Tampere University

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DEVELOPMENT OF DRONE ORGANIZATION FLIGHT OPERATIONS MANUAL

Faculty of Engineering and Natural Sciences
Master of Science Thesis
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ABSTRACT

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This thesis describes the development process of a Flight Operations Manual for an organization conducting aerial work with unmanned aerial vehicles. The manual is developed for the Faculty of Engineering and Natural Sciences at Tampere University

Aerial work with unmanned aerial vehicles is a complicated subject from the regulatory viewpoint, as legislation exists on multiple hierarchical levels and it also extends beyond common air law. The national occupation and health legislation is in important role, as it defines familiarization requirement for the employer. The central problem in this thesis is on how this requirement is met.

This thesis presents the regulatory framework, including both national and international law, that is relevant for operations with unmanned vehicles. This analysis also includes the expected changes in the regulatory environment. This analysis produces the regulatory requirements for the manual. These requirements are supplemented with practical requirements, that are derived by analyzing the operational environment. Technical solutions for the publishing, distributing, and updating the manual are also discussed based on the practical requirements.

The thesis produced the initial version of the Flight Operations Manual suitable for this organization. The manual complies with the regulatory requirements, but also with the practical requirements specific for the organization. Further development areas were also defined, that require further collection of information and experience from practical operations with unmanned vehicles.

Keywords: drone, remotely, piloted, organization, documentation

TIIVISTELMÄ

Samuli Niemi: Drone-organisaation lentotoimintakäsikirjan kehittäminen
Diplomityö
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Tämä diplomityö käsittelee lentokäsikirjan kehittämistä miehittämättömiä ilma-aluksia käyttävälle organisaatiolle. Työn aiheena oleva käsikirja kehitettiin Tampereen Yliopiston Tekniikan ja luonnontieteiden tiedekunnan käyttöön.

Miehittämättömien ilma-alusten käyttäminen lentotyöhön on lainsäädännöllisten vaatimusten näkökulmasta haastavaa, koska säätelyä on usealla eri lainsäädännöllisellä tasolla ja se ulottuu myös miehittämätöntä ilmailua ja ilmailua koskevan lainsäädännön ulkopuolelle. Erityisessä roolissa on kansallinen työturvallisuuslaki, joka määrittelee työntekijän perehdytysvelvoitteen työnantajalle ja tämä diplomityö pyrkii vastaamaan siihen, että miten tämä velvoite täytetään.

Työssä käydään läpi kansallinen ja ylikansallinen lainsäädäntö, joka on relevanttia miehittämättömillä ilma-aluksilla suoritettujen lento-operaatioiden kannalta. Tämä tarkastelu sisältää myös tulevien muutosten ennakoinnin. Tämän tarkastelun perusteella määritellään käsikirjalle lainsäädännölliset vaatimukset, joita lisäksi täydennetään käytännön vaatimuksilla, jotka on saatu organisaation toimintaympäristöä tarkkailemalla. Myös erilaisia teknisiä ratkaisuja käsikirjan julkaisuun, jakeluun ja päivittämiseen analysoidaan käytännön vaatimusten perusteella.

Työn tuloksena saatiin aikaan organisaatiolle sopiva miehittämättömän ilmailun lentotoimintakäsikirja, joka vastaa sekä lainsäädännöllisiin vaatimuksiin, mutta myös erityisesti juuri tätä organisaatiota koskeviin käytännön vaatimuksiin. Lisäksi määriteltiin jatkokehityskohteet, jotka edellyttävät pidemmän aikavälin tiedon ja kokemuksen keräämistä käytännön lento-operaatioista.

Avainsanat: drone, miehittämätön, ilmailu, organisaatio, dokumentaatio

PREFACE

This thesis was produced while working for the Mechatronics Research Group at Tampere University. While the research in this thesis is literary centered, working with drones greatly aided the research and writing process. Building and testing the actual equipment has given a deep insight, on how these complex and highly technical devices function.

I want to thank Professor Kari Koskinen and Doctor Jussi Aaltonen for supervising my thesis. Your guidance and feedback helped me to define relevant content and find a logical structure for this thesis, when the subject area was extensive, complex, and purely analytical approach did not work.

I also like to thank my mom and dad for putting pressure on me by constantly asking, if my thesis has been finished. It is now.

Tampere, 28th October 2019

Samuli Niemi

CONTENTS

LIST OF SYMBOLS AND ABBREVIATIONS

aCOLOR	Autonomous and Collaborative Offshore Robotics
AIP	Aeronautical Information Publication
BVLOS	Beyond Visual Line of Sight
ENS	Faculty of Engineering and Natural Sciences
EU	European Union
FOM	Flight Operations Manual
JARUS	Joint Authorities for Rulemaking on Unmanned Systems
MRG	Mechatronics Research Group
MTOW	Maximum Takeoff Weight
PDF	Portable Document Format
RPAS	Remotely Piloted Aerial System
TAU	Tampere University
Traficom	Finnish Transport and Communications Agency
TUNI	Tampere Universities

1 INTRODUCTION

Remotely Piloted Aerial System (RPAS) is a term that describes unmanned aviation with remotely piloted aircraft. Terms and abbreviations such as Unmanned Aerial Vehicle (UAV), Unmanned Aerial System (UAS), Remotely Piloted Aircraft (RPA) or colloquial terms such as 'drone' are also often used interchangeably, but may also be considered more specific terms. The term and the abbreviation RPAS are used through this thesis to cover all of the previously mentioned terms and possible variations of them.

1.1 Objectives of the thesis

The objective of the thesis is to create a set of guidelines, practices, and procedures, that are combined into a Remotely Piloted Aerial System (RPAS) Flight Operations Manual (FOM) for the Faculty of Engineering and Natural Sciences (ENS) at Tampere University. The Flight Operations Manual is a document that includes the requirements for any conducted RPAS operations, personnel qualifications, and documentation.

The primary focus of this thesis is in ensuring that the Flight Operations Manual and the operations conducted based on it comply with the relevant laws and regulations. Secondary focus is to meet the practical and unique requirements for Tampere University, that are derived from the type of operations that may be expected to be part of research projects, education, or other activities.

Another secondary focus is to define goals and guidelines for long-term development. This secondary focus includes the parts of the Flight Operations Manual that may require specific long-term experience and knowledge but also preparing for the expected changes in the regulatory framework.

Third secondary focus, or maybe even tertiary focus, is in developing the Flight Operations Manual into a document with practical instructions, that refer to aspects outside of the scope of regulatory requirements. These instructions, while included in the Flight Operations Manual itself, are not in the scope of this thesis, and neither extensively covered.

