The future of the U-Space:

Assessing the broader economic impact of U-Space regulation on the EU Drone Sector

Scenario analysis on the cost layers and the extent of the U-Space regulation

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Executive Summary

- Through the use of unmanned aircraft systems (UAS), we are on the brink of automating the sky above us. Widely referred to as "drones", remotely controlled aerial systems have the potential to revolutionize the way we work. Not only are they already freeing our workforce from dull, dirty and dangerous tasks, they are creating new opportunities to improve productivity. More importantly yet, drones are becoming a driving force for innovation throughout a wide variety of industrial sectors. They are an ideal kickstart to economic growth at a time when the European economy is struggling to fulfill its societal role of providing jobs and brighter perspectives for the younger generations.

- In order to capitalize on the enormous potential of drones, it is necessary that we develop comprehensive concepts on how UAS can be safely integrated into our often densely populated European airspace. Manned or unmanned, professionally or recreationally used, it is imperative that we strive for an all-encompassing airspace regulation—one that follows the vision set forth by the Single European Sky project. Part of this project is the so-called "U-Space". It is intended to function as an air traffic management system for drones and provides a system that interfaces with conventional air traffic management.

- The U-Space regulation of unmanned aircraft systems proposed by the European Commission (EC) sets out a number of requirements UAS must meet in order to be operated. These requirements are mostly concerned with the collection of information on the current status of an UAS, as well as making sure this data is available to other nearby aircraft and ensuring that flight information is communicated to a central database. In order to operate an UAS legally, the operator will have to buy the services of a U-Space Service Provider (USSP). The prices users will have to pay for U-Space services will largely depend on the exact design of the final regulation.

- The European Union Aviation Safety Agency (EASA) was asked to deliver an opinion on a "High-level regulatory framework for the U-Space". Presented to the EC in March 2020, the opinion provides important contributions on how to safely integrate UAS. This study is intended as a complement to the EASA opinion and was comissioned to add insights on the economic dimension of the planned U-Space regulation. It is intended to provide impulses for a debate on how best to take advantage of the economic opportunities presented by drones. The EASA opinion so far only offers a descriptive analysis of the likely economic impact of the proposed regulation. This leaves the reader without any information concerning the crucial question of how the proposed regulation will impact this technology's potential to create growth. That being said, a more detailed update to the opinion is expected in October 2020.

- In order to overcome this knowledge gap, a qualitative and quantitative analysis was designed with two main objectives: (1) to qualitatively describe both the direct and potential indirect costs of the regulation and (2) to quantitatively estimate the direct costs resulting from the regulation as currently planned. These direct costs are the additional costs for every UAS in the affected weight classes that are still being purchased post-implementation plus the revenue lost due to shrinking in the market. The reduced market size hits both recreational users who are unwilling to pay the additional costs as well as commercial users whose use of drones will become

unprofitable as a result. The estimation also provides an alternative scenario, which makes different policy options comparable from an economic impact perspective.

- The quantitative analysis focuses on three direct cost layers of the regulation: software costs (both the digital infrastructure and equipment), infrastructure costs (the physical infrastructure for data connections) and customer support costs. The total cost of the regulation is then derived at as the sum of direct costs and lost revenue, which is due to reduced demand as a result from higher prices. Discounted with the average harmonized consumer price index for the EU over the last 10 years (1.36 percent), we estimate that the present net cost of the U-Space regulation is between 7.55 billion EUR and 8.69 billion EUR.

- In addition to these direct costs, the qualitative analysis sheds light on the substantial risk of indirect costs. These costs are likely to arise from the foreseeable low level of competition in the future U-Space services market. U-Space services are dependent on mobile data connections and the expertise to coordinate large numbers of aircraft; and in each country in Europe this is the domain of a rather limited number of mobile network operators (MNO) and air navigation service providers (ANSP). Due to their dominant positions in their respective markets or fields of expertise, both MNOs and ANSPs could choose to provide U-Space services collectively, as observed with the German joint venture Droniq. Together, they could offer their own customers discounted rates or only allow other USSP to make overpriced offers to their customers. Thus, they might apply their market power to collectively threaten the competitive structure of the market for U-Space services.

- Alternative regulations are possible. Instead of pursuing the current draft proposal, it would be advisable to exclude all UAS' below 900 g. This would reduce costs significantly. The estimated cost of this scenario ranges between 4.84 billion EUR and 6.00 billion EUR, which represents a cost reduction of around 33 percent. This value should be compared to what can be achieved by reducing the individual cost factors. Infrastructure costs are the only direct cost layer adjustable by regulation (see section 2.1). If the current proposal were implemented with low infrastructure costs, savings would merely be around 13 percent of the high cost estimate. The cost reduction of the alternative proposal is therefore two and a half times greater than what can be achieved by lowering the cost factors alone. This makes it obvious that the exclusion and inclusion of weight classes is the primary regulatory cost lever. Another calculation based on excluding certain categories of operations - open, specific, or certified – was considered but not feasible due to data availability issues.

- This report concludes that while safety concerns are legitimate in the design of the U-Space, regulators must not lose sight of the transformative power of UAS. To only exclude so-called "toy drones" under 250 g from U-Space may hinder innovation in and around the industry. It cannot be stressed enough that the economic impact of a high-cost U-Space regulation would not only affect drone producers but also drone-based service providers and their commercial customers in economic sectors such as utilities, construction or agriculture. In these industries drone-based services, such as inspection or surveying, offer cost savings and productivity gains. The same holds true for private users or public institutions like universities and emergency services. If the use of UAS were to become too expensive, these economic benefits would be lost. Hence, the EC must take a more pragmatic approach to regulating the use of drones and must ensure costs and benefits are adequately balanced so that net social benefits are maximized.

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1 Introduction

UAS are a prime example of a 21st century technology that implies both a significant potential for innovation in the EU and a challenge for regulators. While UAS might well still be in their infancy in terms of mass usage, the technology has already broken through traditional barriers in many industries. They are now giving rise to new business models and promising noteworthy productivity gains in multiple industries such as construction, transportation, utilities, and energy, as well as in branches of civil government such as law enforcement and firefighting. Within recent years, UAS have proven that they are central to certain functions within businesses and government organizations and have managed to bring innovation to areas that for a long time seemed to be stagnating or lagging behind. From inspecting pipelines with drones instead of helicopters to quickly delivering goods in densely populated urban areas, UAS are providing increasingly significant benefits, especially in places where humans are unable to reach or unable to perform efficiently. In summary, UAS have the potential to bring productivity gains to many industries and to decrease workload and costs, all the while offering new opportunities for businesses to refine their services.

In order to make full use of their potential, drones need to be safely integrated into airspaces where manned aircraft systems still dominant. To achieve this the EC has continuously expanded its efforts to update its existing air traffic management system, with new European regulations for UAS operations in the “open” and “specific” category. However, in the eyes of EASA this air traffic management system is already reaching its limits due to the significant growth of UAS operations.[1] EC is therefore seeking to complement existing regulation with a new regulatory framework which will enable a harmonized implementation of U-Space and can ensure safe air traffic management for UAS operations.[2] In order to unleash the innovative potential of drones[3] and to address safety concerns, the EC is proposing a regulatory novelty: the U-Space regulatory framework. In a nutshell, U-Space is destined to become Europe`s unmanned air traffic management framework, enabling the safe integration of drones into the airspace. This is particularly important in densely populated areas, over cities and close to airports. In order for this traffic management system to work, a set of services must be provided to the operators of UAS. This includes basic services such as e-identification and geo-awareness (which helps to establish no-fly zones, e.g. around airports), initial services for drone operations management (e.g. flight approval or tracking) or advanced services supporting more complex operations in dense areas (e.g. assistance for conflict detection). Providing a crucial, first-ever technological benefit, U-Space will enable European UAS operators to use their drones beyond visual line of sight (BVLOS) and for automated operations.[4] This opens the gate for new applications of UAS and will further foster the commercial use and innovative potential of drones.

1 European Union Aviation Safety Agency Opinion No 01/2020: High-level regulatory framework for the U-Space

2 PWC Legal: EASA publishes first rules for safe drone operations in Europe’s cities

3 Please note the terms drone and UAS are being used synonymously in this text

4 PWC Legal: EASA publishes first rules for safe drone operations in Europe’s cities

The proposed U-Space regulation for unmanned aircraft systems has set out a number of requirements a UAS must meet in order to be operated in the airspace. These requirements are mostly concerned with collecting information on the current status of the UAS, making this data available to other nearby aircraft and communicating the flight information to a central database. In order to legally operate a UAS, the operator will have to buy the services of a USSP. The prices users will have to pay for U-Space services will largely depend on the exact design of the final regulation.

With its opinion on the "High-level regulatory framework for U-Spaces"[5], the European Union Aviation Safety Agency (EASA) laid out the technical basis for further regulatory actions for unmanned airspace traffic. Based on this EASA report, the EC published a draft for a regulation[6] to create a new legal framework that covers the implementation of U-Space. While the proposed legislation creates many benefits and lifts many of the current restrictions UAS operators are subject to, too little attention is paid to the economic costs of the regulation. This is problematic. One fundamental criterion for evaluating any regulatory measure is whether it strives to maximize societal benefits. The U-Space regulatory framework should maximize net societal benefits by safely integrating UAS into the airspace and minimize economic costs by making full use of drone technology's innovation potential to boost economic growth.

"The U-Space regulatory framework should maximize net societal benefits by safely integrating UAS into the airspace and minimize economic costs by making full use of drone technology's innovation potential to boost economic growth."

In order to prevent significant economic drawbacks and ensure the proportionality of regulatory frameworks, the EC has developed a set of rules and standards that recommend conducting economic, social, and environmental impact assessments prior to any regulatory implementation. These assessments are mandatory if *"the expected economic, environmental or social impacts of EU action are likely to be significant,"*[7] as is the case concerning the published U-Space regulation draft. As a matter of fact, the existing impact assessment, performed by EASA in its opinion,[8] does not fulfill these necessary standards as specified by the Commission's Better Regulatory Toolbox.

Hence, one must come to the conclusion that the design of the EC draft for a U-Space regulatory framework has not been well-informed. The EASA Opinion has not adhered to one of the major principles for Better Regulation, which the EC has set for itself: Comprehensiveness. The EASA Opinion does not address all relevant impacts of the proposed U-Space regulation. While it pays a lot of attention to safety aspects, the economic impacts are only dealt with in a superficial manner. In its opinion, EASA does not produce a quantitative assessment of how much the regulation will cost UAS operators, nor

[5] European Union Aviation Safety Agency Opinion No 01/2020: High-level regulatory framework for the U-Space

[6] Commission Implementing Regulation Draft: 15.06.2020

[7] EC Better Regulation Toolbox: Tool #9 page 48

[8] European Union Aviation Safety Agency Opinion No 01/2020: High-level regulatory framework for the U-Space, Chapter 3

does it reflect if such costs could have a significant impact on the UAS market. In addition, the Opinion does not address alternative policy solutions. It does reflect the impact of different policy implementation alternatives, i.e. EU-wide implementation by a single authority vs. implementation by the EU member states. But it does not analyze policy alternatives that are different in content, and which may deliver the same benefits as the preferred regulation, while generating lower costs. Hence, the EASA Opinion simply does not enable regulators to come to an evidence-based conclusion on which policy alternatives maximizes net societal benefits.

