industries.

The Danish drone service companies are in a situation where they are ready to contribute to and comply with future common standards for legislation and rules for drone aviation. The readiness to contribute actively to the standardization work gives the Danish drone industry the opportunity for a competitive advantage and the opportunity is present. EASA's publication (2015) Technical Opinion's contains overall instructions for the development of common standards, including a proposal for general rules for drone flight. It is suggested that the national authorities contribute so that the many different national rules and legislation can be internationally harmonized over time. This is in line with the Danish Government's investments in recent years, where investments has been done in research and development of the drone industry as well as the development of a new legislation that defines the framework and rules for drone service companies' use of drones. The rules takes into account, in particular, the respect for flight safety and privacy. In addition, the Danish Government (2016) has published a national strategy for the drone industry with the purpose of promoting the development and use of drone technology. According to Danish Technological Institute (May 2016) over 340 Danish drone operators can contribute to the development of common, unified and quality assured legislation and rules for drone flight by e.g. participate in the ICAO RPASP Panel, as mentioned in section 5.1. According to the ICAO (EASA, 2015), the RPASP Panel will work with proposals for standardized procedures, thus playing a crucial role in developing future rules for drone flight. Allowing Danish drone operators to participate in international standardization work will ensure that the Danish drone industry gets influence on the requirements and frameworks that are set in the final standards, which according to Dansk Standard (April 4, 2016) gains the Danish drone industry a significant competitive advantage.

According to EASA's instructions, the respective national standardization organizations - in Denmark headed by Dansk Standard - are tasked with establishing standards for risk scenarios for the most widely used drone applications in order to ensure the safety in drone flight at an evenly high level across EU countries in opposition to today scenario, where rules and risk scenarios diverge from country to country. The EASA instruction is supported by Danish Technological Institute (April 7, 2017) as standards according to the institute (Dansk Standard, April 4, 2016) can be a step towards establishing common guidelines for e.g. safety and risk scenarios as well as operational procedures, which currently do not exist at international level. The Danish Technological Institute thus sees standards as an important part of the solution to the constraints currently associated with drone technology and recommends that the Danish drone industry find inspiration in the standard of ISO 9001 for quality management, which, in addition to paving the way for international cooperation, among other things is expected to contribute to increased safety during the use of drones across national borders (ibid.). The EASA instruction (2015) gives the Danish drone industry a potential competitive advantage, as the Danish Government (2015) has already launched an interministerial analysis to identify regulatory areas where national requirements can be replaced by relevant international standards - e.g. legislation and rules for drone aviation. This is done on the basis of an analysis from the Danish Government's Productivity Commission, which points out that Danish companies' competitiveness is generally weakened due to national special rules - as well as special rules establish barriers for foreign companies in the Danish market. The Danish Technological Institute (Dansk Standard, April 4, 2016) thus define a task in developing standards for drones that enable cross-border cooperation in order to guarantee that a drone service company meets a set of quality requirements in their use of drones. This will make it easier and safer to use drones across national borders (ibid.).

As mentioned in section 5.1 the Danish drone industry is represented in the international standardization work as the Dansk Standard working group S-831 (April 15, 2017) is a Danish representative of the ISO Technical Committee ISO / TC 20 / SC 16. Even though both of these working groups is yet to publish their first draft or applicable standards it is still remarkable having a Danish representative working on standardization, which is the first step towards co-involvement and thus a significant competitive advantage as the industry can actively influence international standards actively and after Danish interests. The research and results of this thesis aims to be available for the working group after submission.

6.2 SUMMARY

This chapter has sought to link knowledge about the Danish drone industry together with ongoing initiatives on the preparation of international standards in relation to the international drone industry. The purpose of the chapter has been to investigate the importance of a future implementation of international standards in the European industry of drones for the Danish drone industry's competitiveness in order to estimate the potential for gaining a competitive advantage. Based on the research in this chapter, an implementation of international standards is considered to be in advantage for the Danish drone industry, as such an implementation is expected to further strengthen the industry's current strong competitiveness. The current competitiveness is due to e.g. the Danish legislation for drone flight, which is at a high level and comparable with the legislation of neighboring countries. The alignment in legislation paves the way for the Danish drone service companies to operate in both their near markets and on the international markets. The political focus and willingness from the Danish Government to contribute actively to the preparation of standards also speaks to the Danish drone industry's advantage. The political ambition that Danish drone service companies shall participate in international standardization work in the field of e.g. ISO, EASA and ICAO - including ICAO's RPASP panel - is expected to provide the Danish drone industry with a competitive advantages as Danish drone operators themselves actively can influence future legislation, whose rules they are to work under. If the Danish drone industry succeed in positioning themselves in the international regimes of standardization, the industry could gain an advantageous competitive position.

Despite the recognition of the major benefits of contributing to international work on future standards, the use of the standards today is relatively low in Denmark compared to the neighboring countries. Consequently, the Danish Government has launched a strategy for how to use international standards to increase the contribution to the economic growth. As part of this strategy for standardization, the Government will work for increased use of international standards in the Danish drone industry and let Danish companies and stakeholders actively contribute to the development of international standards (Ministry of Business, May 6, 2015). The research conducted in Chapter 5 demonstrated that in both the IT and wind industry, working groups have been established with representatives from a wide range of their respective industries, academic researchers as well as authorities that actively contribute to the development of new standards, which - according to the participants - help to gain a competitive advantage as participants exert active influence while gaining insight into future standards.

The research conducted in Chapters 5 and 6 has shown that interoperationality will become a buzzword for those industries and companies striving to ensure their competitive advantage in the future globalized market. This applies in the drone industry, but also in the aviation-, healthcare- and IT industry, all of which are the industries dealt with in Chapter 5 and continued in Chapter 6. In these industries, new technology may necessarily speak together to be interesting for the users and the market - also in the long run. For the Danish drone industry, it means that interoperability and standardization become key concepts, as drone technology is developing technically at a rapid pace. If the Danish drone industry succeed in contributing and conforming to international standards they will be able to maintain and - over time strengthen - its current competitiveness in the global market. The Danish Government's strategy for standardization - including seeking to replace national requirements with relevant international standards - is considered to be another step in the right direction of increased use of international standards, which is further expected to strengthen the Danish drone industry's competitiveness.

The Danish Government's strategy for the Danish drone industry is another indication that the drone industry has political support as the Government consider the civilian use of drones as a major growth potential. This political support combined with the Danish strength positions within drone-related academic research fields such as sensor- and robotic technology and IT (Technological Institute, May 2016) is believed to positioning the Danish drone industry with good opportunities in the global competition for maintaining its current competitiveness. The following chapter is based on the hypothesis that standards are in favor of the Danish drone industry as proposals for standards for operational procedures for the use of drones is designed to support the growth conditions of the Danish drone service companies.

CHAPTER 7: OPERATIONAL PROCEDURES IN THE DRONE INDUSTRY

This chapter will cover the third working question of the thesis' problem formulation:

With the knowledge of best practices and established standards in industries related to the drone industry and within the drone industry, how can operational procedures for the use of drones be designed, so that they support the Danish drones service companies' growth conditions?

As set out in Chapter 3, so-called standard operating procedures (abbreviated SOP, in this thesis referred to as operational procedures) are used to provide a quality assured procedure for performing a given task. In relation to the Danish drone industry, the preparation of operational procedures for the use of drones is a slow-hanging fruit in the effort to maintain and strengthen the industry's current competitiveness. As stated in chapter 6, the work on drafting standards and operational procedures has been initiated by Dansk Standard's working group S-831 (April 15, 2017), but despite recommendations from Danish Technological Institute (Dask Standard, April 4, 2016) for developing such standards due to the fact that drone flights take place across the country on a daily basis, standards are yet unpublished. In spite of the fact that research conducted by academics has shown that the Danish drone industry has the political backing to be at the forefront of international standardization work with the adoption of the Danish Government's (2015 & 2016) strategies for partly the drone industry and partly for using international standards. Accordingly, it is relevant to investigate how such operational procedures can be designed so that they simultaneously support the growth conditions of Danish drone service companies and, are interoperable and can cross national borders and guarantee that drone service companies use international standards with recognized quality requirements in their use of drones.

Chapter 3 describes how standards can create value for companies, and Chapter 6 examined and confirmed the importance of standards already - and in the future - for the Danish drone industry. Based on these chapters, this chapter serves to design operational procedures for the use of drones with the boundaries defined in section 1.1. The chapter initially contains a theoretical review of operational procedures followed by a presentation of the thesis' proposal for the design of specific operational procedures for the use of drones. In the following chapter 8, these procedures will be tested in a case study in the form of a technical feasibility study where the investigations intend to assess the effect of the operational procedures on the case company measured at the measurement points 1) safety during the use of drones 2) the degree of efficiency in the operations and 3) the degree of quality in the data collection.

7.1 OPERATIONAL PROCEDURES EXAMINED

Operational procedures is defined as a set of written instructions that document and indicate how a given routine or repeated task should be performed in a given organization (U.S. Environmental Protection Agency, 2007). The procedures describe both technical and operational actions in an organization's core processes and may include description of how equipment is to be handled, including maintenance, calibration and practical use (ibid.). Operational procedures thus ensure that all procedures are considered and each assignment in a given procedure is performed in the same way every time (Anderson, April 30, 2017). Operational procedures also ensure that a given task is performed correctly in regards of compliance with internal quality standards and drone flight safety requirements (ISO Update, April 30, 2017) as well as with applicable rules and legislation (U.S. Environmental Protection Agency, 2007).

Operational procedures are used in a range of industries ranging from manufacturing (e.g. ISO 9000), healthcare (e.g. ISO 13485), FDA (e.g. ISO 22000, GMP), information technology (e.g. ISO 20000), accounting (e.g. GAAP) and Human Resources (e.g. FMLA). Regardless of industry, operational procedures are based on the critical core processes of a organization and exist as a consequence of the recognition that not all procedures are always performed as planned. Operational procedures allow important data to be collected and recorded, such as errors and deviations, by which corrective actions can be taken forwardly (Anderson, April 30, 2017).The operational procedures are designed to be unique to the organization whose core processes are contained in the specific procedures and the operational procedures thereby become an integral part of a well-established quality system as it gives the organization's employees instructions to perform a given task correctly and to desired quality (U.S. Environmental Protection Agency, 2007). For example, organizations certified to the International Quality Standard ISO 9001 face requirements of documenting its core processes in specific operational procedures as soon as the core process has the least impact on the quality of the organization's product or service (ISO, 2011).