1.2 Research methods and restrictions

This thesis is not purely scientific writing in the sense that it is not possible to derive all of the results (the complete Flight Operations Manual) analytically. Conventional research methods are also not directly usable, and instead, mixed-methods are used with some adaptations or simplifications.

Literature review, especially related to the regulatory framework, is the primary method for determining the regulatory requirements for RPAS operations. As the main subject for the literature review is a legal text, some restrictions may be applied. The nature of the legal text is such that for example, a critical examination of presented arguments is not applicable, but instead, the statements may be in practice considered as facts. This literature review produces strictly fact-based and so-called hard requirements for the Flight Operations Manual.

Another literature review is produced about secondary material, that may imply future changes in the regulatory framework. Example of this would be guidelines or recommendations made by the relevant authorities, as they (or part of them) may be implemented into law later in the future. This literature review is more speculative than the previous ones, but some trends may be possible to find with a critical examination. Even if the results from this review are not relevant to the initial version of the Flight Operations Manual, they can be used as a basis for further developments.

Planned RPAS related projects and other activities at Tampere University are analyzed to find any unique aspects that may not be well defined from the pure regulatory viewpoint. This analysis includes a simplified comparative analysis relative to typical RPAS operations.

1.3 Outline and contribution of the thesis

The report part of this thesis is relatively short and divided into eight chapters that are summarized below. The thesis first considers regulatory requirements, then practical requirements, and in the end, the structure and contents of the Flight Operations Manual.

Chapter 2 presents the regulatory framework related to RPAS operations, including both current and upcoming legislation. The legislation is analyzed, and a distinction is made between operational knowledge and requirements for the Flight Operations Manual.

Chapter 3 presents the requirements for RPAS operations, that are published by the competent Finnish aviation authority Traficom. A very simple comparative analysis is made against the regulatory requirements found in the previous chapter, for finding any possible contradictions. This chapter, in conjunction with the previous one, produces the hard requirements for the Flight Operations Manual.

Chapter 4 is an introduction to the planned RPAS operations at Tampere University. The

planned operations are compared to the common and typical RPAS operations, to find unique aspects that may impose additional and specific requirements for the Flight Operations Manual. The findings of this chapter imply soft requirements for the manual and while these are not explicitly stated, nor compliance rigorously checked, the general tone and practical instructions should mirror these requirements.

Chapter 5 contains a brief technical analysis about different filetypes and mediums for the Flight Operations Manual, that are common and deemed attractive. Preferred solution, both short and long term, is presented.

Chapter 6 presents and describes the Flight Operations Manual itself. The manual is included in the appendix section and is fairly long, so only main requirements and solutions are presented and discussed.

Chapter 7 presents a case study. The object of the case study is a complex RPAS operation that is planned as a part of a research project, that was first introduced in chapter 4. This case study also acts as an example of how new RPAS operations should be commenced.

Chapter 8 is the final chapter of this thesis. The results and further developments are discussed.

An initial version of Flight Operations Manual for Remotely Piloted Aerial System operations was produced in this thesis, with further areas of development defined. The Flight Operations Manual is ready for the pilot stage, where additional experience and knowledge is collected from RPAS operations in practice.

2 REVIEW OF THE REGULATORY FRAMEWORK

Unmanned aviation is a complicated subject from the regulatory viewpoint, as aviation is regulated by the European Union, but also on the national level by the member states. The regulatory framework also extends beyond aviation law, as aspects such as occupational health and safety, or privacy laws are relevant in unmanned aviation.

Changes in the regulatory framework are also to be expected, as the number of RPAS operations increase. Future is hard to predict, but recommendations made by the relevant authorities should be noted, as these may also be implemented into law in the future.

Laws are subject to changes, so they should not be extensively included in the Flight Operations Manual, but referenced in a way that relevant personnel can access the information whenever necessary.

2.1 Legislation by the European Union

The current EU law includes two relevant regulations, the regulation (EU) No 923/2012 for common rules of law and regulation (EC) No 785/2004 for insurance requirements for air carriers and aircraft operators.

Article 1 of the regulation (EU) No 923/2012 states the subject matter and scope. The objective of the regulation is to establish common rules for air traffic, and it applies particularly to airspace users and aircraft engaged in general air traffic, including RPAS operations (Regulation (EU) No 923/2012).

The regulation (EC) No 785/2004 includes the insurance requirements related to aerial work with drones (Regulation (EC) No 785/2004).

The EU level legislation is essential information and should be considered as operational knowledge for the flight crews, but it does not present any obvious requirements for the Flight Operations Manual. The exceptions are the insurance requirements, but these are in practice met by purchasing the insurance from appropriately regulated market.

2.2 National legislation

Relevant Finnish national legislation related to RPAS operations are Finnish Aviation Act (864/2014), regulation OPS M1-32, government decree (930/2014) on areas where aviation is restricted, and act (1562/2011) on plant protection products.

Finnish Aviation Act (864/2014) applies to aviation in Finland and abroad with Finnish aircraft if European Union decree or any other international commitments state otherwise. Acccording to Traficom, the relevant parts in Finnish Aviation Act are 2 § Definitions, 9 § exemptions from the rules of air, 11 § airspace restrictions, Chapter 5 common requirements for flight operations, 76 § use of aerodromes and other areas, 136 § liability for damages, 159 § activities causing danger to flight safety (Traficom 2019, Ilmailulaki 7.11.2014/864 [Aviation Act 864/2014]).

OPS M1-32 covers the regulation of the use of remotely piloted aircraft and model aircraft, based on section 9, 57, and 70 of the Aviation Act (864/2014). OPS M1-32 applies to remotely piloted aircraft and model aircraft weighing over 250 grams and defines rules for common remote flight operations. (Regulation (Trafi) OPS M1-32).

The rules and requirements on OPS 1-32 are practical, compared to the Aviation Act that is higher in the legislation hierarchy. The OPS M1-32 presents the information, that could be inferred as the following requirements for the Flight Operations Manual:

- Reporting duty to the Traficom about the nature of conducted RPAS operations.
- Requirement of safety management that aims to minimize risk to third parties.
- Requirement for aircraft markings - aircraft must carry the name and contact details of the operator.
- Requirement for documentation of flights in a specific manner.
- Requirement for storing documentation.
  - Flight logs for two years.
  - Description of operations, safety assessments, and operational instructions for three months.
- Reporting duty to Traficom about accidents and serious incidents.
- Special requirements for specific type of operations, including BVLOS (Beyond Visual Line of Sight) operations.
  - Mass limits.
  - Distance and height limitations in relation to aerodromes, airspace, crowds of people, and densely populated areas.
  - Requirements for descriptions of operations, safety assessments, and operational instructions.
- Requirements for an exemption application.

