The Future of Drones and their Public Acceptance

Miquel Macias*, Cristina barrado*, Enric Pastor* and Pablo Royo*
*Computer Architecture. Castelldefels School of Telecommunications and Aerospace Engineering - Technical university of Catalonia
Castelldefels, Catalonia, Spain
miquel.macias@upc.edu.

***Abstract*—Any emergent technology in history has raised an initial rejection by part of the society. Added to the several problems that the non-mature technology may have, the lack of any previous experience about side effects and the humans psychological fear to the unknown play an important influence in its acceptance. As drones bring up high social and economic expectations due to their capabilities and bussiness applications, the social acceptance is key to the complete development of drone technology's potential. Experts believe that social acceptance is ruled by a balance between beneficial usages and inconvenient issues regarding the technology. This balance in the aeronautical sector is also conditioned by the strict safety policies and regulations of the airspace and the current airspace users. To analyse this balance situation in actual and future environments, regarding drone technology, different use cases will be presented. These use cases have been proposed and analysed by different stakeholders from the U-space community network (UCN), a network of airspace and drone stakeholders who participated in the context of the SESAR CORUS project.**

The purpose of this paper is to analyse some of these use cases by obtaining responses from different stakeholders point of view using a survey in order to see how economical, safety and political aspects are balanced in each one of the cases. From the survey responses we will perform an analysis by means of three different acceptance indicators, one for each aspect commented.

Main results and conclusions point out that the economical indicator is, in general, positive, especially for the low cost payload use cases. In contrast the economic indicator is close to neutral for city transport and airports use cases, which leads to propose some economic promotion action may be needed to make them a reality. For the safety indicator we observe that they are close to negative values as use case complexity increases. Thus we can conclude that some of the proposed missions start affecting the current levels of safety. Finally, the political indicator is mostly neutral, with some positive trends for scenarios related with inspection tasks or done in non-populated areas.

***Index Terms*—Drones; Social acceptance; Unmanned Aerial Vehicles (UAV); SESAR CORUS; aviation.**

I. Introduction

Drones are one of the most challenging current emergent technologies. They appear after a very high historical growth of aviation, in the era of the Internet, the autonomous cars, the Internet-of-things and the smarts cities. In many urban areas the mobility on ground is very saturated while the demand is still increasing. The environment preservation is addressing mobility towards electrical-powered vehicles and the sharing paradigm. Drone can provide a solution perfectly compatible with the current trends. For these reasons drones bring high social and economic expectations as presented in the European Drones Outlook Study [1]. But social acceptance of drones is key for the full development of the economical expectations. In order to succeed in the introduction of a new technology, experts believe that the balance between the beneficial usages and the inconvenient issues derived from the emergent technology deployment must lean towards the benefits. In one side we have the additional services bringing social benefits (e.g. transport of urgent medicament, blood, search and rescue) and the high economical expectations around the drone industry. In the other side we found several disturbances that drones can arise to the citizens (e.g. the noise, decreased privacy). In the special case of the airspace and aeronautics world, with strong safety policies and regulations [2] [3] [4], a third side appears on the balance: the airspace safety. Current airspace users, especially those flying in airspace F and G, such as VFR, gliders, parachutes, etc., can percept drones as dangerous obstacles, small and almost invisible, but in fact drones can also provide new opportunities and changes which can benefit them.

This paper has been done within the context of the SESAR CORUS project [41], this project has been developed by the European Commission (EC), the European Aviation Safety Agency (EASA), the SESAR Joint Undertaking (SJU), and EUROCONTROL all working together, and alongside such organisations as the Joint Authorities on Rulemaking for Unmanned Systems (JARUS), to develop rules and standards to make the safe execution of UAS operations easier and more understandable for both commercial and recreational pilots in Europe. The EC has developed a vision for the phased introduction of procedures and services to support safe, efficient and secure access to airspace, called U-Space. EASA has proposed that regulation of UAS should be proportional, operation-centred, risk-based, performance-based, and progressive and has produced a draft implementing regulation, defining categories of operation and classes of drone. In line with this, EUROCONTROL has produced a draft high-level UAS air traffic management (ATM) operational concept to describe the operational ATM environment in which manned and unmanned aircraft must co-exist safely.

The U-space environment has been designed for the Very Low-Level (VLL) Airspace, the airspace below the minimum safe altitude for manned aircraft (500-1000ft) defined in the SERA, and the ground or maximum altitude of an obstacle such as a building. This airspace is used by gliders and paragliders, emergency (HEMS) aircraft, aircraft landing and taking-off, etc. CORUS has proposed to divide VLL in different airspace types:

- X: No conflict resolution service offered.
- Y: Only pre-flight conflict resolution is offered.
- Z: Pre-flight conflict resolution and in-flight separation are offered.

In Table I are shown the principal characteristics of each type.

TABLE I
X, Y AND Z AIRSPACE VOLUMES.

Volumes	Access Requirements
X	Operation plan not needed
	VLOS and EVLOS operations
	Other flight modes require risk mitigation assessments.
Y	Approved operation plan
	VLOS, EVLOS and BVLOS operations.
	Piloting station connected to U-space.
	Position must be reported.
	Strategical de-confliction.
Z	Approved operation plan.
	VLOS, EVLOS and BVLOS operations.
	Pilot or automatic drone approved for Z operation.
	Piloting station connected to U-space
	Position must be reported.
	Specific technical requirements.
	Tactical de-confliction.