Operational procedures should be written in a concise, easy-to-read format - often with a appendix with step-by-step instructions on how a given sub-task should be performed in a quality assured manner to eliminate errors in the organization's core processes (ibid). The procedures indicated should be clear, explicit and not too complicated in order to remove any doubts as to what is required in given assignment. It is recommended to use flow chart diagrams to illustrate the overall procedure as well as the individual sub-tasks described, as well as to use checklists, which are also used e.g. by ISO's own inspectors for audits of ISO certified organizations. Checklists can be used to document actions taken during the procedure, but do not in themselves constitute an operational procedure - they are rather a guideline for how to follow the procedure (U.S. Environmental Protection Agency, 2007). Operational procedures must be readily available in the work areas of the employees performing the individual sub-tasks and assignments, and they must be regularly reviewed and enforced by management in order to create real value to the organization. Ultimately, the benefits of having well-established operational procedures are more efficient work and improved competitiveness, to a greater extent comparable with their competitors and collaborators, as well as increased credibility and reliability in terms of quality in their product or service (ibid.).

7.2 DESIGNING NEW OPERATIONAL PROCEDURES

This section present the thesis' proposals for a standard for operational procedures for the use of drones under the auspices of the case company Dronops, which performs drone services in the field of infrastructure inspection, 3D mapping and agriculture analysis. The operational procedures in this chapter describes both technical and operational actions in connection with the handling of three types of drone operations and retrieves its theoretical foundation in the theory examined in section 7.1. To focus on the core purpose of this section, only one of three designed operational procedures is included in the chapter, being infrastructure inspection, as the two others - which has been specially designed for this thesis as well - is included in the appendixes, covering 3D mapping and agriculture analysis. The review of the procedures in this section is conducted with the two other in mind, as the operational procedures regardless of type of operation is rather the same in regards of the checks during flight and before- and after flight. The procedures has been developed with respect to the different categories of drones being *Open, Specific and Certified* as the procedures has been developed from flight with different types of drones, as mentioned in section 8.1.

The purpose of these operational procedures is partly to ensure that a given assignment during drone flight is performed correctly, partly to comply with applicable quality and safety requirements, and to comply with applicable national rules and legislation for drone flight. This section will go through the standard for operational procedures step by step starting with the operational procedure shown below in figure 7.1 and attached as Appendix 1:

Document # **1**	Title: **Operational procedure for infrastructure inspection**	Print Date: **April 2nd 2017**
Revision # **1.0**	Prepared By: **Christian Møller, Dronops**	Date Prepared: **March 3rd 2017**
Effective Date: **May 1st 2017**	Approved By: **Jonas Laurien, Dronops**	Date Reviewed: **April 3rd 2017**

Purpose: The purpose of this operational procedure is to specify how drone operators must conduct drone operations before, during and after infrastructure inspection operation. The aim is to increase safety, effectiveness and quality during flight and data collection.

Scope: This operational procedure is valid for all drone operators within Dronops conducting drone operations.

Responsibilities:

Drone operators are required to follow this operational procedure.

Flight planners are required to keep this operational procedure in mind during desktop planning of drone operations within Dronops.

References:

Transport-, Bygnings- og Boligministeriet (2016): *BEK nr 1119 af 22/08/2016 (Bydronebekendtgørelsen).* Hentet fra: https://www.retsinformation.dk/Forms/R0710.aspx?id=183645

United States Environmental Protection Agency (2007): *Guidance for Preparing Standard Operating Procedures.* Hentet fra: https://www.epa.gov/sites/production/files/2015-06/documents/g6-final.pdf

Figure 7.1: Operational procedures for infrastructure inspection

The document serves to scope the use of the operational procedure as well as underlining which references has contributed, so the user can read more if needed. Responsibilities are allocated to whom it may concern in order to eliminate any doubts on who the procedure is relevant for. This operational procedure is based on a step by step checklist covering the entire process of technical and operational actions divided into before, during and after a operation. From desktop planning, in which all conditions related to the flight and operation are performed, to the pre-flight check at the location of the operation, where drone and sensors are checked before flight. Also during the flight, a checklist will be followed to ensure that safety is respected while optimizing resource consumption and ensuring high quality in the data collection. After the operation the post-flight check will be followed, where flight data from the operation is examined as well as the quality of the data collection should be carefully reviewed on location. These checklist is shown in figure 7.2 below:

Checklist and operational procedures:

<u>Before operation - desktop planning</u>

1.0	M	Control of NOTAM for selected flight area
2.0	M	Control of weather forecast for selected flight area
3.0	M	Flight planning of selected flight route (using automated flight track)
3.1	M	Flight planning of dedicated emergency landing area near flight route
4.0	M	Notification of authorities and police

<u>Before operation - pre-flight check</u>

5.0	M	Visual screening of selected flight area
5.1	M	Obstacles nearby selected flight area
5.2	M	Actual weather condition on location
5.3	M	Secure landing area and dedicated emergency landing area
6.0	M	Visual on location flight route planning in selected flight area
7.0	M	Test of GPS signal and electronic flight systems
8.0	M	Safety briefing of personel within dedicated safety area
9.0	M	Pre-flight check of drone and sensors
9.1	M	Firmwire updated
9.2	M	Compass calibrated
9.3	M	IMU calibrated
9.4	M	Flight batteries condition
9.5	M	Drone aircraft physical condition
10.0	M	Control of fail safe mode

During operation

11.0 ᴍ Monitor flight batteries condition and level

12.0 ᴍ Monitor flight compass status

13.0 ᴍ Monitor actual flight route complies with planned flight route

14.0 ᴍ Visual screening continuously of selected flight area

15.0 ᴍ Monitor recording quality of footage of infrastructure for inspection

16.0 ᴍ Monitor distance and height from infrastructure for inspection

After operation - post-flight check

17.0 ᴍ Monitor flight batteries condition and level

18.0 ᴍ Monitor actual flight route complies with planned flight route

19.0 ᴍ Log flight data and required information

20.0 ᴍ Examine recorded footage of infrastructure for inspection

21.0 ᴍ Report unintended event during flight to authorities

22.0 ᴍ Inspection and repair as necessary on location

23.0 ᴍ Recharging of flight batteries

Figure 7.2: Operational procedures for infrastructure inspection

As examined in section 7.1 checklists as presented in this section do not constitute an operational procedure in themselves but serves as a guiding document for proving the use of the procedures. As checklists are intended for usage on location, process maps is ideal for a quick overview of the steps. Such a map is presented in figure 7.3.

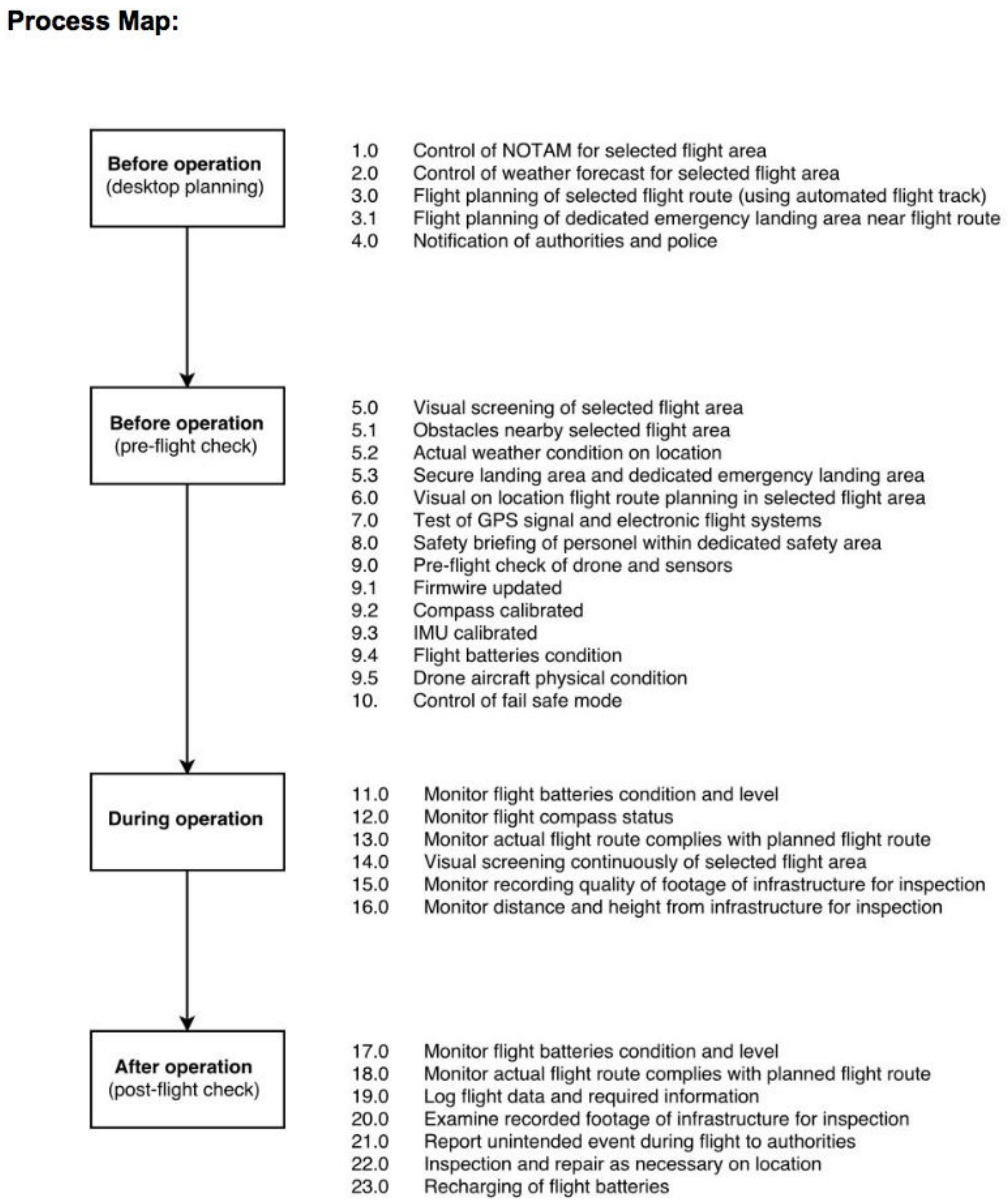


Figure 7.3: Operational checklist for infrastructure inspection

7.3 SUMMARY

This chapter has considered the third working question of the problem formulation concerning proposals for a standard for operational procedures for the use of drones. The chapter has examined the theoretical foundation for operational procedures and presented proposals for how such procedures can be designed based on the tasks solved by the case company of the thesis. It has been the purpose to lay the foundation for testing the operational procedures on a number of measurement points related to safety, efficiency and quality during drone flight and data collection, which will be conducted in Chapter 8.