The Government decree (930/2014) on areas where aviation is restricted defines areas, where aviation is continuously or temporarily prohibited or otherwise limited. These areas include nuclear powerplants, military-related locations, industrial zones, and temporary restriction areas (Valtioneuvoston asetus ilmailulta rajoitetuista alueista 13.11.2014/930 [Government Decree on on areas where aviation is restricted 930/2014]).

Act (1562/2011) on Plant Protection Products prohibits air spraying of plant protection products (Laki kasvinsuojeluaineista 29.12.2011/1563 [Act on Plant Protection Products 1563/2011].

Aviation Act and other mentioned pieces of legislation are essential information and should be considered operational knowledge for the flight crews, but they do not present obvious requirements for the Flight Operations Manual itself. Information about areas where aviation is restricted can also be found on the Aeronautical Information Publication (AIP).

2.3 Occupational safety and health

According to the Occupational Safety and Health Act, employers are required to take care of the health and safety of their employees, by preventing, removing, or reducing dangerous or harmful factors related to the work. The employer should continuously monitor the work environment, state of the work community, and safety of work methods (Työturvallisuuslaki 23.8.2002/738 [Occupational Safety and Health Act 738/2002] chapter 2 § 8).

The employer has the responsibility to give the employee a sufficient familiarization to the work, work conditions, working methods, work tools, and their proper use before starting the job, or whenever any changes occur. The employee should be given instructions to avoid hazards and dangers in all situations, including emergencies and other abnormal situations (Työturvallisuuslaki 23.8.2002/738 [Occupational Safety and Health Act 738/2002] chapter 2 § 14).

Tampere University comply with the principles of the Occupational Safety and Health Act, so there are not any specific requirements for the content of the Flight Operations Manual. Instead, the occupational health and safety is the primary reason behind the development of the Flight Operations Manual. In other words, Flight Operations Manual is a tool to meet the responsibilities of the employer.

2.4 JARUS recommendations

Joint Authorities for Rulemaking on Unmanned Systems (JARUS) is an international organization of regulatory professionals from 59 countries, European Aviation Safety Agency (EASA), and EUROCONTROL. The purpose of JARUS is to recommend a common set

of requirements for all relevant factors regarding RPAS operations (JARUS 2019).

JARUS recommendations do not have any legislative power, but it could be assumed that they or part of them may be implemented into law in the future. JARUS recommendations include Specific Operations Risk Assessment (SORA) package, Certification Specifications for Light Unmanned Rotorcraft Systems (CS-LURS) and Light Unmanned Aeroplane Systems (CS-LUAS), and requirements for UAS Category Operations (OPS A and OPS B), which future RPAS operations may require compliance with. The nature of these documents, describing very complex RPAS aircraft and operations, does not seem reasonable when compared against the current regulatory framework and common RPAS operations. These items could be used as guidance material for specific RPAS operations, but they do not indicate any practical requirements for the Flight Operations Manual.

When the JARUS recommendations are compared against the current regulatory framework, only the Flight Crew Licensing (FCL) seems relevant in the short time frame. The document describes recommendations for flight crew licenses, knowledge requirements, training requirements, required flight experience, and other similar items (JARUS FCL Recommendation).

The FCL recommendations are not relevant to Flight Operations Manual itself, but these should be used as the basis for the structure and the content of the RPAS related training offered under the organization. Specific training programs are not part of the initial development of the Flight Operations Manual or in the scope of this thesis, but they are recognized as a topic for long term development.

2.5 Upcoming changes to the regulatory framework

European Union has published a new regulation on the rules and procedures for the operation of unmanned aircraft, that shall primarily apply from 1 July 2020 forwards. The new regulation will institute changes to multiple aspects of RPAS operations, such as registrations, types of operations, altitude limitations, and training requirements (Regulation (EU) 2019/947).

At the time of writing this thesis, the date is so far away (almost a year), that the new regulations do not impose any immediate requirements for the initial version of the Flight Operations Manual. Instead, the new regulation is used as a guideline for defining the relevant content for the manual. The primary impact of the new regulation is competency and training requirements.

The current regulatory framework does not impose any specific competency or training requirements for RPAS operators, including pilots and other personnel. Also, more specific instructions are to be expected when the regulation is entered into force, so short term internal training requirements should not be extensively considered.

3 REGULATORY REQUIREMENTS FOR RPAS OPERATIONS

The Finnish Transport and Communications Agency - Traficom, has consolidated a list of requirements for aerial work. The list is divided into sections based on the nature of operations, including the minimum requirements, requirements for operations above populated areas, requirements for BVLOS operations and requirements for exemptions from mass, altitude or other limitation.

This chapter summarizes the requirements in the form of a list, as the source material is in list form, but also to allow easy comparison between different type of operations. Requirements are also briefly discussed from the organizational point of view, meaning if the requirements are more relevant for the day to day operations or to the organization as a whole. This discussion is used as a basis to define duties and responsibilities between different subjects, such as people in operational roles or people in managerial roles.

3.1 Minimum requirements

Traficom has published a list of minimum requirements for RPAS operations. These requirements can be summarized as follows:

- RPAS operators are required to make a notification on the use of remotely piloted aircraft and keep it updated.
- RPAS operators are required to have insurance against third party damages according to the regulation (EC) 785/2004.
- RPAS operators are required to mark the remotely piloted aircraft with contact information.
- RPAS operators are required to log all flights according to the OPS M1-32 and keep a record for at least two years.
- RPAS operators are required to report any occurrences, including incidents and accidents to Traficom (Traficom 2019).

These minimum requirements do not present any complicated challenges, as Traficom has also published fillable forms and additional instructions on how to comply with the notification and reporting duties. This additional information should also be included in

the Flight Operations Manual when relevant.

Occurrence reporting and flight logging are primarily relevant for daily operations, but from the organizational point of view, the practices should be unified across all operations. The notification on the use of remotely piloted aircraft and insurances are more relevant for the people in organizational positions, but people in operational roles should be sufficiently aware on how these requirements are met and if there are any limitations. For example, the people in organizational positions are responsible for acquiring suitable insurance for operations, but operational personnel needs to be aware of what type of operations are covered by it.

3.2 Additional requirements when flying above densely populated areas

The additional requirements when flying above densely populated areas are divided into two class, based on maximum takeoff weight. These items can be summarized as the following items:

- The maximum takeoff weight for the remotely piloted aircraft is 3kg.
- The remote pilot is required to be familiar with the area of operation, ensured the technical condition of the aircraft, and assessed that the operation could be performed in a safe manner (Traficom 2019).

