The opportunities of drone technology in food delivery services

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ABSTRACT
Drone technology offers new possibilities in different logistic sectors. One of these sectors is food delivery services. However, how mature is the technology for this service application?
The Space 53 Quick Scan tool was used to enable the research, which outlined the readiness of different dimensions. These dimensions were technical-, social-, business-, ethical-, and legal readiness. The results outlined the importance of constant development along each of the five dimensions. The intercorrelation of these levels enhanced this claim and showed further insights into the future of this service. Nevertheless, different regions reached different levels of maturity of drone technology in food delivery services, in which the legal regulations played a defining role in hindering the technology to embrace fully.
Research should answer this question as well as identifying possible limitations and challenges. Furthermore, the research should enable future implications among the topic of drone technology in food delivery services. Primarily through the global pandemic of the COVID-19 virus outbreak, new services and technologies should be empowered.

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Drones, UAV, Food delivery, Space53, Design thinking, Technological acceptance

1. INTRODUCTION

1.1 Situation and complication

Our world today is under the pressure of constant change, ranging from social change to technological change. One technological innovation where an emerging market is on an uprise is drone technology. Drones can be explained as unmanned aerial vehicles, also referred to as UAVs (Butcher et al., 2019). The first application areas were mainly concentrated in the military sectors; nevertheless, commercialization of drone technology for non-military use was achieved in 2006. (Butcher et al., 2019). It was estimated that the global market of drone technology would rise from 2 billion USD in 2016 to around 127 billion USD in 2020 (Moskwa, 2016).

The commercialization of drones also brought up the idea of professionalization. Today, drones can be seen in several sectors, for example, in agriculture or logistics. However, the opportunities of drone technology are limited by different factors:

1. The technological ability, which implies that different applications need specialized drones. For example, drones that transport blood samples need specialized boxes for transportation (Roca-Riu et al., 2019)
2. Society, which needs to accept and work with technology.
3. Regulations, which have an immense impact on technological development.

An unexplored professional area of drone technology is food delivery services. If we look at the idea of food delivery services in terms of drone technology, we will think about drones with specialized boxes which can carry the food to the front step of houses. Nowadays, these services are based on delivering food directly to the specified address of an ordering person. The delivery process can be done by using different vehicles, for example, cars or scooters. Due to the global pandemic, human contact had to be minimalized by the most. This aspect influenced the process of delivering, which means that the deliveryman must keep his distance. This is most often achieved by placing the food in front of the door, ringing the bell, knocking on the door, and taking a step back. Drone technology could offer new opportunities, which could enhance the efficiency of delivering food. Drones could deliver food to the front doorstep or the garden of the ordering person.

1.2 Research Objective

The idea of this research is to analyze the possibilities of drone technology in food delivery services, as well as future implications for improving the technology. To achieve this, the Space 53 UAV Readiness Quick Scan will be used. This is a scan that can be used as a tool to measure the readiness of drone usage in five dimensions.

1.2.1 Research Question

"What is the current position of drone technology in food delivery services and, what future prospect can it be?"

Additionally to the research question, a primary focus should be laid on the design thinking process, where three sub-questions apply:

1. Is the technology desirable?
2. Is the technology feasible?
3. Is the technology worth it?

The objective of the research is achieved by working closely with the interrelated questions and hence answering all of them.

1.3 Theoretical Framework

Drone technology in food delivery services is, in today's world, not a commonly usage service. Different aspects contribute to this scenario. Nowadays, UAVs are undergoing debates among advocates and adversaries, which slows down the implementation of drones in different application areas. Not only debates but also regulation is an aspect that influences the work alongside drone technology.

1.3.1 Technology Acceptance Model

The theoretical framework will be concentrated on different theories/models. One theory, which will be considered for unconventional technologies is the technology acceptance model (TAM) (Davis, 1989).

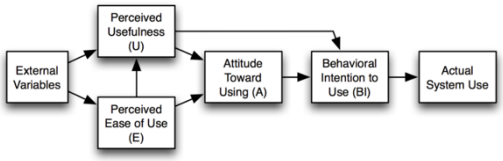

Figure 1 - Technology Acceptance Model

The TAM should "*explain the potential user's behavioral intention to use technological innovation* "(King et al., 2006). The model has two leading parts, perceived usefulness and perceived ease of use. Both parts are influenced by external variables, which can range from experience to the implementation process. Perceived usefulness is described as "the degree to which the person believes that using the particular system would enhance her/his job performance" (Marangunić et al., 2015). *Perceived ease* of use is defined as "the degree to which the person believes that using the particular system would be free of effort" (Marangunić et al., 2015). Perceived ease of use has a direct impact on the perceived usefulness. These two parts should lead to a user's attitude towards a system and decide whether technology is accepted. Nevertheless, there can be cases where users will not form any attitude towards a new system; they would instead form a behavioral intention.

1.3.2 Technology Readiness Levels

Nowadays, technologies are measured by the technology readiness levels (TRL) (Mankins, 2009). It "measures the extent to which a technology is suited for deployment in a natural operational environment "(Engel et al., 2012). The nine technology readiness levels used in the Space53 tool will be explained in the following section.

TRL 1 – Basic principles observed and reported

This marks the beginning of the research, in which the scientific research transforms into applied research and is developed.