In assessing the economic impact of the two scenarios (i.e. national implementation vs. EU-wide implementation) the Opinion tries to quantify the impact by scoring it. However, the scoring mechanism behind the assessment seems rather arbitrary. The conclusion the assessment arrives at is not intuitive. In the national implementation scenario, the Opinion states that:

"National implementation of the U-Space will have a negative economic impact on USSPs. In general, USSPs will have to bear the most significant investment in terms of infrastructure and performance capabilities. The cost to launch and maintain their activities includes the operation and maintenance of specific infrastructure and equipment that they will need in order to provide services in the U-space."[9]

Besides a negative economic impact on USSPs, the Opinion also highlights infrastructure costs for ATMs (air traffic managers) and high implementation costs for public authorities due to the need for airspace redesign. Contradicting to this statement, the Opinion concludes that the economic impact of U-Space implementation will vary between member states and that the overall economic impact will be neutral (score of 0). This begs the question if there will be economic benefits to the implementation at national level which will compensate for the implementation and maintenance costs for USSPs, ATMs and public authorities. However, the Opinion does not clarify that in detail, which is why it is unclear to the reader how EASA came to its conclusion of a neutral economic impact.

The assessment of an EU-wide implementation scenario is structured in the same way. It concludes that in this scenario the regulatory framework will have a marginal positive impact (Score of +2). However, it acknowledges that:

"...for the authorities, the initial implementation of the U-space airspace may have a high cost due to the need for airspace redesign, accuracy of aeronautical data used for airspace structures definition."[10]

While the assessment mentions both costs and benefits of the regulation, it remains unclear how costs and benefits were weighted against each other. In this case, a cost-benefit analysis on the economic impact of the regulation is particularly difficult since it is purely descriptive. A quantitative assessment is lacking. Therefore, the reader does not know exactly how the assessment concludes that the economic

9 European Union Aviation Safety Agency Opinion No 01/2020: High-level regulatory framework for the U-Space, page 37

10 European Union Aviation Safety Agency Opinion No 01/2020: High-level regulatory framework for the U-Space, page 39

impact in an EU-wide implementation scenario will be positive. That being said, a more detailed update to the opinion is expected to be published in October 2020. Furthermore, it is not the aim of this study to refute the findings of the EASA opinion. Rather it must be seen as a complement which is intended to continue to provide impulses for a debate on how best to take advantage of the economic opportunities presented by drones.

To round off the incomplete analysis by EASA, this study aims to evaluate the costs and the lost economic benefits induced by the proposed regulation. This is done by performing a qualitative as well as a quantitative impact assessment. In the qualitative part of the study (Chapter 2), a short review of the key elements of the regulation is presented and the main direct and indirect costs, such as software costs or social costs associated with negative impacts on the competitive structure of the market for U-Space services, are discussed. Further, a short description of the potential of the drone market is presented. It highlights that a well-designed U-Space regulation, which minimizes both operational and economic limitations for UAS users, will generate significant economic benefit and will positively affect many business sectors within the EU economy. Drones and drone-based services offer productivity gains in industries such as construction and utilities. It should be stressed that U-Space airspace should be designated judiciously, as the additional costs associated with it should be avoided wherever possible, i.e. in airspace that does not need traffic management. Chapter 2 introduces the idea of a revised regulation that excludes drones up to 900 g. Following the qualitative part, Chapter 3 proceeds with the cost analysis by quantifying the main direct costs, as well as the expected market response by potential drone users. It concludes that excluding drones up to 900 g (alternative proposal) would significantly reduce costs for a relevant segment of users and preserve innovation drivers, while maintaining the benefits of the proposal. Furthermore, a quantitative economic cost comparison of the existing regulation draft and a revised regulation is performed. The study concludes with a summary of the main findings and policy implications.

2 Qualitative cost analysis

This chapter discusses the costs that may result from the current draft of the U-Space regulation. Importantly, this focus on cost is not an end in itself but serves as criteria for evaluating whether the proposed regulatory measure maximizes net societal benefits. In this regard, it must be stressed that the establishment of a U-Space in the EU itself is not an economic regulation in the first place, which would refer to both the direct legislation and administrative regulation of prices and entry into industries or markets. It is instead, first and foremost, a social regulation designed to enable advanced drone operations.[11] Nevertheless, the U-Space regulation has economic and therefore societal impacts — UAS operators would face additional costs when flying their drones. This in turn can negatively impact the demand for drones and their related high value-added services and thereby limit their innovation potential in other industries. This raises the question on the net effectiveness of the U-Space regulation as it is currently proposed.

[11] Joskow & Rose – The Effects of Economic Regulation (1989)

In order to understand which type of U-Space regulation would maximize net societal benefits, costs and benefits need to be carefully weighed against each other. The benefits of the regulation are, in principle, significant. U-Space services will ensure the safe integration of UAS with other airspace users. This will put UAS operators into the position of being able to operate their drones in areas previously unallowed. This is particularly relevant for urban areas and critical areas such as airports. Therefore, U-Space as a social regulation will bring significant benefits; it will increase safety in the airspace and it will enable productivity gains for many European industries interested in innovative drone-based services (e.g. surveying, inspection). However, if the regulation does not pay sufficient attention to fostering further innovation in this sector, economic opportunities can quickly turn into economic liabilities. For instance, there will be some direct costs associated with the establishment of the U-Space, such as infrastructure or software costs. These costs will undoubtably be passed on to the users in the form of higher prices for products and drone-based services. Furthermore, the regulation in its current form entails risks to a competitive structure in the market for U-Space services, as MNOs and ANSPs may have a competitive advantage when providing U-Space services in cooperation. This could further drive up prices for UAS operators, negatively impacting demand. If drone-service providers are forced to greatly increase prices due to high costs of the U-Space, the economic benefits will be lost as demand for UAS and related services will decrease significantly. Against this backdrop, it is worth considering the economic impact of U-Space as well and carefully evaluating the regulatory alternatives that would secure its important benefits and, at the same time, minimize its costs, i.e. the price increases for users.

2.1 Direct costs

The proposed U-Space regulation for unmanned aircraft systems has set out a number of requirements UAS must meet in order to be operated in the airspace. These requirements are mostly concerned with collecting information on the current status of the UAS, making this data available to other nearby aircraft and communicating the flight information to a central database in order to manage the air traffic, for example via routing and deconfliction. In order to be able to operate a UAS legally, the operator will buy the services of a USSP. A USSP is a private company (at least for commercial use cases) that is certified by the relevant competent authority to provide U-Space services. According to the current plans of EASA, a company must demonstrate its capability of providing four mandatory services in order to be certified as a USSP: Network identification, geo-awareness, traffic information and UAS flight authorization.[12]

Such services can however only be provided if all UAS affected by the regulation are equipped with the necessary hardware and software to fulfill all requirements before, during and after flight. Before each flight, a flight authorization request must be sent to the USSP containing both drone and pilot information, as well as a planned flight route. While in flight, UAS must continuously transmit information on position and height, orientation, registration, the flight's starting position and an emergency status indicator. All of the information will be shared publicly by the USSP so that other aircraft are notified and can coordinate with the pilot. After the flight, the information will be stored for 30 days in the evet that the pilot needs be identified due to complaints or accidents.

[12] European Union Aviation Safety Agency Opinion No 01/2020: High-level regulatory framework for the U-Space

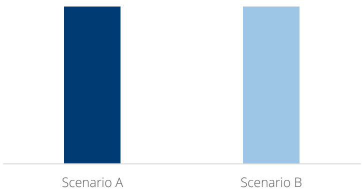
For information exchange to be possible, each drone must be outfitted with the software (and hardware) necessary to collect the required data and share it with the USSP. This collection of data and its transmission to the USSP will create considerable costs. Additionally, for the transmission of data to be possible in real time, the adequate infrastructure, namely a well-functioning 4G network, which covers dedicated airspaces, must be in place. All these cost layers will to some degree be paid by the drone operators in the form of higher prices. These types of cost are called the direct costs of the U-Space regulation, as these cost layers are integral to the social regulation achieving its main goal: safety in the airspace. Without the necessary software, hardware, and infrastructure the provision of U-Space services will not be possible. The most obvious direct costs that will arise from the U-Space regulation are:

<u>Software costs:</u> The majority of the software costs will be generated by the in-flight requirements. Constantly collecting precise data on the position and heading of the UAS and transmitting it to the USSP is the main consideration. Receiving information on current air traffic and geo-awareness of authorized flight areas and routes makes up the bulk of the incoming network traffic. This cost layer consists of mostly unavoidable costs, as the tracking software, data processing and equipment would be needed in every conceivable scenario.

<u>Infrastructure costs:</u> The successful deployment of U-Space requires U-Space services to be available in the dedicated airspaces. For UAS operators to be able to connect to U-Space from wherever they are located, highly reliable, wide reaching, low latency communication networks are required. If the future regulation would require drones to communicate directly with the radio towers, this would make additional investments in the infrastructure necessary to ensure that airspace is covered completely and reliably. Such investments will be costly and will most likely be priced in by mobile network operators (MNOs) and ultimately will be passed on to UAS users. This cost factor therefore contains a large amount of adjustable costs that depend on the details of the regulation.

<u>Customer support costs:</u> According to the current draft of the regulation, take-offs in U-Space airspace will not be permitted if a connection to the USSP cannot be established. This adds a new potential point of failure for any planned flight with an unmanned aircraft system. If the connection fails, the owner of the UAS is likely to demand customer support either from the USSP or the manufacturer of his or her aircraft. Because of the new technical requirements, manufacturers and USSPs would need to hire additional specially trained customer support staff, resulting in additional customer support costs. These costs can be attributed to the regulation directly since they would not occur in airspaces as they currently exist. This cost layer depends almost entirely on the number of flights taking place and not on the details of the regulation.

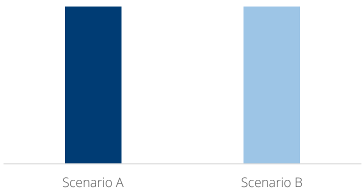
Software costs



This cost layer consists of mostly of unchangeable costs, as the necessary tracking software, data processing and equipment would be needed in every conceivable scenario.

Not adjustable by regulation

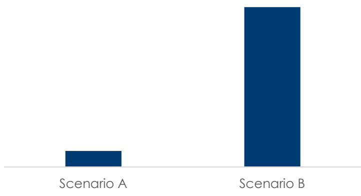
Customer support costs



This cost layer depends almost entirely on the number of flights taking place and not on the details of the regulation.