In the other class, the items can be summarized as the following:

- The maximum takeoff weight for the remotely piloted aircraft is 7kg.
- RPAS operator should be prepared for emergencies with operational procedures, safety equipment, or a combination of these so that the risk to people and property is minimized.
- RPAS should have written operational instructions, that include information about the area of operation, times, altitudes, and aircraft used.
- RPAS should have written safety assessment that includes identification of hazards, assessment of risks, and measures to mitigate risks.
- RPAS should have written procedures for normal operations and emergencies.
- RPAS should keep a record of operational instructions and safety assessments for at least 3 months (Traficom 2019).

The requirements in the first class are trivial to meet, but the second class adds significant challenges compared to the list of minimum requirements. Most of these items are documentation related and relevant to both operational and managerial positions. Concepts such as densely populated area or specific content requirements for each document should be defined in the Flight Operations Manual.

3.3 Additional requirements when flying close to crowds of people

Requirements when flying above crowds of people, including the additional radius of 50 meters, are similar to the previous section. These requirements can be summarized as the following items:

- The maximum takeoff weight for the remotely piloted aircraft is 7kg, not including the weight of a parachute system.
- RPAS operator should be prepared for emergencies with operational procedures, safety equipment, or a combination of these so that the risk to people and property is minimized.
- RPAS should have written operational instructions, that include information about the area of operation, times, altitudes, and aircraft used.
- RPAS should have written safety assessment that includes identification of hazards, assessment of risks, and measures to mitigate risks.
- RPAS should have written procedures for normal operations and emergencies.
- Written documents should be sent to Traficom (Traficom 2019).

These requirements are almost identical to the requirements for operations in densely populated areas (when maximum takeoff weight is between 3 and 7 kilograms), apart from the additional requirement about sending the documents to Traficom. This additional requirement is relevant to people in both operational and managerial positions, as there is not an obvious position of responsibility for the actual task.

3.4 Requirements for BVLOS operations

Requirements for beyond visual line of sight (BVLOS) operations can be summarized as the following items.

- RPAS should have written operational instructions, that include information about the area of operation, times, altitudes, and aircraft used.
- RPAS should have written safety assessment that includes identification of hazards, assessment of risks, and measures to mitigate risks.
- RPAS should have written procedures for normal operations and emergencies.
- Written documents should be sent to Traficom.
- Reservation of airspace should be made at least eight weeks before and activated one workday before commencing the operation (Traficom 2019).

Most of the requirements for BVLOS operations are identical with the previously mentioned operations, apart from the airspace reservation requirement. This requirement is

similar to the requirement about sending the documents to Traficom that there is not an obvious position of responsibility for the actual task.

The airspace reservation requirement alone makes BVLOS operations a complicated task. The Flight Operations Manual should define the documentation requirements, as already pointed out in a previous section, but also possibly present guidelines to define when BVLOS operation is required instead of operation in visual line of sight.

3.5 Requirements for exemptions from given rules and guidelines

Requirements for exemptions from given rules and guidelines can be summarized as the following items:

- RPAS should have written operational instructions, that include information about the area of operation, times, altitudes, and aircraft used.
- RPAS should have written safety assessment that includes identification of hazards, assessment of risks, and measures to mitigate risks.
- RPAS should have written procedures for normal operations and emergencies.
- Application for exemption should be sent to Traficom with the documents attached (Traficom 2019).

The requirements for exemption are similar to the requirements in previous sections. Additional considerations could be appointed in creating a set of guidelines and instructions for defining when an exemption is required, instead of complying with the regulations by other measures.

3.6 Comparison of Traficom list and the requirements defined in chapter 2

List of regulatory requirements was previously defined in chapter 2 and a simple comparative analysis can be made against the Traficom's consolidated list of requirements. A comparison shows that the essential content is the same in both lists, but Traficom's consolidated list is better organized, than the law text where the initial regulatory requirements were inferred. The similarity is expected, as Traficom is the competent authority that has produced both the original regulatory text and the consolidated list.

Consolidated list of requirements is better organized, contains the relevant information, and allows easy comparison between different types of operations. For these reasons, the Flight Operations Manual should follow a similar structure where relevant.

3.7 RPAS Flight Operations Manual template by Traficom

Traficom has published an extensive template for a Flight Operations Manual with multiple sections, which aim to describe all aspects of common RPAS operations. These sections may be considered as requirements, and as a basis for practical instructions.

The template is not adequate for this organization, and therefore some changes are required to be made. The utilization of the template and the required changes are described in chapter 5 where technical formats is discussed, and the chapter 6 describes the implemented changes and the resulting internal structure of the Flight Operations Manual.

4 OCCUPATIONAL HEALTH AND SAFETY AT TAMPERE UNIVERSITY

Tampere University is a new higher education community in Finland, which is a result of a merger of the Tampere University and Tampere University of Technology at the beginning of 2019. Tampere University conducts multidisciplinary research and is divided into seven faculties (*Tampere universities* 2019, *Key information* 2019).

Occupational Health and Safety is one the primary motivations behind the development of the Flight Operations Manual. The key aspects of the RPAS operations and organizational risks are analyzed in this chapter, and the duties and responsibilities of the employer are further defined.

4.1 The nature of RPAS operations

The primary objectives for operations conducted by the Faculty of Engineering and Natural Sciences are research and teaching. These operations include, but are not limited to, testing experimental constructions and software, inspections, measurements, and flight training. Operations are expected to range from simple local flights with commercial products to extremely complex autonomous operations with experimental aircraft.

Autonomous and Collaborative Offshore Robotics (aCOLOR) is an example of a project, that includes complex RPAS operations. aCOLOR is a multi-disciplinary research project to create an offshore robotic system that can be utilized for varying tasks with different components. The project combines surface, underwater, and air components in a system of an autonomous surface vessel, autonomous underwater vehicle, and autonomous aircraft. One RPAS specific mission described is the launch and recovery of a fixed-wing autonomous aircraft from a moving autonomous surface vessel (Koskinen 2019, Villa Escusol 2018).

The described mission contains multiple unique aspects that are not typical for RPAS operations. Simultaneous operation of multiple autonomous vehicles, RPAS operation above large water areas (possibly BVLOS), and launch and recovery on moving platform are unique and complex tasks, that present a challenge for the Flight Operations Manual. It is not reasonable, or maybe even possible to include every scenario in the Flight Operations Manual, but instead, the efforts should be concentrated on creating requirements

for mission-specific instructions. These instructions should cover operational instructions, risk assessments, and other similar items, as described in section 3. When applicable, the Specific Operations Risk Assessment (SORA) recommendations by JARUS, as presented in the section 2.4, could also be considered.