Airspace Z is subdivided in Zu and Za. The main difference between these airspaces is the presence of manned aircraft traffic. In Zu traffic will be entirely made up of drones and Za will be normal controlled airspace with drones included.

With this paper, we will start showing the state of the art on social acceptance of drones, by presenting surveys from the literature and from the project, we will introduce the proposed tool to measure the social impact of the drones based on a three axis diagram: safety, economy and social perception, each one assessed through a stakeholder acceptance indicator (SAI), named as SAI SA for safety, SAI EC for economy and SAI PO for political.

The principal objective of these social acceptance indicators is to contribute to convert the high economical expectations in facts by ensuring that drones traffic growth follows the principles of sustainability, as proposed by United Nations: non-exclusiveness, health and nature preservation, sustainable cities, climate action, peace and justice. More specifically, the objectives of the SAI include the provision of an assessment tool to measure the deployment of drones, help to detect any unbalance situation and to propose regulations to avoid unfair scenarios, extend the safety culture also across drone operators, pilots and industry, be transparent with the drones inconveniences, and to serve as a performance evaluation tool for new drone technologies, new airspace organization and legislation changes. So in the context of CORUS to analyse all the work proposed in U-Space by different stakeholders and experts in an easy and understandable way.

At the end we will show the resulting values of the 3 indicators calculated for a set of drone scenarios. A 3-axis radar plot is used to easily visualize the results and contrast the different scenarios. The indicators have been calculated from the responses of experts. In particular from the U-space community network (UCN), a network of airspace and drone stakeholders who participated in the second CORUS workshop in June 2018.

II. State of the art in Social Acceptance

State of the art references regarding public acceptance can be found in areas related to impact of human activities such as climate change, dams management or noise in the vicinity of airports, as well of emerging or well-established technologies such as security screening technologies (i.e. in airports to passengers and baggage), nuclear power and nuclear residuals disposal, and electrical grid deployment [17] [18] [19] [20] [21] [34]. According to these works, most of the principles for social acceptance are common, and they include transparency and inclusiveness. Transparency means that information shall be transmitted in an accurate and timely way, using common and understandable language, and shall be verifiable. Inclusiveness means that the affected individuals and social associations shall be empowered in influencing the decision making process. Another aspect that influences the perception of an emerging technology is the capability of the law enforcement agents, agencies or public to mitigate the negative impacts and of the governments to punish the actors responsible for wrong-doings.

A. *Economic impact and growth potential*

A number of studies exists about on the benefits in to the economy due to the deployment of drones [1] [5] [30] [31] [32] [33]. Expectations are very high and involve large amounts of business turnover, capital investment and the creation of direct and indirect jobs. Very diverse economical areas such as agriculture, energy, transport, construction, inspection, security, insurance, commercial, but also arts or leisure, are expected to benefit from the use of drones in the very near future.

B. *Social acceptance of Drones*

The European Union has been studying the effects on society coming from the extensive use of drones during the previous decade [22] [26] [27]. These effects include the economic development, but also the general public opinion. In 2011, after the ICAO circular 328 expedited the introduction of drones in the airspace, the EC launched an initiative to explore the competitive situation of drones. As part of the initiative, a workshop about the social dimensions of the drones was held to identify the key challenges for the successful development of this new market. Two different approaches were captured:

1) Some proposals supported that no specific provisions for drones appear to be necessary since current provisions concerning privacy and data protection (processing of

data) are in fact also applicable to drones, same as for satellite or manned aviation;
2) Others presented alternatives similar to the specific French law addressing the public video surveillance cameras as an alternative reinforcement [35].

The University of Nevada, Las Vegas, published a summary of several surveys of public knowledge of drones at US national level [11]. A total of 636 citizens completed the survey and the main highlights are that a very large majority knew about drones, but still they related them to military (91%), while other uses knowledge dropped to only one every 3 persons. For the one third knowing about drones market applications the greatest public support was for emergency and environmental activities (above 85%), while package delivery and surveillance activities scored less than half (40% approximately). Major concerns against drones were in privacy, especially over homes (72%), but reduced in public spaces (26%).

Alice Tam [12] work extended the research done by MacSween George [13] about the public acceptance of the drones used for cargo operations with questions addressing also commercial airlines. Direct questions about the knowledge of drones and the opinion about supporting and/or flying in an unmanned aircraft suggest that only cargo operations (with a 60% of acceptance) can be possible in a near future. Given the nature of the task of the drones (transportation and not surveillance) no ethical or social issue was raised in either of the surveys. Interesting approach was conducting in the former survey, in which the same questions were dispatched with and without some explanations to educate the respondent about drones, to different but comparable sampling groups, each with sixty participants. Differences of a 15% more positive answers show that the educational paragraphs had influence in the opinions of the public perception.