Not adjustable by regulation

Infrastructure costs



Low-cost scenario:
Regulation requires drones to communicate with their controlling device (the smartphone).

High-cost scenario:
Regulation requires drones to communicate directly with the radio towers.

Adjustable by regulation

2.2 Indirect costs

The impact of a regulation, be it an *"economic regulation"* or a *"social regulation"*, generally depends on a variety of factors: the motivation for the regulation; the nature of the selected regulatory instruments; the economic characteristics of the regulated industry; and finally, the legal and political environment in which the regulatory process takes place. With that being said, it becomes obvious that the expected economic impact of a regulation such as the establishment of the U-Space is difficult to predict. For this reason, the EC Toolbox for Better Regulation stresses that when conducting an impact assessment an appropriate analysis must achieve both (1) a focus on the intended and unintended impacts that are expected to be significant and (2) a consideration of the risk of negative unexpected consequences.[13] Significant impacts to be expected are, for example, the cost layers explained above (e.g. software costs) which will be passed on to UAS operators in the form of higher prices and ultimately result in lower demand for drones. In contrast, negative unexpected consequences refer to something different: They occur if the regulator gets the policy wrong and, as a result, significant unexpected costs can put an additional burden on users and/or producers in the EU. In this report, this sort of costs is called indirect costs.

Of course, which type of unexpected consequences are likely to occur depends on the final design of the regulation. However, in this paper the argument is made that the establishment of the U-Space, if inadequately designed, presents risks to an open and competitive market for U-Space services. Hence, when designing the U-Space regulation, regulators must pay special attention to technical requirements which private companies must fulfill in order to be licensed as USSP. As explained previously, in order to be certified as USSP a company must demonstrate its capability of providing four mandatory services:

[13] EC Better Regulation Toolbox

Network identification, geo-awareness, traffic information and UAS flight authorization.[14] In order to provide such services, USSPs must have access to a reliable 4G mobile network.[15] For this reason, the economic realities of the market must be considered. In other words, it is important to have an understanding of the costs that companies will face in order to provide the services. If costs for receiving access to 4G networks are very high, they can also serve as market entry barriers to smaller firms, so that ultimately only established players will be able to provide U-Space services leaving the market in a non-competitive structure. In this case the economic burden on drone operators would be even higher. In addition to the direct costs for the provision of services which the drone operators will have to cover, prices will additionally increase if a large provider takes over a position in the market in which it will generate excessive returns.

One of the reasons why the market for U-Space services may be prone to market distortions is the fact that it relies on a good 4G network architecture. U-Space services, which are essentially designed to ensure safety in the airspace, will especially require highly reliable, low latency communications.[16] Under certain circumstances, the current expansion plans for 4G-network coverage could cover the needs of U-Space. But it is equally possible that for the full deployment of U-Space, an improved infrastructure is required, e.g. through upgrades to existing 4G network for wireless communication.[17] The quantitative part of this report makes estimates for both of these possibilities.

The establishment of U-Space can be the driver of significant innovation processes in sectors like health, smart cities, manufacturing, transportation and, of course, aviation. However, whether this potential innovation will be unleashed or not depends on the competitive structure of a given market. Previous experience suggests that innovation can flourish if the structure of a given market gives entrepreneurs the freedom to experiment with new business models and test new services. For UAS operators to be able to experiment with new applications of drones, affordable usage of UAS is necessary. High costs in the cooperation between USSPs and MNOs would function as de facto market entry barrier for entrepreneurs and thereby as a constraint to innovation, because prices for U-Space services in a non-competitive market environment would be high.

[14] European Union Aviation Safety Agency Opinion No 01/2020: High-level regulatory framework for the U-Space

[15] Recent studies have shown that a 4G connection would be sufficient for communication with UAS. Therefore, this report assumes that U-Space will basically rely on 4G technology as it is already wide-spread and integrated into most devices. While the use of more advanced communication standards like 5G would also be possible, it can be expected that 4G will form the basis of connectivity in the foreseeable future.

[16] EU CORDIS – Hybrid satellite and network architecture shaping the future of drone communication (2019)

[17] SESAR – SUPPORTING SAFE AND SECURE DRONE OPERATIONS IN EUROPE

There is reason to assume such market entry barriers would be high for U-Space services. In order to advance that point it must be understood that the USSPs could in principle decide to offer their services in one of two different ways:

1. They only offer an app which can be downloaded to a smartphone or tablet. The customer is responsible for the Internet connection, which he gets in the form of an unlimited data contract[18] from one of the mobile phone providers. This version is especially relevant if a communication drone-smartphone-USSP is sufficient.
2. They offer the U-Space services and a data package. For this, the USSPs would have to cooperate with the mobile phone providers who operate the mobile phone network. This version is particularly relevant if the drone itself must establish a direct Internet connection to the USSP.

MNOs have the advantage of operating the required mobile phone network themselves. In addition, this is a very concentrated market. Hence, in both cases MNOs could transfer their market power in mobile communications to the USSP market.

In case 1, MNOs could offer the data packages (which are included in their own U-Space offer) at a lower price compared to the normal mobile phone contracts. Hence, they could give UAS users an incentive to buy their services by offering them reduced rates on mobile phone contracts. This gives them a competitive advantage over other USSPs due to their direct access to the mobile network since they cannot sell complete packages or the customers of other USSPs are dependent on a more expensive data contract. A modified version could be mobile operators offer U-Space services separately from the mobile contracts but offer their U-Space customers a discount on the data contracts.

If USSPs want to sell their service together with a data package as in case 2, they need to cooperate with at least one mobile network provider. The latter could use its market power and decide not to offer USSP at all or only overpriced co-operations. As a result, USSPs can offer their customers nothing or only overpriced packages.

Either way, the bottom line is that due to their dominant market position in the mobile communications market, MNOs can offer their own USSP customers discounted offers or only allow other USSP providers to make overpriced offers to their customers. This is possible because a mobile data connection is a basic requirement of the U-Space regulation / for the USSP market.

"... due to their dominant market position in the mobile communications market, MNOs can offer their own USSP customers discounted offers or only allow other USSP providers to make overpriced offers to their customers. In fact, they transfer their market power in the mobile communications market to the USSP market. This is possible because a mobile data connection is a basic requirement of the U-Space regulation / for the USSP market."

[18] The existing proposals for U-Space do not specify how much data will have to be exchanged between UAS and USSP. Due to this uncertainty, this report uses a data contract that will cover all eventualities for calculations.

However, MNOs are not the only actors with potential economic interests – and a substantial market advantage. Each Air Navigation Service Provider (ANSP) in Europe already has the necessary expertise to coordinate aircraft in large numbers. The coordination of manned and unmanned aircraft by communicating with the respective ANSP will be the central task of U-Space. Therefore, having this crucial expertise in-house can be considered to be a significant advantage. Should ANSP's enter the market for U-Space services and join forces with MNOs, they could become dominant market players. This, however, would make the objective of competitive markets virtually unattainable. As is invariably the case in non-competitive markets, the result will be higher costs for users and less innovation and eventually less growth for the European economy.

Against this backdrop, there is a high risk that entrepreneurial USSPs will have to compete with MNOs and ANSPs directly, if they should decide to offer their own U-Space services. For example, in 2019, the German ANSP, *Deutsche Flugsicherung (DFS)*, and the German MNO *Deutsche Telekom* announced their joint venture *Droniq GmbH*. Droniq provides a technical platform for locating drones, which in the future will enable drones to fly outside the pilot's visual range – an essential element of U-Space services.[19] This highlights that both MNOs and ANSPs can be assumed to have a strong economic interest in providing U-Space services on their own. They anticipate a lucrative business opportunity for themselves in this market and are obviously inclined to secure this strategically important position early on. It therefore appears safe to assume that MNOs would not be interested in a very competitive market with numerous entrepreneurial USSPs – fostering competitive markets being, however, a permanent stated goal of all EU regulation. That said, MNOs stand a good chance of succeeding since they do not have to face most of the costs that entrepreneurial USSPs will. As MNOs, they already have access to 4G networks and do not need to purchase access. Under such conditions, it is unlikely that any serious entrepreneurial competition will develop: Since MNOs face lower costs, they will be able to quickly price out any entrepreneurial competition in the market. This is especially true for the U-Space services market, as demand for U-Space services is expected to be initially low. While demand for UAS is growing fast, it is still a market in its infancy. Entrepreneurial USSPs are likely to only have a realistic shot if they can develop a range of USSPs which would allow them to dominate the market. Otherwise there is very low incentive for these firms to enter a market with large, technically advanced, established competitors.[20]

Under these circumstances, it is likely that the market for U-Space services will not develop in a competitive fashion. MNOs and ANSPs have their eyes set on the market for U-Space services and have the technical capability and the financial capacity to make partnership agreements with entrepreneurial USSPs very demanding. Ultimately, one or two MNOs or ANSPs would provide U-Space services at prices above the market equilibrium. This will result in UAS operators having to pay additional costs on top of the direct costs of the regulation which are passed on to them in the form of higher prices.

19 Press release of Deutsche Flugsicherung and Deutsche Telekom

20 Unmanned Airspace – UTM market fragments and service suppliers rethink business plans

2.3 Lost economic benefits

Excessively high prices of U-Space services are a problem because they can damage the innovative potential and productivity gains that UAS offer to the European economy as a whole. First, drones have managed to make the leap into the consumer market. In recent years demand for hobbyist drones has taken off, with still more potential for growth. Now, drones are growing into tools that offer new business opportunities and (high-value added) economic services. They are being used in commercial and civil government applications and offer a huge innovative potential in many different industries. According to Goldman Sachs Research, the fastest growth opportunity for drones today comes from the business and civil government sector. And with the ongoing technological advances in UAS, new potential applications for the commercial use of drones are constantly being added.[21]

Currently, the most common commercial use for drones in Europe is inspections. This is particularly important in the agricultural sector. Drones enable farmers to monitor crops in critical seasons faster and more accurately than planes or satellites. More than half of all drones operated by companies in Europe are being used for inspection. This is particularly important for sectors like construction where building sites need to be inspected or the utility sector in general. UAS offer a more effective and cheaper means to inspect power lines, hydroelectric dams, pipelines, solar panels, or wind turbines. If a gas company, for example, wants to inspect one of its pipelines and scan for defects, it can do so using a drone instead of a much more expensive helicopter crew. Hence, drones offer large cost saving potential in some industries and furthermore enable a more consistent monitoring of critical infrastructure, such as pipelines.[22]

In the future, UAS will offer numerous additional applications for many different industries. However, it is important to note that some of these operations require regulations that allow them to operate beyond a UAS' operators line of sight (e.g. taxi drones). This underscores the significant benefits that the establishment of the U-Space brings for individual UAS users, companies and the economy as a whole. If a U-Space can be developed that would guarantee the safe integration of unmanned aircraft into the airspace, this could unleash significant innovation potential and productivity gains across European economies for certain types of operations that otherwise would not be permitted. However, the expansion of the beyond visual line of sight (BVLOS) market should not come at the expense of the visual line of sight (VLOS) market. In fact, in order to fully raise the potential societally benefits of drones it is important to create as much incentive for innovation in all types and classes of drones as possible. Innovations in one type can quickly spill over into other types, including commercial ones, which in turn increases productivity in a wide variety of economic sectors. A strong innovative basis for drones in all types and classes is therefore the best precondition for quick and thorough productivity gains in eventual commercial use.