The chapter's proposal for operational procedures aims at providing a quality assured procedure for performing a given operation during drone flight in operations such as infrastructure inspection, 3D mapping and agriculture analysis. Based on the process of designing the operational procedures in this chapter, standardization of operational procedures for the use of drones is considered both possible and relevant for the drone operators specifically and the Danish drone industry generally. It will ensure a quality assured approach to the vital, however, repeated daily tasks of conducting a drone flight and are expected to strengthen industry competitiveness as it will streamline e.g. the time spent on flight and heighten the quality in the data collection - to mention a few of the positive consequences of such implementation. The proposed standard for the operational procedures has been developed to be generic and usable for drone operators across drone services and has taken into consideration all known best practises from standards and operational procedures from related industries. Thus the proposed procedures are assessed to be valid and reliable. They will change the way drone operators work with their flight operations and is thus assessed to benefit the industry in general, as the drone services providers gain an competitive advantage by streamlining their operations and heightning safety during flight, compared to the past where no procedures has been followed.

CHAPTER 8: TESTING NEW OPERATIONAL PROCEDURES

This chapter will cover the last working question of the thesis' problem formulation:

Which effect do the new operational procedures have for the drone service companies measured at the following measurement points?

- *The degree of safety during the use of drones*
- *The degree of efficiency in operations*
- *The degree of quality in the data collection*

Chapter 7 established and designed a proposal for new operational procedures for the use of drones with the thesis' theoretical framework in mind. Based on the theoretical review of operational procedures examined in chapter 7, this chapter include a test of the proposed procedures. The test is carried out at the thesis' case company as a technical feasibility study and is designed to test the procedures at the measurement points mentioned above in a real operation environment.

The overall hypothesis of the thesis is, that the Danish drone industry can achieve a significant competitive advantage in the global market by implementing and following international standards for operational procedures for the use of drones. These standards is expected to bring a number of operational benefits to the case company in specific as well as strategic benefits for the drone industry in general. For the case company the procedures is expected to heighten the level of flight safety during operation, streamlining the planning process and making operations more efficient as well as increasing the quality in the data collection. As a strategic result, it is expected that the new designed operational procedures will increase the interoperability of the Danish drone industry in general due to easier access for collaboration with foreign companies and stakeholders with all the competitive strengths it brings. This hypothesis will be subject to thorough tests in the following.

8.1 TEST DESIGN

This section will cover how the test of the operational procedures proposed in chapter 7 has been designed and tested in different operational environments and with different platforms of drones from selected drone categories. Included in this section is an in depth description of the data collection process of the thesis. Also it will be covered how the data has been analyzed, in order to enable stakeholders to review and utilize the knowledge created in this thesis. The tests has been carried out from June to August 2017 with assistance from the thesis' case company Dronops, who holds all relevant permissions for operating drones in drone service operations such as these included in the thesis.

The tests has been carried out by comparing three different drone service operations conducted respectively with and without the proposed operational procedures, as presented in chapter 7. The services included is inspection of critical infrastructure, 3D mapping and agriculture analysis, all of which implies a wide range of different issues related to any given drone service operation in regards of the use of manual versus autonomous flight paths, the way of conducting pre- and post flight checks as well as the respect to flight safety. Thus these selected drone services is assessed to be representative for the test of operational procedures in relation to drone services in general. Additionally, the tests has been conducted in a range of different operational environments with varying weather conditions. In the first test scenario, flights was conducted in conditions with less to zero wind speeds and no rain, which constitute the optimal conditions for drone flight. The weather conditions in the second test scenario was up to 6 m/s (Metric) and no rain, which constitute the most likely operational environment in the Danish drone industry. In commercial drone flight, the services included in this thesis is not likely to be conducted in heavy wind and rain - or by night - as such conditions prevent an optimal data collection nor a safe operation in respect of flight safety. Thus the different test scenarios included in this test is assessed to be representative for the operational procedures for drone services in general.

Figure 8.1: Pre-flight check before operation of the DJI Inspire 1

To ensure a high degree of validity to the test, different drone platforms from the consumer- and prosumer segment has been tested during the different drone services. This include the consumer drone model DJI Phantom (included in the *Open* category with a cost price from DKK 7.000,-) and the prosumer drone model DJI Inspire (included in the *Specific* category with a cost price from DKK 30.000,-). These drone platforms is among the most frequently used drones commercially in the Danish drone industry as well as globally (Forbes, 2015). The drones is illustrated in Figure 8.2 below:

Figure 8.2: Drones from the Open and Specific categories from www.DJI.com

The tests is carried out with a drone operator from the case company, Dronops, systematically following the test scenarios listed in Figure 8.3 from test # 1 to # 12. For each test number the drone operator conducts first a flight without any operational procedure[1], next a flight using the proposed procedures. The drone operator is instructed to conduct the given drone service, and subsequently log his immediate assessment evaluating how the operation went, by scoring the main test parameters *safety, efficiency and data quality* using the statements and parameters given in Figure 8.5 presented further below in this section. To eliminate any unforeseen sources of error or coincidences that may affect the test result with undesirable deviations, each flight is conducted three times in a row before the score is logged. Also the tests of each service is conducted at the same day, securing comparable conditions when testing e.g. 3D mapping in a windy scenario using different drone platforms, as goes for test number # 6 and # 8. All tests has been conducted during a time period of 2 weeks from first to final test in order to be able to test in different operational scenarios without risking to big deviations in the overall weather conditions such as lower temperature which affects battery performance negatively. The different tests carried out can be mapped as illustrated in Figure 8.3:

# TEST NUMBER	Inspection of critical infrastructure	3D mapping	Agriculture analysis
DJI Phantom / No-wind scenario	# 1	# 5	# 9
DJI Phantom / Windy scenario	# 2	# 6	# 10
DJI Inspire / No-wind scenario	# 3	# 7	# 11
DJI Inspire / Windy scenario	# 4	# 8	# 12

Figure 8.3: Overview of tests of operational procedures

[1] The current way of conducting the given drone service, where the case company currently have no operational procedures for the use of drones applied.

During the test and the drone operators' evaluation and scoring of the operation, the "PIECES" framework for feasibility study is taken into consideration as well. According to the University of Toronto (2004) this framework is useful for the initial identification of potential problems to be solved as well as their urgency, when used as a part of a technical feasibility study. Usually feasibility studies involves research of the technical and operational perspectives of a given process (Bright Hub Inc., May 20 2017) when organisations is to determine whether a future project or process is feasible and beneficial (University of Toronto, 2004). The framework consider the following areas and questions as shown in Figure 8.4 below, which will be utilized for inspiration for the drone operator to reflect on the three main areas of the research *safety, efficiency and data quality* when scoring the flight and operations.

Performance
- Is current performance adequate?

Information
- Do users and managers get timely, accurate and usefully formatted information and data?

Economy
- Are services provided by the current system cost-effective?
- Could there be a reduction in costs and/or an increase in benefits?

Control
- Are there effective controls to protect against fraud and to guarantee information accuracy and security?

Efficiency
- Does current system make good use of resources such as people, time and data?

Services
- Are current services reliable?

Figure 8.4: Overview of the PIECES framework (University of Toronto, 2004)

As illustrated in Figure 8.5, the test scores from the drone operator is divided into the boxes, determined by the limits set from +0.5 to -0.5 (where +0.5 being the best score and -0.5 being the worst score in matter of experienced quality within the test parameters). Also a set of upper and lower limits is added to clarify eventual high scores from -0.2 to -0.5. The drone operators is given an index connected to the divided scores, assisting them to assess the flight accordingly to the test design with scores from +0.5 to -0.5. The index is designed with a set of standard statements related to the drone flight and operation as listed in Figure 8.5. The test scores can be examined in depth in Appendix 5 and will be included in the following section when analyzing the three test parameters in depth.

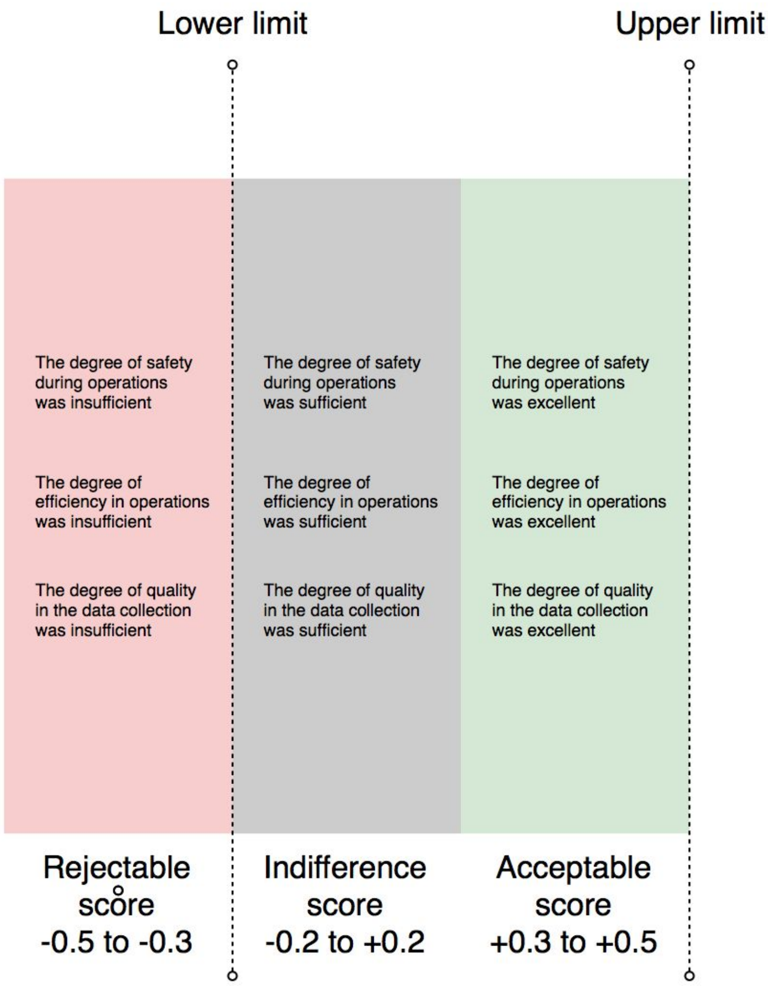


Figure 8.5: Overview of test index and statements

The average test scores of each test ranging from -0.5 to +0.5 is then plotted into an Excel sheet divided into the test conducted with the operational procedures in column B (***w)*** and the test conducted without (***w/o)*** as seen in column D for test number # 1 in Figure 8.6 below - column C and E will be explained later in this chapter:

	A	B	C	D	E
1		**w**		**w/o**	
2	#1	0,4	0,5793831055	0,2	0,7365402806
3		0,3	0,6664492058	0,1	0,782085388
4		0,5	0,483941449	0,2	0,7365402806
5		0,5	0,483941449	0,2	0,7365402806
6		-0,3	0,6664492058	0,4	0,5793831055
7		-0,2	0,7365402806	0,4	0,5793831055
8		0,5	0,483941449	-0,3	0,6664492058
9		-0,2	0,7365402806	0,4	0,5793831055
10		0,4	0,5793831055	-0,1	0,782085388
11		0,3	0,6664492058	-0,1	0,782085388
12		0,3	0,6664492058	0,1	0,782085388
13		0,4	0,5793831055	-0,1	0,782085388

Figure 8.6: Example of Excel spreadsheet with test scores

In the next phase of the test, acceptance control charts is applied in order to analyze the data gathered and defining the upper and lower limits presented in Figure 8.5. This use of acceptance control charts enables the stakeholders to read the data gathered from the case company properly, as the data needs to be fused in order to be readable for stakeholders, allowing them to evaluate the results obtained in the test from a quantitative perspective.

According to ISO (July 10, 2017) control charts combines consideration of control implications with elements of acceptance sampling. It is an appropriate tool for helping to make decisions with respect to process acceptance. The basis for the decisions may be defined in terms of whether or not a designated percentage of a service level derived from a procedure will satisfy the requirements of a given drone service quality specification. In this case a difference from most acceptance sampling approaches is that the concept of process acceptance is introduced in the process control with emphasis on process acceptability rather than on product disposition decisions. A check on the inherent stability of the process is required. Therefore, variables can be monitored using a Shewhart-type range or sample standard deviation control charts to confirm, that the variability inherent within rational subgroups remains in a steady state. Ideally, the average value of such a control chart would be at the target level (ISO, July 10 2017). A Shewhart control chart is illustrated in Figure 8.7 and will be utilized to make the score data from the test readable:

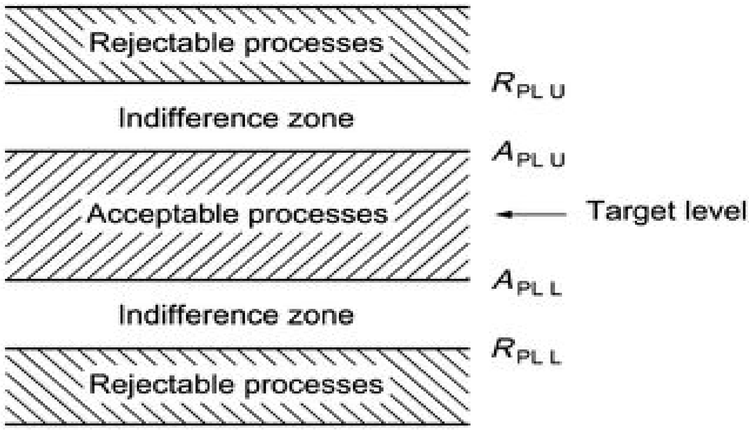


Figure 8.7: Shewhart control chart (ISO, July 10, 2017)

In the control chart shown in Figure 8.7, one should pay attention to the three greyed boxes which determines whether a score is within the acceptable zone or not. In turn this determines whether there is a difference in the test parameters of interest from the proposed operational procedure one the one side and the current state on the other side, where no operational procedure is being followed.

With all scores gathered from the drone operators - as presented in Appendix 5 - the data set is put into a histogram graph, which can be used as a graphical tool to visualize data in a bar chart as shown in Figure 8.8, where the height of each bar represents the number of observations falling within a range of rank-ordered data values (Quality America, July 23 2017) enabling an analysis of the scores. The analysis seeks to determine if there exists a difference in the conducted drone services with or without the proposed operational procedures respectively as presented in chapter 7.

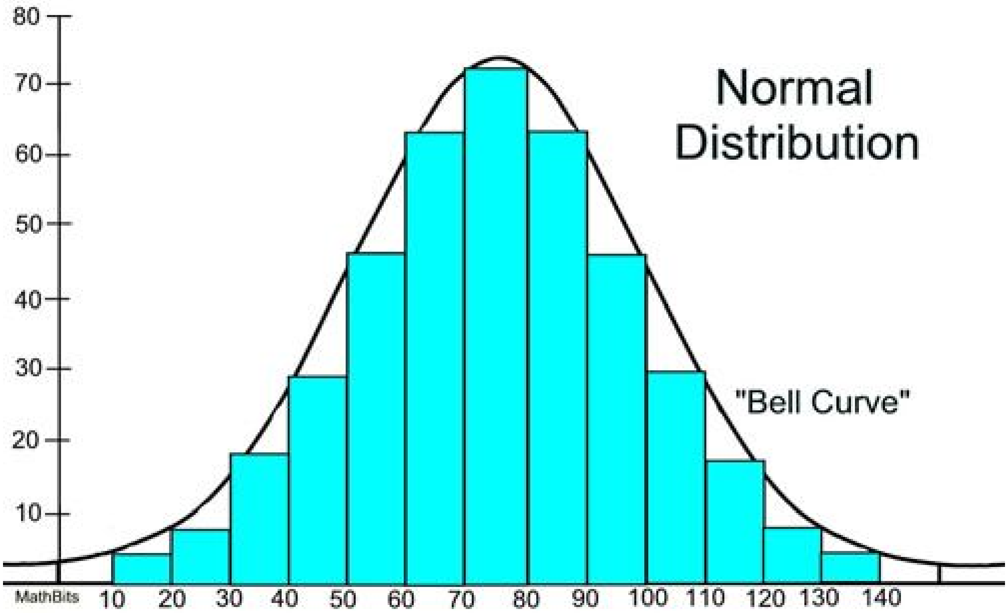


Figure 8.8: An graphical example of a Normal distribution curve

An acceptance control chart is typically used when the process variable under study is normally distributed as the example goes in Figure 8.7 (ISO, July 10 2017). Normal distribution is the spread of information of e.g. performance scores where the most frequently occurring value is in the middle of the range and other probabilities tail off symmetrically in both directions. Normal distribution is graphically categorized by a bell-shaped curve also known as a Bell Curve or a Gaussian distribution. For normally distributed data, the mean and median are very close and may be identical. Normally distributed data is needed to use a number of statistical tools such as control charts (iSixSigma.com, July 23 2017). With the data set of this thesis being normal distributed, the Gaussian distribution is assessed to be suitable for this analysis to sort out all the data gathered in form of tests scores. Looking at figure 8.6 again, column C and E represents the formula for creating the graph which is created with a mean = 0 and a standard deviation = 0,5 which takes into account a given score - i.e. 0,4 - and connects the score with the mean and standard deviation using the Excel formula *NORMDIST*:

=NORMDIST (*0,4*; 0; 0,5; FALSE)

With the above described method, the following sections 8.2 to 8.4 will analyze the test parameters *safety (section 8.2), efficiency (section 8.3) and data quality (section 8.4)* as they are evaluated individually using the data set from the test scores. Subsequently in section 8.5, a summarization is presented with the total score of all tests presented graphically, as well as the individual scores for each test from number #1 to # 12. is presented. Each of the following section's analysis will be based on the results of the data gathered from the test conducted by the case company, which also can be found in Appendix 5, where the scores of the test parameters is included as well. Figure 8.3 should be kept in mind during the reading of the sections in order to keep track on which test # number is being scored by the drone operator.

8.2 SAFETY DURING OPERATION

All drone operations during the tests was conducted in public areas causing the need for high demands to safety during operation in order to avoid personal injury, property damage or violation of rights and legislations. The operations was conducted within the boundaries of the Danish drone legislations but especially the infrastructure inspection had to take full advantage of the limits of the law, as the operation demanded the drone to fly close to the road inspected during operation. When using the operational procedure thus operating with the automated flight path, the operation not only was performed more safely than when flying manually, it was also performed with less risk of compromising safety. With a significant difference to note, the operation where operational procedures and automated flight path was used, the flight paths - which is automatically tracked by the drones' onboard GPS - followed a flight path in appropriate distance to the area inspected, which is in full compliance with Danish rules and legislation. Where the operational procedures was not used, flight paths diverged from the desired flight path thus breaking the rules for distance to public roads, which is applicable due to safety reasons. This had an significant impact on the drone operator's scoring in the favor of the operations using operational procedures. In general, safety issues was respected the most when operating using the operational procedure, as it e.g. was possible to monitor the airspace in which the operations was performed to a higher degree, than in the case where flight was conducted manually. Also, there was better time for monitoring the distance and height of the drone in relation to the road inspected, when following the procedures, as the test scores in Figure 13 shows:

SAFETY								
	Inspection of critical infrastructure							
# Test number	1		2		3		4	
With (W) or without (W/O) procedures	W	W/O	W	W/O	W	W/O	W	W/O
Area of test								
Degree of safety during the use of drones								
Adherence of legislation	0,4	0,2	0,3	0,1	0,5	0,3	0,3	0,1
Breakage of risk during operation	0,3	0,1	-0,3	-0,4	0,4	0,3	-0,2	-0,3
Monitoring of airspace during operation	0,5	0,2	0,5	-0,3	0,5	0,4	0,5	-0,1
Lines of communication during operation	0,5	0,2	0,4	0,1	0,4	0,3	0,3	0,1
	3D mapping							
# Test number	5		6		7		8	
With (W) or without (W/O) procedures	W	W/O	W	W/O	W	W/O	W	W/O
Area of test								
Degree of safety during the use of drones								
Adherence of legislation	0,4	0,2	0,3	0,1	0,5	0,3	0,3	0,1
Breakage of risk during operation	0,3	0,1	-0,3	-0,4	0,4	0,3	-0,2	-0,3
Monitoring of airspace during operation	0,5	0,2	0,5	-0,3	0,5	0,4	0,5	-0,1
Lines of communication during operation	0,5	0,2	0,4	0,1	0,4	0,3	0,3	0,1
	Agriculture analysis							
# Test number	9		10		11		12	
With (W) or without (W/O) procedures	W	W/O	W	W/O	W	W/O	W	W/O
Area of test								
Degree of safety during the use of drones								
Adherence of legislation	0,5	0,3	0,4	0,2	0,5	0,4	0,3	0,1
Breakage of risk during operation	0,3	0,2	-0,1	-0,3	0,4	0,2	0,1	-0,2
Monitoring of airspace during operation	0,5	0,4	0,4	-0,4	0,4	0,3	0,2	-0,2
Lines of communication during operation	0,5	0,4	0,3	-0,1	0,5	0,3	0,4	-0,2

Figure 8.9: Test score data regarding safety during operations

The test score regarding safety during operation also resulted in the advantage of the operation using operational procedures with a significant differences especially in the ability to communicate during operation, as a result of lots of manual work being replaced by autonomous flight paths during inspection. The same goes for the test scores of the operational procedures for 3D mapping and agricultural analysis, as the use of drones for especially these services depends on a consistent drone flight that should not be paused during flight, as is it possible with other drone services. Here the use of autonomous flight increased the overall performance when following the procedures.

