Work Package 2: Technological Innovation for Sustainable Development

Deliverable T2.3.1: Project report

Drone Surveying for the Protection of Natural and Built Heritage Sites

Jessica Giannoumis

March 2021

SUSTAINABLE RESILIENT COASTS

Project Partners

Landbúnaðarháskóli Íslands

UCC Coláiste na hOllscoile Corcaigh, Éire University College Cork, Ireland

Comhairle Contae Mhaigh Eo Mayo County Council

OAMK Oulu University of Applied Sciences

Causeway Coast & Glens Heritage Trust

Northern Periphery and Arctic Programme 2014–2020

European Union

This contributes to Future Earth Coasts, a Global Research Project of Future Earth

Executive Summary

The potential of drone technology to support local authorities to promote sustainable development of coastal regions has been appreciated but has thus far been underutilised. This report provides practical guidance to local authorities in the use of drone technology to digitally preserve, document, and monitor natural and built heritage sites to promote the sustainable development of regions at the coast. The report has been produced as part of the EU-funded Sustainable Resilient Coasts (COAST) project, a collaboration between partners from Iceland, Finland, Ireland, and Northern Ireland focusing on the future challenges and development of coastal areas in Europe's Northern Periphery and Arctic (NPA) region. The project seeks to deliver practical guidance for coastal local authorities to support resilience building and coastal sustainability. This document is therefore intended to enable local authorities with limited experience but a desire to understand and use drone technology for the digital preservation and documentation of natural and built heritage sites.

This report describes a six-step process that guides local authorities through the considerations that need to be taken before, during, and after conducting drone surveys. The key steps include 1. Flight purpose; 2. Study design; 3. Pre-flight fieldwork; 4. Conducting drone survey; 5. Processing of aerial data; 6. Quality assurance. Each step will be described and explained to ensure that drone surveys are conducted efficiently and safely. The flight purpose sets out the intent of the survey and will introduce Rathlin Island as a case study and different ways in which drone survey applications may be used to support the Rathlin community. Rathlin Island in Northern Ireland has many natural features and landscapes in addition to many built heritage sites and as such provides a unique case study. Due to current Covid-19 travel restrictions (March 2021), the testing of the presented methodology in this report has not yet commenced. More details on the case study and the piloting of this methodology will be presented at a later time. The flight purpose includes the access to drone survey output as an important consideration that has to be taken prior to the study design. The study design focuses on technical aspects of the drone, the drone classification and potentially necessary training, and the drone regulations and aviation authorities. The pre-flight fieldwork describes the planning and some practical considerations pre-flight fieldwork. The planning stage ensures that the next step, conducting the drone survey, is done safely and efficiently. Processing of aerial data provides some practical considerations regarding the data management and data sharing and some of the General Data Protection Regulations (GDPR) that have to be considered for the presentation of the output. Quality assurance ensures that drone survey operations have used the best practice guidelines for drone operations. The final chapter of this report provides local authorities with a quick drone operator's checklist for safe drone operations.

Acknowledgement

This report has in large parts been produced with the aid and help of Dr. Sarah Kandrot, Green Rebel Marine. Thank you to Dr. Fiona Cawkwell (UCC), Tryggvi Stefánsson (SVARMI), Teresa O'Hare (Causeway Coast & Glens Heritage Trust), Mikko Posio (Oulu University of Applied Sciences), and Brian Wilson (County Council Mayo) for the valuable feedback and input into this report.

Acronyms

EASA European Union Aviation Safety Agency

FOV Field of View

GCP Ground Control Point

GNSS Global Navigation System

GRC Ground Risk Class

GSD Ground Sampling Distance

ICAO International Civil Aviation Organization

JARUS Joint Authorities for Rulemaking on Unmanned Systems

LiDAR Light detection and ranging

OM Operations Manual

RGB Red, green, blue (visible portion of the electromagnetic spectrum)

RTH Return to Home

RTL Return to Launch

SOP Special Operating Permission

SORA Specific Operations Risk Assessment

STS Standard Scenario

UAS Unmanned Aerial System

UAV Unmanned Aerial Vehicle

VLOS Visual Line of Sight

Contents

1. Introduction

Unmanned Aerial Vehicles (UAVs) such as drones can be used to contribute to promoting sustainable development in coastal regions. UAVs enable the cost-effective, relatively easy documentation and digital preservation of natural and built heritage sites in coastal regions. UAV or drone surveys also allow the exploration of difficult-to-reach and/or inaccessible sites with none to minimal impact and disturbance to the natural and built environment. Additionally, repeat surveys can easily be undertaken to monitor changes of the natural and built environment over time. Many of these coastal regions are threatened by the effects of climate change, sea-level rise, and coastal erosion. Hence, drone surveys of these regions could contribute to documenting and digitally preserving these heritage sites through photography, video recordings, surveying and modelling using various sensors like cameras, LiDAR, magnetometers, radars, and more. The use of drone surveys has become a preferred method for geoscientists due to drones' easy-to-use interface and the wealth of data that can be collected efficiently and effectively in a relatively short time (Jiménez López & Mulero-Pázmány, 2019; Joyce, Duce, Leahy, Leon, & Maier, 2019). However, the potential to support local authorities in monitoring remote areas and promoting sustainable development through the use of UAV or drone surveys for natural and built environments has not yet been fully realised (Manfreda et al., 2018).

This practical guide is designed for local authorities in coastal regions as a one-stop-shop providing information and key considerations for the use of drones for the digital preservation and documentation of sites of cultural and natural significance. Drone surveys can be useful for small survey areas and when mapping can be done using RGB cameras[1]. Drone surveys are one way to digitally preserve natural and built heritage sites. However, before diving deeper into the practicalities of drone surveys for digital preservation, local authorities consider the purpose of the survey and the most suitable and appropriate way of obtaining remote sensing data. Remote sensing is the process of collecting data without physically being in contact with the object (Simic Milas, Cracknell, & Warner, 2018). Depending on the purpose of the survey, using remote sensing data collected from satellites or plane surveys, or hiring expert drone operators to carry out the survey may be alternative options to consider. Expert drone operators can also advise on the most suitable sensors to obtain the data and create output from the data as high-end sensors will produce higher quality data.

In particular, this report outlines key considerations for the use of drone surveys to monitor the natural environment and to preserve built heritage in coastal regions. This practical guide loosely follows the Unmanned Aerial Systems (UAS)-based mapping according to Tmušić et al. (2020). The UAS-based mapping identified five key considerations which help structure the planning and operating of drone surveys. The five key areas are: 1. Flight purpose; 2. Study design; 3. Pre-flight fieldwork; 4. Conducting drone survey; 5. Processing of aerial data; 6. Quality assurance (figure 1). This report has built on the work Tmušić et al. (2020) and is structured on the modified methodology. This report is tailored to local authorities' needs and considerations when planning the digital preservation and documentation of sites of the natural and built environment.

[1] RGB (red, green, and blue) cameras are able to capture the same bands of light that the human eye can capture. Kandrot and Holloway (2020) detail the applications of drone technology for sustainable development of the coastal zone and provide an in-depth literature review of the available uses and abilities of state-of-the-art drone technology, available here: https://coast.interreg-npa.eu/subsites/coast/DT2.1.1_Applications_of_drone_technology_for_sustainable_development_of_the_coastal_zone.pdf

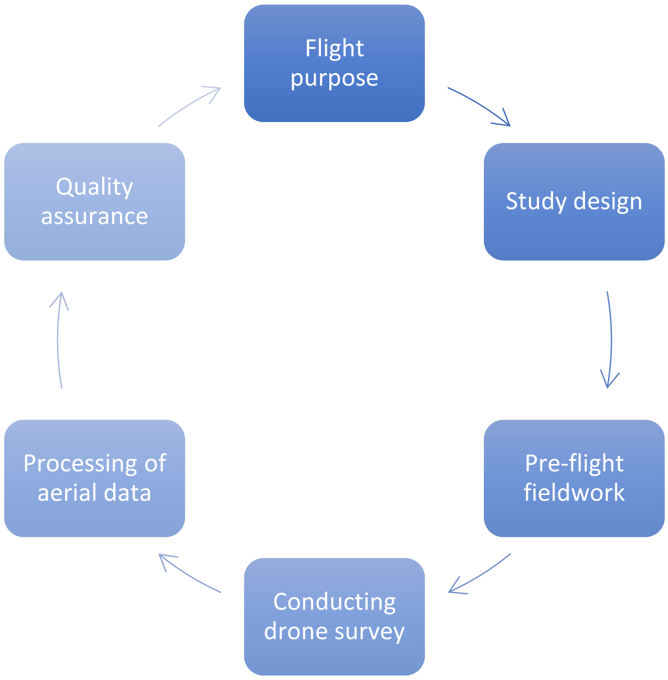


Figure 1: Activities involved in UAS-based mapping, adapted from Tmušić et al. (2020)

This document aims to provide local authorities practical guidance in how to digitally preserve the natural and built environment using drone technology. Rathlin Island in Northern Ireland has agreed to partner up with Causeway Coast & Glens Heritage Trust (CCGHT) and University College Cork (UCC) to implement and test the six-step methodology to use drone surveys to digitally preserve and monitor the natural and built heritage sites. Due to current Covid-19 travel restrictions (March 2021), the testing of the presented methodology in this report has not yet commenced. More details on the case study and the piloting of this methodology will be presented at a later time.

This report was produced as part of the Sustainable Resilient Coasts (COAST) project, a collaboration between the Agricultural University of Iceland, Oulu University of Applied Sciences, Mayo County Council, University College Cork, and the Causeway Coast and Glens Heritage Trust. This collaborative project focuses on the future challenges and sustainable development of coastal areas. Information from this repot will be integrated into our Sustainable Resilient Coasts Toolbox for local authorities, an online resource focusing on SMART Blue Growth[2].

For more information see: http://coast.interreg-npa.eu/

[2] SMART Blue Growth refers to the sustainable development of marine and maritime sectors based on the principles of Sustainability, Mitigation, Planning, Adaptation, Resilience, and Transition (SMART) (De Vet, Edwards, & Bocci, 2016).

2. Drone Operation at Natural & Built Heritage Sites

Drone surveying and operations can be used for many applications among others the preservation and documentation of natural and built heritage sites. To make the most out of the drone survey, it's useful to establish the flight purpose, this will ensure that the drone survey will be able to deliver the needed outputs. In this report, drone surveys may include 360° video, photogrammetry mapping, single images taken by drones, and LiDAR scanning[3]. Natural and built heritage sites require careful consideration and planning to ensure that the drone survey will not cause any damage or harm to the sites. Using drones or unmanned aerial vehicles (UAVs) at natural and built heritage sites enables drone operators to monitor changes over time, condition of the site, and an easy-to-use birds-eye view on the heritage sites. These data can in turn be used to appropriately manage the site (Liao, Mohammadi, & Wood, 2020).

2.1. Flight Purpose

In this report, we will focus on providing useful information on using drones at natural and built heritage sites and have therefore focused on the four different drone applications: 1. Monitoring the natural environment in coastal areas; 2. Preservation of built heritage in coastal areas; 3. Virtual tourism; and 4. Educational purposes. To demonstrate these different applications, Rathlin Island has been chosen as a case study which will follow the guidance given in this report to illustrate the different applications of drone usage to support the documentation and preservation of the natural and built environment. However, due to current Covid-19 travel restrictions (March 2021), the testing of the presented methodology in this report has not yet commenced. The following section introduces Rathlin Island briefly, more details on the case study will be presented at a later time.

2.1.1. Case Study Rathlin Island

Rathlin Island is uniquely positioned between Ireland and Scotland off the north east coast of the island of Ireland and is Northern Ireland's only inhabited offshore island. Rathlin's geological composition consists of Cretaceous Chalk on the southern part of the island and Lower Basalt on the rest of the island, which causes differences in landscape features on the island. Additionally, Rathlin has a rich and diverse cultural heritage. As such, Rathlin Island presents an excellent case study[4]. The Rathlin community has agreed to partner up with the CCGHT and UCC to pilot and test some of the methodology that is presented in this report. This report hence provides some practical guidance on how drone technology can be used to digitally preserve the natural and built heritage of Rathlin.

2.1.2. Monitoring the Natural Environment in Coastal Areas

Drone are easy-to-use tools to help monitor the natural environment, which is of particular interest in coastal areas where the environment changes quickly due to tides or in hard-to-reach areas such as cliffs. Coastal areas are under constant threat of destruction due to natural occurrences such as coastal erosion and sea-level rise and due to human-induced causes such as climate change and extreme weather events, waste and plastic pollution which may have long-term effects on the natural environment (Van Rijn, 2011). Drone surveys are cost effective solutions that enable the monitoring of the natural environment spanning over weeks, months, or even years. This in turn allows a comparative analysis of the site, which would help local authorities to make decisions on necessary

[3] Kandrot and Holloway (2020) detailed different types of survey data that can be collected through the use of unmanned aerial vehicles (UAVs), available here: https://coast.interreg-npa.eu/subsites/coast/DT2.1.1_Applications_of_drone_technology_for_sustainable_development_of_the_coastal_zone.pdf

[4] More information on Rathlin Island can be found here: http://www.rathlincommunity.org/

mitigation plans. One such example is the surveying of beach cusps[5] in Ireland, where Nuyts, Murphy, Li, and Hickey (2020) use drone technology to determine the changes in the cusps. Enabling the monitoring and video capturing of the coastal geomorphology revolutionises our understanding and our ability to monitor and manage the coastal area (French & Burningham, 2009).

2.1.3. Preservation of Built Heritage in Coastal Aeras

Drones can contribute to a cost-effective and efficient way of documenting and preserving the built environment and to use as ways to rebuild or restructure historically accurate buildings (Themistocleous, Ioannides, Agapiou, & Hadjimitsis, 2015). There is a growing need for the protection and preservation of historic architecture and buildings using innovative technologies to document and conserve built heritage (Banfi, 2016). Using drones to map historic sites can support the restoration of historic sites, which is particularly important in areas where there may be natural deterioration of the buildings, or the natural environment may have reclaimed buildings. drones can thereby increase the safety of the operation by identifying areas where precaution needs to be taken.

The drone surveys of sites with cultural and historic significance require careful planning and may, in some instances, also require permission from the landowner or the local authority prior to conducting the survey. Additional considerations also include the data protection of people and their property.

2.1.4. Virtual Tourism

Drones may provide additional income streams for communities living in remote areas through virtual tourism (Kandrot & Holloway, 2020). Virtual tourism is a way of experiencing a place digitally without a need to be physically present in the area (Kitonsa & Kruglikov, 2018). This enables a new and innovative way of exploring sites from a different perspective while also providing additional information on interesting features or historic encounters. This new way of exploring sites from the comfort of any digital device will only gain importance and has been particularly accelerated through the current coronavirus pandemic (Ilkhanizadeh, Golabi, Hesami, & Rjoub, 2020; Templin & Popielarczyk, 2020).

If the flight purpose is to create a virtual tourism campaign, it is advisable to consider aesthetics that highlight the features of the natural or built environment. Creating a 3D model ready for virtual reality can be challenging, in terms of obtaining data that can be used for virtual reality and processing the data. To process the data, access to different virtual reality processing programmes and platforms may be needed. It would be advisable to consider how the survey would be consumed, i.e. an immersive experience through the use of virtual reality goggles would require different considerations than virtual tourism campaigns designed as short videos to be viewed on mobile devices. It is also advisable to consider the *typical tourist* that would access the information. Additional considerations include language preferences, accessibility for people with hearing or visual disabilities, age appropriateness and whether the tourist travels by themselves or with a family, etc. Understanding the needs of the *typical tourist* could either take place through physical surveys while the tourists are at the site or through the use of machine learning and utilising points of interest through social media platform[6].

[5] Beach cusps are formations in the shoreline that appear in the swash zone where waves push sediment, i.e. sand or gravel, into moon-shaped formations along the coast (Pitman, Hart, & Katurji, 2019)

[6] Giglio, Bertacchini, Bilotta, and Pantano (2020) used georeferenced images to understand the behaviour and movements of *typical tourists* in Italian cities.