TRL 2 – Technology concept and/or application formulated

The following step of maturation uses the observed physical principles. Practical applications of those characteristics can be "invented" or identified. This stage of maturation also does not include any experiments; it instead keeps a speculative view.

TRL 3 – Analytical and experimental critical function and/or characteristic proof-of-concept

The subsequent step introduces active research and development. Two necessary aspects need to be included in this section. Firstly, analytical studies and secondly, laboratory-based studies. This should enable a "proof-of-concept" validation.

TRL 4 – Component and/or breadboard validation in laboratory environment

This step follows up on a functioning "proof-of-concept" in which "basic technological elements must be integrated to establish that the "pieces" will work together to achieve concept-enabling levels of performance for a component and breadboard." (Mankins, 1995)

TRL 5 – Technology validated in (industrially) relevant environment

Step five implements a first test; this can be done in a simulation or somewhat realistic environment. Therefore, the basic technological and supporting elements need to be integrated.

TRL 6 – Technology demonstrated in (industrially) relevant environment

The following step initializes a demonstration of a representative model or prototype system. This demonstration should be done in the corresponding environment; for example, in the case of drone technology, a demonstration in space should take place. The demonstration can range from one technology to many technologies.

TRL 7 – System prototype demonstration in operational environment

Step seven obligates an actual system prototype demonstration in the operational environment (Mankins, 1995). This step is of major importance because it assures the system engineering and development management confidence. Nevertheless, not every technology will be included in this step.

TRL 8 – System complete and qualified

In step eight, "all technologies being applied in the actual system go through" (Mankins, 1995). Most often, this step ends the system development for the technical elements.

TRL 9 – Actual system proven in operational environment

In the last step, the technology is fully implemented, and systems have been fully demonstrated. Nonetheless, the last bug fixes can most often arise, which need to be solved.

These nine levels will be included in the Space 53 Tool, which will analyze and measure the readiness of the technology. To create a further understanding of the maturity of the technology, four more dimensions will be used. Therefore, a greater picture should be created to identify if drone technology in food delivery services is reaching the readiness it needs to be successfully implemented in society.

1.4 Academic Relevance

The academic relevance of the thesis is of significant relevance due to the limitations of drone technology. To identify the maturity of the technology, the Space 53 tool will evaluate the five dimensions, which are as followed:

1. Technical readiness level
2. Business readiness level
3. Ethical readiness level
4. Legal readiness level
5. Social readiness level

Consequently, the output will not only identify the current situation but moreover advice should be found for future ideas and scenarios for drone technology development in food delivery services as well as improvements for society.

1.5 Practical Relevance

The outbreak of the COVID-19 virus led to many changes in our today's world. Different measurements against the virus were implemented, where the diminishing of human contact was of major importance. This influenced different professions, like the delivery sector. In this special situation, which is having a worldwide impact, drone technology could be of considerable relevance. It can support technological innovations and lead to further acceptance among societies.

Next to the global pandemic, the environmental facet of delivery systems should be considered. Carbon dioxide emissions created by humans are continuing to grow. Experts believe that if we fail to recognize constant emissions will lead to 1.5 °C or two °C of global warming (Peters et al., 2020). The service of delivering food is mainly focused on delivering via cars or scooters. Therefore, drone technology could be influential in in controlling and lowering carbon dioxide emissions.

1.6 Research design

The research design will be performed to answer the research question as well as the design thinking process. If we look at the research question, the main idea is to see the current and future situation of the maturity of drone technology in food delivery services. It should be of major importance to set a foundation through research of literature in the field of drone technology.

Next to literature, the focus should lay on professionals in this area, whether it be drone technology specialists or food delivery companies, who have experience with drone services. To work with these people, Space 53 UAV Readiness Quick Scan will be used. After gaining the fundamental information through the scan, an analysis will follow. This should create a further understanding of the maturity stage, which enables a first vision of the technology.

Subsequently, I would like to retrieve further information by qualitative semi-structured interviews with experts in the field of drone technology, which should aim to look at future improvements as well as future possibilities of the technology. This information should then be finalized to conduct a level of maturity and highlight future scenarios of drone technology in food delivery services.

2. Literature Review

To provide a foundation of information about the technology, the following part will define three aspects of drone technology. Firstly, the current state of drone technology in food delivery services. Secondly, the limitations as well as challenges which the technology is facing. And lastly, an insight into possible future ideas and situations, which can be achieved.

2.1 Current State

Throughout the years drone technology applications have ranged from search and rescue missions, environmental protection, mailing, and delivery, to marine studies and many more (Hassanalian et al., 2017). The starting point for drone deliveries was set by Amazon back in 2013, which first wanted to implement the new technology (Pierce, 2013). In today's world, drones "have become a suitable transportation mode for package deliveries" (Swanson et al., 2019). Regarding food delivery services, drone technology has evolved, including the application area. Most often, Food delivery services are considered as last-mile deliveries, which is defined "as the segment between the distribution center and the final destination" (Doole et al., 2020). In general, "the goal for a delivery drone is an ideal balance of payload, speed, endurance, and range." (Butcher et al., 2019). If we look at the geographical application area, drones can be used in dense urban cities, where transportation networks are stressed (Doole et al., 2020), as well as delivering packages to the backyard of customers (Roca-Riu et al. 2019).