Taking the “PIECES” framework into consideration, two areas stands out; the level of information and the data obtained by using the operational procedures. These are critical when operating drones in public areas, as the flight information from the drone has to be instantly, accurate and precise in order to conduct an safe operation. Also the onboard services - such as real time GPS tracking systems - is important, as the services guarantee precise data for the flight information and data collected during operation. In this case these factors is considered reliable.

8.3 EFFICIENCY IN OPERATION

In theory, the efficiency in operation should be higher when using the operational procedures, as the flight paths when not flying autonomous often diverge significantly from the desired flight route costing additional time and resources in relation to the operation. Taking the “PIECES” framework into consideration and looking at the degree of economy and efficiency in a given operation - defined by how will the equipment, time and other resources needed for the operation is utilized - the operations using operational procedures still should be the most efficient one, since flight time is minimized. But the test scores gathered in this thesis shows another result, as the operations not using the procedures tends to score higher on most of the parameters in relation to the efficiency in operation as seen in Figure 8.10. The difference is most likely due to the amount of time spent on e.g. time-consuming desktop planning, pre- and post-flight checks, which is part of the operation using operational procedures conducted before operation. These steps is important in order to guarantee a safe and efficient operation, which logically consumes more time than not making the plans and checks prior to the flight. But, as the test scores in Figure 8.11 shows, the planning included in the operations using the operational procedures actually results in time saved during flight, driving these operations to be the most efficient with a significant difference in test score. It can be concluded, that even though it may take more time to get in the air and conduct the operation - whether it is infrastructure inspection, 3D mapping or agriculture analysis - when in midair, the operation itself is far more efficient than the operation not following the procedures.

EFFICIENCY								
	Inspection of critical infrastructure							
# Test number	1		2		3		4	
With (W) or without (W/O) procedures	W	W/O	W	W/O	W	W/O	W	W/O
Area of test								
The degree of efficiency in operations								
Time spent on desktop planinng	-0,3	0,4	-0,3	0,4	-0,2	0,3	-0,2	0,3
Time spent on pre-flight check	-0,2	0,4	-0,2	0,4	-0,2	0,4	-0,2	0,4
Time spent on operation	0,5	-0,3	0,3	-0,5	0,5	-0,4	0,3	-0,5
Time spent on post-flight check	-0,2	0,4	-0,2	0,4	-0,1	0,5	-0,2	0,4
	3D mapping							
# Test number	5		6		7		8	
With (W) or without (W/O) procedures	W	W/O	W	W/O	W	W/O	W	W/O
Area of test								
The degree of efficiency in operations								
Time spent on desktop planinng	-0,3	0,4	-0,3	0,4	-0,2	0,3	-0,2	0,3
Time spent on pre-flight check	-0,2	0,4	-0,2	0,4	-0,2	0,4	-0,2	0,4
Time spent on operation	0,5	-0,3	0,3	-0,5	0,5	-0,4	0,3	-0,5
Time spent on post-flight check	-0,2	0,4	-0,2	0,4	-0,1	0,5	-0,2	0,4
	Agriculture analysis							
# Test number	9		10		11		12	
With (W) or without (W/O) procedures	W	W/O	W	W/O	W	W/O	W	W/O
Area of test								
The degree of efficiency in operations								
Time spent on desktop planinng	-0,5	0,4	-0,4	0,4	-0,4	0,5	-0,4	0,3
Time spent on pre-flight check	-0,4	0,3	-0,3	0,5	-0,3	0,4	-0,4	0,4
Time spent on operation	0,4	-0,4	0,4	-0,5	0,4	-0,3	0,3	-0,5
Time spent on post-flight check	-0,3	0,5	-0,1	0,4	-0,2	0,4	-0,2	0,3

Figure 8.11: Test score data regarding efficiency during operations

It will be a question of prioritizing the resources if time should be invested before and after the flight operation, *or* during the flight. One could state - with the PIECES frameworks focus on e.g. economy in mind - that time consumed midair is more expensive than time consumed during ground planning due to usage of equipment, thus defending the difference in the test scores between by connecting the higher score of the efficiency in operations using operational procedures with the higher degree of safety during operation and better quality of the data collected.

8.4 QUALITY IN DATA COLLECTION

A safe and efficient operations is worth nothing, if the data collected turns out to be useless, as data collected during operation must be of high quality in order to be processed properly in the subsequent analysis. Quality in the data collection is essential and compared across the test scores presented in Figure 8.12, the operations following the operational procedures has the advantage. This is proved by e.g. the test scores from the infrastructure inspection operation being in favor of the operation not using the procedures. That goes for 3D mapping as well, as the test score regarding the quality in the data collection in the favor of the operations using the procedures. For the test of operation during agricultural analysis a similar test ended up being in the favor of the operations using the procedures. The reason for the difference in data quality tend to be utilization of the autonomous flights path, that enables a more precise and accurate data collection due to GPS-tracked flight paths, instead of the manual operation of the drone. Not only is the data collection improved by using the autonomous services provided by the equipment, also the overall performance and controls, as stated in the “PIECES” framework, is enhanced, as the access to monitoring the data collection midair is enabled when following the operational procedures, providing users with way better quality of the data collected in the end. Thus it can be concluded, that high efficiency in operation - when not using the procedures - may affect negatively on the data collected, which in the end is the most important part of any operation during drone services.

DATA QUALITY								
	Inspection of critical infrastructure							
# Test number	**1**		**2**		**3**		**4**	
With (W) or without (W/O) procedures	W	W/O	W	W/O	W	W/O	W	W/O
Area of test								
The degree of quality in the data collection								
Precision of data collection	0,4	-0,1	0,3	-0,4	0,5	-0,2	0,2	-0,4
Monitoring of data collection during operation	0,3	-0,1	0,2	-0,3	0,4	-0,2	0,3	-0,2
Access to control of data after flight	0,3	0,1	0,3	0,1	0,4	0,1	0,4	0,1
Overall quality of data collected	0,4	-0,1	0,3	-0,4	0,5	-0,2	0,3	-0,5
	3D mapping							
# Test number	**5**		**6**		**7**		**8**	
With (W) or without (W/O) procedures	W	W/O	W	W/O	W	W/O	W	W/O
Area of test								
The degree of quality in the data collection								
Precision of data collection	0,4	-0,1	0,3	-0,4	0,5	-0,2	0,2	0,4
Monitoring of data collection during operation	0,3	-0,1	0,2	-0,3	0,4	-0,2	0,3	-0,2
Access to control of data after flight	0,3	0,1	0,3	0,1	0,4	0.1	0,4	0.1
Overall quality of data collected	0,4	-0,1	0,3	-0,4	0,5	0,1	0,3	-0,5
	Agriculture analysis							
# Test number	**9**		**10**		**11**		**12**	
With (W) or without (W/O) procedures	W	W/O	W	W/O	W	W/O	W	W/O
Area of test								
The degree of quality in the data collection								
Precision of data collection	0,5	-0,2	0,2	-0,4	0,4	-0,3	0,1	-0,3
Monitoring of data collection during operation	0,5	-0,3	0,3	-0,4	0,5	-0,2	0,3	-0,1
Access to control of data after flight	0,4	0,1	0,2	-0,2	0,5	0,1	0,4	-0,2
Overall quality of data collected	0,3	-0,3	0,3	-0,3	0,4	-0,1	0,2	-0,2

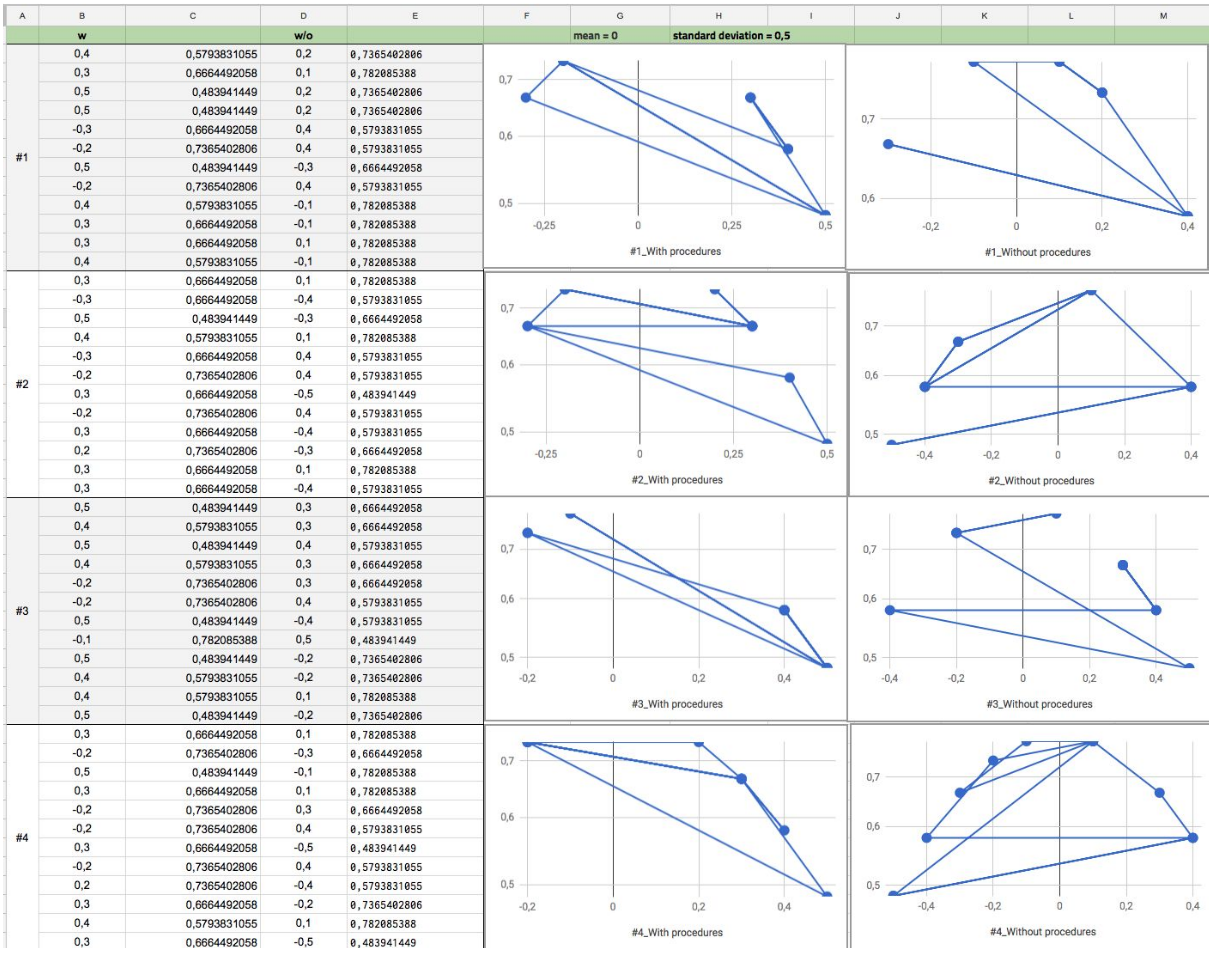
Figure 8.12: Test score data regarding data quality during operations