2.1.5. Educational Purposes

Drone surveys can also contribute to new ways of providing education and teaching materials for students of all ages (Palaigeorgiou, Malandrakis, & Tsolopani, 2017). The use of drones could enhance the learning experience for educational purposes by enabling students' unique access to the sites, for example through virtual field trips. The created output should match the age-appropriate syllabi and it is advisable to consider how the information will be accessed.

If the information is to be consumed in a classroom or at home before an excursion to the field, it would be advisable to create similar visual cues in the videos and on the site, to enhance and deepen the connection to the learning experience. If the information is to be consumed without a follow-on excursion to the field, it may be helpful to the student to create small quizzes that ensure that the learning outcome has been achieved. Much like with using drone surveys for virtual tourism, it is advisable to consider how the content will be consumed.

2.2. Access to Drone Survey Output

One key consideration is where and how the outputs of the drone surveys are going to be accessed. Some tourists, pupils, and students prefer access to the information on site, whereas others prefer access to the output off site. Different solutions to cater to the 'consumers' needs exist but need to be carefully planned before conducting the survey.

2.2.1. Access Information through Site-Specific Mobile Applications

Mobile Applications that can be downloaded on mobile devices before the tourist, pupil, or student visits the site are an easy way for local authorities or tourism boards to collect and present available information regarding the natural and built environment. Integrating the drone survey as an essential part of a mobile application could ensure an easy-to-use and immersive experience for the mobile user. The use of apps to access the output from the drone surveys also enables tracking of user behaviour. The application provider could then gain an understanding of the *typical tourist*, their needs, interest, feedback, etc. Please review national General Data Protection Regulations (GDPR) when considering the use of mobile applications.

2.2.2. Accessing Information through QR Codes

If the drone surveys are to be consumed while tourists, pupils, and students are physically at the site, installing easily accessible QR codes on existing infrastructures, for example on information boards, or in the tourism centre present cost-effective solutions. Once the user scans the QR code, information on a mobile device could be prompted. The use of QR codes could also be used as interactive guided multimedia tours[7].

The information available through the QR codes could be maintained by the tourism board or the community and could be periodically updated providing access to newly available resources. Utilising innovative solutions such as QR codes ensure a non-destructive way of providing tourists and students with information without altering the landscape dramatically. Please be advised, that using QR codes while on site requires internet access on the mobile device (figure 2).

[7] Fino, Martín-Gutiérrez, Fernández, and Davara (2013) conducted a study that show the use of QR codes and interactive tourist guides in a World Heritage city, guiding tourists on different paths providing information on heritage buildings through the city.

Figure 2: Example of a QR code used on IOS device (left) and Android device (right) (Tap2Assist, 2014)

3. Study Design

The flight purpose established the application and the purpose of the drone survey. The study design focuses on some of the technical elements that are determined by the make, model, and specifications of the drone and what kind of output the drone can create. As drone operator there are also some practical considerations regarding the drone classification and potentially necessary training for the drone operator, this will vary depending on the drone used and the flight purpose as well as national regulations which can change.

When using drones, it is important to understand how the drone is equipped, i.e. what specifications does the drone camera have, does the drone have a sensor – if so, which one. Knowing these specifications will ensure that the drone is technically able to create the desired output[8].

The study design will also help determine what (if any) kind of models will be created from the drone survey. Promotional drone videos demonstrating the natural and built environment may not require a very high resolution, because they do not require any modelling. Not every mapping and modelling activity requires software to process the data – more details on this can be found in section 6 – Processing of Aerial Data – of this report.

3.1. Creating 2D/3D Models from Drone Surveys

Drone surveys can create a variety of outputs, including 2D maps and/or 3D models, which can be used to map and document the natural and built environment. The application of the drone survey determines what kind of model can be created. 2D maps are two-dimensional, they capture imagery from directly above or from the side if the flight purpose is looking at walls or cliffs. 3D models are three-dimensional and capture the length, width, and height of features of the environment (Gevaert, Persello, Sliuzas, & Vosselman, 2016). The appropriate resolution to capture the drone imagery depends on the model that is chosen to portray the drone survey data. Cameras producing low resolution output can be used to create 3D models and 2D maps. Higher resolution cameras, which are more complex and may be more costly, will yield better 2D and 3D data.

Figure 3: 2D map of Rathlin Island East Lighthouse (Google, n.d.)

[8] Kandrot and Holloway (2020) detailed the applications of drone technology for sustainable development of the coastal zone and provide an in-depth literature review of the available uses and abilities of state-of-the-art drone technology, available here: https://coast.interreg-npa.eu/subsites/coast/DT2.1.1_Applications_of_drone_technology_for_sustainable_development_of_the_coastal_zone.pdf

Drone imagery can be processed to produce 3D point clouds using photogrammetric techniques. Point clouds are clusters of data points in space which represent a 3D shape or object that contain X, Y, and Z-coordinate locations and some other information, for example RGB colour value. The UAV camera captures an object from different angles and perspectives and uses sophisticated computer vision algorithms to detect each shape or object from different angles. By knowing the parameters of the camera, the algorithm can reconstruct a point cloud based on the matching pixels in all the images. Exact geo location of each image greatly helps in this modelling and provides a model with absolute Global Navigation Satellite System (GNSS) coordinates with accuracy in direct translation to the GNSS sensor linked to the images as well as accurate relative distances. GNSS is the general term used and consists of the Global Positioning System (GPS) used in the United States of America, Glonass used in Russia, Galileo used in the European Union, and BeiDou (China). Photogrammetry is therefore at its core a modelling technique but not a direct measurement. There are multiple parameters that can affect the accuracy.

3.1.1. Photogrammetry parameters

Parameters that greatly affect photogrammetry are lighting conditions (such as sunny or cloudy conditions, or nightfall), visibility, the relationship between flight speed and flight height, and the surface that is being mapped. Photogrammetry that relies on computer vision needs some heterogenous features in the ground, i.e. stable physical properties that make distinctions possible. A homogenous surface like snow, sand, water, tarmac, or rooftops can create errors or failures in photogrammetry models. At the same time, the mapped area needs to be constant and cannot move, i.e. drone survey data collected during windy conditions causing waves in the sea or in rivers or moving trees may be unusable.

One key photogrammetry parameter is the resolution which comprises of three metrics: the pixel resolution, the ground sampling distance (GSD), and the spatial resolution. Pixel resolutions refers to how many pixels compose one image and is generally expressed in the number of columns and rows or by the total numbers of pixels, e.g. 1920 x 1080 or 2.1 MP. The GSD is the measurement between the centres of two adjacent pixels, i.e. the closer the camera is to the object, the smaller the distance between the pixels, the higher the resolution of the image (Flyability, 2021). GSD is directly affected by the pixel count, the sensor size, the flight height and the focal length of the camera lens. Spatial resolution, as well as sensor size, camera quality, flight height, atmospheric conditions among other parameters, are affected by the GSD. Spatial resolution refers to the smallest details visible on the image and can account for blur, image noise, contrast, etc. (Flyability, 2021). The characteristics of the camera and its flying height will influence the resolution of the images (Kandrot & Holloway, 2020). Drone operators need to be aware of these photogrammetry parameters to ensure that the collected survey data is usable for the desired output. The flight purpose and application of the survey will determine many of the photogrammetry parameters.

3.1.2. Sensors
Depending on the specifications of the drone, it may be equipped with different types of sensors. The most commonly used are RGB cameras – this refers to the red-green-blue visible bands of the electromagnetic spectrum which are typically used in cameras; thermal infrared sensors which are able to capture thermal radiation from objects or surfaces; multispectral sensors and hyperspectral sensors which are able to capture radiation across a range of wavelengths reflected from a surface or object; and Light Detection and Ranging (LiDAR) sensors which are also able to collect point clouds or direct elevation measurements (Kandrot & Holloway, 2020).

The flight purpose will determine the required resolution and the necessary sensors to capture the imagery. If the purpose of the drone flight is to capture images from a birds-eye view for promotional videos, then RGB cameras may be sufficient to deliver that output. For environmental monitoring of coastal areas where the output should provide an in-depth image of the site, sensors that are able to capture a higher spectral and spatial resolution may be necessary.

3.2. Drone Classification and Training
The classification of drone operations does not distinguish between commercial and leisure activities but is based on the weight and specification of the drone itself. Operating a drone comes with rights and obligations to ensure that drone surveys are carried out safely. The European Union Aviation Safety Agency (EASA) provides detailed information on the safe operation of drones. EASA distinguishes between Open Category – Civil Drones, for drone activities of leisure nature, the Specific Category – Civil Drones for riskier operations that are not covered in the Open Category, and the Certified Category – Civil Drones where the operating of the drone requires a certified drone operator due to the high risk involved in flying the drone.

3.2.1. Open Category
The Open Category – Civil Drones classifies UAS by their weight class, depending on their class and maximum take-off mass (MTMO) the drone operator may have to register their drone and undergo some training modules before operating a drone safely. Most drones used for leisure activities or low risk commercial activities fall under the open category.

Until January 1, 2023, drone operators may fly drones without any class identification labels which specify the weight class and determine operational restrictions. Operational restrictions depend on the subcategory under which the drone operation may fall. The drone operations are divided into three subcategories: A1 (drone operator may fly over people but not over assemblies of people); A2 (drone operatory may fly close to people); and A3 (drone operator may fly far from people). The sub-categories have additional requirements that the drone operator should familiarise themselves with (EASA, 2021a). Table 1 shows the limited open category for drones without class identification labels, drone operation subcategories, operational restrictions, and additional information on drone operator competence valid until January 1, 2023.

Table 1: Limited open category valid until January 1st, 2023 using drones without class identification label (EASA, 2021a)

UAS		Operation		Drone Operator/pilot		
Class	MTOM	Subcategory	Operational restrictions	Drone Operator registration	Remote pilot competence	Remote pilot minimum age
Privately built	< 250 g	A1 (can also fly in subcategory A3)	- No flying expected over uninvolved people (if it happens, should be minimised) - no flying over assemblies of people	No, unless camera / sensor on board **and** a drone is not a toy	- no training needed	No minimum age
Drones without class identification label	< 500 g			Yes	- read user manual - complete the training and pass the exam defined by your national competent authority	16*
Drones without class identification label	< 2 kg	A2 (can also fly in subcategory A3)	- no flying over uninvolved people - keep horizontal distance of 50 m from uninvolved people (this can be reduced to	Yes	- read user manual - complete the training and pass the exam defined by your national competent authority	16*
Drones without class identification label or privately built	< 25 kg	A3	- do not fly near people - fly outside of urban areas (150 m distance)	Yes	- read user manual - complete the training and pass the exam defined by your national competent authority	16*

Table 2 shows the open category for drones with class identification labels, drone operation subcategories, operational restrictions, and additional information on drone operator competence valid after January 1, 2023.

Table 2: Open category after January 1, 2023 (EASA, 2021a)

UAS		Operation		Drone Operator/pilot		
Class	MTOM	Subcategory	Operational restrictions	Drone Operator registration	Remote pilot competence	Remote pilot minimum age
Privately built	< 250 g	A1 (can also fly in subcategory A3)	- may fly over uninvolved people (should be avoided when possible) - no flying over assemblies of people	No, unless camera / sensor on board **and** a drone is not a toy	- no training needed	No minimum age
C0					- read user manual	16*, no minimum age if drone is a toy
C1	< 900 g		- No flying expected over uninvolved people (if it happens, should be minimised) - no flying over assemblies of people	Yes	- read user manual - complete online training - pass online theoretical exam	16*
C2	< 4 kg	A2 (can also fly in subcategory A3)	- no flying over uninvolved people - keep horizontal distance of 30 m from uninvolved people (this can be reduced to 5 m if low speed function is activated)	Yes	- read user manual - complete online training - pass online theoretical exam - conduct and declare a self-practical training - pass a written exam at the NAA (or at recognized entity)	16*
C3 C4 Privately built	< 25 kg	A3	- do not fly near people - fly outside of urban areas (150 m distance)	Yes	- read user manual - complete online training - pass online theoretical exam	16*

More information on class identification labels is expected to become available in January 2022 (see EASA for more information: https://www.easa.europa.eu/home).

3.2.2. Specific Category

Specific Category – Civil Drones require operational authorisation from the national aviation authority. This means that any drone operation that falls into the specific category requires a risk assessment prior to the drone operation, unless the operation falls under Open Category or is a Standard Scenario (STS)[9]. If the drone operation qualifies as specific category, risk assessment will have to be carried out (EASA, 2021b). See Section 4.1.2. Site Survey and Risk Assessment for details on the Specific Operations Risk Assessment (SORA).

3.2.3. Certified Category

Drone operations within the certified category require the operator to be a licensed remote pilot and operator that is approved and certified by their national aviation authority due to the high risk of the drone operation. Drone operators intending on conducting surveys falling into this category are subject to the rules and regulation of the national aviation authority.

3.3. Drone Regulations and Aviation Authorities

Drone operators should always check their national aviation authorities when planning drone operations. National drone operation rules have been replaced by common EU rules as of July 2020. This means that once a drone operator has been certified and completed the necessary training in their national state, they may operate the drone safely within the European Union. More information can be found on the national aviation authority websites (table 1).

In Ireland, as of February 2021, registered drones may not be flown above 120 metres (394 feet) and they may not be flown within 30 metres (98.4 feet) of people, crowds, vehicles, or buildings. Drones can also not be flown over national monuments (Irish Aviation Authority, 2021). In Northern Ireland and Iceland the height restrictions remain at 120 metres (394 feet) and the drone may not be flown within 50 metres (164 feet) of buildings and/or people (Police Service of Northern Ireland, 2021; UAV Coach, 2020). Whereas in Finland, drones may not be flown above 120 metres (394 feet) and may not be flown within 30 metres (98.4 feet) from people and crowds or 1:1 ratio distance to height (Traficom, n.d.). The drone should always be operated within the visual line of sight (VLOS), or in the VLOS of an assisting observer should the flight path be beyond VLOS.

Table 3: Aviation Authorities within the project partner regions and website

Aviation Authority	Website
European Union Aviation Safety Agency (EASA)	https://www.easa.europa.eu/light/topics/flying-drone-how-be-safe-drone-pilot
Irish Aviation Authority (IAA)	https://www.iaa.ie/general-aviation/drones
United Kingdom – Civil Aviation Authority (CAA)	https://www.caa.co.uk/Our-work/About-us/UK-EU-transition/
Icelandic Transport Authority	https://www.icetra.is/aviation/drones/
Finland Traficom	https://www.droneinfo.fi

[9] Standard Scenario (STS) refers to pre-defined operations, to date there are 2 STS: STS-01 "*covers operations executed in visual line of sight ("VLOS"), at a maximum height of 120 m over a controlled ground area in a populated environment using a CE class C5 UAS.*" STS-02 "*covers operations that could be conducted beyond visual line of sight ("BVLOS"), with the unmanned aircraft at a distance of not more than 2 km from the remote pilot with the presence of airspace observers, at a maximum height of 120 m over a controlled ground area in a sparsely populated environment, and using a CE class C6 UAS*" (The European Commission, 2020).

4. Pre-Flight Fieldwork

The design and planning of drone operations requires careful considerations as it ensures the safe drone operations within the natural and built environment. Outlining the flight purpose and study design will help in the planning process of the pre-flight fieldwork.

4.1. Planning

Some drone operations require the permission of the national aviation authority prior to conducting the drone survey. This means that the drone operator will have to prepare and submit an operations manual and conduct a site survey and risk assessment. Once approved by the national aviation authority, the operator may safely conduct the survey. This is not necessary for all flight operations, but it is required for drone operations that are beyond the limits prescribed in the regulations. In that case the drone operator may apply for a Specific Operating Permission (SOP) which is issued to commercial drone operators and allows the operator to fly the drone within specific windows of time without breaking the law. To qualify for SOPs the operator has to undertake additional safety training to minimise risk and ensure high safety standards for some drone operations (Irish Aviation Authority, 2019).

Natural heritage sites can include Special Areas of Conversation (SAC) and Special Protection Areas (SPA) where different rules and regulations for natural protection of animals such as nesting birds or grey sales may exist during different times of the year. The drone operator may have to seek permission to fly in these areas and may only operate a drone following specific guidelines to protect the wildlife. Please check with your local aviation authority before operating a drone in these areas.