4.2 Risks related to the organizational structure

RPAS operations are also performed by multiple different groups (e.g., research groups), and this presents an additional challenge for the Flight Operations Manual. The Flight Operations Manual should be comprehensive enough to allow independent RPAS operations, but also describe the practices that make all operations compliant to the regulatory requirements under one organization. The division into multiple groups presents some organizational (or systemic) risks. Risk analysis is part of every RPAS operation, but also these systematic risks need to be analyzed. The following general categories were found in the analysis:

- Availability of information - non-available information cannot be used
- Correctness of the information - incorrect information may not be usable, or it may cause an accident or other harm.
- Correct usage of the information - the personnel need to understand how relevant information is correctly used, as incorrect use may cause an accident or other harm.
- Respect to the rules of the organization - disregard of the given rules may cause an accident or other harm.

Two aspects can be recognized from this list, information, and human behavior. Information related risks, availability, correctness, and usage, are the very essence of the Flight Operations Manual, as they can be directly mitigated. The information for the Flight Operations Manual should be derived from official sources, and the compliance regularly checked. Revision process should also be designed for the Flight Operations Manual in such a way, that the information related risk aspects are controlled.

Correct usage of the information and respecting the rules of the organization are linked to human behavior. These risk aspects can be controlled with education and training, but also by minimizing the bureaucratic nature and other unnecessary friction in the organization. Example of such friction could be complicated documentation requirements and practices, which could lead to insufficient documentation by the operational personnel, either by neglect or the lack of understanding of the requirements or practices. These kinds of risks can be mitigated by creating comprehensive instructions, that are easy to find, adequately concentrated, and in the proper order, but also by including templates (documents that are quickly filled by the user), that either reduce or even altogether remove the guesswork related to the documentation work.

Education and training are also directly linked to the occupational health and safety as-

pect described in section 2.3. Occupational health and safety law dictates responsibilities for the employer to give a sufficient familiarization to employees, and this the main challenge in the creation of the organization and the Flight Operations Manual. Regulatory requirements and other common knowledge can be distributed with the Flight Operations Manual, taught with courses and other educational events, or by under direct supervision. This kind of information can be tested with exams, interviews, or other similar methods.

The more complicated aspect of the occupational health and safety is the information related to specific aircraft or other relevant systems. These include both commercial and experimental built aircraft, but also ground station equipment and specific subsystems in aircraft, such as radios and sensors. Commercially bought equipment can usually be assumed to include relevant manuals and other instructions, but for experimental designs, the information may not be as readily available. In the worst-case scenario, the relevant operational instructions need to be created from the ground up. In practice, this means that the personnel is required to study and test the equipment by themselves, to reach the required level of familiarization, and this can be considered as a conflict against familiarization requirement. In other words, personnel may need to work with unknown aspects and issues with the equipment.

Working with unknown aspects and issues is an obvious risk, and it is not an acceptable situation for normal RPAS operations. The issue is required to be removed from normal operations, and this is achieved with two tools. These tools are documentation requirements for specific aircraft and testing practices.

Every aircraft should have specific documents to describe all the relevant technical information and operational procedures so that they can be used safely. As pointed out before, all of the information may not exist, so it needs to be systematically collected. This systematic collection of information can be achieved with controlled testing.

Testing practices are a set of general instructions, that help the systematic testing of equipment and the relevant features. In practice, it may not be possible to create testing procedures suitable for all aircraft, equipment, or configurations, but universal principles for safety and planning can be sufficiently reasoned. When a suitable testing procedure does not exist, it can also be defined under supervision, for example, of the Technical Director or another person with the relevant knowledge.

4.3 Duties and responsibilities of the employer

Based on the findings in the two previous sub-chapters the duties and responsibilities of the employer can be further refined to be applicable in RPAS operations.

The planned RPAS operations include complex elements, such as the possibility of BVLOS operations. The possibility of BVLOS operations mean further regulatory requirements for the operations and as presented in the chapter 3, most of these additional

requirements are documentation related.

Considering the additional requirements, and the documentation related risks that were analyzed in the previous sub-chapter, the documentation related duties for the employer can be defined as following.

- The employer has the duty to supply sufficient information and documentation for safe operations.
- The employer has the duty to keep relevant information up to date and to fix any possible errors within the documentation.
- The employer has the duty to define documentation requirements and applicable procedures for situations, where no pre-existing information and other documentation is available.

The Flight Operations Manual aids the employer with these duties. The manual itself should be primary source of information for practical information and procedures specific to the organisation, but should also contain references to other applicable instructions. Examples of other applicable instructions could be the relevant regulations or Aeronautical Information Publication. Both of these examples are information sources that are maintained and updated independently of this organization, so they should be considered primary sources of information when applicable.

The Flight Operations Manual should have a amendment and revision process that ensures correct and up to date information. The process should also include the distribution of new versions of documents. Organization should also include a named person, who has the top level responsibility of the process.

In addition to the documentation related duties and responsibilities, some more broadly defined items can also be named. These are the following.

- The employer has the duty to the train and familiarize the employees to the given tasks and equipment.
- The employer has the duty supervise operations to ensure, that proper procedures are used.
- The employer should further define its own duties and responsibilities, when a need for it occurs.

As these items are more broadly defined, they are also more broadly applicable and not limited to the RPAS operations. The Flight Operations Manual should include information about the relevant training and familiarisation, but the other items are expected to be part of the normal leadership practices at Tampere University

5 TECHNICAL CONSIDERATIONS FOR THE FLIGHT OPERATIONS MANUAL

The Flight Operations Manual is a document, that should be readily available and practical to use. The manual can be presented and shared to the end-user in different formats and mediums, each with different strengths and weaknesses related to the stated goals. Different formats and mediums are briefly analyzed in this chapter.

5.1 Considerations for the source file format

The Flight Operations Manual template published by Traficom, and presented in the section 3.7 is in proprietary doc format. This file format is quite commonly used (it is the format used in Microsoft Word text editor), and the file contents are easily modifiable, but the format also has some drawbacks. These drawbacks are related to compatibility and formatting the text content. The formatting options for the text layout are limited and also inefficient to use, as any modification in the basic text may require additional formatting. The compatibility of the file format with different text editors (including different versions of the Word editor) adds to the issue, as the formatting may not completely transfer.

LaTex is a typesetting system suitable for scientific or technical publications. The text content and the document design are separated in the LaTeX system, and it also contains multiple advanced features such as cross-referencing and complex math typesetting (*An introduction to LaTeX* 2019).

LaTex, which can be considered more complicated than text editors such as Microsoft Word, is a flexible system for generating technical documents. LaTeX allows advanced formatting of the text and other content, but it also has other features that could be utilized.