8.5 SUMMARIZATION ON TEST SCORES

This chapter has tested the new designed operational procedures for the use of drones in a operational environment conducted with the thesis' case company by following the procedures during different drone service operations. The results has been compared to operations not using operational procedures. These tests serves to research whether the Danish drone industry can achieve a global competitive advantage by implementing international standards for the use of drones. A competitive advantage is believed to be possible through the use of procedures, which will heighten the level of flight safety, streamline the planning process and make operations more efficient and lastly increase the quality in the data collection.

In this section the total score of all tests is presented graphically as well as the individual scores for each test from number #1 to # 12. The previous sections has considered the data from this data set by analyzing the data obtained from the experimental analysis and by correlate the results with the three test parameters (safety, efficiency, quality). This sections aims to clarify that the proposed operational procedures will assist to achieve an competitive advantages as well as increase the interoperability, thus showing the benefits of such procedures for the Danish drone industry, by proving the positive effect of using operational procedures in the use of drones in a range of drone services.

Overall the tests has proved that operations using operational procedures performs better than operations not using the procedures, with only a few mentionable findings that favors the latter. In this section the total result of the test scores will be examined, as the final data set is presented and evaluated. Figure 8.13 shows the total test results for infrastructure inspection, where the result favors the operations following the operational procedures, as described previously in this chapter:



A	B	C	D	E
	w		w/o	
#1	0,4	0,5793831055	0,2	0,7365402806
	0,3	0,6664492058	0,1	0,782085388
	0,5	0,483941449	0,2	0,7365402806
	0,5	0,483941449	0,2	0,7365402806
	-0,3	0,6664492058	0,4	0,5793831055
	-0,2	0,7365402806	0,4	0,5793831055
	0,5	0,483941449	-0,3	0,6664492058
	-0,2	0,7365402806	0,4	0,5793831055
	0,4	0,5793831055	-0,1	0,782085388
	0,3	0,6664492058	-0,1	0,782085388
	0,3	0,6664492058	0,1	0,782085388
	0,4	0,5793831055	-0,1	0,782085388
#2	0,3	0,6664492058	0,1	0,782085388
	-0,3	0,6664492058	-0,4	0,5793831055
	0,5	0,483941449	-0,3	0,6664492058
	0,4	0,5793831055	0,1	0,782085388
	-0,3	0,6664492058	0,4	0,5793831055
	-0,2	0,7365402806	0,4	0,5793831055
	0,3	0,6664492058	-0,5	0,483941449
	-0,2	0,7365402806	0,4	0,5793831055
	0,3	0,6664492058	-0,4	0,5793831055
	0,2	0,7365402806	-0,3	0,6664492058
	0,3	0,6664492058	0,1	0,782085388
	0,3	0,6664492058	-0,4	0,5793831055
#3	0,5	0,483941449	0,3	0,6664492058
	0,4	0,5793831055	0,3	0,6664492058
	0,5	0,483941449	0,4	0,5793831055
	0,4	0,5793831055	0,3	0,6664492058
	-0,2	0,7365402806	0,3	0,6664492058
	-0,2	0,7365402806	0,4	0,5793831055
	0,5	0,483941449	-0,4	0,5793831055
	-0,1	0,782085388	0,5	0,483941449
	0,5	0,483941449	-0,2	0,7365402806
	0,4	0,5793831055	-0,2	0,7365402806
	0,4	0,5793831055	0,1	0,782085388
	0,5	0,483941449	-0,2	0,7365402806
#4	0,3	0,6664492058	0,1	0,782085388
	-0,2	0,7365402806	-0,3	0,6664492058
	0,5	0,483941449	-0,1	0,782085388
	0,3	0,6664492058	0,1	0,782085388
	-0,2	0,7365402806	0,3	0,6664492058
	-0,2	0,7365402806	0,4	0,5793831055
	0,3	0,6664492058	-0,5	0,483941449
	-0,2	0,7365402806	0,4	0,5793831055
	0,2	0,7365402806	-0,4	0,5793831055
	0,3	0,6664492058	-0,2	0,7365402806
	0,4	0,5793831055	0,1	0,782085388
	0,3	0,6664492058	-0,5	0,483941449

Figure 8.13: Total test results for infrastructure inspection

	0,4	0,5793831055	0,2	0,7365402806
	0,3	0,6664492058	0,1	0,782085388
	0,5	0,483941449	0,2	0,7365402806
	0,5	0,483941449	0,2	0,7365402806
	-0,3	0,6664492058	0,4	0,5793831055
#5	-0,2	0,7365402806	0,4	0,5793831055
	0,5	0,483941449	-0,3	0,6664492058
	-0,2	0,7365402806	0,4	0,5793831055
	0,4	0,5793831055	-0,1	0,782085388
	0,3	0,6664492058	-0,1	0,782085388
	0,3	0,6664492058	0,1	0,782085388
	0,4	0,5793831055	-0,1	0,782085388
	0,3	0,6664492058	0,1	0,782085388
	-0,3	0,6664492058	-0,4	0,5793831055
	0,5	0,483941449	-0,3	0,6664492058
	0,4	0,5793831055	0,1	0,782085388
	-0,3	0,6664492058	0,4	0,5793831055
#6	-0,2	0,7365402806	0,4	0,5793831055
	0,3	0,6664492058	-0,5	0,483941449
	-0,2	0,7365402806	0,4	0,5793831055
	0,3	0,6664492058	-0,4	0,5793831055
	0,2	0,7365402806	-0,3	0,6664492058
	0,3	0,6664492058	0,1	0,782085388
	0,3	0,6664492058	-0,4	0,5793831055
	0,5	0,483941449	0,3	0,6664492058
	0,4	0,5793831055	0,3	0,6664492058
	0,5	0,483941449	0,4	0,5793831055
	0,4	0,5793831055	0,3	0,6664492058
	-0,2	0,7365402806	0,3	0,6664492058
#7	-0,2	0,7365402806	0,4	0,5793831055
	0,5	0,483941449	-0,4	0,5793831055
	-0,1	0,782085388	0,5	0,483941449
	0,5	0,483941449	-0,2	0,7365402806
	0,4	0,5793831055	-0,2	0,7365402806
	0,4	0,5793831055	0,1	0,782085388
	0,5	0,483941449	0,1	0,782085388
	0,3	0,6664492058	0,1	0,782085388
	-0,2	0,7365402806	-0,3	0,6664492058
	0,5	0,483941449	-0,1	0,782085388
	0,3	0,6664492058	0,1	0,782085388
	-0,2	0,7365402806	0,3	0,6664492058
#8	-0,2	0,7365402806	0,4	0,5793831055
	0,3	0,6664492058	-0,5	0,483941449
	-0,2	0,7365402806	0,4	0,5793831055
	0,2	0,7365402806	0,4	0,5793831055
	0,3	0,6664492058	-0,2	0,7365402806
	0,4	0,5793831055	0,1	0,782085388
	0,3	0,6664492058	-0,5	0,483941449