Surveys in Europe [15] and Australia [14] have been conducted to general public to assess the public acceptance of civil drones. Conclusions are that the deployment context of the drone usage are very relevant for the public acceptance, being emergency applications perceived as very beneficial and thus with a high level of acceptance while hobby drones are only acceptable to active users and drone pilots. The European study could not detect any specific fear against drones, but some concerns about privacy, especially from non-users of drones. In case of pilots of drones their main concern was in relation to the risk of accidents.

The Australian work asks specifically to compare the level of risk of drones with the commercial (manned) aviation. Drones risks are largely seen as comparable as manned aviation risk, or even less. Interestingly, safety of drones is not the major concern of responders. Instead lack of knowledge of the technology and the privacy issues were considered by general public the main determinants, followed by the military use and the potential misuse of drones. The use of certified software and encrypted transport layers in the wireless communications are seen as the solutions to avoid the misuse of drone by third parties in [15].

Eurocontrol dashboard [37] shows the major figures of drone research projects founded in Europe with about 500 million Euros during the last decade. Of the 101 projects reported, none is devoted to improve the public acceptance, although close to one third of them resulted in CONOPS or regulation proposals. For example, the project ULTRA [24] has a work package devoted to social impact which proposes to increase the public acceptance by supporting pilot applications of drones, making current drones applications visible to the general public and stimulating positive opinions by convincing arguments. They also suggest the use of the term ”civil drone” to avoid confusion with military use which set the perception of drones as potential killing machines. In this project metrics of social acceptance are given related to risk, proposing 5 different levels of hazard severity, from Severity I or catastrophic, to Severity V of failures without consequences. EASA estimates that the rate of catastrophic events per flight hour involving drones should fall between the civil aviation (10^{-7} meaning on average one catastrophic incident in every 107 hours of operation) and helicopter rates (10^{-5}), such as two orders of magnitude below the accident rates of military drones, which is established around 10^{-4} incidents per flight hour [16].

German Aerospace Center DLR has also performed a survey over 832 people asking about the acceptance of drones and concerns about this technology [40]. Questions like how people would describe their attitude towards drone technology,which are people concerns, which kind of applications would they accept or if they would allow drone flights over cities or their homes were performed in the survey. As a result a somewhat consolidated pattern of acceptance was found, as slightly the 38% of the respondents were rather negative about civil drones, about 53% were positive. The major concerns about drone technology were the misuse for criminal purposes and the loss of privacy that the citizens could get. The study showed that german population is still forming its opinion about civil drones but it is needed to perform further research on the development of public acceptance to foster the succesful development of the U-space concept for drones in Europe.

The social aspects of risk acceptability include the following determinants according to [24]:

1) Voluntary involvement in the risk, this is, if third parties can potentially be affected.
2) The capability of controlling the risk response.
3) Type and nature of the consequences of failures.
4) Mass media dissemination of adverse events.
5) Transparency and available information.
6) Level of automation, being the high levels of automation perceived as a loss of control.

In US a survey conducted with 100 participants of a recent risk management conference [23] showed that the top concern for commercial drones is the potential invasion of privacy (61%) very far away from other concerns such as potential damages/injuries and the insurance coverages in such events (9-15%). The report of the discussions in a journalist workshop [36] addresses several challenges posed by the use of drones in news gathering applications. The potential deployment of drones for media purposes can be limited by the safety principles inherited by the aviation culture. Another potential limitation for the application of drones by the media is the conflict that will be created with law enforcement and emergency services also flying in the vicinity of accidents and emergencies. These are not new; conflicts have occurred in the past between media helicopters, e.g. the 2007 Phoenix news helicopter crash. New coordination procedures shall be developed for drone interactions. From the journalist point of view the use of drones by the authorities [29] may produce public opposition because of the civil liberty issues related with surveillance and privacy. The European Commission published an Opinion document about drones and privacy issues [25] in which privacy risks are related with images, sounds and geo-information obtained from a drone that could be associated with an identifiable person. The document lists the obligations about privacy to drone operators: the transparency principle (inform subjects), the proportional principle (use proportional technology to avoid collecting unnecessary data), and purpose limitation (avoid secondary use). Similarly, the necessity to adopt security measures, delete/anonymize personal data of third persons and embed privacy friendly design to their applications design. A full chapter details the recommendations of the EC to specific stakeholders: drone operators, regulators, manufacturers and law enforcement agencies.

The book [8] assesses the security screening technologies used with aircraft passengers. It mentions a workshop aiming to capture information from passengers and other stake holders as technological providers and law enforcement agencies. The potential concerns they detect where: health effects, convenience, privacy issues and comfort. A number of suggestions are given to improve the social acceptance of such technologies and their applications. As conclusions they addressed two main solutions: good communication efforts and the application of some procedural steps to alleviate some of the concerns.

The FP7 project CECILIA2050, entitled ”EU Climate Policy Beyond 2020 - Options for a Low-Carbon Future”, presents in [9] their conclusions about the social acceptance factor affecting the public policies related to the environment. The method used started with a systematic literature review, and followed by two surveys, first a qualitative one and then an extensive, data gathering, quantitative survey. The results were significantly different depending on the socio-economic profile of the respondents. The main concerns expressed were about the restriction of the personal freedom, the cost and effectiveness of the policies and trust in the institutions. Using taxation as a political instrument has very low acceptance, even in the case the tax is to cover the social cost of the negative externalities.