4.1.1. Operations Manual

The Operations Manual (OM) is necessary when the drone operator intends on using the drone for different or alternative purposes than allowed in the certified category. OMs explain to the national aviation authority how the drone operator will conduct themselves when operating drones. OMs are comprehensive detailed documents that set out their internal procedures in relation to safety, equipment, and operation, among others, to ensure that operations are conducted safely and do not pose a risk to people and property. Any organisation or commercial drone operator that uses drones will most likely have prepared an OM. OMs detail the pilot competency and include: 1. Administration, control, and responsibilities; 2. Crew composition and requirements; 3. Operational procedures; and 4. Aircraft operation. OMs will be prepared for each specific survey as the objective of the survey, and risk assessment vary depending on the flight purpose. A detailed example of an OM can be found in the Appendix.

A key part of the operational procedures includes a detailed site survey and risk assessments to ensure the safe and successful operation of drones in the field.

4.1.2. Site Survey and Risk Assessment

Depending on the category under which the drone falls and the flight purpose, site survey and risk assessment may have to be carried out. If the used drone falls under the open or certified category, or if the drone operation falls under STS in specific category, different safety procedures may have to be undertaken.

The Joint Authorities for Rulemaking on Unmanned Systems (JARUS) represents an expert group of National Aviation Authorities (NAAs) and regional aviation safety organisations. Together they have developed risk assessment guidelines for safe drone operations: Specific Operations Risk Assessment (SORA). Other risk assessment procedures equivalent to SORA may also be used by the drone operator. SORA is systematic approach to risk assessment and provides a 10-step procedure that ensure that any potential risks for drone operations are considered prior to conducting a survey. The SORA process with detailed explanations, illustrations, and additional information can be found here: https://www.easa.europa.eu/document-library/easy-access-rules/online-publications/easy-access-rules-unmanned-aircraft-systems. Be advised that drone operation safety the guidelines are being constantly reviewed.

4.2. Practical Considerations Pre-Flight Fieldwork

After having designed and planned a drone survey and having completed the operations manual, it is time to carry out the drone survey. Before going into the field and carrying out the drone survey, it is advisable to follow these simple steps to ensure safe and successful drone surveys.

4.2.1. Adjusting and Saving Data Settings

The data settings, i.e. resolution of the captured imagery, flight route, etc. should be adjusted pre-flight. This ensures that the drone operator is familiar with the settings of the drone and can produce the drone surveys efficiently in the field.

Most drones will enable the saving of the data settings to ensure that the same settings can be used more than once without having to reconfigure the settings for the survey. The data settings depend on the application and flight purpose, the needed resolution, and the desired output. Saving the data settings ensures that the drone survey can be repeated or replicated should the need arise or should more data with the same resolution be necessary. Saving the data settings, and including them in an output, also ensures that similar surveys with comparable data of the same site can be produced.

4.2.2. Plan Flight Route

A plan flight route is the survey pathway on which the drone will collect data points. The drone operator determines the plan flight route prior to entering the field through the use of available plan flight route applications. Typically plan flight route is a pathway that covers the survey site by flying parallel lines above the site at a certain elevation.

Figure 4: Example of plan flight route showcasing the flight pathway (UgCs, n.d.)

Planning the flight route in advance enables the operator to start the survey automatically without having to manually operate the drone. Following the flight route, the drone will collect imagery systematically surveying the entire site. Planning the flight route in advance maximises the operator's time in the field as the operator activates the automated flight path and can, if they wish, record the same flight path several times. Depending on the drone and the available software, different options compatible with the drones are available.

4.2.3. Drone Data Storage and Data Back-Up

The available storage on a drone depends on the model and make of the drone, most drones will have limited onboard storage available and may require additional data storage which can be installed using Secure Digital Cards (SD Cards). A wide range of these are available, however, a drone may not be able to read certain SD cards or may only operate with class 10 micro SD cards that are able to record 4k imagery. It is important to consult with the drone manufacturer, or documentation provided by them, regarding appropriate storage extensions for each drone make and model.

One parameter to consider for appropriate drone data storage is the resolution at which the imagery is acquired. This will determine how much storage is necessary to perform the survey; typically, a higher resolution drone survey requires more storage. Other factors include the format used for the survey, the frame rate of the video or the number of images required when carrying out a photogrammetry survey. The number of images required for the survey depend on the flight height, field of view (FOV) of the camera lens, the sensor size, and the amount of pixels. It is advisable to have additional storage or additional SD cards available, should you need to change the storage between surveys. Once the surveys are completed, it is advised to create data back-ups of the recorded data. Follow the instructions of the drone manufacturer to ensure that the data are safely stored.

4.2.4. Informing About the Survey

Drone surveys, while typically causing minimal impact on the environment or on people, can cause nuisance or disturb people. It is advisable to inform anyone that could be impacted by the drone survey prior to operating the drone to minimise the nuisance or disturbance. As drone operations are a still new occurrence, many people may be surprised and interested in learning more about the drone operation. It is recommended for the drone operator to wear a clearly labelled visibility jacket to easily identify them. Using signs in the area to inform people could also be considered. The use of regional information boards to inform the public about the planned and ongoing drone surveys are also recommend, see for example AVIAMAPS, currently used in Finland to track all airspace activity, including drone surveys (https://aviamaps.com/map?lang=en#p=3.92/64.96/26.1).

4.2.5. Weather monitoring

Monitoring the weather prior to conducting the drone survey is one of the most important tasks. The weather conditions of the day such as wind and precipitation could negatively impact the survey outcome. Monitoring the weather is therefore a vital task for the drone operator to avoid any unnecessary delays when operating the drone. This is particularly important in high-wind areas or where the wind direction could change quickly, such as in coastal areas or in areas with little to no wind-protection. This is to ensure the safety of the drone operator and to minimise risks of crashing the drone. Mobile applications, such as UAV Forecast (https://www.uavforecast.com/) can be used to monitor the weather and update the windspeeds (figure 6). Most drones are not able to operate in strong winds and/or precipitation. The drone should not be operated outside the manufacturer's limits for temperature, wind, precipitation, or any other limits provided by the manufacturer.

Figure 5: Mobile applications such as UAV Forecast can also be used on mobile devices available for IOS devices https://apps.apple.com/us/app/uav-forecast/id1050023752 and Android devices: https://play.google.com/store/apps/details?id=com.uavforecast

5. Conducting the Drone Survey

The following sections outline some of the practical considerations the drone operator will have to make in the field. Battery logging is survey independent and a vital part of operating drones safely. The use of ground control points depends on the purpose of the survey, and may not always be necessary.

5.1. Battery Logging, Charge State, and Battery Health

Batteries are a vital component of drones, keeping them healthy is very important. A faulty battery can produce incorrect readings, drain much faster, or lead to crash landings. It is recommended that batteries are always kept at storage charge when not in use. Batteries should never be fully drained during a flight. Draining the battery completely during a flight will trigger the battery failsafe function which causes the drone to return home automatically. However, this reduces battery life and can result in crash landings. In windy conditions, the drone requires more battery to return home safely. If the failsafe function has been triggered, there may not be enough battery charge left for the drone to return safely. Returning the drone with some battery charge left is good practice, as this minimises the risk of crash landings in case the drone cannot land immediately due to unexpected reasons such as crowds of people too close to the landing area or wind gusts.

A battery log is a record of drone batteries and charging cycles of them, this is particularly useful when the drone operator owns more than one battery and wants to keep track of the safety and health of the batteries. The battery log should detail when and how often the battery has been used and charged, and the percentage of battery life during take-off and landing to avoid crash landings or battery failures during drone operations. It is advisable to check that batteries are fully charged before going to the field to ensure that the survey can be carried out efficiently and with maximal aerial flight time. The battery log is a requirement within the OM (see Appendix).

5.2. Ground Control Points

Ground control points (GCPs) are used to mark targets placed strategically on the ground to improve the absolute accuracy of photogrammetry. The use of GCPs depends on the flight purpose and the desired output, i.e. GCPs are required when the drone surveys are used to plan restoration on historic buildings, monitoring coastal erosion or for comparison with other georeferenced data, to name a few. Hence, a 3D model of a building or of coastal features will require GCPs. A drone survey produced for promotional visual tourism will not require GCPs. The use of GCPs for promotional videos could potentially disturb the imagery, as the GCPs could seem out of place. Hence, GCPs are not always necessary to use but they are helpful to "calculate the scale, orientation, and absolute position information" (Madawalagama, Munasinghe, Dampegama, & Samarakoon, 2016, p. 3). This ensures that the modelling of the site is accurate. GCPs are visual targets and should have two high contrasting colours that make them visible from the air (figure 7). The targets are typically about one metre in diameter, smaller targets may also be used, and are typically made out of heavy plastic or wood panels. GCPs should be heavy enough to not be moved through light winds. GCPs are available in shops that sell aerial survey equipment but can also easily be home-made.

Environmentally friendly marking paint is an alternative solution, where signs will be painted directly on the ground or on a road. This is important to not obstruct traffic flow and to ensure traffic safety.

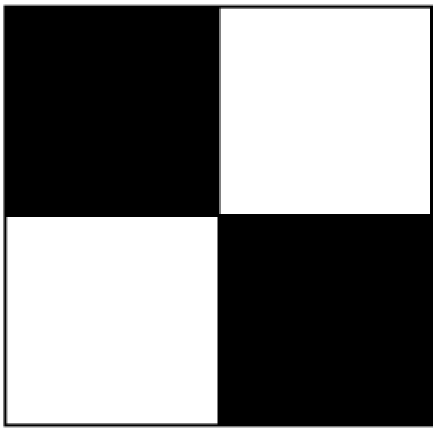


Figure 6: Example of Ground Control Point (GCP)

To ensure high accuracy for the drone data at least 3 GCPs should be placed carefully around the survey site. They should be placed offset from one another, i.e. in good distance from the to-be-surveyed site. If a building is to be surveyed, it would be advisable to place the coordinates on each of the corners of the survey site. If surveying a natural site, such as a beach or a cliff, the GCPs should not be placed in a line. Placing the GCPs across the surveyed area and in the middle will help 'pin' the captured images to the points.

GCPs should be placed in plain sight of the survey site and throughout the entire survey site. GCPs should be placed on different elevation points of the site, even if the area that is of most interest is clustered in one corner of the site. It is advisable to place GCPs in a configuration where the points could easily be connected. If the GCPs are placed as suggested in figure 8, the operator runs the risk of reducing the accuracy of the survey as a large area of interest is omitted, whereas GCPs laid out as in figure 9 will increase the accuracy of the drone survey (Propeller Aero, 2018).

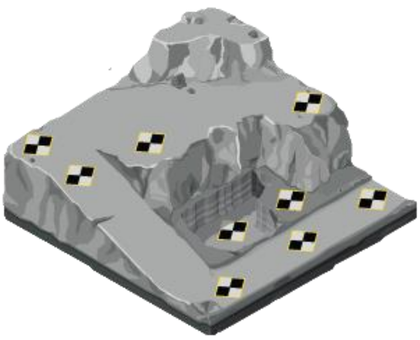


Figure 7: Example of 'badly' used GCPs (Propeller Aero, 2018)

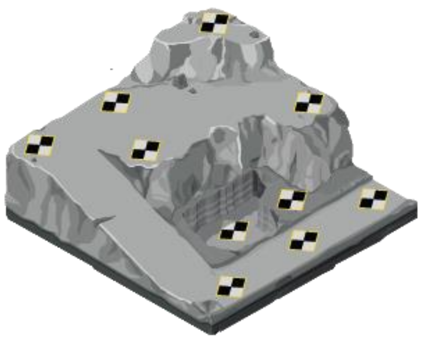


Figure 8: Example of well-placed GCPs (Propeller Aero, 2018)

Once put into place, the coordinates of the GCPs should be measured using geolocation measurement devices, such as multi frequency survey grade GNSS devices. The GCPs and their coordinates are then used in the mapping software to increase accuracy and positioning of the data collected through the drone survey. This will ensure that the model will be accurately positioned and mapped in relation to the real world around it. A range of GNSS devices are available.

5.3. Pre-Operational Safety

As some of the drone surveys may be carried out in remote places that are difficult to access, be aware of the surroundings and ensure personal safety at all times, ideally by working in pairs or teams. It is advised to let others know where you will be operating the drone and, in case a SOP has been granted, ensure that the drone is being flown within the windows that the national aviation authority specified.

5.4. Deploying the Drone

On site, or in the field, a suitable spot for the take-off and landing of the drone should be chosen. Before deploying the drone, the operator has to ensure that there are no risks or hazards that could impact the drone operation. Once this has been confirmed, the drone operator may initiate take-off. The drone will take-off to 1-1.5m or 4-6ft height when the performance of the propellers is checked before the operator can activate the planned flight path. The take-off height depends on the drone that is being used. Please consult with your drone manufacturer for details.

Most drones will have automatic flight features such as take-off options and return-to-home (RTH) or sometimes called return-to-launch (RTL). The return-home feature ensures that the drone will automatically return to the location from where the drone has taken off, either in case of a malfunction, low battery, or when the operator calls the drone back. These features depend on the make and model of the drone, it is advised that the drone operator becomes familiar with the available features of the drone before deploying the drone. It is also important that the drone operator does understand the limitation of drone operations and is ready to take over manual control in case there is a serious malfunction that makes the RTH function not work properly.

During the drone survey, the operator has to always be in the VLOS of the drone or use observers to ensure VLOS and follow the safe operation of the drone survey. The drone operator has to adhere to national aviation regulations and ensure the safe operation of the drone. The operator has to ensure that during the flight operation there are enough battery reserves for the drone to safely return to the starting point, see section 5.1. battery logging, charge state, and battery health.

Before landing the drone, the operator has to ensure that there are no risks or hazards to landing the drone before safely bringing it down.

6. Processing of Aerial Data

Data processing occurs when the collected data and footage from the drone survey is translated into usable information through data processing software and data analysis. Several data processing software are available, these include ArcGIS Drone2Map (https://www.esri.com/en-us/arcgis/products/arcgis-drone2map/overview), Pix4D (https://www.pix4d.com/), Drone Deploy (https://www.dronedeploy.com/), Precision Hawk (https://www.precisionhawk.com/), and Agisoft Metashape (https://www.agisoft.com/) among others. It is advisable to have a good understanding of how these software operate or consider investing in training for the software. This ensures that the collected drone survey data can be used for the desired output, prior to deploying the drone.

Mapping software can produce 3D point clouds which are the default data created in photogrammetry for any surface or object through geo-referenced aerial pictures. In essence, this means that the pixels are turned into points, all data is exported using point clouds, including orthomosaics. The mapping software creates the aerial pictures that are corrected to accommodate lens distortion, camera tilt, perspective, and topographic relief influenced by the elevation of the Earth's surface (Hawkins, 2016; Hung, Unger, Kulhavy, & Zhang, 2019). Once the survey data are collected, and data back-up is ensured, data processing can commence. The data can be put into the software and the software operator can create and catalogue the desired output. The operator needs to be trained in a way where they will be able to identify and mitigate any potential errors or failures that may occur, further information can be found in 3.1.1. Photogrammetry parameters.

6.1. Data Management and Data Sharing

Managing and organising the drone data appropriately on the computing device used for processing data will simplify the process. The INSPIRE Directive, a European directive on spatial data management[10], aims to standardise the data organisation of spatial data so that specific areas i.e. Metadata, Data Specifications, Network Services, Data and Service Sharing and Monitoring and Reporting, adhere to the same Implementing Rules (IR) (European Commission, 2007). This way the survey data collected by Member States is ensured to be compatible and usable by a wider community and can be used in transboundary contexts. Standardising data organisation could also contribute to promoting sustainable development by enabling local authorities to access the data and enable informed monitoring and managing of the natural and built environment.

The data processing software may require a dedicated data management structure to be able to process the data efficiently. A well-thought through folder structure to manage the data effectively should be considered as this could ensure smooth and efficient processing of the data. Embedded data management technology exist and may be useful for some applications.