Current examples of drone technology in food delivery services can be seen in different cases, for example, in Shanghai, China. The online food delivery platform Ele.me launched a drone delivery service in 2018 (Whittaker, 2018). In South Korea, multiple food services have already successfully adopted drone technology in food delivery systems (Hwang et al., 2019). Another company named Wing has performed tests around Australia to transport small packages which provided food and beverages (Roca-Riu et al. 2019). Furthermore, fast-food restaurants like Domino's (Pepitone, 2013) or McDonald's (Technology Review, 2019) are investing in implementing the technology in their delivery systems.

To facilitate the understanding of why organizations, invest in drone technologies in food delivery services, we should examine the advantages. Firstly, the environmental impact of drones. Typically, food is being delivered via cars or motorcycles. These vehicles exhaust gases and cause serious air pollution (Hwang et al., 2019). Drones are fully operated through electricity; hence they positively contribute to the reduction of pollution and "could decrease greenhouse gas emissions" (Goodchild et al., 2018). Moreover, through the decrease of vehicles on the road, the level of safety on roads can increase (Doole et al., 2020). Correlated to the environmental factors are the economic factors, in which (Liu et al. 2017; Tang et al. 2017) suggested that "consumers are willing to buy more environmentally friendly products/services and spend more money for such products/services." For companies, it does also influence their service; via drones, it is possible to reduce labor and transportation costs (Pillai, 2019). (J.M. Schröder et al., 2016), stated that last mile deliveries provide a new level of convenience and reduce the cost on the consumer but correspondingly increases the revenue for the companies.

Following the economic factors, the convenience of the service does influence the usage of drones. The technology enables quicker deliveries, which correspondently creates a greater satisfaction level for consumers (Pillai, 2019). "It has also been observed that using drones as a medium of transport leads to less destruction of goods as compared to those deliveries which are done by humans while maintaining time in the process." (Tarun et al., 2021). Moreover, the infrastructure of urban cities cannot accommodate a comfortable increase of traffic (Samouh et al. 2020), which correlates to longer delivery times and hence create a satisfactory negative level of customers. Lastly, the prospect of the Internet of Things (IoT) should be considered. It can enable an "interconnection between the drones to exchange instructions, data for better functioning of the drones" (Zabunov et al., 2015). This results in an increased capability of autonomous flying (Tarun et al., 2021).

2.2 Limitations & Challenges

After identifying the current situation as well as possible advantages, this section will consider the limitations as well as challenges that drone technology faces.

Firstly, drone technology is still viewed as negative upon society. Consumers are concerned about their privacy as well as security (Chang et al., 2017). The first drones were used as military weapons; additionally, drone attacks in Saudi Arabia have influenced the perceived risk upon consumers (Tom et al., 2020). This doubt can additionally be underlined by the aspect of manipulation. This defines the possibility of hacking drones and taken control. Through that, the user has access to spying or harming individuals (Tarun et al., 2021). On the contrary, consumers aged from 18 to 34 had a positive perception of the new technology. Therefore, societal differences among ages can inhibit the acceptance of drone technology in food delivery services (Tom et al., 2020). Moreover, the concerns were created through the lack of information about the new service; hence time for acceptance needs to be put into perspective (Tom et al., 2020).

Following the limitations of drone technology, the influence of weather does hinder the service. Performance can vary through different weather conditions. Several aspects define these conditions (Butcher et al., 2019).

1. Wind
2. Visibility
3. Precipitation
4. Temperature

If we consider the factor of wind speed, it directly influences the possibilities of maneuvering drones. For example, in coastal areas, an increased wind speed can be located, which concludes in the unavailability of drone technology for food delivery services (Butcher et al., 2019). Heavy rain also enhances the practicality for drones to be used as a delivery service (Tom et al., 2020). In addition the wind speed, the visibility of drones is of importance. In the US, it is mandatory to visibly operate drones below the maximum of 400-foot altitude (Butcher et al., 2019). This challenge introduces one of the most influential limitations of drone technology, which are regulations. Due to the novelty of the technology, permissions have not been regulated so far. Each country is following different rules, and authorities create a time-consuming process (Dejonghe, 2019). Strict flight regulations created an overflow of work, which needs a transparent view. The most influential problem is the line

of sight (LOS) stipulation. In the United States, it "requires the drone to be in visual sight of a remote pilot certificate holder with a small UAS rating at all times" (Butcher et al., 2019). Additionally, this defines the limits of autonomous flying. Business-wise, companies face stagnant processes to gain permissions regarding commercial use for drone technology (Tom et al., 2020).
In addition, along the limitations of the technology, flight range and capacity are limited. The approximate range with a load is around 15km. Furthermore, drones can carry around 2.5kg of shipping (Roca-Riu et al., 2019). Lastly, the traffic upon streets can be transferred into air traffic, which can also create difficulties in planning (Roca-Riu et al., 2019). This air traffic can also be hindered through man-made and natural obstacles. For example, "Paris has more than 350,00 man-made permanent obstacles with carrying heights, within an area of 105km2." (Doole et al., 2020).