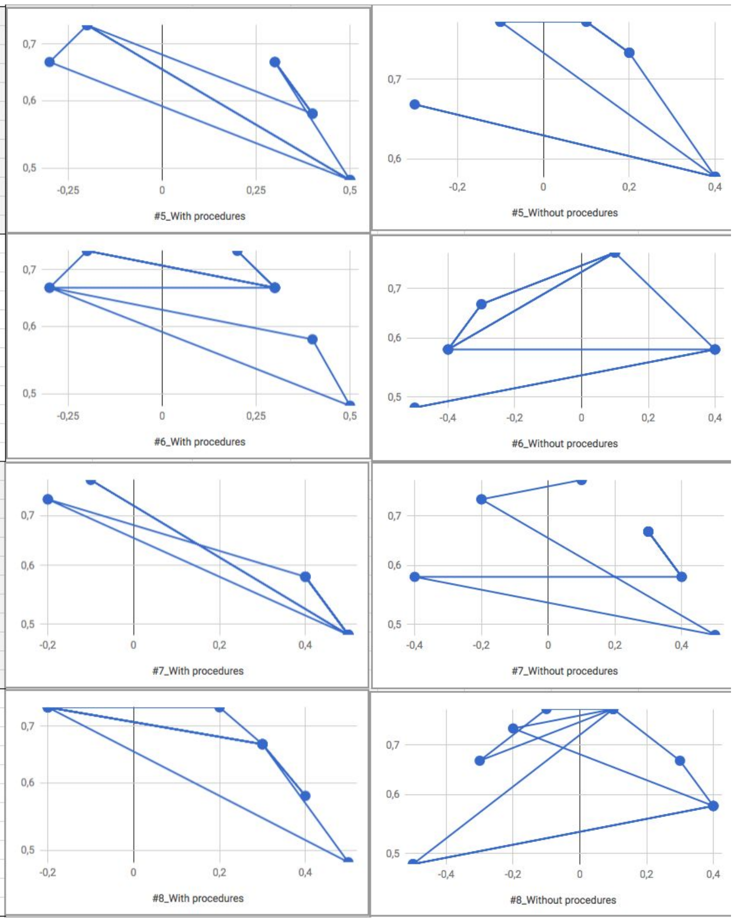


Figure 8.14: Total test results for 3D mapping

	0,5	0,483941449	0,3	0,6664492058
	0,3	0,6664492058	0,2	0,7365402806
	0,5	0,483941449	0,4	0,5793831055
	0,5	0,483941449	0,4	0,5793831055
	-0,5	0,483941449	0,4	0,5793831055
#9	-0,4	0,5793831055	0,3	0,6664492058
	0,4	0,5793831055	-0,4	0,5793831055
	-0,3	0,6664492058	0,5	0,483941449
	0,5	0,483941449	-0,2	0,7365402806
	0,5	0,483941449	-0,3	0,6664492058
	0,4	0,5793831055	0,1	0,782085388
	0,3	0,6664492058	-0,3	0,6664492058
	0,4	0,5793831055	0,2	0,7365402806
	-0,1	0,782085388	-0,3	0,6664492058
	0,4	0,5793831055	-0,4	0,5793831055
	0,3	0,6664492058	-0,1	0,782085388
	-0,4	0,5793831055	0,4	0,5793831055
#10	-0,3	0,6664492058	0,5	0,483941449
	0,4	0,5793831055	-0,5	0,483941449
	-0,1	0,782085388	0,4	0,5793831055
	0,2	0,7365402806	-0,4	0,5793831055
	0,3	0,6664492058	-0,4	0,5793831055
	0,2	0,7365402806	-0,2	0,7365402806
	0,3	0,6664492058	-0,3	0,6664492058
	0,5	0,483941449	0,4	0,5793831055
	0,4	0,5793831055	0,2	0,7365402806
	0,4	0,5793831055	0,3	0,6664492058
	0,5	0,483941449	0,3	0,6664492058
	-0,4	0,5793831055	0,5	0,483941449
#11	-0,3	0,6664492058	0,4	0,5793831055
	0,4	0,5793831055	-0,3	0,6664492058
	-0,2	0,7365402806	0,4	0,5793831055
	0,4	0,5793831055	-0,3	0,6664492058
	0,5	0,483941449	-0,2	0,7365402806
	0,5	0,483941449	0,1	0,782085388
	0,4	0,5793831055	-0,1	0,782085388
	0,3	0,6664492058	0,1	0,782085388
	0,1	0,782085388	-0,2	0,7365402806
	0,2	0,7365402806	-0,2	0,7365402806
	0,4	0,5793831055	-0,2	0,7365402806
	-0,4	0,5793831055	0,3	0,6664492058
#12	-0,4	0,5793831055	0,4	0,5793831055
	0,3	0,6664492058	-0,5	0,483941449
	-0,2	0,7365402806	0,3	0,6664492058
	0,1	0,782085388	-0,3	0,6664492058
	0,3	0,6664492058	-0,1	0,782085388
	0,4	0,5793831055	-0,2	0,7365402806
	0,2	0,7365402806	-0,2	0,7365402806

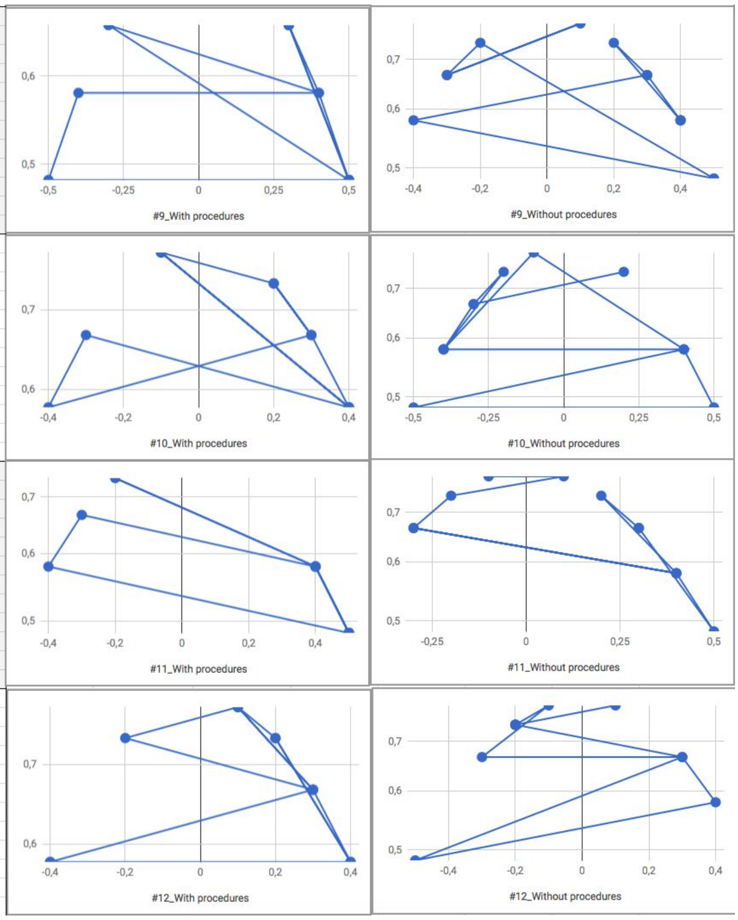


Figure 8.15: Total test results for agriculture analysis

Figure 8.16 shows the total test results for all drone services using the operational procedures during tests, presented in a Normal distribution/Bell Curve. The curve is the result of all data gathered in the above mentioned figures and as it is seen, only few scores is beneath the mean of 0 with a overweight of scores ranging from +0.2 to +0.5, stating that the test overall has resulted in positive results in the favor of the operational procedures:

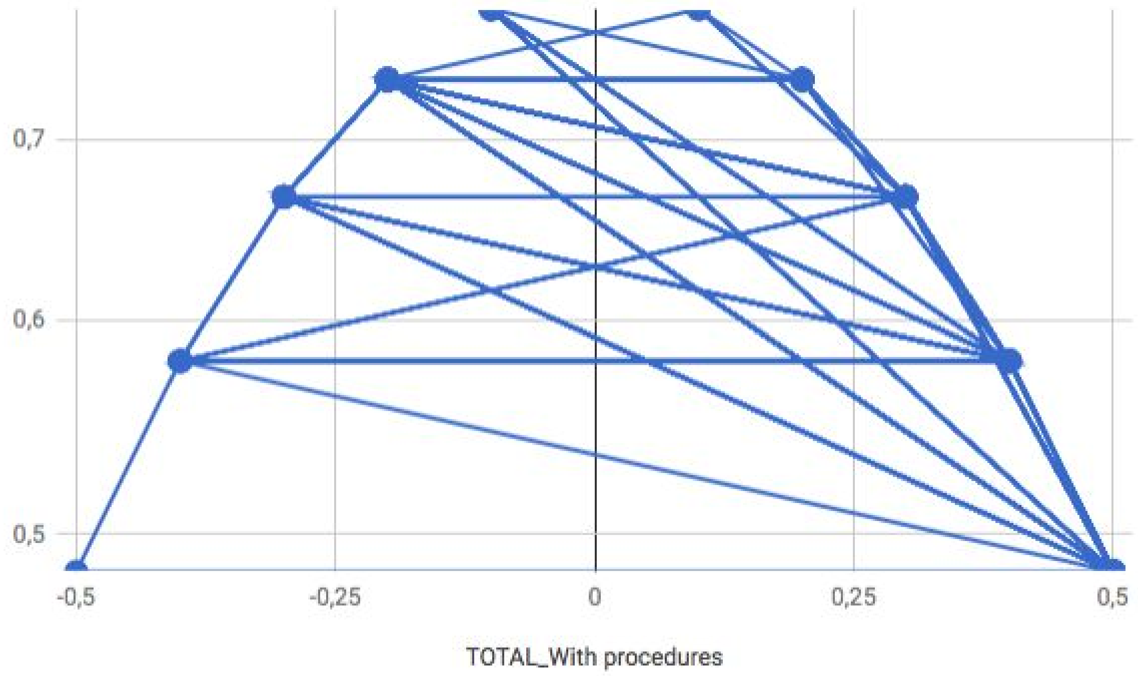


Figure 8.16: Total test results for operations using operational procedures

Figure 8.17 shows the total test results for all drone services *not* using the operational procedures during tests, also presented in a Normal distribution/Bell Curve. The curve is the result of all data gathered in the above mentioned figures and as it is seen, the scores is wide spread ranging from -0.5 to +0.5, stating that the test overall has resulted in both negative and positive results for the operations not using the operational procedures. The conclusion is that there is an overweight of scores beneath the mean of 0 compared to the similar test shown in Figure 8.16.