There are a large number of works about public acceptance of nuclear energy waste. For instance, according to Posiva, a Finish Expert Organisation in Nuclear Waste Management, the Finish parliaments selection of a waste disposal site almost with unanimity was achieved by an intensive research work, an extensive use of modern technologies and by making public in their website the environmental impact assessment Reports, Nuclear Waste Management Plans and Annual Reports [10].

C. Privacy concerns

The use of aerial surveillance technologies in Europe is covered by Article 7 (Respect for private life) and Article 8 (Data protection) of the Charter of Fundamental Rights of the European Union (2000/C 364/01) (CFREU), and also by Article 8 of the European Convention on Human Rights (ECHR, done at Rome on 4 November 1950) about the respect for a private life, addressing data protection for the video footage where natural persons are identifiable. Discrepancies exist about the implementation within different countries; for instance, differences exist in the application of the law depending if the video is being recorded or only used for live monitoring; another discrepancy is about drone registration for vehicles smaller than 250g if carrying cameras on-board. Some countries have specific laws on CCTV or police surveillance operations refer to drones. According to the Art 7 of the old Directive 95/46, the aim was to embed appropriate measures in ICTs both at the time of the design of the processing system and at the time of the processing itself, particularly in order to maintain security and thereby to prevent any unauthorized processing of private data. Recently (with effect from 25.5.2018) the Directive 95/46 has been repealed by the GDPR (Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data. Explicit consent for data storage and usage is required, which includes the right to the personal data, including images. Moreover the conditions of the data transfer have to be very clear and infringements have very high penalties for enterprises. Issues related to privacy that are reported in [22] are:

- **chilling effect** - individual believe they could be observed by a silent drone at any moment,
- **dehumanisation** - decrease on the moral responsibility perception of distant surveyed persons by the drone operator,
- **transparency** -visibility, accountability and voyeurism,
- **function creep** - misuses from the primary and announced function of the drone and
- **privacy of body**, location and association.

As a major ethical issue the document reports the possibility to use drones for discriminative actions.

D. Noise concerns

According to a study [6] the social costs of aircraft noise in the EU can be estimated to amount to 6.8 billion Euros a year. The study tries to relate the nuisance of aircraft noise annoyance to an economic value, using the contingent valuation method. For the area around Paris-Orly airport (population of 62,350 people), where more than half of the people are annoyed by aircraft sound, they calculate that the yearly social costs (measured as the willingness to pay in order to suppress the sound annoyance) are about 2 million Euros a year. If it is assumed that in this area a number of 35,000 people are annoyed, the willingness to pay per annoyed person can be estimated to 57 Euro per year. For a number of 120 million annoyed people in Europe, the social costs would be 120 million times 57 Euro, which equals 6.8 billion Euros a year. In [7] two KPI are proposed to assess the aircraft noise and its impact to individual citizens: the Person-Event Index (PEI) and the Average Individual Exposure (AIE), both targeting at the improvement of concept of acceptability, which is very sensitive to each individual. Social surveys indicate that for most people the most noise sensitive times are night-time, evenings and early mornings and weekends. According to [7] the broad principles for social acceptance of the noise from an airport is the need of an information regime with the principles showed in Table II.

TABLE II
SOCIAL ACCEPTANCE PRINCIPLES [7]

Broad Principles	Key Areas
Transparency	Completeness
Inclusiveness	Accuracy
Empowerement of the individual	Comprehensibility
	Timeliness

Following the principals presented in Table II information shall be provided in common language, which can be easily verified by the law enforcement officers, monitored by the public, not excluding anybody who believes to be affected, and placing the individual in a position in which they can formulate their own opinion on acceptability, and take decisions consequently.

E. Others

Airbus performed a study to know the public perception of the deployment of Urban Air Mobility (UAM) [38]. This study was performed across a wide range of demographics such as experts, city officials, aircraft manufacturers, academics and policy makers. In total 1540 respondents were included in the survey from 4 different countries, Los Angeles (USA), Mexico City (Mexico), New Zealand and Switzerland. The study revealed that the overall concern of the respondents was related to the safety of the individuals on the ground (almost 56% of them were concerned). The next grouping of concerns were the type of noise that would be generated, the volume of noise and time of day or altitude of the operations. The study also revealed that the traffic in the cities of the respondents conditioned in someway their attitude towards UAM. So that the greater the traffic were in their cities, people were more open to integrate UAM. Something similar happened with the age of the contestants, in this case, the younger they were the better the initial acceptance they manifested.

The UK government has also developed one study, in this case to receive feedback on some new proposals that they had to develop new policy and regulations surrounding the use of drones [39]. They consulted things such as if the current airport restriction is sufficient or not, it it is necessary to propose an age limit for small drone operators, the estimated growth in number of commercial drones that will be in the following years or how to use the counter-drone technology. Social responses were positive towards all the proposals, except the ones that people thought had something related with privacy issues or the ones that seem to advantage commercial use of drones in front of leisure drones. In general this survey has revealed that people is open to the use of drones and to new regulations over them even if they are more restrictive. But it also showed that all the respondents agreed on the need of informing the population about this regulation in a more intense way.