Data sharing and storing are both among the initial and the final considerations of drone surveys. The sharing of the data is largely informed by the chosen output that has been decided in the planning phase. Yet, there may be opportunities to use the collected raw data for similar survey operations or to use the data for operations in a different way than originally intended. Considering how the data could be shared and would be accessible for other drone operators may therefore be helpful.

6.2. General Data Protection Regulations (GDPR)

According to the General Data Protection Regulations (GDPR), when processing data that are publicly available, any personally identifiable information, including vehicle license plates, clearly identifiable faces, etc. are required to be removed. Please familiarise yourself with the national GDPRs.

[10] The full INSPIRE Directive can be accessed here: https://inspire.ec.europa.eu/inspire-directive/2

7. Quality Assurance

Drone technology is still considered a fairly new technology and no standardised version to assure quality in the use of drones and their data exists. Currently, there is no need for a detailed survey report post-operation or final product assessment (Tmušić et al., 2020). Collected imagery of drone surveys therefore does not adhere to any standardised regulations, which becomes problematic when considering the use of drones for environmental management or monitoring where legally binding standards may exist.

Local authorities have an opportunity to design best practices for quality assurance of drone operations in the natural and built environment. Together with following the implementing the standardisation of the INSPIRE Directive, local authorities could ensure that the use of drones to monitor and manage coastal regions is also promoting sustainable development goals.

8. Drone Operator's Checklist

Flight purpose
- Understand purpose of survey
- Be familiar with national aviation regulations

Study design
- Design and plan aerial survey from start to finish
- Consider drone survey output
- Be familiar with the drone specifications

Pre-flight fieldwork
- If necessary, prepare and submit operations mantual
- Consider practicalities of pre-flight fieldwork

Conducting drone survey
- Consider practicalities in the field
- Deploy drone safely

Processing of aerial data
- Manage data effectively by considering the INSPIRE Directive
- Adhere to GDP regulations

Quality assurance
- Use best practice guidelines for quality assurance

9. References

Banfi, F. (2016). *Building information modelling–A novel parametric modeling approach based on 3D surveys of historic architecture.* Paper presented at the Euro-Mediterranean Conference.

De Vet, J. M., Edwards, J., & Bocci, M. (2016). *Blue Growth and Smart Specialisation: How to catch maritime growth through 'Value Nets'*. S3 Policy Brief Series No. 17/2016 Retrieved from https://s3platform.jrc.ec.europa.eu/documents/20182/154989/Blue+Growth+and+Smart+Specialisation.+How+to+catch+maritime+growth+through+%27Value+Nets%27/17053ed6-705f-4905-9963-c63a78df26bc

EASA, E. U. A. S. A. (2021a). Open Category - Civil Drones. Retrieved from https://www.easa.europa.eu/domains/civil-drones-rpas/open-category-civil-drones#:~:text=The%20'open'%20category%20is%20the,the%20new%20European%20drone%20rules.

EASA, E. U. A. S. A. (2021b). Specific Category - Civil Drones. Retrieved from https://www.easa.europa.eu/domains/civil-drones-rpas/specific-category-civil-drones

European Commission. (2007). INSPIRE Directive. Retrieved from https://inspire.ec.europa.eu/inspire-directive/2

Fino, E. R., Martín-Gutiérrez, J., Fernández, M. D. M., & Davara, E. A. (2013). Interactive tourist guide: connecting web 2.0, augmented reality and qr codes. *Procedia Computer Science, 25*, 338-344.

Flyability. (2021). Drones camera resolution: Three metrics you should know about. Retrieved from https://www.flyability.com/articles-and-media/drones-camera-resolution-three-metrics-you-should-know-about

French, J., & Burningham, H. (2009). Coastal geomorphology: trends and challenges. *Progress in Physical Geography, 33*(1), 117-129.

Gevaert, C. M., Persello, C., Sliuzas, R., & Vosselman, G. (2016). Classification of informal settlements through the integration of 2D and 3D features extracted from UAV data. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 3*, 317.

Giglio, S., Bertacchini, F., Bilotta, E., & Pantano, P. (2020). Machine learning and points of interest: Typical tourist Italian cities. *Current Issues in Tourism, 23*(13), 1646-1658.

Google. (n.d.). Rathlin Island East Lighthouse. Retrieved from https://www.google.com/maps/@55.3012459,-6.1722128,334m/data=!3m1!1e3

Hawkins, S. (2016). *Using a drone and photogrammetry software to create orthomosaic images and 3D models of aircraft accident sites.* Paper presented at the ISASI 2016 Seminar.

Hung, I., Unger, D., Kulhavy, D., & Zhang, Y. (2019). Positional precision analysis of orthomosaics derived from drone captured aerial imagery. *Drones, 3*(2), 46.

Ilkhanizadeh, S., Golabi, M., Hesami, S., & Rjoub, H. (2020). The Potential Use of Drones for Tourism in Crises: A Facility Location Analysis Perspective. *Journal of Risk and Financial Management, 13*(10), 246.

Irish Aviation Authority. (2019). *Basic Guidance Material for Small Unmanned Aircraft (SUA) Permission, Pilot Competency Certificate (PCC) & Special Authorisation / Approval (SA)*. Retrieved from https://www.iaa.ie/docs/default-source/misc/update-guidance-material-for-small-unmanned-aircraft-sop-pcc-sa-051119.pdf?sfvrsn=d3d201f3_0

Irish Aviation Authority. (2021). IAA says 'Know the Drone Safety Rules Before You Fly'. Retrieved from https://www.iaa.ie/news/2020/12/17/drone-safely-this-christmas#:~:text=10%20drone%20safety%20tips%20from%20the%20IAA%3A&text=Do%20not%20fly%20your%20drone%20within%205%20kilometres%20of%20an,your%20direct%20line%20of%20sight.

Jiménez López, J., & Mulero-Pázmány, M. (2019). Drones for conservation in protected areas: present and future. *Drones, 3*(1), 10.

Joyce, K., Duce, S., Leahy, S., Leon, J., & Maier, S. (2019). Principles and practice of acquiring drone-based image data in marine environments. *Marine and Freshwater Research, 70*(7), 952-963.

Kandrot, S., & Holloway, P. (2020). Applications of Drone Technology for Sustainable Development of the Coastal Zone: A Literature Review.

Kitonsa, H., & Kruglikov, S. V. (2018). Significance of drone technology for achievement of the United Nations sustainable development goals. *R-economy, 4*(3), 115-120.

Liao, Y., Mohammadi, M. E., & Wood, R. L. (2020). Deep Learning Classification of 2D Orthomosaic Images and 3D Point Clouds for Post-Event Structural Damage Assessment. *Drones, 4*(2), 24.

Madawalagama, S., Munasinghe, N., Dampegama, S., & Samarakoon, L. (2016). *Low cost Aerial Mapping with consumer grade drones.* Paper presented at the 37th Asian Conference on Remote Sensing.

Manfreda, S., McCabe, M. F., Miller, P. E., Lucas, R., Pajuelo Madrigal, V., Mallinis, G., . . . Ciraolo, G. (2018). On the use of unmanned aerial systems for environmental monitoring. *Remote Sensing, 10*(4), 641.

Nuyts, S., Murphy, J., Li, Z., & Hickey, K. (2020). A Methodology to Assess the Morphological Change of a Multilevel Beach Cusp System and their Hydrodynamics: Case Study of Long Strand, Ireland. *Journal of Coastal Research, 95*(SI), 593-598.

Palaigeorgiou, G., Malandrakis, G., & Tsolopani, C. (2017). *Learning with Drones: flying windows for classroom virtual field trips.* Paper presented at the 2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT).

Pitman, S. J., Hart, D. E., & Katurji, M. H. (2019). Application of UAV techniques to expand beach research possibilities: A case study of coarse clastic beach cusps. *Continental Shelf Research, 184*, 44-53.

Police Service of Northern Ireland. (2021). Small Unmanned Aircraft - Drones. Retrieved from https://www.psni.police.uk/advice_information/drones---small-unmanned-aircraft/drone-faqs/

Propeller Aero. (2018). How to Optimize Your Ground Control Point Placement. Retrieved from https://www.propelleraero.com/blog/how-to-optimize-your-ground-control-point-placement/

Simic Milas, A., Cracknell, A. P., & Warner, T. A. (2018). Drones–the third generation source of remote sensing data. In: Taylor & Francis.

Tap2Assist. (2014). How to scan a QR code on iPhone and iPad. Retrieved from https://www.tap2assist.me/MoreInfo/ScanningQRCodes

Templin, T., & Popielarczyk, D. (2020). The use of low-cost unmanned aerial vehicles in the process of building models for cultural tourism, 3D web and augmented/mixed reality applications. *Sensors, 20*(19), 5457.

The European Commission. (2020). *II (Non-legislative acts) Regulations - Commission implementing Regulation (EU) 2020/639 of 12 May 2020 amending Implmenting Regulation (EU) 2019/947 as regards standard scenarios for operations executed in or beyond the visual line of sight*. Official Journal of the European Union

Themistocleous, K., Ioannides, M., Agapiou, A., & Hadjimitsis, D. G. (2015). *The methodology of documenting cultural heritage sites using photogrammetry, UAV, and 3D printing techniques: the case study of Asinou Church in Cyprus.* Paper presented at the Third International Conference on Remote Sensing and Geoinformation of the Environment (RSCy2015).

Tmušić, G., Manfreda, S., Aasen, H., James, M. R., Gonçalves, G., Ben-Dor, E., . . . Mészáros, J. (2020). Current practices in UAS-based environmental monitoring. *Remote Sensing, 12*(6), 1001.

Traficom. (n.d.). Droneinfo. Retrieved from https://www.droneinfo.fi/fi/

UAV Coach. (2020). Drone Laws in Iceland. Retrieved from https://uavcoach.com/drone-laws-in-iceland/

Van Rijn, L. (2011). Coastal erosion and control. *Ocean & Coastal Management, 54*(12), 867-887.

Appendix: Operations Manual – Sarah Kandrot Environmental Consulting Services

KANDROT	SUA OPERATIONS MANUAL				
AUTHOR: Sarah Kandrot	APPROVED BY: IAA	PUBLISHED BY: Sarah Kandrot Environmental Consulting Services	ISSUE 1	REVISION 2	DATE 28 March 2019

KANDROT

Environmental and Geospatial Consulting Services

OPERATIONS MANUAL

Specific Operating Permission Number: 150383

Document Reference:

Issue 1.2 – 28 March 2019

KANDROT	SUA OPERATIONS MANUAL				
AUTHOR: Sarah Kandrot	APPROVED BY: IAA	PUBLISHED BY: Sarah Kandrot Environmental Consulting Services	ISSUE 1	REVISION 2	DATE 28 March 2019

List of Effective Pages

Page Number	Issue Number	Revision Number	Date
1	1	2	28 March 2019
2	1	2	28 March 2019
3	1	2	28 March 2019
4	1	2	28 March 2019
5	1	2	28 March 2019
6	1	2	28 March 2019
7	1	2	28 March 2019
8	1	2	28 March 2019
9	1	2	28 March 2019
10	1	2	28 March 2019
11	1	2	28 March 2019
12	1	2	28 March 2019
13	1	2	28 March 2019
14	1	2	28 March 2019
15	1	2	28 March 2019
16	1	2	28 March 2019
17	1	2	28 March 2019
18	1	2	28 March 2019
19	1	2	28 March 2019
20	1	2	28 March 2019
21	1	2	28 March 2019
22	1	2	28 March 2019
23	1	2	28 March 2019
24	1	2	28 March 2019
25	1	2	28 March 2019
26	1	2	28 March 2019
27	1	2	28 March 2019
28	1	2	28 March 2019
29	1	2	28 March 2019
30	1	2	28 March 2019
31	1	2	28 March 2019
32	1	2	28 March 2019
33	1	2	28 March 2019
34	1	2	28 March 2019
35	1	2	28 March 2019
36	1	2	28 March 2019
37	1	2	28 March 2019
38	1	2	28 March 2019
39	1	2	28 March 2019
40	1	2	28 March 2019
41	1	2	28 March 2019
42	1	2	28 March 2019
43	1	2	28 March 2019
44	1	2	28 March 2019
45	1	2	28 March 2019
46	1	2	28 March 2019

47	1	2	28 March 2019
48	1	2	28 March 2019
49	1	2	28 March 2019
50	1	2	28 March 2019
51	1	2	28 March 2019
52	1	2	28 March 2019
53	1	2	28 March 2019

Record of Amendments

Amendment No:	Date:	Amendment Details:	Amended By:	Date of Inclusion:
Issue 1 Revision 0	March 2019	Initial Issue	Sarah Kandrot	16 March 2019
Issue 1 Revision 1	24 March 2019	Response to initial first stage review	Sarah Kandrot	24 March 2019
Issue 1 Revision 2	28 March 2019	Response to final review	Sarah Kandrot	28 March 2019

Commitment of Accountable Manager

This Operations Manual describes the organisation and procedures by which Sarah Kandrot Environmental Consulting Services carries out its small unmanned aircraft operations.
It is accepted that these procedures do not override the necessity of complying with any new or amended regulation published by the Irish Aviation Authority (IAA) from time to time, where these new or amended regulations are in conflict with these procedures.

Signed Sarah Kandrot

Accountable Manager: Sarah Kandrot

For and on behalf of Sarah Kandrot Environmental Consulting Services, a company registered in the Republic of Ireland with the Company Registration Office No. 577701
Enquiries regarding the content of this document should be addressed to:

Sarah Kandrot
21 Highlands
Passage West, Cork
T12PTF2
e. skandrot@gmail.com
m. 087 2613244

Table of Contents

Part A
General

Section 1: Administration, Control & Responsibilities

1.1 Introductory Statement

It is intended that Sarah Kandrot Environmental Consulting Services (hereinafter referred to as the "Company") will operate SUA for commercial purposes in accordance with the procedures as set out in this manual and in accordance with applicable legislation in force at the time of operation.

1.2. Safety Statement

This Safety Statement sets out the health and safety policy of Sarah Kandrot Environmental Consulting Services.

Our aim, with the assistance of this policy, is to ensure that we comply with the Safety, Health and Welfare at Work Act 2005, General Application Regulations 2007 and all other relevant legislation therefore protecting the safety, health and welfare of our employees, contractors, members of the public and other third parties who may be affected by our operations.

Health and safety is everybody's responsibility and it is the responsibility of everyone at Sarah Kandrot Environmental Consulting Services to ensure that all reasonable precautions are taken to avoid injury to themselves or to others who may be affected by their actions.

Sarah Kandrot Environmental Consulting Services accepts that we have overall responsibility for ensuring the safety, health and welfare of our employees as is outlined under Section 8 of the Safety, Health and Welfare at Work Act 2005.

The success of these policies and procedures also depends on employee co-operation and is a legal requirement under section 13 of the Safety, Health and Welfare at Work Act 2005. It is therefore important that you read this document and fully understand the role you play in making it a success as well as the overall arrangements for safety, health and welfare at work.

This Safety Statement is prepared in accordance with section 20 of the Safety, Health and Welfare at Work Act 2005.

This Safety Statement is a working document and therefore is reviewed on an annual basis or at more regular intervals, should substantial changes to work practices, work equipment or the working environment take place.

Furthermore, we welcome any suggestions you may have as to how we can improve safety, health and welfare at Sarah Kandrot Environmental Consulting Services and give an undertaking to continual improvement.

1.3. Scope

This Operations Manual applies to all personnel involved with the operation of Sarah Kandrot Environmental Consulting Services.

SUA

A small unmanned aircraft (SUA) is defined by the IAA as an aircraft including a drone having a mass of 150 kilograms or less. A set of conditions are set out by the IAA. These conditions are laid down in Statutory Instruments No.563 of 2015 and further defined in Aeronautical Notice U.02 by Specific Operating Permissions.

All SUA's which have a mass of 4 kilograms or more and less than 25 kilograms may not be flown unless that person has successfully undertaken a course of safety training accepted by the Authority. In specific parts of controlled airspace certain drone operations may take place without prior permission from the Authority but must remain below 15 metres (50ft). These operations must remain outside prohibited areas and 5 kilometres from any active airfield. Operators can apply for use of segregated airspace. The operator must also have in place, a third-party liability insurance policy. This summary does not placate the operator from being familiar with the relevant documentation from the Authority which may state further restrictions.