5.2 Electronic versus physical medium

The Flight Operations Manual can be shared in multiple mediums, core categories being electronic and physical. Physical medium in practice means an ordinary book, which has limited design choices.

A physical book has the distinct disadvantage of being a static product, meaning that

modifications and updates may be impossible to do without extensive reprinting. This limitation can be reduced by using a binder (instead of bind book) and using chapter-specific page numbering. Binder allows the addition or removal of individual pages, and chapter specific page numbering limits the reprinting requirement to an individual chapter. Even with these considerations the book option is non-optimal at least in the initial use phase (when multiple and extensive changes to the Flight Operations Manual are expected) but could be considered after the manual has matured enough.

Electronic medium has more options than physical medium, but the practical solution is the Portable Document Format (PDF) format, because of the high compatibility. Advantages of electronic formats like PDF is the availability, in both online and offline, and the ability to issue and amend updates. While these advantages are remarkable, they also present some challenges. For example, if the PDF is used offline, how the flight crew can know if they are using the latest version of the Flight Operations Manual. Another similar issue is how the updates are distributed and how changes are indicated. Updates can be distributed by more conventional means, such as through email list or other internal messaging systems, but the more advanced solution could be to consider the LaTeX formatted manual as source code and utilize distributed version control services such as the commonly known Github.

5.3 Conclusion of the technical considerations

There are multiple options for file formats and mediums, but based on the overviews in previous sections, optimal choices can be defined. These choices have a different meaning in the short term and long term development.

LaTex should be the primary file format, as it allows more control over the text layout and other formatting compared to the other options. Even though LaTeX can be more complicated to use and the initial time investment is substantial, the formatting only needs to be done once, and the further development of content and document design can be delegated to different people.

Short term choice should be using the electronic medium, namely a PDF file and updates and other information should be distributed by common channels, such as email list or other internal messaging systems. This allows rapid deployment of the Flight Operations Manual and aids further development of the content. On the long term, different distributed version control services should be analyzed and one taken into use, to aid collaboration and the amendment process for changes.

6 STRUCTURE OF THE FLIGHT OPERATIONS MANUAL

As previously mentioned in chapter 4, the RPAS operations at the Faculty of Engineering and Natural Sciences are conducted by multiple groups, that may be in practice considered being separate and independent operators. This division presents a challenge for the structure of the Flight Operations Manual.

To combat this issue, the Flight Operations Manual is divided into two separate parts, the main part, and the supplement part. The main part includes the universal rule of conduct and other items applicable to all groups. The supplement part is a group-specific, and it primarily includes information about relevant personnel and RPAS equipment in use.

6.1 Main part of the Flight Operations Manual

The main part of the Flight Operations Manual is created according to the template supplied by Traficom, but with some changes. Especially the chapter OM-B Aircraft operations - type related chapter is transformed into a requirements list for RPAS specific documentation. Faculty of Engineering and Natural Sciences operates a large fleet of different aircraft, some with constantly changing configuration, so it would be practically unmanageable to keep the Flight Operations Manual up to date. There are also other minor changes made to the template for the same reason.

Following subchapters describe the main chapters of the Flight Operations Manual. The relevant information that can be inferred as requirements, from the Traficom template is summarized, and the corresponding content of the Flight Operations Manual is briefly described. The Flight Operations Manual itself is included as the appendix A.

6.1.1 Introductory chapter

Introduction chapter contains basic information about the Flight Operations Manual and the RPAS operator. According to the template issued by Traficom, the chapter should include definitions of terms and abbreviations that are incorporated into the manual, name, and address of the RPAS operator, basic information about the areas where operations

are conducted, the type of operations and the types and number of aircraft used (Traficom n.d., p. 1)

This chapter is mostly written according to the template. A slight change is made by moving the list of aircraft (including the types and numbers) to the appendix section.

As pointed out before, the list is subject to constant changes. Another change from the template is the appointment of key people. From the regulatory standpoint, an organization is not required but taken an account the specific nature of RPAS operations at Tampere University, two preliminary organizational roles are created based on the merits of existing staff members. These appointed roles are Director of Flight Operations and Technical Director, and they are given specific rights and responsibilities on later chapters.

6.1.2 Revision status and list of effective pages

According to the template by Traficom, this chapter should describe the amendment process and include the revision status of the Flight Operations Manual. Traficom also suggests including a list of effective pages and document identification markings (Traficom n.d., p. 1).

The Flight Operations Manual is the initial version of the document, and therefore a subject to significant changes in a small timeframe. The key people have the initial responsibility for the amendment process and revision of the document, but a further long-term development should be put towards to formalize the process. The technical considerations from the chapter 5 should be noted and considered, namely the use of a version control system.

The suggestion about document markings is also taken into account. Pages of the document are marked with names of the document, chapters, and subchapters, and with the publication date. The pages are marked with running numbers, but these could be converted to chapter-specific numbering if the manual is preferred in printed form.

6.1.3 Duties and responsibilities of management and operational personnel

This chapter should contain information about personnel and their duties, especially related to operational safety. The chapter should also include instructions for emergencies, and an emergency response plan is given as a suggestion (Traficom n.d., p. 1).

This chapter contains the rights and duties of the key people, and also for the group managers. These duties are defined based on regulatory requirements, existing merits, or special needs set by the organizational structure. Duties and responsibilities for the

operational personnel are split to an additional chapter, as these are more flexible and operation-specific roles.

6.1.4 Description of safety management system

At the minimum, this chapter should include procedures and instructions on how risks and their mitigation needs are evaluated. The chapter should also include a safety policy and a description of how safety performance and compliance is evaluated. The template also describes a complete safety management system, with specific requirements for safety policy and objectives, management of safety risk, assurance of safety, and promotion of safety (Traficom n.d., p. 2).

This chapter was written by using the complete safety management system as a guideline, but in a limited manner and respecting the minimum requirements. The reasoning for the limited approach is the need for the long-term development and collection of experience, before the entirely rational system can be implemented. Some of the subsections in this chapter are very limited in their content but are included as place holders for future developments.

6.1.5 OM-A General/Basic section

According to the template, this section should include practical instructions that describe how normal operations are planned and conducted, and an extensive list of examples are given for what to include. Some of these examples are either redundant or airframe specific, so these are not included in this chapter (Traficom n.d., p. 3-4).

This section includes multiple chapters, and it describes how normal operations are conducted. Most of the chapters in this section are considered to be practical instructions, but the chapter on occurrence reporting is relevant from the regulatory requirement standpoint. In the occurrence reporting chapter, both the required process by Traficom and the Faculty's internal process are described.