After studying the ethics implications of 11 scenarios with drones flying surveillance missions [28] concludes that the marginal benefits offered by civil drones significantly outweigh the marginal harms related to ethical and privacy issues, except for the biomimetic spy drones, for which a ban shall be placed because they are highly imperceptible.

III. SCENARIOS

This section will present the environment, vehicle, activity and conditions of each scenario chosen. The survey will be based on considering these different situations. These use cases have been done within the context of the SESAR CORUS project where around 15 use cases were presented. They are meant to be indicative operations that might be routine in a future drone environment. Some of them may be even routine operations right now. They attempt to show the different scenarios and levels of interaction between UAS and other airspace users. From this 15 scenarios four have been selected, as we consider them to represent a sufficient variety of situations. All scenarios will be seen from two different points of view. In one hand as if the operations were performed nowadays. But in the other hand it will be supposed that the airspace volumes proposed by the U-space European initiative is applied. This volumes being X, Y, Zu and Za [41].

A. Use case 1: Photo activity

In this scenario one professional photographer is taking pictures of the countryside or wildlife. The conditions during the entire working time are visual line of sight (VLOS). The drone platform is weighting between 250g and 900g. The operation is taking place in the countryside, far from houses and people. This area is also far from any airport or aerodrome. The ceiling is set at 400 ft. In the U-space scenario X Volume will be assumed so the pilot should follow regular process of registrations and pre-flight activity and he will be responsible for the avoidance of collision or avoiding to fly above people (e.g. hikers). The payload will be only a visual camera to take the pictures/videos.

B. Use case 2: Bridge inspection

An architect wants to inspect the state of a bridge after a tornado. Part of the mission is BVLOS and the ceiling is at 400 ft. The location is sparsely populated but the bridge is well known by VFR pilots as a reference point for their navigation; moreover, a lot of leisure drone pilots use to fly around the bridge. The area is classified as Y Volume in the U-Space scenario so the operator must submit a flight plan and the operation will be strategically de-conflicted. The pilot is in charge of collision avoidance or to avoid flying above or near people. Nevertheless the pilot will be informed before take-off if another drone is expected to fly at the same time. The payload of the drone are a laser pod, a thermal camera and a visual camera with a total weight of less than 4 Kg.

C. Use case 3: Runway inspection

A pilot thinks he has seen an object on the runway while landing. The ATCs proceed to a runway inspection with a drone. The operation takes place on the maneuvering area of a big airport; the volume is controlled airspace and part of the mission will be in BVLOS. In the U-Space scenario Za Volume is considered so the operator must submit a drone operation plan and will receive tactical advisory and/or instructions in case of conflict. The instructions to proceed with the operation will be directly given to the remote pilot by ATC, with a perfect knowledge of every other drones, manned aircraft and vehicles movements on or above the manoeuvring area. The payload on-board is a wide angle visual camera and the overall weight is less than 4 Kg.

D. Use case 4: Police surveillance

The police department uses a drone to overfly a city during 8 hours, in order to be able to provide help to the police officers in case of intervention. This mission is BVLOS. The area overflown is urban (populated), other drones are expected to fly, including taxi-drones, as well as manned aircraft such as EMS helicopter, helicopter of the fire department, or other. So in U-Space situation a Zu Volume must be taken into account, so traffic is said to be strategically and tactically de-conflicted. A drone operation plan must be submitted and validated by the U-Space Service Provider. Payload is an infrared sensor along with other surveillance material turning the overall weight over the 25 Kg so due to regulation aircraft must be certified.

E. Use cases summary

TABLE III
SUMMARY OF USE CASES CHARACTERISTICS.

Use cases	Range	Type of operation	Objective	Weight
1: Photo activity	Short	VLOS	Commercial Photo/Video	250g - 900g
2: Bridge inspection	Short	BVLOS	State inspection	<4Kg
3: Runway inspection	Short	BVLOS	Inspections	<4Kg
4: Police surveillance	Long	BVLOS	State surveillance	>25Kg

IV. Stakeholders Acceptance Indicators (SAIs)

SAI's are the proposed tools to measure the social impact of the drones through three different branches, safety, economic impact and social perception. Each branch is summarized in an indicator with values from – – to + +, most negative and most positive respectively. All possible values are presented in Figure 1.

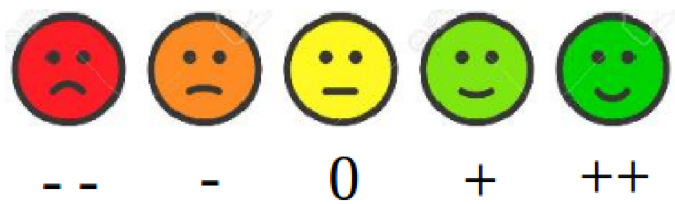

Fig. 1. Symbol based responses options.

A. Objectives

The principal objective of these stakeholders acceptance indicators is to contribute to convert all the economic, social and safety expectations regarding drones into facts. Nevertheless, the growth must follow the principles of sustainability, as proposed by United Nations: non-exclusiveness, health and nature preservation, sustainable cities, climate action, peace and justice. More specifically we can list the objectives of the SAI in:

- Provide an assessment tool to measure the deployment of drones.
- Help to detect any unbalance situation and to propose regulations to avoid unfair situations.
- Check the necessity of funding.
- Be transparent with the drones inconveniences.
- Serve as a performance evaluation tool for new drone technologies, new airspace organization or changes in legislation.
- Extend the safety culture also across drone operators, pilots and industry.
- Assess the level of compromise of the airspace safety.
- Help citizens to have a funded opinion about drones.