2.3 Future State

The last section of the literature will define future ideas and developments of drone technology in food delivery services.
"The United States Federal Aviation Association forecasts the market for drones to be one of the fastest-growing segments in aviation over the next ten years." (Swanson et al., 2019). Future applications could introduce decentralized operations of drones—for example, blockchain technology, which secures data from IoT devices (Alsamhi et al., 2021). Additionally, blockchain can enable "multi-drone collaboration task allocation with low energy consumption in a high level of security and enable trustworthy communication among drones," as well as diminishing faults by the technology (Alsamhi et al. 2021). New technologies can be of use in global problems, for example, an outbreak of a virus-like the COVID-19 outbreak. Through the multi-drone collaboration, food can be delivered to quarantined areas.

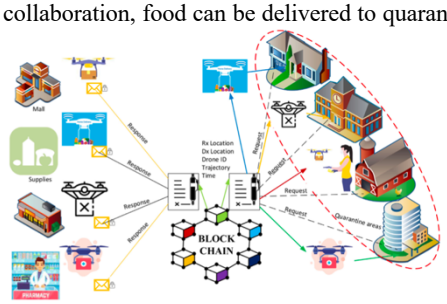

Figure 2 - Blockchain E2E delivery system using multi drone technology

Request for deliveries will be made via smart contracts, which include different factors that are encrypted. These factors can be, e.g., person location, denote location, etc.

3. Methodology

The methodological approach, as well as the research question, will be answered through the Space 53 tool. The research should identify whether drone technology in food delivery services is mature enough to be fully implemented in society or if the technology needs further development. To simplify the research, three sub-questions were already named in the research objective:

1. Is the technology desirable?
2. Is the technology feasible?
3. Is the technology worth it?

These three sub-questions should build a more comprehensive understanding of the aim of the research question.
The Space 53 Quick Scan tool offers five tools which will be answered by different companies or organization which specialized in drone technology. These tools are as followed.

1. Social tool
2. Ethical tool
3. Technical tool
4. Business tool
5. Legal tool

Each tool is designed to ask specific questions regarding one topic. For example, ethical tools ask for the goal or the effects of the technology.
To begin the research, participants needed to be found and contacted. Hence, it was of major importance to know what type of participants were needed. Due to the niche of this research, I first looked up companies that work with drone technology in regard to food delivery services. Most often, the organizations were based on last-mile deliveries, which is the last segment of delivery Swanson, D. (2019). To put it into perspective, last-mile deliveries in food delivery services define the process of delivering the food from the restaurant to the customer via a drone. After contacting different companies from around the world, I managed to receive an answer from Manna drone delivery. After a short meet-up where I distributed the scan, I did receive a fully filled out scan.
To ascertain the research, I had to define a new strategy to finalize the research and fulfill the scan. Therefore, literature along with one fulfillment of the scan from Manna drone delivery would be gathered. The literature should answer the space 53 tool. Each level is corresponding to one aspect, which needs to be looked upon to further develop and improve the technology of drone technology. In the Academic relevance section, I have already listed each level which will be shortly explained in the following part.

3.1 Space 53 Quick Scan Levels

3.1.1 Technical readiness level

As I already established in 1.3.2, the technical readiness level "measures the extent to which a technology is suited for deployment in a real operational environment "(Engel et al., 2012). This is measured upon nine different levels, which are displayed in the following figure.

Technology Readiness Levels Summary

TRL 1	Basic principles observed and reported
TRL 2	Technology concept and/or application formulated
TRL 3	Analytical and experimental critical function and/or characteristic proof-of-concept
TRL 4	Component and/or breadboard validation in laboratory environment
TRL 5	Component and/or breadboard validation in relevant environment
TRL 6	System/subsystem model or prototype demonstration in a relevant environment (ground or space)
TRL 7	System prototype demonstration in a space environment
TRL 8	Actual system completed and "flight qualified" through test and demonstration (ground or space)
TRL 9	Actual system "flight proven" through successful mission operations

Figure 3 - Technology Readiness Level

3.1.2 Business readiness level

The business readiness level "aims to get insights into the question whether developing the business case is realistic and if so whether a sustainable balance of costs and

benefits is possible for the drone development." (Qualtrics, N.D) This level is answered on a five-point scale and is divided into six elements.

1. The customer
2. The value propositions
3. Market forces
4. Alliance partners
5. The value delivery process
6. Financials

3.1.3 Ethical readiness level

The ethical readiness level "aims to get more insights if and how the development process influences values such as freedom, autonomy, justice, and privacy." (Qualtrics, N.D) This viewpoint can create ethical issues, which arrive "when values are neglected." (Qualtrics, N.D) Hence, this level asks for the goal and the effect of the drone. This level is again answered by a five-point scale from not at all applicable to completely applicable.

3.1.4 Legal readiness level

The legal readiness level "aims to provide insight in legal aspects when developing drone technology. It is intended for businesses wanting to develop or use drones and interested in ascertaining whether legally they are ready to do so without unnecessary legal risks." (Qualtrics, N.D) The level is estimated on a ten-point scale and is branched into five topics.

1. Public safety & security
2. Environmental burden
3. Privacy
4. Data-protection
5. Liability (civil & criminal)

This level is interrelated to the technical readiness level, with levels six to nine.

3.1.5 Social readiness level

The last readiness level "aims to provide insights into the societal context of the drone. Therefore, it considers four possible situations for the drone, which are called Lab Levels. These Lab Levels are derived from the TRLs." Additionally, three fields have been identified, which are centered around the questions.