6.1.6 OM-B Aircraft operations — type related

According to the template, this section should include type related information regarding technical aspects of the operational aircraft, including general information, emergency procedures, performance and operating limitations, minimum equipment and procedures for securing flight data. (Traficom n.d., p. 5-6).

This section in the Flight Operations Manual is radically different from the template, as the organizational structure and wide variety of remotely piloted aircraft would otherwise

present a challenge. Instead, the section is converted into a list of requirements regarding aircraft specific manuals and instructions.

6.1.7 OM-C: Areas of operation, routes and charts

The section about areas of operation, routes, and charts should contain description of procedures and instructions related to the operational environment. These procedures should cover factors like limited areas, airspace classifications, aerodromes, and populated areas. Guidance and sources should also be included for necessary information related to described items, for example, to the Aeronautical Information Publication or some other relevant publication (Traficom n.d., p. 7).

The chapter on airspace and areas of operations includes common altitude and distance limits based on the regulatory requirements. The chapter on airports and other aerodromes include practical information about airports in Tampere and Pirkanmaa area, including locations and risks involved.

6.1.8 OM-D: Personnel qualifications and training section

This section should include the requirements for qualification and training for the personnel, but may also contain training syllabi or instructions on how training records are kept (Traficom n.d., p. 8).

The regulatory framework does not require training, and the Flight Operations Manual is the initial version, so no specific training is either required nor described in the chapter. Training should be a part of long-term future development and may also be integrated with the RPAS related education at Tampere University. What is included in the chapter, is the list of documents that a RPAS pilots and other personnel should be aware of, for example, laws and regulations, and technical and operational knowledge of the remotely piloted aircraft.

Another reason for defining only limited training requirements is the new upcoming EU regulation, as presented in the section 2.5. The regulation will introduce new training and competency requirements.

6.1.9 OM-E: Documentation

The template issued by Traficom does not include a section for documentation, but it is added for organizational reasons. The section about documentation includes instructions and requirements for any RPAS related documentation. Including, but not limited to logbooks, safety assessments, and other operational instructions.

This section also describes the documentation and instructions related to the supplement part of the Flight Operations Manual. Multiple document templates were created to aid documentation tasks, and these are included in the appendix section of the manual.

6.2 Supplement part of the Flight Operations Manual

Supplement part of the Flight Operations Manual is intended for groups, which prefer to conduct independent RPAS operations. Supplement part includes information about the group in question, people of responsibility, qualified pilots, and RPASs in use. This information should be kept up to date and available to the organization management at all times.

The reasoning for collecting this information is derived from Traficom's requirements. Traficom requires notification on the use of remotely piloted aircraft, and the notification requires specific information about the aircraft.

6.2.1 Group information page

The Group Information page is created as a cover page for the group-specific supplement part. Group information page includes the contact information and any other relevant information of the person of responsibility, who is named as Group Manager in the Flight Operations Manual.

Group information is required to be updated if any changes occur. Group Manager, or another specifically appointed person is responsible for filling and updating the Group Information page.

6.2.2 Aircraft information pages

Traficom requires the following information before remotely piloted aircraft may be used for aerial work:

- Manufacturer
- Model
- Maximum Takeoff Weight (MTOW) in kilograms
- Number of aircraft
- Availability of parachute system
- Intended tasks
- Is there an intention to operate above densely populated areas
- Is there an intention to do Beyond Visual Line of Sight (BVLOS) operations

- Is there an intention to operate above crowds of people

This information is part of the aircraft specific pages of the Supplement. The pages are required to be up to date and copies to be given to Technical Manager, as he/she is responsible for making the notification to Traficom. This requirement is met by creating a form, that can quickly be filled with the relevant information.

7 CASE STUDY: RPAS OPERATIONS IN ACOLOR PROJECT

The Autonomous and Collaborative Offshore Robotics (aCOLOR) project was introduced in chapter 4 as an example of a complex RPAS operation. The project is treated as a case study in this chapter from the Flight Operations Manual viewpoint, and also as an example on how new RPAS operations should be commenced. The aCOLOR project includes both fixed-wing aircraft and rotorcraft, but only the latter is considered in this example.

7.1 Preliminary preparations

The RPAS operations included in the aCOLOR project are primarily conducted by the Mechatronics Research Group (MRG), which falls under the Faculty of Engineering and Natural Sciences. According to the Flight Operations Manual, a group manager should be pointed, but as the current Technical Manager is part of the research group, these two roles can be shared in this specific case.

The next step is to prepare the relevant documentation, such as group information page for the research group, and aircraft notification pages and logbooks for specific aircraft. Some of the specific information may be challenging to define, for example, the Maximum Takeoff Weight, as the research group has a wide variety of complex and self-built experimental aircraft, but reasonable estimates can be made. The roughly estimated absolute MTOW for hexacopter (multicopter with six rotors) operated by the group is 10 kilograms, so the reported value could, for example, be 12 kilograms, but it can also be less if other factors limit the maximum payload. The same logic should be applied to all aircraft, that do not have reported values by the manufacturer.

7.2 Preparing aircraft for operations

Any commercially manufactured aircraft with comprehensive instructions can be entered into active service, as soon as the operational personnel has been familiarized with the equipment. The self-built experimental aircraft require extensive testing and the generation of instructions, before entering active service.

The testing phase of an experimental aircraft should include both static and flight tests. Static tests could include issues like power system tests, where onboard power consumption measurements are compared to external measurements or connections tests, where the actual operational ranges of the remote control and other connections are tested. The former is an example of a functional test, that verifies that the values reported by the system are correct, while the latter is example more of an operational test, that produces practical instructions for flight planning purposes. Flight tests could include testing the control responses of the aircraft and tuning them to suitable levels but also similarly testing operational items as in the static tests. Operational tests in flight phase could include items such as maximum flight time or the accuracy of the automatic positioning system.

Tests should be as extensive as possible, but it is also important that they are relevant from the operational perspective. This means for example that it is not necessary to extensively test non-BVLOS aircraft in BVLOS flight conditions, but it might be necessary to test and define procedures for situations, where the non-BVLOS has flown outside of the visual line of sight without intention by the pilot. Tests for this specific example could include connection tests in a cluttered environment (such as in a forest or behind a building), but procedures can also be defined through a technical analysis e.g., what are the theoretical capabilities of the aircraft. The results from these kinds of tests can also be used as aid in the risk assessment process, in the case of non-BVLOS aircraft the recovering measures (what actions can be taken when the aircraft is beyond visual line of sight) can be limited, so the effort should be concentrated on preventive measures (how accidental flight beyond visual range is avoided).