B. Proposed indicators

The development of social acceptance indicators (SAI) must comply with the following requirements:

1) SAI shall consider all aspects of the impact of drones on society, not only economical.
2) A feasible methodology shall be proposed to obtain SAI values for different scenarios, use cases, type of drones, technologies, etc.
3) SAI values shall be easy to understand.

To consider all aspect of social impact (Req.1) we propose three indicators that we named as safety (SAI_SA), economic (SAI_EC) and political (SAI_PO):

- **SAI_SA** is the Safety indicator and measures the benefits/risks that drones pose to rest of air space users and to people on ground.

- **SAI_EC** is an Economic indicator that measures the accomplishment of economical expectations of the new emerging drone market
- **SAI_PO** encompasses any other social issue, named as Political, which includes aspects such as the citizens affectations from the drones noise, the privacy potential compromise, the visual impact etc. SAI_PO also includes the increase of governments and administrations complexity and new management requirements. Moreover SAI_PO includes the potential affectation (positive and negative) on emergency situations resulting from the introduction of drones. Finally, environmental considerations are included also as part of the impact of drones for future generations and Earth preservation.

C. The SAI Survey

In order to capture the complete view of the society up to 10 different profiles were used:

1) Drone operator.
2) Current and potential users/clients of drones.
3) Drone industry, including manufacturers and suppliers.
4) Future generations, Earth and environment.
5) Citizens.
6) Emergency responders and police.
7) Administrations and governments.
8) General aviation (VFR) and other VLL airspace users.
9) Airports, ANSP, air-safety agencies.
10) Airlines (IFR).

Each of the profile has been assigned with a set of questions that may concern them. Up to 45 questions have been proposed. For instance, one of the questions proposed that may concern drone operators (Profile.1) is How flexible is the system for last minute changes of a planned drone operation?. Another example of question, in this case, concerning citizens (Profile.4) is How cameras on drones are useful or dangerous to citizens?. To aggregate these 45 questions into the three stakeholders acceptance indicators, the 10 profiles have been assigned to each one of the indicators. Although one same profile may have interest in more than one area, such as for instance the Airports, which can be potential users of drone services (Profile 2), but also part of Profile 9, we have assigned the profile only to the most significant indicator. With this we want to avoid the excessive representation of some roles in the results. The assignment of profiles to each indicator is as follows:

- **SAI_SA**: General aviation, VFR and other VLL airspace users; Airports, ANSP, air-safety agencies; and Airlines (IFR).
- **SAI_EC**: Drone operator; Current and potential users/clients of drones; and Drone industry, including manufacturers and suppliers.
- **SAI_PO**: Future generations, Earth and environment; Citizens; Emergency responders and police; and Administrations and governments.

Further, in order to ease the survey the questions have been group into 24 metrics according to their topics. For instance, there are three questions about the noise of drones which are merged into a unique metric named SAI_PO04 analysing if the noise is Increased/Decreased in the pertinent use case. Answers to these questions (metrics) are entered with an easy symbol based with 5 degree levels, as in a satisfaction feedback device, but substituting the images by + and - as shown in Figure 1.

Table IV shows the final format of the SAI survey, showing the 24 metrics divided by indicator and profile (stakeholders).

TABLE IV
SAI SURVEY FINAL FORMAT.

SAI_ID	Stakeholder	Benefits/Risks metrics
SAI_SA01	*VFR and other VLL airspace users*	Easy/Difficult access to cheap airspace services.
SAI_SA02		Decreased/Increased risk perception.
SAI_SA03		Availability/Absence of additional equipment or services.
SAI_SA04		Extended/Limitations to airspace access
SAI_SA05	*ATM, Airports and Safety Agencies*	Opportunity/Complexity for digitalization and automation
SAI_SA06	*IFR and Airlines*	Improve/Deteriorate maintenance
SAI_SA07		Improved/Lack of situation awareness of drones flights.
SAI_EC01	*Drone operator*	Fast/Complex implementation of a mission.
SAI_EC02		Low/High cost of the on-board equipment.
SAI_EC03		Low/High cost of the ground station and personnel.
SAI_EC04		Partial/Full insurance
SAI_EC05	*End-Users*	Availability/Limitations to drone services.
SAI_EC06	*Industry and suppliers*	Creation/Destruction of some economical sector.
SAI_PO01	*Environment*	Preserve/Danger natural life.
SAI_PO02		Decrease/Increase of CO2 emissions.
SAI_PO03		Cleaning/Stressing the environment.
SAI_PO04	*Citizens*	Decreased/Increased noise.
SAI_PO05		Reinforcement/Loss of privacy.
SAI_PO06		Reinforcement/Loss of liability laws.
SAI_PO07		Positive/Negative visual impact.
SAI_PO08		Increase/Decrease leisure activities.
SAI_PO09	*Emergency and police*	Increase/Decrease danger for humans.
SAI_PO10		Reinforcement/Difficulties in law-enforcement for non-legal drones.
SAI_PO11	*Administration*	Easy/Complex administration procedures.