21 Goldman Sachs Research – Drones: Reporting for work

22 Drone Industry Insights – The European Drone Industry (2018)

On the one side, recreational use of drones is still more common than commercial use. The total value of the consumer market for UAS in 2020 is estimated to be 2.60 billion USD, while the commercial market is estimated to be worth 0.53 billion USD. Recreational users can be an important source of product innovation, as they too experiment with their drones and may find new useful applications for drones. These may later be adopted by commercial users. On the other side, the highest estimated growth in the next years will occur in the commercial segment. This implies that companies in other industries will increasingly demand drone-based services such as mapping, surveying or inspecting. From 2018 to 2022 the commercial segment is expected to grow by 380.3%.[23] This expansion of the commercial UAS market will be an important source of innovation for other industries. The use of UAS will provide important productivity gains in sectors such as utilities, education, agriculture or firefighting.

Hobbyists usually fly UAS below the 900 g threshold. If the application of such UAS would become too expensive for users, even if they only use them within their visual line of sight for recreational purposes, this would effectively decrease demand for drones below the 900 g threshold significantly. This would be problematic because at this stage it is especially the experimentation with drones by hobbyists which produces new innovative applications for UAS, which may later spread into the market for commercial drone-based services. In the end, fewer product innovation would spill over from the recreational market into the commercial market and less productivity gains would be observed in other economic sectors.

The outcome would be a regulation that reduces operational limitations for the BVLOS market but increases economic limitations in the VLOS market. Yet, the goal of an effective regulation should be to create safety in the airspace while at the same time keeping operational and economic limitations to a minimum both in the BVLOS and the VLOS market. Only under such conditions can regulators integrate UAS safely into the airspace and simultaneously create an innovation friendly environment where users are able to experiment with new applications for UAS in the BVLOS and VLOS market without facing disproportionally high economic costs. [24]

The majority of drones used in Europe today are below 900 g. Within this weight threshold the use of commercial applications (e.g. surveying, inspection, etc.) is growing. This can be explained by changes on both the demand and supply side of the market for drone services. On the demand side, companies for example in the construction or energy sector have realized that they can generate significant cost savings if they purchase certain services from drone-based service providers. The manual inspection of a pipeline or its inspection by a helicopter crew is usually much more expensive. On the supply side, there is a growing number of entrepreneurs offering the drone-based services that companies in other economic sectors are interested in. Very often these services are a result of an innovation process in which UAS users who started as hobbyists experiment with drones and come up with new applications for them. Hence, it is worth considering alternative regulatory approaches and to carefully weigh costs

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[23] Molina & Oña – The Drone Sector in Europe (2017)

[24] The company PrecisionHawk has already been awarded a patent for Unmanned Traffic Management complementary to the air traffic management system of the FAA in the US, which shows the desire to expand the market for BVLOS applications.

against benefits for each proposed regulation in order to find an approach which secures the significant benefits of U-Space but does not impose disproportionate costs on UAS operators. A well-regulated U-Space should enable actors on the supply side to innovate and invent new drone-based services by allowing users to operate UAS beyond visual line of sight and should at the same time keep economic limitations for using UAS low. In a nutshell, the future U-Space regulation should increase the airspace in which UAS operators are allowed to fly their drones, and secondly, should enable them to do so affordably. This would maximize the economic benefits of UAS way beyond the industry of drone producers itself.

It therefore needs to be stressed that a reduced demand in UAS due to a spike in costs for users would not only result in price increases for private UAS users and in a revenue loss for UAS producers. Much more importantly, it would hurt the EU economy as a whole, as many more industries would be affected. Growth in the novel industry for drone-based services would slump, as entrepreneurs would have to add high costs for using the U-Space on the prices for their services. This would hinder the growth of revenue streams, jobs and innovation in general in this industry. As a result of higher costs for drone-based services, companies in other economic sectors (e.g. construction, utilities, etc.) might decide to continue to use conventional surveying or inspection services instead. This will not enable them to generate cost savings and thereby productivity gains which they could achieve if they could switch to drone-based services at reasonable market prices. Both the potential economic benefits from a well-designed U-Space regulation and the economic cost of an overly stringent one will impact a wide range of economic sectors across the EU.

Economic impact on market actors in a scenario where costs for the U-Space are high

Supply Side		**Demand Side**	
Drone producers	**Drone-based services providers**	**Private & commercial UAS users**	**Commercial customers of drone-based services**
Producers of UAS will suffer from a high cost scenario due to lost revenue. If UAS users have to pay high additional prices for U-Space services, demand for drones will decrease. On top of that, providers of drone-based services will purchase fewer drones, if demand for their services shrinks.	The providers of drone-based services such as mapping, surveying or inspection will suffer revenue losses, if costs for using the U-Space are too high. Commercial customers might decide to remain with conventional service providers which use helicopters or satellite images.	Private users will face higher costs for operating their UAS due to high prices for U-Space services. Likewise commercial users who are already productive under existing regulatory frameworks will also face additional costs. As a result users will experiment less with drones and fewer innovation for drone-based applications will take place.	The application of UAS for services like surveying can offer productivity gains in many other industries. If costs for drone usage are very high, drone based service providers will add these costs to their prices and potential cost savings for other industries are lost. Cost for internal drone programs of companies will also rise.
Revenue loss due to reduced demand for drones.	Revenue loss due to reduced demand for U-Space services.	Reduced innovation which can spill over to the commercial sector.	No productivity gains because other industries do not make use of drone-based services.

Negative economic impact across
multiple industries in the EU economy

2.4 Alternative regulations

When looking for alternative regulatory approaches that may secure the benefits of U-Space at lower economic costs, it is important to analyze which kind of drones should or should not be subject to the regulation. **The more drone categories included in the U-Space requirements, the more likely UAS operators are to face higher costs and demand will shrink for a broad range of UAS products.**

In this regard it is important to take a closer look at the sub-categories of drones, as defined in the EU. First of all, drone operations are currently subdivided into three categories[25]:

1. Open category: Drone operations in this category are considered low risk and UAS operators are not required to ask for prior flight authorization.
2. Specific category: Operations in this category are expected to entail some sort of risk and therefore require prior authorization by a competent authority.
3. Certified category: Operations in this category require a certified drone, a licensed pilot and an organization approved by a competent authority to ensure an appropriate level of safety.

The existing U-Space draft by the EC does not apply to the drones below 250 g in the open category. All other categories and weight classes above 250 g will be affected by the regulation. UAS below 250 g are almost exclusively being used for recreational purposes.[26] However, it is questionable if this proposal strikes a good balance between the weight of a given UAS, proportionate to its potential hazards in the airspace, and the related economic impact resulting from the regulation. After all, the owners of UAS' in all weight classes above 250 g will face additional costs in order to integrate their drones into the airspace. In a recent draft, the commission has already stated there could be exceptions for UAS operating within Open Category A1 (drones in weight classes below 900 g, no flight over crowds, VLOS).[27] This paper argues that it would be preferable to extend this exception to all operations with drones weighing less than 900 g. This would be justified for mainly three reasons:

First, as the next chapter will point out, **the exclusion of UAS below 250 g only will be significantly more costly than the alternative regulation: excluding all drones below 900 g from U-Space.** The drone market would be impacted in a negative way if higher costs would be passed on to UAS users. For business use cases like inspections where only short-range flights are required, the additional cost could make the use of UAS prohibitively expensive, especially for small businesses and private individuals. The innovative potential of this novel technology would be significantly reduced and productivity gains for other industries and EU economies at large may be lost. Less drones sold also implies less drone-based services provided and less companies from other industries generating cost savings for mapping, surveying or inspection services. For the economy as a whole this implies that less drone-related jobs and tax revenue will be created. It is therefore worth considering whether the existing proposal really is best suited for optimizing net societal benefits or if there are other, better solutions.

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[25] As defined in Commission Implementing Regulation (EU) 2019/947

[26] EC Implementing Regulation (Draft) on a regulatory framework for the U-Space (2020)

[27] European Union Aviation Safety Agency Opinion No 01/2020: High-level regulatory framework for the U-Space

The second argument against the inclusion of drones between 250 g and 900 g into the U-Space is the potential development of a free-rider problem in the market. As of now, it can be assumed that a significant portion of UAS users are in favor of U-Space. As stated above, it will allow the use of BVLOS and will therefore give users much more freedom to use their drones for new applications. However, if EASA should insist to push UAS between 250 g and 900 g into U-Space, this would increase costs for UAS users and could dramatically change how Europeans are using drones. The regulation would then require drones between 250 g and 900 g in European airspace to connect to U-Space in order to fly legally or to go even further, to be able to take off at all. Older drone models, that are already on the market, but are not equipped for internet connectivity, will have to be retrofitted. If such costs are unreasonably high, this would imply the risk that acceptance for the regulation among UAS users will decrease. In this case, users that were originally open and positive towards a balanced U-Space regulation might turn away from the system and perhaps even use older, non-retrofitted UAS which are not suited for U-Space. They would effectively fly under the radar and might make use of the new possibility to operate their UAS beyond visual line of sight without purchasing USS. Ultimately, such a regulation would be at risk of not achieving its safety goals, nor would it foster the innovational potential of drones in the EU.

Finally, it would not necessarily create any additional safety benefits to include drones between 250 g and 900 g into U-Space. As a result of the Commission Delegated Regulation (EU) 2019/945, from January 1st, 2021 onwards, new drones must have a connection to a new real-time in-flight signal system, i.e. direct electronic broadcast remote ID. Hence, excluding all drones below 900 g from U-Space would not mean that these drones fly under the radar. There is already a system in place that would ensure their identification and monitoring. The drone's broadcast signal will respond to a specific protocol that will enable the identification of:[28]

> The operator's registration number
> UAS serial number
> Geographical position and height above the ground
> Direction and speed of the UAS
> Take-off coordinates

Hence, this system of direct electronic remote ID that is about to enter into force already allows the competent authorities to accurately identify and monitor drones. It is therefore questionable if there is even a need to include low risk UAS under 900 g into the U-Space. Their identification and monitoring in the airspace will already be possible from January 2021 onwards.

Excluding even heavier drones, even for operations that would fall under the open category, would in all likelihood create an unacceptable level of risk for EASA and the EC, which is why this paper did not investigate that possibility in depth.