All SUA operators must ensure that they are familiar with the contents of this manual and adhere to all operational, risk assessment, logging and reporting procedures contained in this manual.

This manual must be available for the operational reference along with the checklists for use in operations.

1.4. Definitions and Abbreviations

Acronym	**Definition**
ATC	Air Traffic Control
ATS	Air Traffic Service
BLOS	Beyond Line of Sight
COMMS	Communications
CP	Chief Pilot
EVLOS	Extended Visual Line of Sight
FOM	Flight Operations Manager
F/S	Flight Simulator
GHz	Gigahertz
GCS	Ground Control System incl. launch system, flight control and communication equipment
GPS	Global Positioning System
IAA	Irish Aviation Authority
MAN	Manual Control
MTOM	Maximum Take-Off Mass
OSD	On-Screen Display
PIC	Pilot in charge
PUT	Pilot under training
SUA	Remote Piloted Aircraft System
RTH	Return to Home
Rx	Receiver
SOP	Standard Operating Procedures
SOP	Specific Operating Permission
SUA	Small Unmanned Aircraft (up to 150 kg)
Tx	Transmitter
UAS	Unmanned Aerial System incl. airframe, payload, launch station and ground station
UAV	Unmanned Aerial Vehicle
VLOS	Visual Line of Sight

1.5. Document Control and Amendment Process

The Operations manual is issued on the authority of the Company, and the Accountable Manager (AM) will authorise all ammedments to it, as required by the Company, or by the Irish Aviation Authority (IAA).

The following procedures apply:

(a) All amendments will normally be in the form of replacement sections. Single page amendments may be issued where practicable. Complete manual digital replacement is permitted.

(b) Revision sections/pages will be annotated in the header to show the following:
  (i) Issue number
  (ii) Revision Number
  (iii) Effective date

(c) Each amendment will be accompanied by a revised list of effective pages.

(d) An amendment list record will be maintained at the front of each manual.

(e) Any amendment must be approved by the Accountable Manager.

1.6. Proposal to Amend the Manual

Any member of Staff may propose an amendment to this manual. All such proposals should be submitted to the AM, a copy of which is kept in the forms folder. The AM will forward the proposed amendment to the other post holders for consideration, holding meetings when necessary. The AM will be the final arbiter in relation to adopting or rejecting a proposed amendment.

1.7. Distribution and Control

The Company will ensure that a copy of the manual is available to all training and operations staff. One digital copy is to be lodged with the Irish Aviation Authority.

The following applies:

(a) The copy numbers and locations will be recorded.
(b) Amendments will be issued to copyholders or nominated individuals for incorporation. Amendments should be entered on receipt, and the amendment record completed.
(c) Certificates of incorporation, if applicable, should be returned to the company as soon as possible after the amendments have been completed.

The table below indicates the distribution of serialised copies of the Operations Manual and the nominated person responsible for the amendment of each.

Copy Number	Holder
1 Master Copy	Accountable Manager
2	Operations &Training Department (digital)
3	Irish Aviation Authority (digital)

The AM will have the master copy that will also be the **Control Copy**. Access to this copy will be limited to the AM. This electronic copy will be kept on a password-protected computer. Amendments are not permitted to this copy without following the procedures listed in this section.
Only current documents must remain in the parent folder. Older versions of documents must be removed to avoid confusion.

Revision procedure is as follows:

1. Report necessary changes to the AM.
2. AM will make the necessary revisions.
3. AM will apply, when necessary, to the IAA for amendment approval.
4. Save revised documents with new version number and date.
5. Move old documents to archive folder.
6. Print revised pages to update office paper document.
7. Update field versions as necessary.
8. Securely destroy old paper versions.
9. Ensure all personnel are aware of any significant changes.
10. Send revised PDF version of the Operations Manual to the IAA referencing the changes.

1.8. Referenced Documents

Type	Reference	Title	Issue	Date
Statutory Instruments	S.I. No. 563 of 2015	Irish Aviation Authority Small Unmanned Aircraft Drones) and Rockets Order, 2015	1	21/12/16
Aeronautical Notice	NR U.02	Specific Operating Permission for Small Unmanned Aircraft or Drones	1	08/01/16
Aeronautical Notice	NR U.04	Exemption from Controlled Airspace Permission Requirement for Certain Drones Operations	12	20/12/18

Additional relevant documentation:

- Pilot & SUA Flight Log
- Battery Log
- Incident Log
- Maintenance Log
- Site Safety Assessment & Risk Rating Form
- Insurance Documentation
- IAA Specific Operating Permission

1.9. Organisation

Company Profile and Organisation:
Sarah Kandrot Environmental Consulting Services has 1 type of SUA in operation presently:

- DJI Phantom 4 Pro

Sarah Kandrot Environmental Consulting Services have 1 SUA pilot and 1 dedicated payload operator.

- SUA Pilot: Sarah Kandrot
- SUA Payload Operator: Andrew O'Callaghan or sub-contracted where necessary

The payload operator may also be a sub-contracted surveyor, photographer or cameraman but will not under any circumstances be given flight control. This designated person must undergo Company training and be briefed on their responsibilities prior to undertaking this role.

1.9.1 Nominated Personnel

Accountable Manager
Sarah Kandrot
Qualification: Completion of Aeronautical Theoretical Subjects (SkyTec Academy), SUA Pilot Competency Certification
Tel: 087 2613244

Safety Manager
Sarah Kandrot
Qualification: Completion of Aeronautical Theoretical Subjects (SkyTec Academy), SUA Pilot Competency Certification
Tel: 087 2613244

Chief Pilot
Sarah Kandrot
Qualification: Completion of Aeronautical Theoretical Subjects (SkyTec Academy), SUA Pilot Competency Certification
Tel: 087 2613244

SUA Pilots
Sarah Kandrot
Qualification: Completion of Aeronautical Theoretical Subjects (SkyTec Academy), SUA Pilot Competency Certification
Tel: 087 2613244

1.9.2 Insurance Information

Policy number:	CDA22067754EUR
Underwriter:	Lloyd's Insurance Company S.A.
Insurance Adviser:	Faye Holding
Effective date:	28/03/2019
Policy expires:	27/03/2020
Renewal date:	28/03/2020
Third Party Liability:	€ 1,300,000

1.10. Responsibilities

1.10.1. Accountable Manager

The Accountable Manager assumes overall responsibility within the organisation and financial control. The Accountable Manager has corporate authority for ensuring that all operations and maintenance activities can be financed and carried out to the standard required by the authority, and any additional requirements defined by the operator.
By virtue of his position, he has overall responsibility (including financial) for managing the organisation.

They will also have overall responsibility for Sarah Kandrot Environmental Consulting Services management, including the frequency, format and structure of the internal management evaluation activities.
She will ensure that employees are aware and comply with the laws, regulations and procedures of the states in which the SUA operate and that all crew members are familiar with the laws, regulations and procedures pertinent to their duties.

The main responsibilities and duties of the Accountable Manager

- Determination of the flight safety policy
- Allocation of responsibilities and duties and issuing instructions to individuals, sufficient for implementation of the operator's policy and the maintenance of safety standards
- Monitoring of flight safety standards by means of inspections & written reports
- Recording and analysis of any deviations from the operator's standards and ensuring corrective action
- Evaluating the safety record of the operator in order to avoid the development of undesirable trends
- Conduct periodically a data evaluation as an input to the management evaluation process.
- Promoting corporate culture for safety and quality

1.10.2 Safety Manager

The Safety Manager will insure everyone in the company and any sub-contractors complies with health and safety laws. Under the guidance of the Accountable Manager he will be responsible for establishing policies that will create and maintain a safe workplace

The main responsibilities and duties of the Safety Manager

- Developing and executing health and safety plans in the workplace according to legal guidelines.
- Preparing and enforcing policies to establish a culture of health and safety.
- Evaluating practises, procedures and facilities to assess risk adherence to the law.
- Will ensure the compliance and correct methods of any Risk Assessment required for and flying activity as well as other associated duties and tasks while engaging in company business.

1.10.3 Chief Pilot

The single individual who is designated as the person responsible for the execution of all flights in accordance with the national regulations and all processes concerning the flights within the organisation.
The Chief Pilot:

- Ensures and is responsible that the operation is carried out according to the valid legal rules and regulations such as national regulations and observes changes, amendments and/or revisions in national and/or international air legislation
- Ensures and is responsible for the safe operation of aircrafts
- Manages, supports and is in charge of the pilots as superior and is responsible for their standard of performance
- Is responsible for the supervision of the licenses, medicals and ratings of all employed pilots.
- Is responsible for the compilation and content of the Operations Manual (OM).
- Supervises and ensures that crewmembers apply procedures, performance and flight safety standards in accordance with the OM. In case of ineffectiveness and/or non-compliance takes corrective action.
- Develops and implements standard operating procedures
- Ensures sufficient crew available for the scope of operation by developing planning guidelines and compilation in coordination with Ground Operations, controls the pilot’s schedules on a regular basis
- Is responsible for the crew scheduling, in compliance with the Duty Time Limitations
- Informs the AM about irregularities and occurrences of personnel and operative matters
- Organises the recruitment of new pilots
- Is responsible for the coordination and the regulatory reporting (in time) to the authorities within his field of competence (approvals, occurrence reporting).
- Provides feedback regarding standard of performance, qualification and competence
- Defines together with the AM the intended routes and aerodromes to be serviced, and is responsible for the safe implementation
- Is responsible for periodical data evaluation
- Designs a feed-back-system including closed loop principles and processes

1.10.4 Pilot in Command

The Pilot in Command has the full authority over the flight, the aircraft and the payload. His duty is the execution of a safe and efficient flight. His responsibility starts with the flight planning and ends with all the work after the flight. The Pilot in Command has to keep record of his flights and the flights of the SUA in a logbook. It is strictly prohibited to record, have record or allow recording any incorrect data or any incorrect notes. It is prohibited to damage and/or destroy the logbook. The Pilot in Command will normally be the Remote Pilot but could also be the observer if he holds a SUA operator's license.

The pilot-in-command of the SUA shall, whether manipulating the controls or not, be responsible for the operation of the SUA in accordance with the rules of the air, except that the pilot-in-command may depart from these rules in circumstances that render such departure absolutely necessary in the interests of safety.

With reference to this OM the Pilot in Command must comply with the following:

1. Ensure that all pre-flight procedures have been carried out.
2. Ensure that appropriate permissions have been obtained and IAA regulations are adhered to.
3. Ensure that the Site Safety Assessment and risk assessments have been completed.
4. Define safe working areas and cordon as necessary.
5. Liaise with crew, client and public before flight to brief fully and ensure that they understand the need to be compliant with requests or orders of the Chief Pilot.
6. Brief the observer(s) on their responsibilities.
7. Wear protective clothing and/or high visibility equipment as necessary.
8. Adhere to site safety procedures as necessary.
9. Operate the SUA in a safe, responsible and professional manner.
10. Fill in all logs and documentation.
11. Download images and video to the laptop before leaving site to ensure that appropriate information has been fully recorded.
12. On completion, correctly shutdown the SUA and equipment and check site to ensure all equipment is collected and the site is left as found.
13. Retain responsibility for the airworthiness of all craft.

1.10.5 Observer

The observer assists the Pilot-in-Command or Remote Pilot as appropriate to ensure the safety and security of the flying operation. They will announce verbally to the PIC any situation that may adversely affect the operation of the SUA. This may include, but is not limited to, other aircraft, vehicles and/or people encroaching the operating area; a change in the weather conditions or the serviceability of the SUA. When the PIC moves position to remain in visual contact with the SUA, the observer will ensure his path is free of obstruction.

Section 2: Crew Composition and Requirements

2.1. Flight Team Composition

For every operation in every phase of flight the crew will consists of a minimum:

- One Pilot in Command or
- One Pilot plus one payload operator or
- One Pilot plus one observer and/or payload operator as required.

At no point during the operation may the Pilot in Command be relieved of his/her duties. The other crewmembers, observer and payload operator may be relieved of their duties during any time of the operation given the fact that they can be replaced by qualified crewmembers.

2.2. Qualification Requirements

All personnel operating Sarah Kandrot Environmental Consulting Services unmanned aircraft as Remote Pilots must have undertaken the following:

- IAA approved ground training and PCC Flight Assessment
- Sufficient flight training to satisfy Sarah Kandrot Environmental Consulting Services Chief Pilot
- Current and recency Requirements (See para 2.4)

2.3. Crew Health

All personnel operating Sarah Kandrot Environmental Consulting Services unmanned aircraft must have a level of medical fitness equivalent of those required for a Private Pilot's License; however no formal certification is needed at this point.

Being both mentally and physically fit to fly is the only acceptable standard when conducting flight operations. The pilot in command is responsible for the safe operation of the SUA and has to make sure that they are appropriately fit. Under no condition may an operation continue if the capability of the Pilot in Command is impaired by:

- Alcohol and other intoxicating liquor;
- Narcotics;
- Drugs;
- Sleeping tablets;
- Pharmaceutical preparations;

- Immunization;
- Deep diving; 20.9.2008 EN Official Journal of the European Union L 254/209
- Blood donation;
- Meal precautions prior to and during flight;
- Sleep and rest; and
- Surgical operations.
- or any other influence which may cause degraded flying capability.

The mnemonic I.M.S.A.F.E. should be used:

-	**I**	Illness	Do I have an illness or any symptoms of an illness?
-	**M**	Medication	Have I been taking prescription or over-the-counter drugs?
-	**S**	Stress	Am I under psychological pressure from the job? Worried about financial matters, health problems or family discord?
-	**A**	Alcohol	Have I been drinking within eight hours? Within 24 hours?
-	**F**	Fatigue	Am I tired and not adequately rested?
-	**E**	Eating	Am I adequately nourished?

2.4. Currency and Recency

Where personnel train on the various SUA operated by Sarah Kandrot Environmental Consulting Services currency will be maintained on each type and each pilot will be approved as such by the Chief Pilot.

Personnel operating as Pilot-in-command who have not operated an SUA for more than 90 consecutive days require, prior to being assigned as Pilot in Command of a flight, to perform a training flight that includes 3 take-offs and landings.

2.5. Supervision of SUA Operations

The Chief Pilot will ensure that ALL operations are conducted in compliance with IAA regulation and this Operations Manual.

2.6. Logs and Records

On each operation, specific logs of the following will be recorded:

- Onsite weather conditions
- Battery voltage before and after each flight
- Pilot hours
- Aircraft hours
- Any incident small enough not to warrant Mandatory Occurrence Reporting
- Site risk assessment
- IAA Specific Operating Permission

2.7. Crew Training

In order to remain current all pilots will inform the Chief Pilot if they cannot conform to the requirements for type or currency for whatever reason. A request for a training flight can be made any time and must be requested if an operational task has elements which the remote pilot is not familiar with or is unsure of how to complete the task.

All pilots are encouraged to familiarise themselves with any new company SUA and all latest software updates. Training will take place under the guidance of the Chief Pilot and where required under the approval of an RTF.

2.8. Accident Prevention and Flight Safety Programme

Accidents/Serious Incidents involving the operation of a SUA are to be reported to the Air Accident Investigation Unit of the Department of Transport, Tourism and Sport and also to the Flight Operations Department of the IAA.

Incidents are to be reported to the Flight Operations Department of the IAA. Incidents that are likely to need reporting include any incident that endangers or which, if not corrected, would endanger an aircraft, its occupants or any other person.

Any occurrence relating to the SUA operation that resulted in injury or the potential of injury to crewmembers, client or members of the public should be reported. Any occurrence resulting in a collision or near miss with another aircraft should be reported. For this purpose, download from the IAA website the SCOTS Form 1. This is to be used for all Mandatory Occurrence Reports and any Voluntary Reports which this company or any individual in the company feels should be reported.

Following the Operations Manual procedures correctly is the best method of ensuring a safe operation be minimised through preparation and risk assessment. Flight crew must also be fully familiar with the emergency failsafe mechanisms of the DJI flight controller.