D. Conducting the surveys

The surveys were conducted during CORUS workshop 2 and in different seminars performed at the UPC to a wide variety of people all included in the 10 profiles presented earlier in section IV.C. Each contestant was asked to fill somewhat similar to Table IV for each one of the use cases. In each use case it was needed to take into account the present situation of airspace distribution for drones and in the other hand the situation that would bring the implementation of CORUS's proposed volumes X, Y and Z for U-space. So at the end for each use case the table had to be answered twice.

Once the surveys were filled on paper by experts using the symbols (+), or (++) for the positive and very positive perception, (-) and (–) for the negative and very negative perception and (0) for not applicable, the responses were entered in a CVS file coding positive and very positive answers with 1 and 2 respectively and negative and very negative answers with -1 and -2 respectively.

E. SAI presentation plot

Using an R program all responses were processed and converted into plots. All values had a translation of +3 units, converting the answers from (-2 - 2) into the scale (1 - 5). The responses on each metric were then averaged to their corresponding SAI. The main outcome of a single use case survey response is a triangle such as the example shown in the left part of Figure 2. In this part of the figure, one can easily observe a very socially accepted drone use case, and with a very high economic viability. This visualization tool is very convenient for instance to compare situations, as shown in the right part of Figure 2. Three imagined use cases (green, black and red) can be compared very fast: while the green drone mission is the most balanced in the three axis, the black has a very promising acceptability and viability but fails in safety, and red is too expensive.

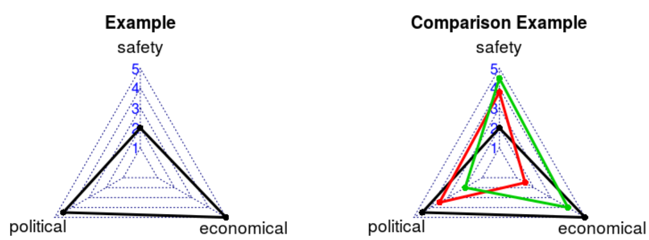

Fig. 2. Presentation plot of the SAI values.

Another type of plots used will be very similar to these presented in figure 2. In this case, although using the same type of plots, each SAI will be broken down in the different metrics composing it. So that it will be one axis representing each metric. This will allow us to see more in detail how each metric is perceived and if some metrics are more relevant than others.

V. Results

This section provides the results of the processing of all the different surveys either for the actual situation or the future U-Space one. A total of 86 surveys were collected. To start presenting some results we will show SAI's breakdown plots in figure 3.

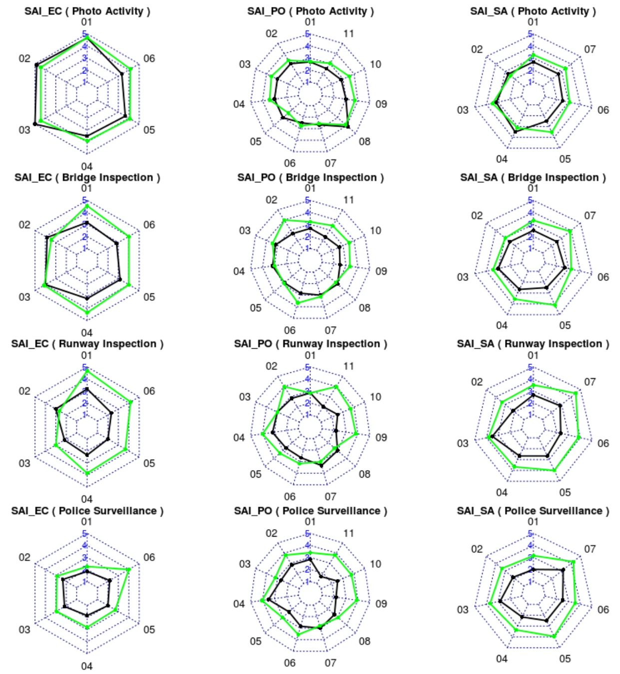

Fig. 3. SAI's broken down plots.

Looking at the first column, economical indicators, we can see that as we increase the complexity of the operation the economical expectations from the respondents decrease. This descent is in both the actual or the U-Space situation. In the political and safety indicators the majority of the metrics are around 3 for the actual use cases, but there is a clear upgrade of expectations in some metrics when analysing the U-space situation. For instance respondents think that CO2 emitions (PO02) will be reduced by using drones, law-enforcement (PO10) will be improved or awereness of drone operations by the different stakeholders (SA07) will be better in a future homogeneously regulated environment.

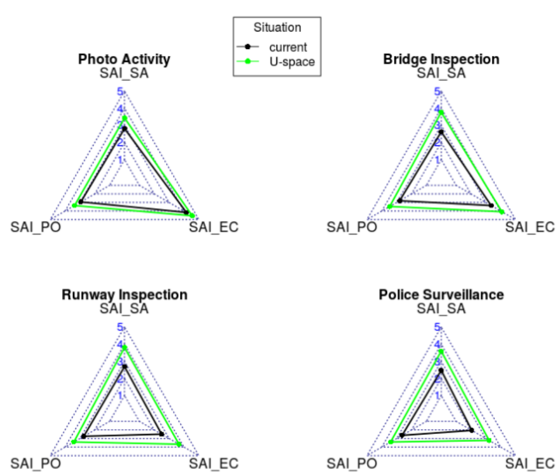

Fig. 4. SAIs global plot indicators.