[28] Grupooneair – New EASA Drone Regulations 2020

3 Quantitative cost analysis

The EASA opinion on the "High-level regulatory framework for the U-Space," in which it submitted a draft regulation to the EC, has not made a detailed analysis of cost layers for this regulation.[29] So far there merely exists a descriptive analysis of the economic impact of the proposed regulation. This paper seeks to remedy this omission.

A quantitative analysis was designed to estimate the direct costs resulting from the regulation as it is currently planned to be implemented. The list of cost factors is not exhaustive, and every estimate is subject to a degree of uncertainty because the technical requirements and use cases for U-Space have not been finalized. Further research will be necessary once the details have been agreed upon. The structure of this chapter is shaped by the research approach. First, the market size will be estimated, followed by an analysis of the three individual cost layers of (i) software costs, (ii) infrastructure costs, and (iii) costumer support costs. These three cost layers are the most obvious costs that will come along with the implantation of the U-Space regulation. The last part of the model includes an estimate for the reaction of the consumer and the resulting changes in the market. For the calculation of costs, it is assumed that every UAS weighing more than 250 g is upgraded to connect to U-Space services and does so for every flight.

Furthermore, the argument could be made that additional cost savings could be realized if rural areas would not be designated as part of U-Space airspace. However, more than 70 percent of the European population live in urban areas[30], which are likely to be designated U-Space, and will experience more flights due to the density of UAS owners. In other words, where more people live, more drones are likely to be flown. In addition, customers will likely expect that every drone they buy is able to connect to U-Space services, otherwise being limited in their use to rural areas.

To illustrate the effect alternative implementations of the regulation could have, an estimate of the total cost in case that drones weighing less than 900 g are exempt from U-Space is also presented.

3.1 Scenario 0: Estimate of market developments in the status-quo

One of the most important drivers of the economic impact of the proposed U-Space regulation is the size of the corresponding market. The larger the market, the greater the potential losses or gains. This section forecasts the market developments of the coming decade (until 2030) under the assumption that the UAS market will remain regulated under the current status (i.e. no U-Space, but instead the basic regulations already completed in the Open category, and perhaps Specific category).

[29] See European Union Aviation Safety Agency Opinion No 01/2020: High-level regulatory framework for the U-Space and its annex Draft Commission Implementing regulation (EU) on a high-level regulatory framework for the U-space

[30] Eurostat: Distribution of population by degree of urbanisation, dwelling type and income group - EU-SILC survey, 2018

Theoretical Considerations

U-Space will induce additional costs for each UAS deployed within it. The full cost of the regulation is therefore dependent on the number of UAS that will be affected by it. This number needs to be estimated. The developments in different weight classes are modeled differently, as the UAS in those weight classes will be affected differently by the regulation (due to exemptions and customer reaction). For example, the current proposal envisions exemptions for drones weighing less than 250 g.

Consultations with industry experts suggest that the European Market is following in the footsteps of the US-market and may even overtake it in the coming years. Making a comparison to the automotive market, the experts have asserted that prices will most likely remain unchanged, while the benefits of innovation will be realized through improved functionality and new features. Following this logic, our model assumes that prices of UAS will remain constant, while the number of sales will experience a strong and steady growth. Due to the high dynamism in the market, the forecast is limited to the coming decade.

Data

The principal challenge when quantifying the size of the UAS market in Europe is a lack of publicly available data. This is far from a unique challenge, as data about UAS is in short supply for the entire market worldwide. As a result, the estimates have to rely on both market research and informed assumptions.

The most reliable data comes from Parrot SA, one of the biggest drone manufacturers in Europe, who regularly discloses drone revenues and sales figures as part of its annual financial reports[31]. Published estimates put their market share somewhere between 2.2 percent (USA) and 15 percent (USA),[32] with the more recent estimates at the lower end. Their data is split into sales of commercial drones and consumer drones. The United States Federal Aviation Administration (FAA) makes a similar distinction in their forecasts for the US market[33], where they differentiate professional UAS (with prices above 10,000 USD), recreational UAS and non-professional commercial UAS (with prices between 1,000 USD and 2,500 USD). However, these classifications are not appropriate for evaluation of the proposed regulation, which is why this analysis uses weight classes, which are more in line with existing European laws. [34] The projection is made for the four categories of UAS weighing less than 250 g (class C0), UAS between 250 g and 900 g (class C1), those between 900 g and 4kg (class C2), and finally UAS that weigh more than 4kg (classes C3 to C6).

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31 Parrot Press Release, March 19, 2020: 2019 full-year earnings
Parrot Press Release, March 15, 2019: 2018 business and earnings
Parrot Press Release, March 15, 2018: 2017 business and earnings

32 Number of registered drones in US Airspace, Droneii, 2019, Goldman Sachs Global Investment research, 2014

33 Federal Aviation Administration: FAA AEROSPACE FORECAST – Fiscal Years 2020-2040.

34 See Commission Delegated Regulation (EU) 2019/945, amended by Commission Delegated Regulation (EU) 2020/1058

The largest player in the European drone market – as well as worldwide – is DJI, who are not publicly traded and have not made any definitive statements regarding their sales figures or revenues. The same is true for almost every competitor, which means this paper has had to rely on proprietary market research and in part on other studies.[35]

The market for UAS is experiencing a very dynamic growth in the EU, especially for professional users. Discussions with industry experts lead to the assumption that the market will, for now, follow a trajectory similar to the one observed in the USA. According to the current FAA Forecast, the market for private consumers (entry level drones weighing less than 250 g, UAS for hobbyists and enthusiasts below 900 g) shows signs of saturation in the US.[36] They estimate growth rates around 5 percent for next year, which will fall steadily over the next years. Their base scenario envisions an average growth rate of 2.3 percent per year. For the professional fleet, the FAA estimates a growth rate of 32 percent that slowly recedes to 7 percent. This results in an average growth rate of 17 percent per year.[37]

Results

For the European consumer market, this paper modeled slightly bigger growth rates than those forecasted by the FAA, starting at 6 percent growth for next year, which slowly declines to a 1 percent growth rate in 2030. This results in an average growth rate of 3.5 percent per year. For the more commercial segments of the market (drones with weights above 900 g), the model in this paper also estimates growth rates of 32 percent, which will slowly decrease towards a modest growth rate as the market matures (7 percent for UAS over 4 kg, 4 percent for UAS between 900 g and 4 kg). Over the next decade, this results in an average growth rate of around 17 percent for UAS with weights above 4 kg and an average of 14 percent for UAS weighing between 900 g and 4 kg. The growth rates used for the market model are shown in Table 2.

For the entire market, these assumptions almost double the number of UAS sold every year over the next decade. The complete market estimate in the Status Quo is shown in Table 1. During this decade, an important shift takes place: While the model estimates that the current market consists almost of 40 percent light-weight hobbyist drones, this share will fall to a quarter of the market, while the number of big and medium-sized commercial and big hobbyist drones (those above 900 g of weight) will grow from its currently 29 percent to nearly 49 percent of the market. While this may indicate a shift away from a private consumer market to a professional market, one important fact cannot be missed: The current UAS market caters mainly to private consumers. Even with high growth rates in the 900 g and above weight category, a large number of drones bought are not for commercial use. Even though the total revenue in the commercial segments will grow rapidly, a sizable portion of the market will still be for private consumers, even in 2030.

[35] Analyse des deutschen Drohnenmarktes: Verband unbemannte Luftfahrt, 2019; Projected commercial drone revenue in Europe 2016-2025, Tractica 2016

[36] Federal Aviation Administration: FAA AEROSPACE FORECAST – Fiscal Years 2020-2040.

[37] Federal Aviation Administration: FAA AEROSPACE FORECAST – Fiscal Years 2020-2040.

In order to estimate how strongly customers will react to price increases caused by the regulation, the model includes an estimate for the price of an average UAS in each category. The price of an UAS is also used to calculate the revenue lost due to the demand reduction. The average price for each weight category was constructed using market research on prices of UAS models in those categories. As explained above, the model assumes that prices remain constant over the next decade. The prices are listed in Table 3.

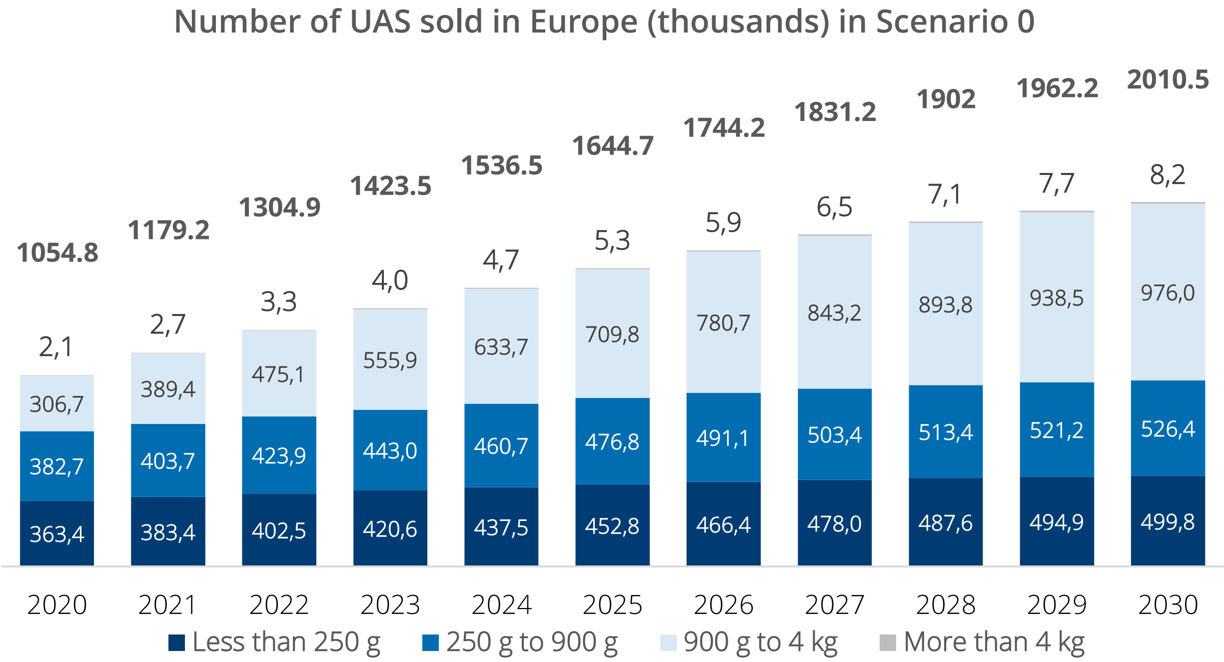


Table 1 **Number of UAS sold in Europe (thousands) in status quo (Scenario 0)**

Weight category	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Less than 250 g	363.4	383.4	402.5	420.6	437.5	452.8	466.4	478.0	487.6	494.9	499.8
250 g to 900 g	382.7	403.7	423.9	443.0	460.7	476.8	491.1	503.4	513.4	521.2	526.4
900 g to 4 kg	306.7	389.4	475.1	555.9	633.7	709.8	780.7	843.2	893.8	938.5	976.0
More than 4 kg	2.1	2.7	3.3	4.0	4.7	5.3	5.9	6.5	7.1	7.7	8.2
Total	1,054.8	1,179.2	1,304.9	1,423.5	1,536.5	1,644.7	1,744.2	1,831.2	1,902.0	1,962.2	2,010.5