Flight crew should wear appropriate protective and high visibility clothing. As a minimum, this should be a high visibility vest. If operating in an industrial environment and protective clothing is provided by the client, it must be used as directed.

The PIC has full responsibility for carrying out operations safely. If at any time the PIC is in doubt, the operation should be halted until the risk is acceptable, regardless of pressure from the pressure from the client or time constraints. Safety of the public, client and crew is paramount and must not be compromised in any way.

Examples of reportable occurrences would be:

- -Loss of control/data link

- -Navigation failures
- -Any incident that injures a third party
- -Battery fire

Information filed and retrieved in SCOTS Form 1 log will be implemented in checklists or flight safety briefings in the future to ensure a constant process of improvement.

Section 3: Operational Procedures

3.1. Types of Operations

The majority of Sarah Kandrot Environmental Consulting Services operations will entail aerial photography and videography for the following:

- Environmental & coastal erosion monitoring
- Aerial photogrammetry
- Geological Surveying
- Archaeology
- Agriculture (crop and livestock monitoring, forestry)
- Architectural planning and visualisation

Sarah Kandrot Environmental Consulting Services is also open to new uses for SUA which may arise in the future. Any new roles will be investigated, tested and demonstrated for the IAA's approval.

3.2. Operating Limitations and Conditions

Aircraft Type No 1: DJI Phantom 4 Pro	**IAA SUA Registration No: IE-122467**
Operational Ceiling – company surveying activities	400ft agl (in line with IAA regulations)
Operating Maximum Horizontal distance from RP – company surveying activities	300 meters
Operational Endurance	Approx. 30 minutes
Maximum Speed	S-mode: 39.1 knots A-mode: 50.4 knots P-mode: 43.4 knots
Maximum OAT	40°C
Minimum OAT	0°C
Maximum Take-off Mass (MTOM)	1.388 kg
Maximum Wind speed for operation	19 knots or 10 m/s

3.3. Flight Planning & Preparation

3.3.1 Determination of intended task and feasibility

Before the commencement of any operation, Sarah Kandrot Environmental Consulting Services designated remote pilot will evaluate the proposed task, ensure that the operation is possible within the bounds of safety, regulation and practicality and if the desired end-product is achievable. If the operation falls outside these bounds and cannot be modified to comply, it will not be undertaken.

3.3.2 Site Survey and Risk Assessment plus Hazard Identification

Before the commencement of any operation, Sarah Kandrot Environmental Consulting Services designated pilot in command will research the proposed location to ensure that it is suitable for SUA operations.

A risk assessment is required for all operations in Irish Controlled Airspace and should be normal practise for all other flights.

A Site Survey and Risk Assessment (Annex D) will be carried out prior to the date of operation. This Site Survey and Risk Assessment will help identify the location particulars but more importantly any hazards that might increase the risk of the operation.

3.3.3 Hazard Identification & Risk Management

The Site Survey and Risk Assessment will identify all hazards.

- Hazards identified will have their risk assessed using the risk matrix. Any risks deemed acceptable with mitigation or unacceptable will be entered in the Risk Rating Form (Annex D) and mitigating criteria to reduce the risk to acceptable levels will be recorded here.
- The hazard will be re-assessed with the influence of mitigating actions considered. If the risk is deemed acceptable the operation can be completed. If the risk is still unacceptable the operation cannot be authorised.

3.3.4 Pre-notification

Should the site fall within a congested area, controlled airspace or within 5NM/ 8KM of an aerodrome boundary, contact will be made with the IAA and controlling authority (local ATC) requesting permission for the operation. The operation will only take place after permission has been achieved. If applicable, local Garda Siochana may also be notified. Use of IAA Form No. U.F.101 will be made when flight in controlled airspace above 50 feet is required and falls outside the limitations of this paragraph. (See Appendix E)

Should it be necessary to conduct operations outside the regulations, contact with the IAA will be required. A general description of the intended operation, reasons for requiring permission to operate outside the regulation and the safety case identifying mitigating actions that allow the operation to be conducted at an acceptable risk level will be given to the IAA. If approval is granted the specific operation may be completed.

3.3.5 Site Permissions

The permission of the take-off and landing site landowners must be sought before the commencement of any operation.

3.3.6 Weather

3 Days before an operation, long range weather forecasts will be reviewed. This will inform the crew of the conditions likely to be faced at the site and any precautions which need to be taken. In the event of weather conditions that fall outside of the operational envelope of the aircraft, the operation will be cancelled or postponed. Onsite weather checks will also be carried out by the designated remote pilot.

The following websites can be used to gather weather forecast information.

http://www.uavforecast.com/
http://www.weathercharts.org/ukmomslp.htm
http://www.windguru.cz/int/index.php?sc=4862

The pilot in command should not commence any flight when the weather indicates it will be exceed any aircraft limits. No operation may be executed with the following conditions forecasted in the period one hour prior to flight and one hour after scheduled landing time:

- thunderstorms
- heavy turbulence and/or wind shear
- heavy precipitation
- sandstorms
- volcanic ash

3.3.7 Preparation and Serviceability of Equipment and SUA

Before an operation, the aircraft that is to undertake the work will be checked over thoroughly to ensure that it is safe to fly. These checks will include all fastenings, propeller condition, and motor bearing condition, fixings of flight controller components, payload fastenings and frame checks for any damage. All supporting equipment will also be checked to ensure serviceability. All batteries will be charged including flight packs, gimbal power packs, RC transmitter packs and camera packs. If any maintenance or repair works have been carried out on the aircraft, a flight test will be carried out to prove serviceability and safety. A pre-flight check will also be made of the aircraft prior to take-off as shown in the pre-flight checklist in Appendix B

3.3.8 Charging and Fitting Batteries

Lithium Polymer batteries are used to power Sarah Kandrot Environmental Consulting Services aircraft. An undesirable by-product of these batteries is the ability to self-combust. Caution must be used in the care and management of the flight packs. Flight batteries may be charged using chargers approved by the Chief Pilot/ Packs will only be charged at 2C charge rate for safety and pack longevity. Flight packs will have their cell voltages recorded before and after charging in the battery log. (See appendix C)

Batteries will be charged on a non-conductive and non-combustible surface away from other equipment in case of fire from a battery failure, and will be stored in LiPo safe storage cases capable of withstanding 1400 degrees C. Flight packs must not be discharged past 3v per cell or irrecoverable damage may occur.

Real time monitoring of flight pack voltage will be available to the pilot on an on-screen display via live telemetry.

3.3.9 Data Protection & Privacy Law

The EU General Data Protection Regulation (GDPR) came into effect on May 25th, 2018 and replaces the Data Protection Directive 95/46/EC. From this date, GDPR, in conjunction with specific Irish law, will give more rights to the individual and will place more obligations on SOP holders and all drone operators, in terms of accountability and transparency, when using and storing personal data.

In undertaking the business of drone operation, you create, gather, store and process large amounts of data on a variety of data subjects including third party client information and members of the public. You should be mindful of the Data Protection Commission guidance to only collect data that is 'adequate, relevant and not excessive.'

Section 2(1)(d) of the Data Protection Acts requires that "appropriate security measures shall be taken" in relation to data. Any data captured should be stored in an appropriately secured environment. Access to the data should be controlled, logged and monitored. This may mean storing imagery or footage on a secure or encrypted medium and only to authenticated and authorised users.

Where a drone operator is undertaking work on behalf of a client, the personal data transmitted and captured by the drone should be secured while in their possession and not retained after handover to a client.

There are several practical steps you can take to ensure that you comply with the data protection regulations when using drones;

- Ensure you have the consent of the individuals whose personal data you will capture, by making timely use of notifications, signage, media, or publicity.
- Ensure that the drones are operated only with the sensor equipment necessary to achieve the purposes for which they are intended, and only record the personal data required to achieve the purposes intended and for which consent has been obtained.

- Have robust security and access controls in place ensuring only authorised persons have access to the images. Ensure that any transfer of personal data is secured and is possible with the consent already obtained.
- Consider mechanisms that automatically blur faces when they are inadvertently filmed during a data collection, or other means to ensure that unintended capture of personal data is avoided, or removed before further processing occurs.
- Use a software programme that automatically deletes the remaining personal data collected once the task is completed.

Operation and usage of Drones is primarily regulated by the Irish Aviation Authority however advice is given on Data Protection and Privacy law. It is up to drone operators to comply with these all regulations and ensure they are operating in accordance with any Data Protection requirements. This information is maintained and is updated over time so it is important that operators are up to date in their knowledge of these regulations, along with any considerations they need to undertake regarding the Data Protection and privacy. Advise from the Data Protection Commission can be found on this link.

https://www.dataprotection.ie/docs/Guidance-on-the-use-of-Drone-Aircraft/1510.htm

3.4. On Site Procedures

3.4.1 Site Survey

Sarah Kandrot Environmental Consulting Services designated remote pilot will carry out the onsite survey to confirm the Risk Assessment is correct and that the site is as expected from the research on the intended location. Any variations on this information will be evaluated to ensure continued safety and suitability of the operation. All hazards identified will be reconsidered to confirm assumptions still apply. If not a full Hazard and risk assessment will be conducted as per Annex D.

3.4.2 Selection of Operating Areas and Alternatives

Onsite, a suitable take-off and landing site will be chosen that fits the requirements of the operation. Alternate landing sites across the area of operation will be chosen so as to allow for quick/emergency landings to be carried out should the need arise.

3.4.3 Crew Briefing

At the start of the operation, the crew of the operation will be briefed. The standard briefing will be given by the designated remote pilot and will include the following:

- Actions on 3rd Party Approach
- Actions on spotting other drone/manned aircraft
- Actions on Approaching weather
- Indicate your designated Alternate Landing Area
- Indicate your designated Holding Area (Safe Hover Area)

- Indicate how to set Return to Home in case of pilot incapacitation

If a third person is being used or you intend to have a customer assisting in lookout etc then that person needs to be included in the briefing.

3.4.4 Cordon Procedure

The take-off and landing area may be cordoned-off to keep third parties safe from aircraft operations. Unless segregated airspace has been granted, in operating in accordance with the IAA Statutory Instruments No. 563 of 2015 and Sarah Kandrot Environmental Consulting Services IAA Permission for Specific Operating Permission the following shall be adhered to:

The aircraft shall not be operated;

(a) within a prohibited area, a restricted area, or controlled airspace without prior permission from the Irish Aviation Authority and in accordance with latest approvals listed in the companies Specific Operation Permission,
(b) in Air Traffic Services airspace, other than controlled airspace, within 5 km of an aerodrome during periods of aircraft operations, unless the aerodrome operator has given permission;
(c) at a distance of less than 30 metres from a person, vessel, vehicle or structure not under direct control of the operator;
(d) at a distance of less than 120 metres from an assembly of 12 or more persons not under direct control of the operator;
(e) beyond direct unaided visual line or sight and not farther than 300 metres from the point of operation;
(f) at a height of more than 120 metres above the ground or water;
(g) permitting or attempting to permit any article or animal, whether or not attached to a parachute, to be released from that aircraft;
(h) unless there is in place a third-party liability insurance policy covering the operation of the system which is acceptable to the Authority.

3.4.5 Communications

Sarah Kandrot Environmental Consulting Services operations crew may communicate using two-way radio headsets. This will ensure that difficult communication due to outside noise or distance between the crew will not compromise the safety or efficiency of the operation. The payload operator will have an ear free in order to listen to customer input, or outside warnings. The pilot will receive any safety warnings or customer input from the payload operator. This ensures no disturbance to the pilot's concentration from unwanted sources and only essential information is relayed. The pre-flight briefing will cover the eventuality of crew communications failure and the procedures to be taken. These communications devices will not operate on a conflicting frequency to any flight operations equipment and Sarah Kandrot Environmental Consulting Services pilots will hold any radio license (if required) to operate them.

Consideration must be given to the requirement to be able to receive mobile calls from Air Traffic Control if operating under an UF101 approval in controlled airspace. This may be delegated to the observer if present or a team member who can immediately act on instructions from ATC by informing the Remote Pilot as necessary.

3.4.6 Weather Checks

Forecasts will be updated before all flights. Wind speed should be measured using the latest weather information or anemometer if available. The aircraft will not be operated outside its manufacture's limits for temperature, wind, precipitation or other parameters that are highlighted.

3.4.7 Loading of equipment

All payloads must be operated within the limitations set down in the manufacturer's manual. Payloads on multirotor aircraft acquired by Sarah Kandrot Environmental Consulting Services in the future may be changed. The aircraft may be required to lift other cameras, or a payload mounting capable of carrying many different cameras or devices. These will all have been balanced correctly to ensure smooth and safe operation of the gimbal and will never exceed the MTOM of the aircraft. The payloads all will have secure fixings in case of a failure. Correct function will be assessed onsite before attempting the operations, if changes were made on the day, but preferably prior to the required day of operation.

3.5. Flight procedures

3.5.1 Use of Checklists

Checklists are employed to ensure all equipment needed is present, that the aircraft to be flown is in an airworthy condition and that steps are taken in the correct sequence and without omission. Ideally two personnel will be involved in checklist completion, and if this is the case, a 'challenge-response' method will be utilised. Specific checklists are featured in Appendix C of this manual.

3.5.2 Pre-departure

A pre-departure checklist ensures all equipment needed to safely complete an operation is present. This also has a battery charging section to be completed ensuring all batteries are fully charged before departure to the site.

3.5.3 Pre-flight

The pre-flight checklist runs through the procedure used to inspect the aircraft and payload to ensure its airworthiness. This also includes a last-minute voltage check of the flight batteries to ensure full charge. Don't forget the site survey.

3.5.4 Start-up

The start-up checklist runs through the power-up procedures of all flight operation equipment to the take-off phase of flight. Aircraft modes will also be confirmed through LED/ on-screen display indications (OSD). The pilot will announce **'Rotors On'** before application of power.

3.5.5 Take-off

When the crew is ready for take-off, after a last scan to ensure no hazards exist, the pilot will start the timer on his radio transmitter or watch and announce **'taking off'** before starting the engines. The aircraft will then lift-off to a height of around 4-6ft off the ground to clear the ground effect of its propellers. A flight control check is then performed to satisfy the pilot that the aircraft responds as it should to his control input before departing to start the task.

3.5.6 In flight

The designated pilot's primary concern whilst airborne is the safety of personnel and other airspace users. The pilot will also ensure that all regulations are adhered to. The operator will monitor elapsed flight-time and ensure to land before the estimated time for battery depletion as well as monitoring LED/ OSD indications for low power. The pilot will fly the craft with anticipation of potential failures at all times and will ensure Failsafe and Return-to-home (RTH) features are armed at all times. The pilot will sacrifice the craft over the safety of personnel and property.

3.5.7 Landing

After returning from the operation, the pilot will scan the landing site for hazards. Once satisfied, the pilot will call **'Landing'** before lowering the aircraft to the ground.

3.5.8 Shut-down

When the aircraft has come to a rest after landing, the shut-down checklist will be completed. Upon shutdown of the rotors the pilot will call **'rotors off'** and will never apply further power without briefing the crew. Subsequent actions will include unplugging the aircrafts flight batteries first to make the aircraft safe, the pilot will call **'safe'** and then on to the shut-down of radio links, video uplinks and the payload. Other than the safety aspect of unplugging the flight packs, the main aim of the shut-down checklist is to ensure that no equipment is left on and subsequently flattening batteries prematurely therefore compromising the continuing operation.

3.6. Emergency procedures

3.6.1 Loss of power to engine

Motor failures may cause the SUA to enter an uncontrolled descent. Multi-rotor aircraft have no gliding capability and this kind of failure will certainly result in a crash. The remaining motors will be shut-down to prevent spinning props making the descent more unpredictable.

A warning will be called by the pilot to the observer and anyone near to make them aware of the situation and potential danger.

3.6.2 Aircraft Battery Failure

This is the same as total motor failure on single battery aircraft. The aircraft will quickly descend to the ground, uncontrollably with no power. Some Aircraft carry two battery packs and are capable of sustaining flight on one battery alone, long enough to affect a safe landing. Should both fail, the aircraft will descend uncontrolled, and a loud warning will be called to help those around avoid the danger.