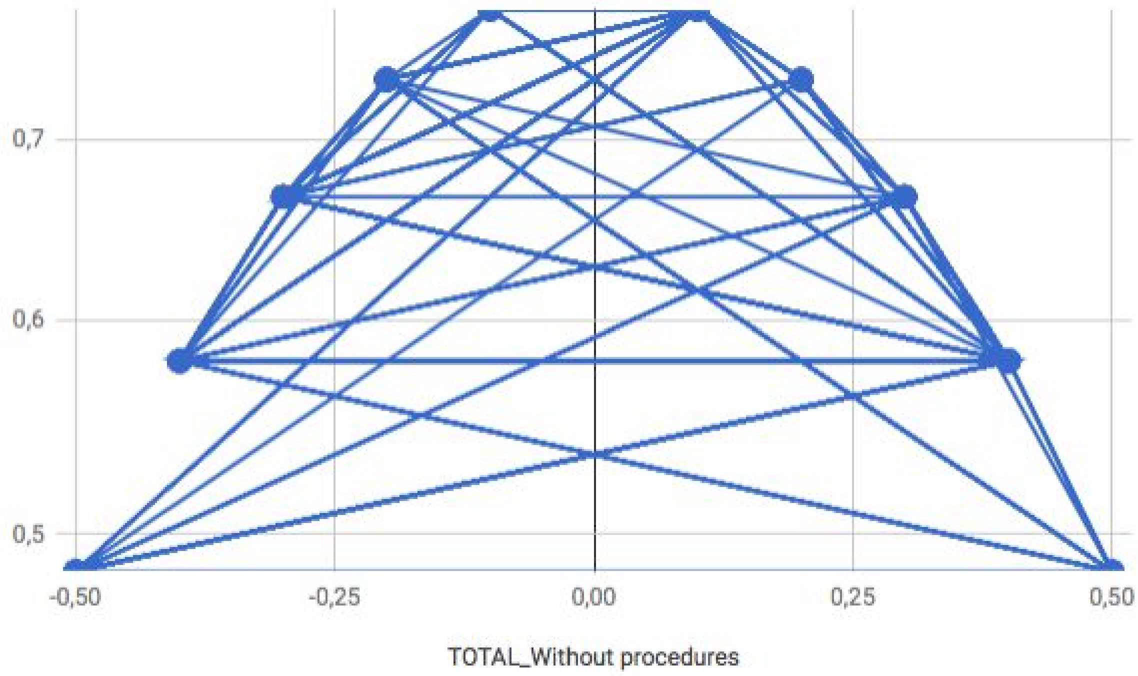


Figure 8.17: Total test results for operations not using operational procedures

As seen in the test scores in this chapter, test data extracted from the drone operator's log proves certain significant differences with relevance for the focus areas of the thesis being flight safety, efficiency in operation and quality in data collection. The test regarding safety during operation ended up in advantage of the operation using the new designed operational procedures with a significant difference, since autonomous flight path ensure a higher degree of adherence of legislation in general as well as lower degree of breakage of during operation. Regarding efficiency in the operation is was concluded that the operation not following the procedures according to the test scores was the most efficient one - most likely due to the time-consuming planning and pre-flight check processes needed before conducting the operation itself. That said, in the end the operation following the procedures did have the advantage in regards of the quality of the data collected, due to the utilization of autonomous flights paths enabling a more accurate data collection with its GPS-tracked flight paths - which in the end is the most essential part of any given drone service operation. To sum up this chapter is should be highlighted, that in regards of safety and the quality of the data collected, the procedures delivers a second to none result compared during three different drone services tested three times in a row. The only area where the operation not following the procedures has the advantage is within the efficiency of the operation, but one should assess whether the time spent on operation or the quality of the end result in form of valid data quality should be the most important. Based on the test and prerequisites of this thesis, this chapter concludes, that the operations following the new designed operational procedures faces great potential for achieving a competitive advantage since such procedures at the same time result in a better drone operation measured on all relevant parameters, as well as positioning the Danish drone industry in a strong position globally by being in the forefront of the international standardization work within the drone industry.

CHAPTER 9: PERSPECTIVES ON THE ANALYSIS

Throughout the analysis and research during this Master's Thesis, certain perspectives has arised and will be discussed in this chapter in order to qualify the subsequent conclusion.

9.1 DISCUSSIONS ON IMPLEMENTATION IN PRACTISE

Even though the procedures has been developed specifically for the thesis' case company, the findings in the thesis are usable for real applications by specialized drone operators as well as Danish and international organisations working with drones, who may will be able to apply parts of the procedures for their own operations with minor adjustments in regards of the services to be performed. The basic procedures for handling drones and their operating systems are to some extent generic across applications and platform, with primarily the sensor package replaced depending on the given operation. The tests in this thesis has examined operational procedures for the use of drones by testing drones from the *Open* and *Specific* category, enabling all drone users within these most common categories to take advantage of the knowledge and findings in this thesis. The *Certified* category has not been examined since the majority of commercial drone operations - within the type of services included in this thesis - belongs to the *Open* and *Specific* categories. The operational procedure could be implemented directly for most operations depending on the drone operators experience within drone operations, as the sub procedures within the procedures for for a professional drone operator to a wide extent consists of common basic knowledge, which in these new designed procedures has been put in order in order to be quality approved.

In order to secure a set of reliable and implementable operational procedures for the use of drones, certain elements has not been included in the standard, as these elements is considered being basic knowledge for professional drone operators in the Danish drone industry. This goes for e.g. which actions to be taken in case of emergency situations, where the drone suddenly performs unintentional due to internal or external issues. The response to such situations is considered as common knowledge learned and experienced during basic flight training, which is mandatory before drone operators can get their professional license. Another limitation from the operational procedure is flight beyond visual line of sight (so-called BVLOS) as such flight is yet not fully commercially available in the Danish drone industry due to legislation issues, where rules is that the drone operator at any time shall have visual contact with the drone during operation. The procedures included in this thesis could be later adopted to handle BVLOS-flight by adding the specific safety-mitigating aspects of such flight. Such flight is yet not possible to perform without a special clearing - which is often impossible to obtain - thus BVLOS-flight has not been included in the research neither implemented in the procedures. Likewise has scenarios with operation of multiple drones simultaneously not been included, since the Danish legislation yet not approves autonomous flights with multiple drones controlled by one single drone operator. In case of a flight with the need of multiple drones, multiple drone operators will carry out the operations by - potentially - following the procedures presented in thesis.

9.2 DISCUSSIONS ON OPEN STANDARDS

For this thesis a relevant question for discussion is whether standardized operational procedures - unintentional - constitute an entry barrier for small businesses that do not necessarily have resources to become e.g. ISO certified, thus can not increase their competitiveness? The question is raised by Zbigniew Ziobro to The European Commission (May 6, 2010) and is highly related to this thesis which exactly is researching the hypothesis that such standards is purely a good thing for businesses. Ziobro focuses on so-called *open standards* in relation to interoperability as he addresses his concern that standards - if not open - will affect negatively on small businesses, as the traditional standards can appear as entry barriers obstructing growth in their innovation and competitiveness.

As this thesis has stated, standards can enable cross-border cooperation between companies from different countries and industries, as some common procedures is followed e.g. regarding quality management, operational procedures or industry-specific terminology. But if smaller companies seeking to make their entry in new markets does not possess the resources to invest in the industry-wide recognized standards within e.g. operational procedures for the use of drones, then the small company will be unable to compete equally with its bigger competitors, as they cannot prove their work, even though it may be seamless or maybe even better than the competitors, who conversely has the certification. Thus open standards is needed in order to remove the entry barriers for smaller companies. The Danish Government (2015) has as part of their nation-wide standardization strategy aimed on providing companies with international standards for a cheaper cost in order to accelerate the growth through the use of international standards. It is the believe in this thesis that also the Danish drone industry, who currently consists mainly of small businesses, will suffer from the lack of international standards as these will be unobtainable for most companies operating with 1-5 employees in a local market, as many drone service companies is operated today. Thus the statement on standards as purely a good thing for companies may be up for discussion sooner than expected, when e.g. common international standards for operational procedures for the use of drones finally is adopted. This could be investigated in a future researched on the topic as a natural extension to this thesis.

CHAPTER 10: CONCLUSION

This Master’s Thesis is motivated by an interest in the emerging drone industry, which represent a relatively new commercial growth area experiencing a rapid development these years, as drones are expected to take over and streamline a range of tasks. E.g. is the Danish Government (2016) is investing in the industry as a consequence of drones being able to solve many tasks more safely, more efficiently and to a better quality than until now. With Denmark being a relatively small but active part at the forefront of the global drone industry, this thesis has examined whether the Danish drone industry can achieve a competitive advantage in the global market of outdoor drone services by implementing international standards for the operational procedures for the use of drones. The hypothesis for the research has been that the Danish drone industry can gain significantly from such standards, as standards are expected to at the same time increase the interoperability with foreign companies, strengthen the industry's global growth conditions, enhance safety issues in the use of drones, streamline the efficiency of drone operations and create better quality in the data collection. Also Denmark does not have the resources to invest in big scale global drone-related projects, thus the industry must find other ways to make their global footprint. In this thesis standardization is believed to be one way of succeed.

The research has included a selected theoretical framework with elements from the subjects of the Master's program, including Total Quality Management and standardization regimes. On this foundation, thorough empirical sources and data has been utilized in order to qualify the prerequisites and conclusions of the thesis’ research. The sources and bibliography of the thesis includes leading organizations within the field of standardization as well as theoretical thinkers of quality management and governmental decision makers with relation to the drone industry or standardization. On this foundation, the thesis has examined which established standards there exist in the drone industry today as well as the competitive landscape of the drone industry in general. Amongst other it is concluded that even though a lot of initiatives is going on, no applicable standards for the use of drones has yet been published. It is also concluded that the Danish drone service companies holds a leading position within the use of drones for services and currently enjoy a competitive advantage as the Danish rules for commercial use of drones is well developed and creates easier access to expand business to the surrounding countries such as Norway and Sweden.

Thus the thesis examine how other related industries benefit from using standards. It is concluded that best practices from e.g. the wind and aviation industry advantageously could be implemented in the Danish drone industry in order to gain and maintain the current competitive advantage - even at a global level. Next the relevance and benefits from using standards in relation to the drone industry is examined. It is concluded that the Danish drone industry could benefit from applying a standardized approach to operational procedures for the use of drones as well as contributing actively in developing the standards of the future in the global drone industry, as Denmark hold a leading position in the development of drone-associated technology as well as the use of drones as services.

With the knowledge of the potential in using standards for the operational procedures for the use of drones, the thesis has examined how such procedures should be designed, and subsequently operational procedures is designed specifically to the thesis' case company. The procedures takes in account the best practises from the related industries elucidated in chapter 5 as well as theory of standards and procedures from chapter 3 and 7. These operational procedures is tested at the case company in chapter 8 leading to a conclusion that even though following such procedures takes longer time before and after a drone operation, the operation itself - measured on the safety during flight, the efficiency of the operation and the quality of the data collected - is more beneficial for the drone service company conducting it.

The major findings of this thesis as concluded and with the delimitations listed in the thesis has not yet been implemented in the context of the Danish drone industry. Thus the thesis is intended to serve as an inspiration for future work regarding standardization in the Danish drone industry. It is emphasized that the interrelationship between standardization, interoperability and true competitive advantage is essential for achieving the benefits from working with standards, which is backed by the Danish Technological Institute, who recognizes the interrelationship as a mean for success when working with standardization (Dansk Standard, April 4, 2016). Thus it is concluded that a focused effort in developing and utilizing standardized operational procedures could positioning the Danish drone industry with a global competitive advantage.

APPENDIXES

Appendix 1: Operational procedures for infrastructure inspection (.pdf)
Appendix 2: Operational procedures for 3D mapping
Appendix 3: Operational procedures for agriculture analysis(.pdf) (.pdf)
Appendix 4: Comparison of drone rules (.pdf)
Appendix 5: Test scores for drone operations (.xlsx)

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