1. Stakeholders
2. Design
3. Acceptance

Each level creates an average score after answering the corresponding questions. Thus, the gained literature and the constructed interview, which is designed to be based on the five levels, should answer the scan. Moreover, the maturity of drone technology in food delivery services will be concluded.

4. Results

The results section will present a dialog between literature that has been acquired as well as scan results from one company. The literature will be implemented in the Space 53 tool. Hence, each level of the scan should be elaborated and therefore create an evaluation of the tool.

4.1 Space 53 Quick Scan Tool

To enable the tool in correlation to literature and the interview, different articles were analyzed and considered. Each level was answered through the outcome of the corresponding literature. Nevertheless, it needs to be contemplated that the Space 53 Quick Scan Tool was developed for companies who work in the field of drone technology; hence some answers can differ from organizational answers.

4.1 Literature View

4.2.1 Technology readiness level

The first level of the Scan was the technological readiness level. Through literature, it can be determined the usage of drone technology in food delivery services around the world. In China (Whittaker, 2018), Iceland (Gilchrist, 2017), or Korea (Hwang et al., 2019), Drone technology in food delivery services is already implemented in society. Through different stages of testing and developing the technology, these countries were able to work along with the technology. Additionally, more organizations will implement the technology through the developing levels to fully reach the maturity of drone technology. Nevertheless, there are obstacles to the development of technology. New technologies need to have "an increase in resource efficiency and effectiveness, productivity, and flexibility, environment preservation, excitement and entertainment, and technology and economic development" (Kapser et al., 2020; Hwang et al., 2019) to fully reach their potential.
Hence, the technology readiness level reached a high score of 8.1 (Table 1). This implies a high level of maturity of the technology.

Table 1. Technology readiness level Literature

Technical readiness level	***8.1***
Score System Integration	6
Score Drone Management	9
Score Flight Components/Functions	8.3
Score Application Components/Functions	8
Score Backend Processing	9

4.2.2 Business readiness level

The second level of the scan was the business readiness level. If we look at the vast growth of drone technology, it was predicted that the market would grow from $2 billion in 2016 to around $127 billion in four years (Moskwa, 2016). These predictions define the opportunities for companies to invest in drones to implement this modern technology. Fast Food restaurants like McDonald's or Dominos are continuously investing in implementing the service into their system. Via 4.1.1, we were able to detect a technological maturity, which directly contributes to the maturity of business readiness. Several organizations identified the economic improvements which can be achieved through technological conversion.
Yet, Drawbacks upon the technology can throw back the business maturity—for example, weather conditions as well as societal and legal implications. Consequently, a score of 5.9 (Table 2) has been reached. Business-wise different specifications need to be ascertained to fully apply drone technology in food delivery services.

Table 2. Business readiness level Literature

Business readiness level	***5.9***
The Customer	6.5
Value proposition	5
The Market	6

The Business Network	5
The Process	7.9
Financials	5

4.2.3 Ethical readiness level

The following level is the ethical readiness level. This level does overlap with the societal and legal readiness level. Duplications can arise among the next three sections. Ethical readiness defined two points. Firstly, the goal of the drone. In the case of drone technology in food delivery services, the service should enable morally good achievements. These achievements are, for example, related to the diminishing of ecological footprints and carbon dioxide production. Additionally, the service should offer a quicker delivery of products, which on the other hand, creates satisfaction among end-users.

The second point is the effects of the technology among users. For example, the aspect of safety is a dominant problem within society. Individuals may fear their privacy. Automation also influences this readiness level in which operating incidents are negatively looked upon by society.

Henceforth, the score of ethical readiness level is at six, which makes it the third-highest level of maturity.

Table 3. Ethical readiness level Literature

Ethical readiness level	***6***
Ethical readiness score	6

4.2.4 Legal readiness level

The fourth level is the legal readiness level. This level reached the lowest score in the Space 53 Scan Tool. This demonstrates the strict legal regulations regarding the technology. Each country must define its own rules and legal actions. One major discussion aspect towards drone technology is the hindering of automation due to the inability of "beyond visual line of sight (BVLOS)" (Roca-Riu et al. 2019). Each operation of drones needs to operate by mankind and be visually seen. In some countries, legal regulations have been achieved, for example, Switzerland. But this is not the case for most countries in which the authorities still are not implementing permissions. This can be traced back to ethical concerns as well as societal backlashes.

Table 4. Legal readiness level Literature

Legal readiness level	***4.9***
Score Public Safety & Security	4.2
Score Environmental burden	4.9
Score Privacy	5
Score Data Protection	5
Score Liability	5.4

4.2.5 Social readiness level

The final level is the social readiness level—this level is related to three topics which were stakeholders, design, and acceptance. Especially, acceptance among society is on a rising trend. Through the aspect of environmental protection, society became more interested in the new technology (Hwang et al., 2019). Different analyses' have developed insight into attitudes towards drone technology. Through these positive attitudes towards the technology, older individuals tend to recommend the services (Hwang et al., 2019). But this should not imply that the social acceptance is fully mature. Society still indicates risks that they fear. For example, safety among their data as well as unsafe maneuvering of drones which could harm individuals, animals, etc.

The score of the final level is the second highest among the five levels, with a score of 6.1. This yet again establishes the trend among society to accept new technologies in the future.