3.6.3 Transmitter Battery Failure

The Sarah Kandrot Environmental Consulting Services Multirotors are equipped with the DJI GO 4.0 app. This system is set up to "fail safe" in the event of loss of control link to the aircraft which is what will happen in this event. Failsafe mode will give control to the flight controller which will climb the aircraft to calculated safety height if below that height, or stay at its present height, if above calculated safety height. The aircraft will then return to overhead its departure point and wait for 5 seconds to see if it can re-establish the control link. Should this not be possible, the aircraft will auto-land at its departure point and shut-down its motors, the shut-down checklist will then be read by the pilot. The designated pilot will ensure this mode is armed before flight.

3.6.4 Loss of Control Frequency

The aircraft will be programmed to enter Autoland/ RTH mode. The shut-down checklist will be read and the aircraft made safe. Investigations will then be made into the failure of the control frequency and the Mandatory Occurrence Report will be completed. No further flights will take place at that site until a cause and resolution has been found.

3.6.5 Malicious or accidental interference with control frequency

If the source of the interference cannot be found and stopped, the operation will be cancelled.

3.6.6 Pilot Incapacitation

Should the pilot become incapacitated for any reason, the payload observer is trained to activate the return-to-home function on the pilot's radio transmitter. This switch is clearly marked and will activate a similar response to the failsafe function. Return-to-home mode will give control to the flight controller which will climb the aircraft to a predetermined height (set to the calculated safety height) if below that height, or stay at its present height, if above calculated safety height. The aircraft will then return to overhead its departure point and wait for 5 seconds for further instruction. If none are received, the aircraft will auto-land at its departure point and shut-down it's motors. The aircraft will be made safe and appropriate help given to the pilot.

3.6.7 Fly Away Action

Fly Aways are uncontrolled aircraft flight where no control input from the pilot has any effect. A Fly Away is very unlikely but still may occur. If the aircraft does not encounter any obstacles, the auto-land feature is likely to be activated when the battery is depleted and the aircraft will attempt to land wherever it is. The other possibility is a collision with an obstacle or the ground. Should a fly-away occur, the flight crew will note the speed and flight direction of the aircraft and inform local Air Traffic Control, if applicable, and the local Gardai. A reasonable estimation could be made about the potential range of a fly-away from the battery duration remaining and the aircrafts speed. Before flight, the designated pilot will ensure that the main controller is programmed to limit flight to 500m range and 400ft height. This may limit the range the SUA will travel. Use reporting form below from the Authority in the event of a lost drone;

https://www.iaa.ie/general-aviation/drones/lost-a-drone-form

3.6.8 Battery fire

LiPo batteries in their initial stages (10-15secs) are almost impossible to extinguish. The designated pilot must have a fire extinguisher on hand to extinguish any secondary fires which may occur. All fires will be reported with a Mandatory Occurrence Report.

Part B
Aircraft Operation

1. Technical Description

1.1 Designation and Type

1. DJI Phantom 4 Pro

1.2 Aircraft Specifications

Description	DJI Phantom 4Pro
Span/Diameter	Diagonal size: 350 mm (Propellers Excluded) Propeller dimensions: 9.4 x 2.8 x 0.8" / 240 x 70 x 20 mm Diagonal diameter: 590 mm
Flight test weight (Kg)	1.388 kg
MTOM (Kg)	1.388 kg
Engine Type	DJI Part 24 2312S Clockwise Rotation Motor
Number of engines	4
Battery size	468 g
Propeller size	9.4 x 2.8 x 0.8" / 240 x 70 x 20 mm
Flight Controller	DJI Phantom 4 Pro RC
GPS Unit	GPS & GLONASS
Ground Station Type	DJI Phantom 4 Pro RC + Apple iPad with DJI GO 4 App
Control Frequency	2.400 - 2.483 GHz and 5.725 - 5.825 GHz

1.3 Ground Station Control System and Communications Specification

Ground station device:	DJI Phantom 4 Pro RC + Apple iPad
Aircraft assistant software:	DJI GO 4 + Pix4Dcapture

APPENDIX A – Specific Operating Permission

Put specific Permission in here when received from the IAA.

APPENDIX B - Checklists

PRE-DEPARTURE CHECKLIST

ITEM	CHECK	TICK
AIRFRAME	CONDITION	
CAMERA	CONDITION AND FUNCTION	
GIMBAL	CONDITION AND FUNCTION	
SD CARD	FORMATTED	
FIRMWARE	UP TO DATE	
IPAD / IPHONE	CONDITION AND CHARGE	
REMOTE CONTROLLER	CONDITION AND CHARGE	
USB LEAD	CONDITION AND FUNCTIONALITY	
CHECKLISTS, MANUALS, LOGBOOKS	PRESENT	
FLIGHT BATTERIES	CONDITION AND CHARGE	
BATTERY CHARGER + WALL PLUG + US/UK ADAPTER	CONDITION	
PROPELLORS	CONDITION	
SPARE PROPELLORS	CONDITION	
FIRST AID KIT AND FIRE EXTINGUISHER	CONDITION AND CONTENTS	
HARD HATS AND HI-VIZ WAISTCOATS	CONDITION	
CORDON CHAIN AND POLES	CONDITION	
WARNING SIGNS	CONDITION	

ARRIVAL CHECKLIST

ITEM	ACTION/CHECK	TICK
SITE SURVEY	CARRY OUT SITE SURVEY WITH OBSERVER	
FLIGHT PLAN/BRIEF	CARRY OUT FLIGHT PLAN/ BRIEFING WITH CREW/CLIENT	
AIRFRAME	UNLOAD AND CHECK FOR TRANSIT DAMAGE	
PROPELLERS	CHECK NUT TIGHTNESS	
IPAD	SET UP	
GROUNDSTATION	SET UP AND CHECK FOR SOLID LINK	
CORDON	SET UP TO ENSURE SAFETY AND COMPLIANCE (IF REQUIRED)	
HARD HATS AND HI-VIZ	ISSUE AS NECESSARY	
CREW IDENTIFICATION	ISSUE AS NECESSARY	
CREW COMMUNICATIONS	ISSUE AS NECESSARY	
FIRST AID KIT	EASILY ACCESSIBLE POSTION	
FIRE EXTINGUISHER	EASILY ACCESSIBLE POSITION	
CREW/HELPERS	POSITIONED CORRECTLY FOR SAFE OPERATIONS	

ON SITE SURVEY

SARAH KANDROT ENVIRONMENTAL CONSULTING SERVICES

PILOT

PAYLOAD OPERATOR

HELPER 1

HELPER 2

WIND SPEED KTS

WIND DIRECTION

OUTSIDE TEMP (C)

ITEM	CHECK	FINDING
OBSTRUCTIONS	MASTS, WIRES, BUILDINGS, TRAIN LINES, TREES, LAKES, RIVERS OR INDUSTRIAL HAZARDS	
VIEW LIMITATIONS	IMPAIRMENT OF LINE OF SIGHT	
PEOPLE	IS A CORDON NEEDED/CROWD CONTROL	
LIVESTOCK	STOCK OR WILDLIFE CONSIDERATIONS	
SURFACE	FLAT, SLOPED, ROUGH, WET?	
PERMISSION	WRITTEN LANDOWNERS PERMISSION	
PUBLIC	RIGHT OF WAY, FOOTPATHS, GATES, INCURSIONS	
AIR TRAFFIC	CLEARANCE IF NEEDED	
COMMUNICATION	CREW COMMS NEEDED?	
PROXIMITY	FROM OBSTACLES, BUILDINGS	
TAKE-OFF AREA	SAFE AND CONVENIENT PLACE	
LANDING AREA	SAME AS TAKE OFF, OR DIFFERENT	
OPERATIONAL AREA	HAZARDS OR OBSTACLES	
EMERGENCY AREA	SAFE CONVENIENT POSITION	
HOLDING AREA	SAFE CONVENIENT POSITION	

PRE FLIGHT CHECKLIST

ITEM	ACTION/CHECK	TICK
AIRCRAFT	CHECK FOR DAMAGE OR WEAR. CHECK SD CARD IS INSERTED CORRECTLY.	
PROPELLORS	CHECK CONDITION. CHECK PROPELLORS ARE CONNECTED TO CORRECT MOTORS (MATCH BLACK/GREY DOTS). CHECK THAT THEY ARE LOCKED IN PLACE.	
FLIGHT BATTERY(IES)	CHECK CELL VOLTAGES FOR FULL CHARGE, RECORD VOLTAGE IN BATTERY LOG.	
	START UP PROCEDURE	
REMOTE CONTROLLER	FIT IPAD/IPHONE TO RC SECURELY. CONNECT DEVICES WITH USB CABLE.	
CAMERA /GIMBAL	REMOVE GIMBAL CLAMP AND FOAM FITTING.	
REMOTE CONTROLLER	POWER ON	
AIRCRAFT	POWER ON	
GROUNDSTATION	TURN ON DJI GO 4 APP. CHECK AIRCRAFT STATUS BAR INDICATES ‘READY TO GO (GPS)’.	
CREW, PUBLIC AND CLIENT	ENSURE ALL ARE IN CORRECT AND SAFE POSITIONS	
CLEARANCE	DO WE HAVE AIR TRAFFIC CONTROL CLEARANCE (IF REQUIRED)	
AIRCRAFT	LAST CHECK OF GPS LOCK AND FLIGHT CONTROLLER STATUS	
	TAKE OFF PROCEDURE	
POWER UP & TAKE-OFF	FINAL LOOK AROUND AND CONFIRM IT IS SAFE TO TAKE OFF. CALL “TAKING OFF”. PERFORM AN AUTO TAKEOFF IN THE DJI APP TO HOVER AT 4 FT/1.2 M.	
FLIGHT CONTROLS	CHECK CORRECT OPERATION OF FLIGHT CONTROLS	
DEPARTURE	DEPART TAKE-OFF AND LANDING AREA AND COMMENCE FLIGHT	

LANDING & SHUT-DOWN CHECKLIST

	PRE-LANDING PROCEDURE	
ITEM	**ACTION/CHECK**	**TICK**
BATTERY LEVEL	CHECK SUFFICIENT TO RETURN & LAND	
LANDING AREA	ENSURE LANDING SITE IS CLEAR	
ORIENTATION	ENSURE AIRCRAFT LANDING WITH FRONT FACING AWAY	
AIRCRAFT	CALL “LANDING”. LAND AIRCRAFT.	
	AFTER LANDING	
AIRCRAFT	ENSURE MOTORS ARE TURNED OFF. REMOVE FLIGHT BATTERY AND CALL “SAFE”	
AIR TRAFFIC	CALL ON THE GROUND IF APPLICABLE	
REMOTE CONTROL	POWER OFF	
	AFTER SHUT-DOWN	
AIRCRAFT	CHECK FOR DAMAGE, WEAR, CONDITION AND TIGHTNESS OF PROPS	
AIRCRAFT	REMOVE SD CARD AND STORE SECURELY FOR DATA DOWNLOAD ON RETURN FROM FIELD SITE	
FLIGHT BATTERIES	CHECK RESIDUAL VOLTAGE AND RECORD IN BATTERY LOG	
FLIGHT BATTERIES	ALLOW TO COOL AND RECHARGE FOR NEXT FLIGHT IF REQUIRED	
AIRCRAFT, RC, IPAD/IPHONE	DISMANTLE AND RETURN TO STORAGE CASE	
FLIGHT LOG	COMPLETE	

APPENDIX C – Records and Logs

KANDROT	SUA OPERATIONS MANUAL				
AUTHOR: Sarah Kandrot	APPROVED BY: IAA	PUBLISHED BY: Sarah Kandrot Environmental Consulting Services	ISSUE 1	REVISION 2	DATE 28 March 2019

AIRCRAFT FLIGHT LOG Sample

Date	Take Off Time	Landing Time	Total Flight Time	RPAS & S/N	Weight <7kg or >7kg	Name PIC	Name Observer	Name Payload Operator	Battery(s) Used	Location	Purpose of Flight	Remarks

BATTERY CHARGE LOG Sample

Battery Number	Battery Residual Charge Before Charging %	Date of Charge	Charge Input mAh	Flight Duration	Pre-Flight Battery Charge %	Notes

KANDROT	SUA OPERATIONS MANUAL				
AUTHOR: Sarah Kandrot	APPROVED BY: IAA	PUBLISHED BY: Sarah Kandrot Environmental Consulting Services	ISSUE 1	REVISION 2	DATE 28 March 2019

MAINTENANCE SOFTWARE & FIRMWARE LOG Sample

Date	Reason for Maintenance / Update	Work Done	Parts Replaced	System Tested Yes / No	Notes

APPENDIX D - Site Survey & Risk Assessment Matrix Samples

Site Survey - Sample

Job Number	1234567	
Job Date	24 March 2019	
Name/Company	**Email**	**Phone**
Sarah Kandrot Environmental Consulting Services	skandrot@gmail.com	087 2613244
Location	**Lat/Long**	**Altitude**
Myrtleville, Co. Cork	51°46'58.04"N 8°17'41.88"W	0 m AMSL
Google Map/Sketch		

SITE Survey Considerations	Finding	Hazard Identified*
Air Space	Shannon CTA Cork	
Restricted Areas	Nearest is EID13 280.83° 20.08 nm / 37.2 km from site	
NOTAMS	None	
Urban/Congested Area	No	
Airports/Airfields	Nearest is EICK 117.28° 8.15 nm/15.09 km from site	
Access	Public access to the beach	
Terrain	Cliffed areas around survey site	1. UAV crash into cliffs
Noise (Comms Probs)	None	
Altitude	15 m AGL / 15 m AMSL	
Obstacles	Cliffs / trees	2. UAV crash into trees
Interference (Antennas)	None	
Land Permission	Foreshore is publicly owned	
Public Areas	Myrtleville Beach / Bunnyconnellan's restaurant	3. UAV contact with member(s) of the general public
Maps/Charts provided by client		
Public Access	Yes	
50m/120m Separation	120 m	
Privacy	Beach users / restaurant patrons (Bunnyconnellan's)	4. Infringement on beach users/restaurant patrons privacy
Signage Required	Yes	

Risk Assessment
Rating Form

	Job Number: 1234567			
	Job Date: Tuesday, 26 March 2019			
No. 1	**Hazard Identified**	**Probability**	**Severity**	**Risk Rating**
	UAV crash into cliffs	3	1	3
	Control Measure (s)	**Amended Probability**	1	**Updated Risk Rating**
	• Detailed operational brief. • Pilot has undertaken a site visit and agreed plan for the operation. • UAV maintained and operated as per operations manual.	2	1	2
No. 2	**Hazard Identified**	**Probability**	**Severity**	**Risk Rating**
	UAV crash into trees	3	1	3
	Control Measure (s)	**Amended Probability**		**Updated Risk Rating**
	• Detailed operational brief. • Pilot has undertaken a site visit and agreed plan for the operation. • UAV maintained and operated as per operations manual.	2	1	2
No. 3	**Hazard Identified**	**Probability**	**Severity**	**Risk Rating**
	UAV contact with member(s) of the general public	3	3	9
	Control Measure (s)	**Amended Probability**	**3**	**Updated Risk Rating**
	• Detailed operational brief. • Pilot has undertaken a site visit and agreed plan for the operation. • UAV maintained and operated as per operations manual. • UAV and transmitter batteries checked before flight • Survey planned to take place on a weekday, rather than weekend when beach may be busy	2	3	4
No. 4	**Hazard Identified**	**Probability**	**Severity**	**Risk Rating**

	Infringement on beach users/restaurant patrons privacy	4	2	8
	Control Measure (s)	**Amended Probability**	**Severity**	**Updated Risk Rating**
	• Usage of signage and leaflets to ensure individuals are adequately and clearly informed before and during the flight • Blurring of facial images or registration plates where inadvertently captured • Storage of data in a password protected computer	2	2	4
No. 5	**Hazard Identified**	**Probability**	**Severity**	**Risk Rating**
	Control Measure (s)	**Amended Probability**	**Severity**	**Updated Risk Rating**

*All Hazards Identified must be individually rated using the Risk Rating Form Risk Assessment Matrix

ICAO Risk Assessment Matrix

Severity							
	Catastrophic	5	5 Review	10 Unacceptable	15 Unacceptable	20 Unacceptable	25 Unacceptable
	Hazardous	4	4 Acceptable	8 Review	12 Unacceptable	16 Unacceptable	20 Unacceptable
	Major	3	3 Acceptable	6 Review	9 Review	12 Unacceptable	15 Unacceptable
	Minor	2	2 Acceptable	4 Acceptable	6 Review	8 Review	10 Unacceptable
	Negligible	1	1 Acceptable	2 Acceptable	3 Acceptable	4 Acceptable	5 Review
			Extremely Improbable	**Improbable**	**Remote**	**Occasional**	**Frequent**
			1	**2**	**3**	**4**	**5**
			Probability				

Risk Assessment – Severity Decode

Aviation Definition	Meaning	Value
Catastrophic	Equipment destroyed. Multiple deaths	5
Hazardous	A large reduction in safety margins, physical distress or a workload such that organisations cannot be relied upon to perform their tasks accurately or completely. Serious injury or death to a number of people. Major equipment damage.	4
Major	A significant reduction in safety margins, a reduction in the ability of organisations to cope with adverse operating conditions as a result of an increase in workload, or as a result of conditions impairing their efficiency. Serious incident. Injury to persons.	3
Minor	Nuisance. Operating limitations. Use of emergency procedures. Minor incident.	2
Negligible	Little consequence	1

Risk Assessment – Probability Decode

Probability of Occurrence	
Meaning	**Value**
Likely to occur many times.	5
Likely to occur sometimes.	4
Unlikely, but possible to occur.	3
Very unlikely to occur.	2
Almost inconceivable that the event will occur.	1

Risk Assessment – Classification Decode

Risk Classification	
Acceptable	The consequence is so unlikely or not severe enough to be of concern; the risk is tolerable. However, consideration should be given to reducing the risk further to as low as reasonably practicable in order to further minimise the risk of an accident or incident.
Review	The consequence and/or probability is of concern; measures to mitigate the risk to as low as reasonably practicable should be sought. Where the risk is still in the review category after this action then the risk may be accepted, provided that the risk is understood and has the endorsement of the individual ultimately accountable for safety in the organisation.
Unacceptable	The probability and/or severity of the consequence is intolerable. Major mitigation will be necessary to reduce the probability and severity of the consequences associated with the hazard.