Table2 **Growth rates of UAS sales in status quo (Scenario 0)**

Weight category	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Less than 250 g	6.0%	5.5%	5.0%	4.5%	4.0%	3.5%	3.0%	2.5%	2.0%	1.5%	1.0%
250 g to 900 g	6.0%	5.5%	5.0%	4.5%	4.0%	3.5%	3.0%	2.5%	2.0%	1.5%	1.0%
900 g to 4 kg	32.0%	27.0%	22.0%	17.0%	14.0%	12.0%	10.0%	8.0%	6.0%	5.0%	4.0%
More than 4 kg	32.0%	28.0%	24.0%	20.0%	17.0%	14.0%	12.0%	10.0%	9.0%	8.0%	7.0%

Table 3 **Average price of UAS (in EUR) in status quo (Scenario 0)**

Weight category	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Less than 250 g	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0	120.0
250 g to 900 g	960.0	960.0	960.0	960.0	960.0	960.0	960.0	960.0	960.0	960.0	960.0
900 g to 4 kg	1,770.0	1,770.0	1,770.0	1,770.0	1,770.0	1,770.0	1,770.0	1,770.0	1,770.0	1,770.0	1,770.0
More than 4 kg	10,970.0	10,970.0	10,970.0	10,970.0	10,970.0	10,970.0	10,970.0	10,970.0	10,970.0	10,970.0	10,970.0

3.2 Estimate of software costs

The proposed U-Space regulation for UAS has set out a number of requirements a UAS must meet. These requirements are mostly concerned with collecting information on the status of the UAS, making this data available to other nearby aircraft and communicating the flight information to a central database to manage flight paths and avoid collisions (See Section 2.1). This section will quantify these costs.

Requirements

Any UAS affected by the regulation will need to be equipped with the necessary hardware and software to fulfill all requirements before, during and after the flight. Before each flight, a flight authorization request must be sent to the USSP, containing both drone and pilot information, as well as a planned flight route.[38] While in flight, a UAS must continuously transmit information on position and height, orientation, registration, the flight's starting position and an emergency status indicator.[39] Where appropriate, weather information must also be exchanged. All of the information will be shared publicly by the USSP so that other aircraft are notified and can coordinate with the pilot.[40] After the flight, the information will be stored for 30 days, so that the pilot may be identified in case of complaints or accidents.[41]

"While in flight, a UAS must continuously transmit information on position and height, orientation, registration, the flight's starting position and an emergency status indicator."

This information exchange will cause considerable costs, as each drone must be outfitted with the necessary soft- and hardware to collect the required data and share it with the USSP. To estimate these costs realistically, the cost of similar services that mirror the requirements mentioned above was researched.

Comparable services

The majority of the software costs will be generated by the in-flight requirements. Constantly collecting precise data on the position and heading of the UAS and transmitting it to the USSP is the main consideration. Receiving information on current air traffic and geo-awareness of authorized flight areas and routes makes up the bulk of the incoming network traffic.

[38] Commission Implementing Regulation Draft: 15.06.2020 - Article 6 Paragraph 4 and Annex 5

[39] Commission Implementing Regulation Draft: 15.06.2020 - Article 8 Paragraph 2

[40] Commission Implementing Regulation Draft: 15.06.2020 - Article 8 Paragraph 3

[41] Commission Implementing Regulation Draft: 15.06.2020 - Article 15 (g)

This paper looked at tracking services that fulfill a similar role in other industries. The most prominent examples are from the automotive industry and personal tracking devices for luggage, pets, and vulnerable persons (kids and the elderly). These tracking devices are usually light weight (less than 30 g), but powerful, which makes them comparable to ones needed for UAS. To update their position continuously, these devices use a connection to mobile networks, although they include only basic data service, usually 2G (GSM or older). The following table gives an overview of both initial costs and monthly costs for sample of appropriate tracking devices:

Table 4 Cost of tracking services in other industries

Tracking Device	Initial investment (EUR)	Range of monthly costs (EUR)
Tractive GPS Dog	49.99	3.33 to 4.99
Weenect Dogs 2	49.99	3.75 to 7.90
prothelis GRETA	79.00	3.69 to 4.86
Kippy EVO	79.00	4.16 to 4.99
Tail it / Tail it Pets	107.23	5.95 to 6.95
Mercedes Benz Vehicle Monitoring	0.00	2.69 to 3.17
Live Orten GPS-tracking	0.00	5.90 to 13.90
Porsche Car Connect	0.00	8.25 to 24.08
BMW Connected Drive	0.00	5.61 to 22.66
PAJ ALLROUND Finder	99.99	4.99
Average cost	53.11	7.02

Sources: Tractive GPS Dog / Weenect Dogs 2 / prothelis GRETA / Kippy EVO / Tail it / Tail it Pets / Mercedes Benz Vehicle Monitoring / Live Orten GPS-tracking / Porsche Car Connect / BMW Connected Drive / PAJ ALLROUND Finder

While most of these devices can fulfill the tracking requirements, they do not provide information on flight weather, no-fly zones or other aircraft and are incapable of planning a route. Those parts of the U-Space requirement have already been addressed by a number of software solutions. These apps contain weather data specifically for UAS and are sold at a monthly price. While this information will not be needed all the time, the necessary infrastructure must be in place and therefore paid for. The information on geo-fenced areas is often included in map software like AirMap[42], Altitude Angel[43], DJI's Geo Zone Map[44] or the DFS drone app[45]. While this software is free for private consumers, there are still costs for maintaining these maps that are usually recouped by collecting and selling customer data or by

42 AIRMAP.com

43 Altitude Angel

44 DJI Geo Zone Map

45 DFS drone app

higher prices charged to commercial customers. As these maps would have to be updated regularly even without the regulation, one can assume that the additional costs attributable to U-Space regulation are negligible. Adding all of these costs to the costs of tracking devices yields the estimate for the software costs.

Table 5 Apps containing weather data specifically for UAS

Flight weather service and geo-awareness	Initial investment (EUR)	Range of monthly costs (EUR)
German Weather Service: pc met	Software only	6.63
Weather Underground	Software only	4.49
UAV Forecast	Software only	1.78
Average cost	0.00	4.30

Sources: German Weather Service: pc met / Weather Underground / UAV Forecast

The total estimate for the software cost is an average monthly cost of 11.32 EUR per UAS,[46] as well as an average initial investment cost of 53.11 EUR to install the necessary hardware on the UAS. It should be added that these estimates are most likely conservative, as the combination of the individual components will lead to additional costs for the customer or any company that wishes to sell an integrated device. In addition, this calculation does not include additional data service costs, as those will be modeled as part of the infrastructure costs.

3.3 Estimate of infrastructure costs

The constant connection of UAS with the USSP may need additional investments in the mobile internet infrastructure. The extend of the necessary investments will largely depend on the details of the regulation, which is why this paper has calculated the cost for two possible scenarios.

Requirements

Current studies have found that LTE-Networks, specifically 4G and 4G advanced-Services, are sufficient for the use cases envisioned by the proposed regulation.[47] Most of the details have not been agreed on yet; however, this leaves room for two distinct scenarios. Depending on whether drones must communicate directly with the network towers or can use a smartphone or other controlling device as a base station, different costs will result.

46 This cost factor is the sum of the average cost of tracking devices (7.02 EUR) and the average cost of flight weather service and geo-awareness (4.30 EUR).

47 A Telecom perspective on the Internet of Drones: From LTE-Advanced to 5G, Yang et al., 2018

"Current studies have found that LTE-Networks, specifically 4G and 4G advanced-Services, are sufficient for the use cases envisioned by the proposed regulation."

In the low-cost scenario, drones will communicate with their controlling device (the smartphone) that in turn will communicate with USSP. In this scenario, every area designated as U-Space would need a reliable LTE connection. As most countries have already passed ordinances pertaining to the completion of 4G-coverage, the costs of U-Space would be covered by existing plans of MNOs. The cost for expanding and running 4G-networks are priced into existing mobile data service packages, which could then be used as a proxy for the infrastructure cost incurred by UAS.

The high-cost scenario envisions a future in which drones must communicate directly with the radio towers and cannot use the currently existing setup of drone communicating with its control unit, which in turn communicates with the mobile network. In this case, additional investments in the infrastructure must take place to ensure that airspace is covered completely and reliably.

Comparable services

If existing 4G-services are ruled to be sufficient for the connection with UAS and smartphones, the infrastructure cost would be covered by any unlimited mobile data contract. Those offerings usually cover a disproportionately higher part of the investment cost in the network, as they are the most expensive per GB of data used. The costs of these types of contracts has already been surveyed by the EC who estimate that the highest volume contracts (50GB of data per month) cost 46.27 EUR per month on average.[48]

However, most UAS owners are likely to use a smartphone as the device to both control their drone and connect to U-Space services. Because smartphone users usually have a mobile phone contract that includes a data service, these users would merely have to upgrade their data service. This paper uses the highest volume data contract as a reference, because a reliable estimate of the actual data needs was not possible at time of writing. Using the highest volume contract guarantees that the actual data needs can always be met, allowing a reliable use of U-Space services at all times. A recent market study[49] found that the average smartphone owner in Western Europe uses 8.2 GB of data per month, while those in Eastern Europe use 5.8 GB per month on average. The average price per gigabyte in EU member states lies between 0.40 EUR and 12.50 EUR.[50] Using the weighted averages for data used and price per gigabyte in EU countries, it is estimated that in 2019 the average smartphone owner payed 16.52 EUR per month for mobile data. In the low-cost scenario, the additional cost caused by the regulation is the difference between existing data service contracts and the unlimited data service, which results in

[48] European Commission, empirica, TÜV Rheinland: Mobile Broadband Prices in Europe 2019

[49] Ericsson Mobility Report June 2020

[50] 2020 global mobile data comparison, Existent Ltd

additional cost of 29.75 EUR per month. If each UAS owner only needs one data contract for his entire fleet, these costs could be mitigated partially.[51]

In the high-cost scenario, the existing infrastructure must be upgraded due to the regulation. The resulting investment cost is attributable to U-Space in its entirety. As the technical requirements have not been stated fully, the model works under the assumption that each radio tower would have to be upgraded with additional 4G antennae to cover its airspace reliably. A recent study has stated the cost of installing additional small cell equipment at around 2,500 GBP, which is equivalent to 2,765 EUR.[52] With an estimated total of 421,000 radio towers in Europe[53], the total cost of upgrading the network would be at least 1.16 billion EUR. These costs are fixed and must be recouped by distributing them across all drones using U-Space, so that each UAS pays for a share of the cost. Going with the projection for the market development, the MNOs would spread these costs across 10 years and 12 million drones, which results in average costs of 98.66 EUR per drone. In this scenario, the mobile data contract mentioned above would be required for each drone, which eliminates the possibility of mitigating these costs.