Table 5. Social readiness level Literature

Social readiness level	***6.1***
The Stakeholders	5.5
The Design	6.6
The Acceptance	6.3

4.3 Company View

The following section will create a comparison from literature to the answers of Manna drone delivery. This should create insight on different views upon the technology, moreover, constitute a representation of the current situation among a real-life company. Manna is an Irish online platform where food delivery services via drone technology are offered. They partnered up with a local restaurant who able to offer the service for the region of Galway.

If we look at each level and compare the results to the literature, we can identify two thought-provoking aspects. Firstly, the technology readiness level. Through the literature, a score of 8,1 was achieved. Manna scored a seven on the scan. The decisive result was the score for system integration, which was a one for the company and a six for the literature. The company has first-hand knowledge, which validates the claim that the results of the scan for literature can differ from company answers—secondly, the legal readiness level. Manna achieved a high score of 7,8 in comparison through literature, a score of 4,9 attained. This does again contemplate the claim explained in the beginning.

Nevertheless, it is interesting to identify that each level achieved a higher score for Manna than for literature. The results were as followed. The business readiness level achieved a 7,7. Their ethical readiness level scored an eight. Lastly, the social readiness level also scored a 7,7. These scores underline the maturity of the organization, which already is actively functioning on delivering food delivery services through drone technology.

Table 6. Technical readiness level Company

Technical readiness level	***7***
Score System Integration	1
Score Drone Management	9
Score Flight Components/Functions	9
Score Application Components/Functions	7
Score Backend Processing	9

Table 7. Business readiness level Company

Business readiness level	***7.7***
The Customer	8
Value proposition	8.3
The Market	6.8
The Business Network	9
The Process	6.4

Financials	7.7

Table 8. Ethical readiness level Company

Ethical readiness level	*7*
Ethical readiness score	7

Table 9. Legal readiness level Company

Legal readiness level	***7.8***
Score Public Safety & Security	8
Score Environmental burden	7.3
Score Privacy	6.8
Score Data Protection	9
Score Liability	8

Table 10. Social readiness level Company

Social readiness level	*7.7*
The Stakeholders	6.8
The Design	7.4
The Acceptance	9

To finalize the results section, which was achieved via literature and Manna's answers, a radar chart should indicate the intercorrelation of each level. The results among literature and company showed deviations as well as similarities. Some levels achieved a relatively high maturity already, for example, social readiness level or technical readiness level. However, the legal readiness level, as the literature implied, still needs to be improved. Manna's level of legal readiness showed a relatively high score. The reason behind their legal maturity lies in their location. The republic of Ireland already created regulations regarding drone technology, which simplified the implementing process. A reason for the maturity of technology readiness level is the fact that before implementing new technology, the whole process of creating the technology needs to be considered. Before the technology has not reached a high maturity, it cannot be introduced among the other levels. Notably, the intercorrelation of the ethical readiness level, legal readiness level, and societal readiness level needs to be taken into consideration. Appealing is the fact that every level on Manna's results has a greater degree than the literature. Hence, a positive attitude towards the maturity is constructed.
Further research should improve these levels to identify needs and developments. Moreover, each level of the Space 53 Quick Scan Tool needs to continuously improve to be fully implemented in society correspondingly be implemented in organizational processes.

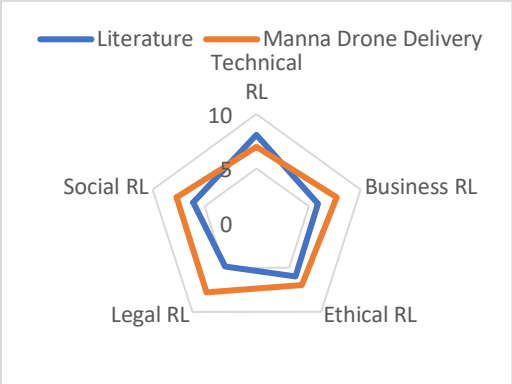

Figure 4 - Space 53 Scan Tool Radar Chart

5. Conclusion & Discussion

The final section of the research will conclude the research which was conducted. Furthermore, it will critically discuss the limitations of the technology as well as imply future research and recommendations.

5.1 Discussion

The idea of the research was to analyze the possibilities of drone technology in food delivery services, as well as future implications for improving the technology. The study demonstrated a correlation between different elements. These elements were provided via the Space 53 Scanning Tool. The tool enabled a glance at the current maturity of the technology, which is already on an uprise of implementation among society. In line with existing evidence, these results can be built upon. The data contributes to a more transparent understanding of the importance of each level. Furthermore, the results underline previous research in which drone technology in food delivery services is considered beneficial for society. Swanson concluded that "the use of drones is one of the fastest-growing aviation segments and will continue to be so in the ensuing decade" (Swanson et al., 2019).
Nonetheless, the reliability of the results is limited by two aspects. Firstly, the results were taken via a small research group, which consisted out of one company. Secondly, the results were taken through literature. Future studies should establish the importance of these five readiness levels. To enable this, future studies must include a wider number of companies, which can diminish a biased view. Moreover, it can give insights into differences and similarities among regions.