Risk Mitigation

Risks should be managed to be as low as reasonably practicable. Risk must be balanced against the time, cost and difficulty of taking measures to reduce or eliminate the risk. The level of risk can be lowered by reducing the severity of the potential consequences, reducing the probability of occurrence or by reducing exposure to that risk. Corrective action will take into account any existing defences and their inability to achieve an acceptable level of risk. Corrective action should be subject to further risk assessment as outlined in above, in order to determine that the risk is now acceptable and that no further risk has been introduced into operational activities

Alternate Example of Risk Assessment & Mitigation Matrix

Hazard	Severity	Probability	Rating	Mitigation	Mit. Factor	Final Rating
UAV crash on populated area	4	3	12	• The built-up area and populated area outside the area of operation is a no-overfly area for the duration of the operation. • Detailed operational brief. • Pilot has undertaken a site visit and agreed plan for the operation. • UAV maintained and operated as per operations manual. • UAV and transmitter batteries checked before flight • Time of operation is during low traffic density.	-4	8

Hazard	Severity	Probability	Rating	Mitigation	Mit. Factor	Final Rating
UAV crash on building site	3	3	9	• Pilot will operate to documented brief. • UAV and transmitter batteries checked before flight. • Site is an open area and UAV will be operating over areas where there will be no site personnel directly below. • All site personnel will be wearing high visibility clothing and protective headwear.	-3	6

Hazard	Severity	Probability	Rating	Mitigation	Mit. Factor	Final Rating
UAV contact with member(s of the general public causing:				• The built up area and populated area outside the area of operation is a no-overfly area for the duration of the operation. • Detailed operational brief. • Pilot has undertaken a site visit and agreed plan for the operation. • UAV maintained and operated as per operations manual. • UAV and transmitter batteries checked before flight • Time of operation is during low traffic density.		
Fatality	3	2	6		-3	3
Injury	3	2	6		-3	3

Hazard	Severity	Probability	Rating	Mitigation	Mit. Factor	Final Rating
UAV contact with members of the contractor's staff:				• IAA approved site, layout and operations. • Pilot will operate to documented brief. • UAV and transmitter batteries checked before flight. • Site is an open area and UAV will be operating over areas where there will be no site personnel directly below. • All site personnel will be wearing high visibility clothing and protective headwear.		
Fatality	3	2	6		-3	3
Injury	3	2	6		-3	3

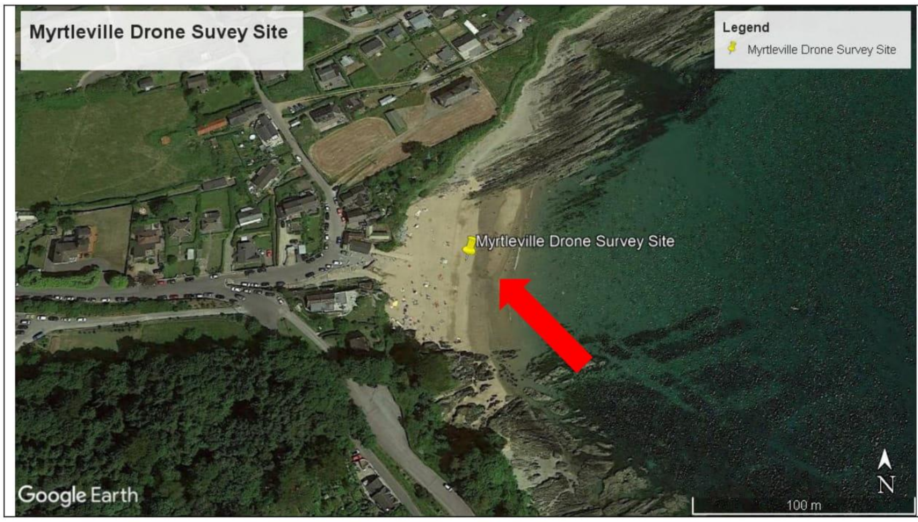
APPENDIX E - Controlled Airspace Application Sample

IAA	Form No. U.F.101 Version No. 8 Issue Date: 20/11/2017 Page 48 of 1	**SUA Flight in Controlled Airspace Application Form**

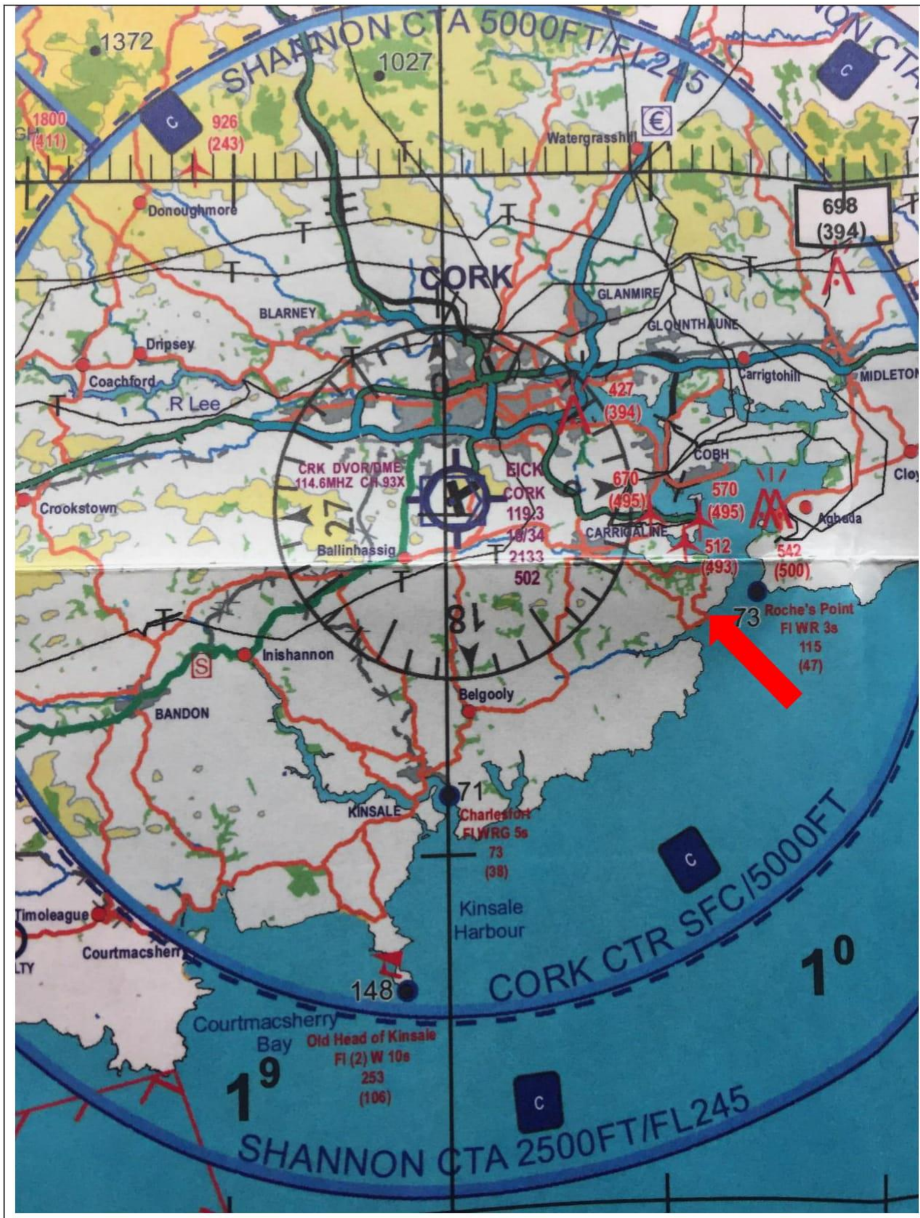
This Form is for the use of **SUA Specific Operations Permission (SOP)** holders when they are applying to the Irish Aviation Authority (Air Traffic Control Operations) to conduct SUA SOP Operations within Controlled Airspace.

SUA SOP Flight Application Form CLASS C / CTR / TRA /Other		
SUA Operator Name & SOP Permission Number	Sarah Kandrot – SOP No.: 150383	
SOP Expiry Date	28/05/2021	
SUA Model & IAA Registration Number	DJI Phantom 4 Pro - IE-122467	
SUA Pilot(s) Name(s)	Sarah Kandrot	
Mobile Phone Numbers: Primary / Alternate (2 Numbers Required)	Primary 087 2613244 / Alternate 087 1014882	
Controlled Airspace Location	Cork	
Latitude/Longitude (Degrees, Minutes and Seconds)	Location, Bearing and Distance from Aerodrome	Radius Of Operation
N 51°46'58.04" W 8°17'41.88"	EICK 117.28° 8.15 nm/15.09 km	300 m
SUA Maximum Altitude (AMSL) & Height Above Ground Level (AGL)	Altitude 400 ft AMSL / Height 400 ft AGL	
Proposed Date(s) & Time(s) (Local)	Duration (HH:MM)	
Tuesday, 26th March 2019 14:30	03:00	
Tuesday, 2nd April 2019 14:30	03:00	
(*Declaration of Completion & Documented*) **Survey** - ✓ **Risk Assessment** - ✓		
Caution: By ticking the above boxes the SUA SOP Holder (or Representative) acknowledges the **limitations as detailed in SI.563 of 2015**, and has mitigated to an **equivalent level of safety** where necessary. The SUA SOP Holder is responsible for all aspects of the SUA flight operations proposed herein.		
Map of Location / Area of Operation Aeronautical Chart etc. – Insert Below		

KANDROT	SUA OPERATIONS MANUAL		Sarah Kandrot Environmental Consulting Services		
AUTHOR: Sarah Kandrot	APPROVED BY: Accountable Manager	PUBLISHED BY: Sarah Kandrot Environmental Consulting Services	ISSUE 1	REVISION 2	DATE 28 March 2019



KANDROT	SUA OPERATIONS MANUAL		Sarah Kandrot Environmental Consulting Services		
AUTHOR: Sarah Kandrot	APPROVED BY: Accountable Manager	PUBLISHED BY: Sarah Kandrot Environmental Consulting Services	ISSUE 1	REVISION 2	DATE 28 March 2019



For Dublin, Cork and Shannon Completed Form must be sent to: suaairspace@iaa.ie
For Sligo Airport (EISG) Completed Form must be sent to: safetymanager@sligoairport.com
For Kerry Airport (EIKY) Completed Form must be sent to atc@kerryairport.ie
For Waterford Airport (EIWF) Completed Form must be sent to sua@waterfordairport.net

For Donegal Airport (EIDL) Completed Form must be sent to sua@donegalairport.ie
For Ireland West Airport (EIKN) Completed Form must be sent to michaelconnolly@irelandwestairport.com

APPENDIX F - Insurance Information

COVERDRONE

SUMMARY OF INSURANCE COVER

The information in this document is a summary only.
For full details of applicable policy cover please refer to the Policy Schedule and Policy Wording.

PART 1	**Policy No.**	CDA22067754EUR		
	Insurer	Lloyd's Insurance Company S.A.		
	Name of Insured	Sarah Kandrot		
	Business of the Insured	Owners and Operators of Small Unmanned Aircraft (SUA) only		
	Address	21 Highlands, Passage West, Cork, T12 PTF2, Ireland		
	Period of Insurance	From	15:46:50 on 28/03/2019	
		to	27/03/2020	
		Both days inclusive		
PART 2	**Particulars of UAS**			
	(1) Make	(2) Type	(3) Year of Manufacture	(4) Registration Marks
	DJI	Phantom 4 Pro	2018	OAXCF1X0B30322
	Non Owned Electronic Equipment	Sum Insured	Not Insured	
PART 3	**Standard Uses:**Commercial	**Special Uses:**	Aerial work being Photography and Filming	
PART 4	**Operators**	Any person approved by the Insured, with a Permission for Aerial work or equivalent approved by the Aviation regulatory body, working in connection with the Insured's business.		
PART 5	**Geographical Limits**	Worldwide Excluding: • Algeria, Burundi, Cabinda, Central African Republic, Congo, Democratic Republic of Congo, Eritrea, Ethiopia, Ivory Coast, Liberia, Mauritania, Nigeria, Somalia, The Republic of Sudan, South Sudan • Colombia, Ecuador, Peru • Afghanistan, Jammu & Kashmir, Myanmar, North Korea, Pakistan • Georgia, Nagorno-Karabakh, North Caucasian Federal District • Iran, Iraq, Libya, Syria, Yemen • Any country where the operation of the insured Aircraft is in breach of United Nations sanctions		
PART 6	**Limits and Deductibles**	(Appropriate boxes to be completed – others to be marked as 'not applicable')		

Coverdrone Policy Schedule *Page 2 of 2*

(A) Policy Section & Risk	(B) Amounts to be deducted	(C) Limit of Indemnity from which must be deducted the amount in column (B)
II Liability to Third Parties (Relating to All SUA operatd by the Insured)	**Bodily Injury** Nil **Damage to Property** You will pay the first € 100 in respect of damage to property each Accident **Professional Indemnity** The amount of € 1,000 shall be deducted from each and every claim	Bodily Injury and Damage to Property Combined € 1,300,000 each Accident (Limited to € 1,000,000 whilst Training) Inclusive of Aviation Liabilities sub-limit € 1,300,000 Limited to € 1,000,000 whilst Training) (never less than 750,000 SDR's) Civil use of MOD Airfields € 7,500,000 Any one Accident Professional Indemnity shall not exceed € 62,500 in the policy period **This policy is fully compliant with EU Regulation (EC) No 785/2004**
III Premises liability Subsection	**Bodily Injury** Nil **Damage to Property** You will pay the first € 100 in respect of damage to property each Accident	€ 1,300,000 Any one Accident
III Hangarkeepers Subsection		€ 1,300,000 Any one Accident
III Products Liability Subsection		€ 1,300,000 Any one Accident and in the aggregate
Important		