3.4 Estimate of customer support costs

According to the current draft of the regulation, take-offs in U-Space airspace will not be permitted if a connection to the USSP cannot be established.[54] This adds a new potential point of failure for any planned flight. If the connection fails, the owner of the UAS is likely to demand immediate customer support either from the USSP or the manufacturer of his or her aircraft.

Theoretical Considerations

Because of the new technical requirements, manufacturers and USSP need to hire additional specially trained customer support staff, which results in additional customer support costs. These costs can be attributed to the regulation directly because they would not occur in airspaces as they currently exist.

Data

The estimate for the additional customer service costs is based on the number of customer service interactions generated by the proposed U-Space regulation and the average cost for those interactions. The total costs are calculated for the next 10 years.

[51] Due to the limited market data, there are no reliable estimate for the fleet size of each UAS owner at this time. Further research on this topic is required.

[52] E. Oughten, Z. Frias: The cost, coverage and rollout implications of 5G infrastructure in Britain, 2018

[53] The economic contribution of the European tower sector, EY and EWIA, 2019

[54] Commission Implementing Regulation Draft: 15.06.2020 - Section 17

The number of attempted connections per drone is equal to the average number of flights per year. According to a recent survey by the FAA, the average owner uses his UAS for 85.2 flights per year.[55] The basis for the number of interactions is the expected rate of technical failures in U-Space communications between USSP and UAS. As these communications are mostly reliant on mobile data services, data on complaints to mobile data providers and toll collection services has been collected. The highest reliable rate of complaints was recorded by the Australian Communications and Media Authority, where 0.58 percent of attempted connections lead to a complaint.[56] The lowest number of faulty connections was reported by Toll Collect Germany, who reported that 0.15 percent of identification attempts lead to errors.[57]

The cost for resolving each complaint was calculated by using data on the cost per ticket for 125 service desks in North America, collected by HDI in 2017.[58] Detailed European Data was not available, but current industry estimates show that customer support centers in Europe are on average more expensive than those in North America. The cost per ticket range from 2.93 to 49.69 USD, with an average of 15.56 USD, or 13.78 EUR. An alternative way of calculating uses the average cost per minute and the average handling time. According to the same survey, the average handling time is 9.70 minutes, while the cost per minute of handling time ranges from 0.76 to 2.50 USD, with an average of 1.60 USD, or 1.42 EUR.

Results

Using the expected number of flights over each UAS' lifespan of three years, the average cost per customer support interaction and the complaint rates above results in an expected customer support cost between 5.28 EUR and 20.41 EUR per drone, for the case of a low or high complaint rate due to technical failure respectively. These costs mainly depend on the number of flights taking place and are therefore the most sensitive to changes in the market.

3.5 Scenario 1: Consumer reaction and estimate of total costs

Price increases in competitive markets are usually passed through to consumers, as each part of the production chain aims to recoup the losses incurred through additional costs. The market for UAS is no exception and it is to be expected that the regulation costs will be added to the price of drones, to which the consumers will react either by buying different UAS or leaving the market altogether. A recent study of the US drone market[59] produced estimates for the elasticity of demand in the UAS market. The US study produced different elasticities for an increase in the initial price of an UAS, in the monthly cost of

[55] Federal Aviation Administration: FAA AEROSPACE FORECAST – Fiscal Years 2020-2040

[56] ACMA (2019): Telecommunications complaints handling 2018 to 2019

[57] Annual Report of Toll Collect GmbH, Fiscal Year 2018/2019

[58] HDI Metric of the Month: Service Desk Cost per Ticket, 02.05.2017

[59] Expert report of Christian M. Dippon, Ph.D. on behalf of DJI Technology Inc., NERA Economic Consulting

ownership, as well as the necessity to publish their flight data. Their calculation is based on a survey of UAS owners who were offered UAS with different equipment at different prices and asked which one they would buy. The revealed preferences were then used to calculate (semi-)elasticities of demand. Using these elasticities, how much revenue would be lost in the UAS market due to the regulation can be calculated.

In this paper, the calculated costs in conjunction with the elasticities result in a reduction of demand between 7.0 and 27.7 percent in the high-cost scenario, depending on the weight class of the drone. In the low-cost scenario the demand reduction is between 6.7 percent and 24.7 percent. The effect is most strongly felt in the 250 g to 900 g weight class, where a quarter of consumers decide to either leave the UAS market or buy an unregulated UAS, i.e. one that weighs less than 250 g or is not sold commercially. The resulting uptick in demand for lightweight UAS cannot compensate for the loss of revenue, as those UAS are on average much cheaper. Each year, the additional value generated by low weight drones amounts to less than 14 percent of the loss in other weight categories. Detailed results are shown in Table 6.

The total cost of the regulation is the sum of direct costs and revenue lost. As mentioned before, the direct cost will largely depend on the specifics of the regulation, while the revenue lost depends on the consumer reaction to those costs. This study has already produced high and low estimates for the individual cost factors. Using the low-cost estimate and high-cost estimate for each factor allows this paper to produce both a ceiling and floor for the economic cost of the regulation. The realized cost will in all likelihood lie between these values.

Discounted with the average harmonized consumer price index for the EU over the last 10 years (1.36 percent per annum), [60] the estimated net present value of the U-Space regulation cost is between 7.55 billion EUR and 8.69 billion EUR. Table 6 shows a breakdown of the cost layers for the high cost scenario. The table for the low cost scenario can be found in the appendix (Table 7).

"Discounted with the average harmonized consumer price index for the EU over the last 10 years (1.36 percent per annum), the estimated net present value of the U-Space regulation cost is between 7.55 billion EUR and 8.69 billion EUR."

[60] All item harmonized index of consumer prices, Eurostat, last updated on 17.07.2020

Table 6 **Estimate of reform effects (high-cost estimate)**

Direct cost (million EUR)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Infrastructure cost	279.89	318.96	355.83	391.16	425.28	456.90	484.63	507.18	526.74	542.77
Customer support cost	12.59	14.34	16.00	17.59	19.13	20.55	21.80	22.81	23.69	24.41
Software cost	116.47	132.73	148.08	162.78	176.98	190.14	201.68	211.07	219.20	225.87
Total direct cost	408.95	466.03	519.91	571.53	621.39	667.58	708.11	741.06	769.63	793.05

Revenue lost (million EUR)

Weight class	Change of demand	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Less than 250 g	+65.8%	-31.9	-32.7	-33.6	-34.4	-35.2	-35.9	-36.5	-37.0	-37.4	-37.6
250 g to 900 g	-27.7%	107.2	112.6	117.7	122.4	126.6	130.4	133.7	136.4	138.4	139.8
900 g to 4 kg	-17.3%	119.3	145.5	170.3	194.1	217.4	239.1	258.3	273.8	287.5	299.0
More than 4 kg	-7.0%	2.0	2.5	3.1	3.6	4.1	4.6	5.0	5.5	5.9	6.3
Total revenue lost		196.7	228.0	257.4	285.6	312.9	338.2	360.5	378.6	394.4	407.5

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total cost (million EUR)	605.65	693.99	777.30	857.13	934.29	1,005.82	1,068.60	1,119.66	1,164.04	1,200.56

Total cost for the coming decade (million EUR)	9,427.03
Net present value (million EUR)	8,689.97

3.6 Scenario 2: Alternative Scenario

As mentioned in Section 2.4, alternative regulations are possible, e.g. an exemption for UAS with weights below 900 g. This would lead to a significant reduction in cost, as another large segment of the market (especially the consumer market) would be exempt. These exemptions would not affect every cost factor equally. While some cost factors are almost entirely dependent on the number of drones – e.g. customer support costs - other cost factors have a large component of investment costs that remain unchanged. These costs would just be spread across a lower number of UAS which results in a higher cost per drone. In the case of infrastructure cost, this cost component would increase from 98.66 EUR per drone to 160.52 EUR. The result will be a stronger consumer reaction for those drones that remain affected by U-Space regulation. The total cost estimates for this alternative scenario are between 4.84 billion EUR and 6.00 billion EUR, which is around 33 percent lower than the main estimate (see Table 8 and Table 9 in the Appendix).

"The cost estimates for this alternative scenario are between 4.84 billion EUR and 6.00 billion EUR, which is around 33 percent lower than the main estimate."

Another alternative regulation would be a result of different implementations of the cost layers of the U-Space regulation. The cost estimate for both the main scenario and the alternative scenario includes a lower and upper bound, which are mostly dependent on the specifics of implementation. The aim of reducing costs through implementation would be to reach the lower bound of the cost estimates. For example, eliminating the need for additional equipment on every radio tower would greatly reduce infrastructure costs. The difference for the upper and lower bound of the main scenario is 1.14 billion EUR. This number can serve as an estimate of the savings that could be realized through prudent implementation of the individual cost layers of U-Space. Compared to the highest cost estimate, this is a reduction of approximately 13 percent.

3.7 Interpretation of results

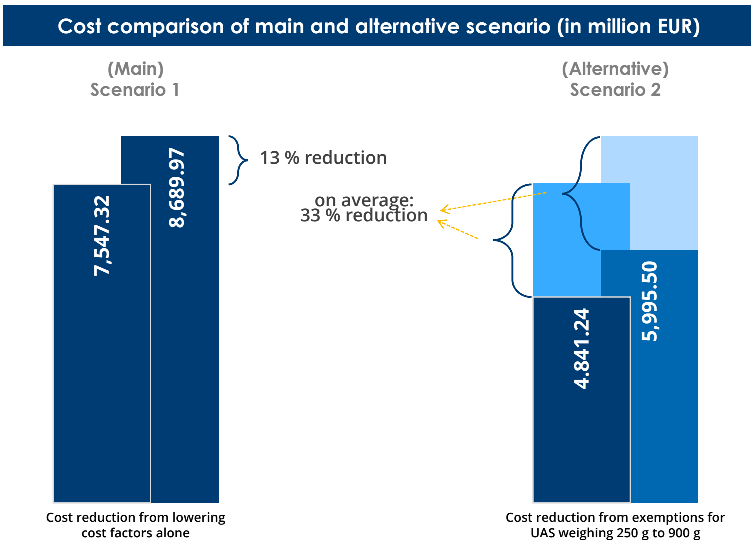
The proposed U-Space regulation (Scenario 1) has been framed as a matter of airspace safety, so that UAS use will be safe and orderly in a future of increased UAS traffic. However, the economic cost aspect has so far not been part of the discussion, which is a major failing of the current proposals. This paper estimates costs between 7.55 billion EUR and 8.69 billion EUR, which will have a profound impact on the market for UAS. In fact, the impact could be so massive that the envisioned future with a high amount of UAS traffic is itself becoming questionable.