5.2 Conclusion

The research section identified the scores and the corresponding maturity of drone technology in food delivery services. If we acknowledge the research question which I constructed at the beginning of the research: *"What is the current position of drone technology in food delivery services and what future prospect can it be?"* and additionally contemplate the sub-questions:

1. Is the technology desirable?
2. Is the technology feasible?
3. Is the technology worth it?

We can create a conclusion for the research. Firstly, "is the technology desirable?". Through the different levels of readiness, it can be noted that society is divided into acceptance and denial. On the one hand, individuals are interested in the service and appreciate the ecological

benefits. The service offers a shorter waiting time for delivering food. On the other individuals fear the unknown and risks of the technology, which could harm their data or safety. Organizations can also benefit from the new technology in which they would decrease their costs of labor.

The second question asks if the technology is feasible. This corresponds to technological maturity. Throughout the research, it has been made clear that the technology is already being implemented and will further grow among society and organizations. Autonomous flying and blockchain technology can facilitate the opportunities of drone technology. It can additionally create a safer environment for society in which data is encrypted, and drone mistakes are reduced.

The final question was if the technology is worth it. To answer this question, each level should be taken into consideration due to the association among every level. Moreover, organizations and society should look upon this aspect. The first two sub-questions already mentioned the benefits for the two attributes. This suggests that the technology is indeed worth it.

To finalize this, we should look at the main research question, which is divided into two elements. Firstly, the current position of drone technology in food delivery services. During the research, it has been implied that the current position is relatively vague. Some countries have successfully worked along with the technology, whereas others did not reach this level due to different reasons, for example, regulations. Nevertheless, positive achievements have been seen and will be improved over time. This ties in with the second element, which is "what future prospect can it be?". In the previous sections, it has been advised that the technology still needs to be improved to reach its full maturity. This improvement can be underlined by each readiness level of Space 53 Scan. Moreover, prospering new elements will be implemented into the drone technology.

To conclude, drone technology in food delivery services will be a fascinating new service, which will grow over time. This growth needs to be enhanced by further development and improvement. Insight for this development can be found in blockchain technology. The technology enables new technological abilities. For example, multi-drone collaboration, autonomous task application, handling of failures, and hijack efficiency (Alsamhi et al., 2021). These new applications are just a small vision of the decentralization which will be offered by blockchain.

5.3 Limitations & Future research

The research for this thesis established some limitations which redefined the outcome. Due to the niche section, answers were rather vague. I contacted around ten to fifteen companies that specialized in drone technology in food delivery services or last-mile deliveries. I tried to reach out to these organizations several times. I received one answer out of these fifteen. It took some time after the organization managed to answer the scan. I already had to implement a new strategy in fulfilling the results section in which I concentrated on literature. Nevertheless, I was able to include both the literature and the answers of the company.

Further research on this topic should include more respondents to further gain insights into the current state of drone technology. A considerable focus should be laid upon the legal, ethical, and social sections. These three build a triangle that has a major influence on the future implication upon the technology. Additionally, feedback from companies who filled in the scan should be considered to further improve the scan. Therefore, a transparent and accessible performance should be offered.

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8. Appendix

Appendix 1: Space 53 Quick Scan Tool Questions

General Questions	
1.	Could you briefly describe the use-case for your drone innovation?
2.	What company/entity are you representing while filling this in? (Only used for improving the tool)

Social Readiness level:	
3.	Who are the stakeholders?
4.	What are the use-situations and user scenario's?
5.	What are the requirements and wishes of the stakeholders?
6.	What are the desired human-machine interactions?
7.	What are expected sound and sound levels?
8.	To what extent do users recognize the function of the drone from its visual appearance? How do the target groups evaluate the visual appearance of the UAV?
9.	What are the planned human-UAV interactions, and how are these evaluated?
10.	What is the role of the stakeholders in the design process?
11.	What methods did you employ for the evaluation of the product design?
12.	For whom have the benefits of the UAV service been assessed?
13.	What kind of benefits have been considered?
14.	What are the perceived and real risk concerns of the UAV for citizens?
15.	What is the basis for the risk assessment?
16.	What role did the analysis of perceived safety risks play in the development process?
17.	To what extent has trust in involved actors and UAV technology been assessed and used in the development process?
18.	What role do trust perceptions play in the development process?
19.	How do you communicate with stakeholders about the social implications?
20.	What are the potential privacy concerns of the UAV for the primary and secondary users?
21.	What role do privacy perceptions play in the development process?
22.	Do you communicate with stakeholders about privacy concerns ?

Technical Readiness level:	
1.	Can you select the appropriate situation for each of the aspects related to drone management?
2.	Can you select the appropriate situation for each of the aspects related to flight components?
3.	Can you select the appropriate situation for each of the aspects related to application components?
4.	Can you select the appropriate situation for the integration of the system?
5.	Can you select the appropriate situation related to back end processing?