As a general behaviour as we go into more demanding environments respondents seem to perceive that U-space will bring more comfortable conditions. This perception can be also seen in Figure 4 where the averaged SAI's for each use case are presented. If we look at the different averaged SAIs in any of the use cases expections are better in the U-space situations. Although photo activity almost doesn't suffer a greater change. In all other indicators and use cases, in general, respondents agreed that U-space could bring a safier, enviromental-friendly and economical scalable environment for drones. At least more prepared that the one present nowadays.

To get an idea of how the opinions were distributed among all the respondents, Figures 5 and 6 presents the main statistics for all the different metrics.

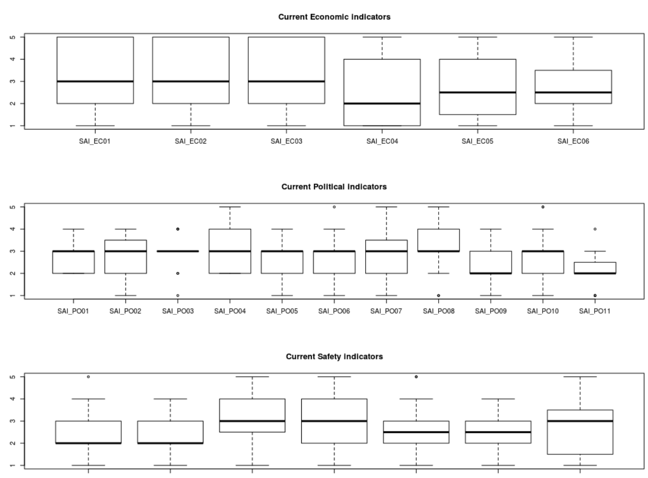

Fig. 5. Current situation main statistics for each metric.

From figure 5 we can extract that the average perception in almost all economical and political metrics are good (mean values around 3) except for EC04, PO09 and PO11 so the perception from the respondents in the airspace access, the creation of danger and the administration complexity seems to be poorer than good (mean values are 2). The safety metrics are also more pesimistics as more than the half of them have mean values at 2 or lower than 3. This means that the safety perception regarding risk increment, access to the airspace or potential damage from drones needs to be improved.

In the other hand if we look at the response statistics from the U-space situation, presented in Figure 6, all the metric's means become higher or equal than 3 (good perception). For instance the perception on how fast missions can be implemented (EC01) goes from 3 to 5 or the opportunity in automation (SA05) from 2 to 4. This confirms again that in general respondents agree that a U-space environment would increase stakeholders trust on drone technology and operations.

One more remarkable fact is that the variance in the economical indicators is the highest one. This shows how all the different profiles selected as respondents see bussiness opportunities diferently than safety or political terms where variance is more tight.

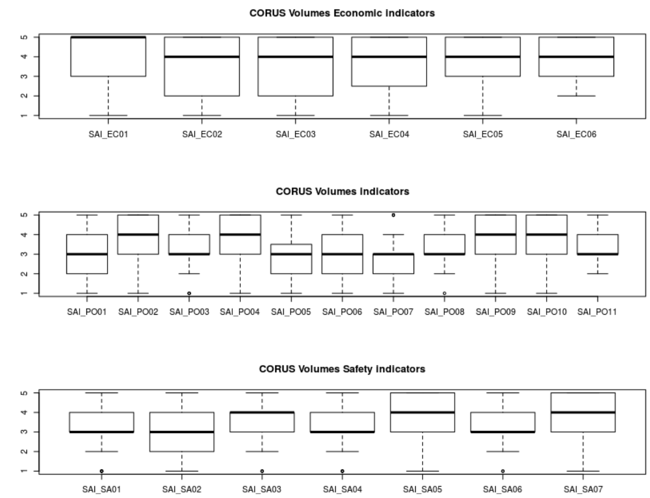

Fig. 6. CORUS Volumes situations main statistics for each metric.

VI. Conclusions

In this paper we have presented three indicators to measure the stakeholders acceptance of the drones and have shown the potential of using them to assess the perception of the drone from three dimension: the safety, the economic growth and the political considerations. The indicators have been calculated for all the use cases using a methodology based in the responses of experts. Main results and conclusions have been presented in section 5.

We can extract some summarizing statements from the results obtained:

- Perception in the three different indicators gets worse or less optimistic as higher is the complexity of the environment.
- Experts has expressed that a U-space environment could entail a safer, better for economical growth and trustable scene for drone technology.

Moreover we propose the following improvements and future work:

- Assess the impact of airspace classes for another near in the future use case, about a long route BVLOS inspection conducted in low populated areas.
- Check and validate individual metric responses, such as metrics SAI_PO05 or SAI_EC01, which show a much more positive trends than the rest.
- Review some metrics such as SAI_PO03, which does not seems to contribute to any assessment.

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