"This paper estimated costs between 7.55 billion EUR and 8.69 billion EUR, which will have a profound impact on the market for UAS. In fact, the impact could be so massive that the envisioned future with a high amount of UAS traffic is itself becoming questionable."

These estimates show that a large contingent of medium-sized UAS, especially in the 250 g to 900 g weight class, is likely to be "downgraded" to products that are not affected by the new regulation or would not be bought at all. This class of UAS is often bought by enthusiasts or businesses making their first venture in this sector. In the long run, disincentivizing these users could lead to a stifling of innovation in the sector, as these kinds of users are the ones willing to experiment and innovate with UAS products. Another potential downside is a lackluster acceptance among UAS users for a regulation that creates high costs for them. Users could decide to operate their non-retrofitted UAS beyond visual line of sight, which would be illegal of course; however, this type of consumer reaction has been recorded in cases where consumers seek to avoid costs they perceive to be unjustified or excessive.

This continues to show that regulatory alternatives to the existing EC draft must be discussed, and costs must be carefully weighed against the benefits. Instead of pursuing the current draft proposal, it would be advisable to exclude all UAS' below 900 g (Scenario 2). This would reduce costs significantly. The estimated cost in this scenario amounts to between 4.84 billion EUR and 6.00 billion EUR, which represents a cost reduction of around 33 percent. This value should be compared to what can be achieved by reducing the individual cost factors (e.g. software costs, infrastructure costs, customer support costs). If the current proposal would be implemented with the aim of creating low cost, the savings would merely be around 13 percent of the high cost estimate. **The cost reduction of the alternative proposal is therefore two and a half times greater than what can be achieved by lowering the cost factors alone. This makes it obvious that the exclusion and inclusion of weight classes is the primary cost lever in the regulation.** The cost impact of specific regulatory changes regarding the direct cost layers (e.g. high-cost and low-cost scenario for infrastructure cost) is lower.

In this scenario only drones above 900 g would have to use U-Space. This would achieve the best compromise between cost enabling safety in the airspace on the one hand and minimizing the negative economic impact on the other hand, e.g. higher prices for users, lost revenue for drone producers and drone-based service providers and lost productivity gains in many other industries.[61] Implementing additional exceptions for UAS with weights up to 900 g would mitigate these problems: Drone-based service providers, small businesses and hobbyists would no longer have to downgrade in order to avoid the costs of U-Space. Experimentation, innovation and the use of UAS for many different cases would remain possible for a larger number of people. In addition, the total economic loss created by the regulation could be reduced by around 33 percent.



61 EASA – Notice of Proposed Amendment 2017-05 (B)

4 Conclusion

- This analysis shows that while the establishment of the U-Space in Europe will allow for the significant benefits of UAS to unfold, the economic costs of an improperly implemented regulation will be significant and must be considered by policy makers. Direct costs of the regulation as it is currently planned will amount to between 7.55 billion EUR to 8.69 billion EUR. These direct costs are the additional costs for every UAS in the affected weight classes that are still being purchased post-implementation plus the revenue lost due to a shrinking the market.

- Additionally, reduced demand in UAS due to a spike in user costs would result in price increases for private UAS users and in a revenue loss for UAS producers. Even more importantly, it would hurt the EU economy as a whole, as many more industries would be affected. Growth in the novel industry for drone-based services would slump as entrepreneurs would have to pass on the high costs of using the U-Space to the prices for their services. This would hinder the growth of revenues, jobs and innovation in this industry. As a result of higher costs for drone-based services, companies in other economic sectors (e.g. construction, utilities, etc.) might decide to continue to use conventional surveying or inspection services instead (e.g. helicopters, planes, satellites). Cost savings will not be had, and any productivity gains that could have been achieved if they had switched to drone-based services at reasonable market prices will have been missed. Both the potential economic benefits from a well-designed U-Space regulation and the economic cost of a too stringent one will impact a wide range of economic sectors across the EU.
- Besides this regulatory proposal being costly, there is also the additional concern that a high-cost regulatory scenario will lack social acceptance. Many of the users of UAS between 250 g and 900 g are hobbyists and small businesses, which are generally open towards U-Space as it will enable them to operate their UAS beyond visual line of sight. However, if they face high costs for retrofitting their drones and paying for U-Space services, they may decide to use their old drones beyond visual line of sight without retrofitting them or abandon drones entirely. This would result in a situation where drones that are unfit to be integrated into the U-Space will be used or innovation itself is halted.
- As explained in chapter 2, there is a significant threat to competitiveness in the market for U-Space services if the regulation ends up being poorly designed. A very limited number of MNOs and ANSPs are likely to dominate the market since they already have a competitive advantage due to their access to mobile networks and their expertise in the field of air traffic management. This could allow them to keep other entrepreneurial USSPs at bay. For UAS operators this will only imply additional indirect costs on top of the direct costs, as prices in non-competitive markets tend to be above the market equilibrium in a competitive market.

- Furthermore, the loss of potential innovation and productivity gains through UAS has not been considered. Against this backdrop, it is can be said that the economic cost of this aspect has not been sufficiently addressed in the EASA opinion. This paper presents an alternative that would be better suited to optimize net societal benefits. Excluding all drones below 900 g from U-Space would likely guarantee a comparable safety level and reduce costs significantly. Between 4.84 billion EUR and 6.00 billion EUR could be saved, a savings of around 2.7 billion EUR over the next ten years.
- Whatever the future holds for UAS operators, one thing is for sure: If safely integrated into the airspace, drones have the potential to transform the EU economy, to save lives and to protect the environment. While safety concerns are legitimate, regulators must not lose sight of the transformative power of UAS. To exclude only so-called "toy drones" under 250 g from U-Space may hinder innovation and impact many other economic sectors in the EU economy negatively. Hence, the EC must take a more pragmatic approach to regulating the use of drones and must ensure costs and benefits are adequately balanced so that net societal benefits are maximized. This paper concludes that excluding drones weighing less than 900 g from the proposed U-Space regulation would produce considerable societal benefits and should therefore be considered as an alternative to the current proposal.

5 Annex

Table 7 Estimate of reform effects (low-cost estimate)

Direct cost (million EUR)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Infrastructure cost	226.81	258.27	287.95	316.39	343.85	369.29	391.61	409.75	425.48	438.37
Customer support cost	3.35	3.82	4.26	4.68	5.08	5.46	5.79	6.06	6.29	6.48
Software cost	120.00	136.64	152.35	167.39	181.92	195.38	207.19	216.79	225.11	231.93
Total direct cost	350.17	398.73	444.55	488.46	530.85	570.13	604.59	632.60	656.87	676.77

Revenue lost (million EUR)

Weight class	Change of demand	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Less than 250 g	+61.4%	-29.7	-30.5	-31.3	-32.1	-32.8	-33.5	-34.0	-34.5	-34.8	-35.0
250 g to 900 g	-24.7%	95.5	100.2	104.8	108.9	112.8	116.1	119.0	121.4	123.2	124.5
900 g to 4 kg	-15.6%	107.9	131.7	154.1	175.7	196.7	216.4	233.7	247.7	260.1	270.5
More than 4 kg	-6.7%	2.0	2.4	2.9	3.4	3.9	4.4	4.8	5.3	5.7	6.1
Total revenue lost		196.7	175.7	203.9	230.5	255.9	280.6	303.5	323.6	339.9	354.2

	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total cost (million EUR)	525.85	602.62	675.02	744.39	811.44	873.60	928.14	972.52	1,011.09	1,042.84

Total cost for the coming decade (million EUR)	8,187.50
Net present value (million EUR)	7,547.32

Table 8 Estimate of reform effects (high-cost estimate for the alternative scenario)

Direct cost (million EUR)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Infrastructure cost	166.15	202.73	237.24	270.52	303.02	333.37	360.10	381.80	401.00	417.15
Customer support cost	6.55	8.00	9.36	10.67	11.95	13.15	14.20	15.06	15.82	16.45
Software cost	60.64	73.99	86.59	98.73	110.60	121.68	131.43	139.35	146.36	152.25
Total direct cost	233.35	284.72	333.19	379.92	425.57	468.20	505.74	536.21	563.17	585.85

Revenue lost (million EUR)

Weight class	Change of demand	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Less than 250 g	+30.1%	-11.4	-12.8	-14.1	-15.3	-16.3	-17.3	-18.0	-18.7	-19.2	-19.6
250 g to 900 g	0.0%	-	-	-	-	-	-	-	-	-	-
900 g to 4 kg	-18.2%	125.7	153.4	179.5	204.6	229.1	252.1	272.2	288.6	303.0	315.1
More than 4 kg	-7.1%	2.1	2.6	3.1	3.6	4.2	4.7	5.1	5.6	6.0	6.5
Total revenue lost		116.5	143.2	168.5	193.0	217.0	239.5	259.3	275.5	289.9	302.0

Total cost (million EUR)	349.82	427.88	501.66	572.89	642.55	707.66	765.05	811.70	853.02	887.85

Total cost for the coming decade (million EUR)	6,520.08
Net present value (million EUR)	5,995.50

Table 9 Estimate of reform effects (low-cost estimate for the alternative scenario)

Direct cost (million EUR)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Infrastructure cost	118.21	144.23	168.78	192.45	215.58	237.17	256.18	271.62	285.27	296.76
Customer support cost	1.75	2.13	2.50	2.85	3.19	3.51	3.79	4.02	4.22	4.39
Software cost	62.54	76.31	89.30	101.82	114.05	125.48	135.54	143.71	150.93	157.01
Total direct cost	182.49	222.67	260.58	297.12	332.82	366.16	395.51	419.34	440.42	458.15

Revenue lost (million EUR)

Weight class	Change of demand	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Less than 250 g	+27.0%	-10.2	-11.5	-12.7	-13.7	-14.6	-15.5	-16.2	-16.7	-17.2	-17.5
250 g to 900 g	0.0%	-	-	-	-	-	-	-	-	-	-
900 g to 4 kg	-15.6%	107.9	131.7	154.1	175.7	196.7	216.4	233.7	247.7	260.1	270.5
More than 4 kg	-6.7%	2.0	2.4	2.9	3.4	3.9	4.4	4.8	5.3	5.7	6.1
Total revenue lost		99.7	122.6	144.3	165.4	186.0	205.3	222.4	236.3	248.6	259.1

Total cost (million EUR)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total cost (million EUR)	282.22	345.29	404.92	462.50	518.81	571.46	617.86	655.59	689.02	717.21

Total cost for the coming decade (million EUR)	5,264.89
Net present value (million EUR)	4,841.24

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