Business Readiness level:	
1.	Customer problems (pains) are identified related to the use of existing technologies
2.	Potential customer gains are identified related to the drone application
3.	Customers declared their willingness to participate as a lead user
4.	The organization is sensitive to changing customer needs
5.	A clear value proposition has been formulated that addresses the pains and the gains of the target customers
6.	Stakeholders have been identified and their interests are taken into account in the design of the value proposition
7.	There is knowledge about how to communicate the value proposition to the market
8.	Countermeasures have been developed to deal with new entrants in the market
9.	Countermeasures have been developed to deal with actions and responses of existing competitors in the drone market
10.	Countermeasures have been developed to deal with substitutive technologies that solve the same customer needs
11.	Customers are **NOT** able to excert power in negotiations
12.	Suppliers are **NOT** able to excert power in negotiations
13.	The characteristics of the target market in terms of customer profiles are known
14.	The size of the target market is known
15.	It is known that the target market is in principle profitable
16.	Partners are identified who can help innovating drone applications and services
17.	Partners are willing to share the risks associated with the development of a market
18.	Suppliers have been contacted about their capability to supply the components or services with the required volume and timing

19.	Suppliers have been contacted about their capability to supply the components or services with the required volume and timing
20.	Suppliers have been contacted about their capability to supply the components or services with the required volume and timing
21.	There is a method, procedure or system that can be used to plan and control the production process
22.	There are methods, procedures or systems that can be used to monitor and control the supporting processes (especially payment/invoicing)
23.	The organization is capable to supply the drones in sufficient quantity and quality when demand increases rapidly
24.	The organization is capable to adapt to rapid technological changes in the drone sector
25.	There is a clear picture of the cost of producing and delivering the drone application and accompanied services
26.	There is a clear picture of the revenues captured by delivering the drone application and accompanied services
27.	The viability of the drone application for target customers based on various scenarios has been checked

Legal Readiness level:	
1.	Regarding your drone development/use as such, that is to say regarding specific rules on ***aviation/use of airspace***?
2.	Regarding the risk that your drone development/use poses to ***on the ground*** objects, activities or persons?
3.	Regarding the risks of harm by having an ***event***, involving 100 persons or more, involving drone development/use, in a ***public space***?
4.	Regarding the risks of harm by having an ***event***, involving 100 persons or more, involving drone development/use, in a ***private space***?
5.	Regarding the likelihood that the use of the drone will impact on ***domestic public security*** interests?
6.	Regarding possible ***transboundary*** drone development/use impacting on non-domestic public safety or security?
7.	Regarding the legal designation of the allowed destination, lay-out and use of the (area of) where the drone is being developed and/or used?
8.	Regarding Environmental concerns of ***manufacturing*** drones, including waste, pollution (ait, soil, water), energy efficiency, and use of scarce or hazardous materials)?
9.	Regarding, when drones are ***used*** (including testing), concerns regarding ***pollution*** of air, soil or water (e.g. use/spraying/emissions of polluting substances)?
10.	Regarding when drones are used (including testing), concerns regarding causing ***nuisance*** *[examples]* to others (i.e. infringing on the possibilities of others to exercise their full legal ability to enjoy their legal rights?
11.	Regarding, when drones ***crash*** or are ***disposed*** of, concerns regarding ***pollution*** or ***nuisance***?
12.	Regarding, when drones ***crash*** or are ***disposed*** of, concerns regarding ***pollution*** or ***nuisance***?
13.	Regarding when drones are used (including testing), concerns regarding disturbance of ***natural habitats, plant and animal life***?
14.	Regarding drone development or use possibly causing an Invasion of the right to ***bodily integrity****?*
15.	Regarding drone development or use possibly causing an invasion (upon enjoyment) of ***private space***, both out- and indoor?
16.	Regarding drone development or use possibly causing an invasion upon the right of ***private association****?*
17.	Regarding drone development or use possibly causing a '***chilling effect***' (i.e. non-usus of a legitimate right merely from fear of being sanctioned for wrongfully perceived misuse?
18.	Regarding whether your drone development/use could bring harm to or could (otherwise) infringe on a duty of care or on rights of contractual parties and consequentially could constitute a ***contractual civil liability,*** vis-à-vis owner, operator, service organisation, customer etc.*?*
19.	Regarding whether your drone development/use could bring harm to or could (otherwise) infringe on public or private rights or legally protected interests that could constitute a criminal offense and thus ***criminal liability*** *?*
20.	Regarding proper precaution versus any of the above drone developments and/or uses as a matter of ***reckless o***r ***malicious dual use*** by others without prior permission?
21.	Regarding any of the above following a ***malfunctioning*** of the drone during development or use (e.g. crashing, unintended data processing), including concern for proper insurance and protection of co-workers/employees?
22.	Regarding whether your drone development/use could bring harm to or could (otherwise) infringe on rights of 3rd parties and consequentially could constitute a ***non-contractual (i.e. 3 party civil (tort) liabiltiy ?***

Ethical Readiness level:	
1.	Moral thinking or even the obligation to develop the application
2.	Doubt about the specific function of the drone
3.	Doubt about the proposed aim of the drone
4.	Conflicting values
5.	Resistance from the specific or other sectors
6.	Minimalizing risks
7.	Feeling of being not safe
8.	Feeling of safety or trust
9.	Freedom of choice in managing the drone
10.	Freedom of choice in decision support
11.	Liability in incidents
12.	Indifference of the pilot
13.	Problems outside the task
14.	Missing crucial details
15.	Perception (magnify and leave out)
16.	Feeling of safety or trust
17.	Outdated laws and norms
18.	Changing values
19.	Changing perception
20.	Positive experiences other sectors
21.	Positive experiences comparable technologies
22.	Influence incidents other sectors
23.	New Responsibilities for businesses
24.	New responsibilities for the public
25.	With the help of the questions, you have answered so far, what do you think your "ethical readiness" is when it comes to your case?