Aircraft in the aCOLOR project are in primarily operated within visual line sight, but in the light of technical specifics, such as the use of autonomous flight modes, they should be in practice treated as BVLOS aircraft. This will add additional requirements for operations derived from the regulatory requirements, as referenced in section 3.4. This further means that comprehensive operational instructions, risk assessments, and written procedures for normal and emergency operations should be created according to the templates and guidelines from the Flight Operations Manual. In this specific example, this only a recommended course of action and not a hard requirement. When aircraft are used for actual BVLOS operations, the documents are required to be sent to Traficom.

7.3 Area of operations

The area of operations, including the lateral and vertical limits, should be defined. The likely operational areas for the aCOLOR project are the Pyhäjärvi and Näsijärvi (lake) areas in Pirkanmaa region, and there are multiple issues from the risk assessment perspective.

The first issue is the densely populated areas, such as Tampere city center and other settlements around the lakes. Not only does the densely populated areas add risks and

therefore limitations to the flight operations, but they also limit where ground operations can be conducted. In this context, the ground operations refer to ground control stations, takeoff and landing areas, including areas designated for emergencies. Suitable locations for these functions should be mapped and analyzed before commencing the flight operations.

The second issue is the vicinity of nearby airports, such as Tampere-Pirkkala Airport and Tampere University Hospital helipad. These airports will add additional requirements for the operational area, especially for the altitude limits. The planned operations will also require coordination with the air traffic control if deviations from the standard limits are required.

BVLOS operations require airspace reservation, and if these type of operations are to be conducted, the application for the reservation should be submitted as early as possible. In practice, all operations should be conducted within the line of sight, if possible, because requirements are less complicated and unnecessary airspace reservations can delay operations significantly.

7.4 Personnel

The aCOLOR project is a special type of operation in a sense that it includes multiple different types of vehicles that interoperate autonomously. This kind of setup presents unique challenges for the flight crew, but also for the support staff that operates the other vehicles.

The complexity of the operation dictates the requirement for a flight crew with accurately defined roles. Multiple remotely piloted aircraft require multiple pilots and Ground Station Operators, but these roles can also be combined. For example, a flight crew of three persons, Pilot in Command in Pilot Not Flying role and two co-pilots in Pilot Flying roles could be considered, if the personnel is experienced enough and the relevant procedures (for example communications or the transfer of controls) are defined.

Additional roles are also required, such as Ground Environment Controller and spotters. The area of operations has multiple vertical and horizontal limitations, which need to be sufficiently monitored in non-BVLOS operations. Area of operations is in the vicinity of populated areas, and public incursion is a possibility, so the spotters will also have the crowd control responsibility.

The boat crew is required to be sufficiently familiar with RPAS operations and unusual set of normal procedures are required. These procedures should, for example, cover preflight and after flight procedures (including securing the aircraft after a crash), takeoff and landing procedures from and to the boat, and approach and missed approach procedures. The missed approach procedure is especially important, as it may require actions from both the flight crew and the boat crew.

7.5 Discussion and conclusion of the case study

The RPAS operations in the aCOLOR project are complex, and they require extensive risk assessment and personnel training. While the Flight Operations Manual aids both of these processes, the manual in the initial version also has its limitations.

The risks in this specific example stem from multiple different sources, such as the experimental aircraft, the number of used vehicles, and the operational areas. The initial version of the manual does not supply the operational personnel with the procedure to avoid or reduce every specific risk but emphasizes the process where the risk related information is collected and analyzed. The project also demonstrates the difficulty in defining all of the risks in operations because of the experimental aspect. The experimental aspect of the operations means that the personnel may be working with unknown issues and, therefore, unknown risks. This puts further emphasis on controlling the known risks. The Flight Operations Manual and the related risk assessment form aids this process.

The case study implies extensive training requirements for operational staff, but the initial version of the Flight Operations Manual only specifies these on the very basic level. Instead, the emphasis is on the flight planning and risk assessment process described in the manual. These processes should be used to create operational instructions, which should further used to define practical knowledge and skill requirements for these specific operations.

This case study was conducted near the end of the writing process of the Flight Operations Manual. While the manual work for the case study and is deemed suitable for use, the study also gave some insights for further developments. One of these insights is the note that also other personnel (that are not considered as part of the flight crew) may be working with or near the drones, and they also require some level of familiarization.

The training requirements and programs are part of future development, but based on this case study, a modular study program should be considered. A modular structure would allow additional staff to study only the relevant aspects of the RPAS operations. Relevant module, for example, for the boat crew, could be about the recovery of the remotely piloted aircraft, which includes the technical knowledge for disarming and powering off the equipment, but also aspects like data protection in the event of a crash.

8 CONCLUSION AND FURTHER DEVELOPMENTS

The initial version of the Flight Operations Manual was created in this thesis, that complies with the governing regulatory framework and practical requirements. Some preparation for possible future changes were also made.

During the development process, a conscious decision was made to limit some sections of the Flight Operations Manual to the bare minimums, as these were deemed to require the collection of long-term practical experience and knowledge. These sections were amendment and revision process, safety management system, and personnel qualifications.

Amendment and revision process was not strictly defined for the reason that the Flight Operations Manual is in its very initial state and may be subject to multiple changes during a short period. The process should be formalized after initial use, and a documentation manager could be appointed if deemed necessary. The use of distributed version control service should also be considered, as discussed in the chapter 5.

Safety is a subject to constant improvement and therefore by default a subject to long term development. The initial safety management system was put in place with a practical approach and limited information in mind, but it should be refined by collecting long-term experience and knowledge from RPAS operations.

Any strict personnel qualification requirements were not put in place, as these are not required, but also because upcoming EU regulation (as discussed in section 2.5) will impose new training and competency requirements in the near future. Training should be a part of the long term development and should cover both students and staff at Tampere University.

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A FLIGHT OPERATIONS MANUAL

Faculty of Engineering and Natural Sciences
Tampere University

RPAS FLIGHT OPERATIONS MANUAL

Initial version

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Disclaimer

This is not a legal document and does not override any rules, regulations, or any other information given in official sources.

Compilation of all relevant legal information can be accessed through the following website, which is maintained by the competent authority - Traficom:

`https://www.droneinfo.fi/en/unmanned_aviation`

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Amendment process and revision status

Amendment process

This Flight Operations Manual is subject to changes for regulatory, flight safety or other reasons. Changes are made and distributed by the organizational management listed in the section 1.3.

In case of errors or mistakes in this manual, the users of this manual should contact the key people listed in the section 1.3.

Revision status

- Initial version published

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Part I

INTRODUCTION

Special Terms and Abbreviations

AIP Aeronautical Information Publication.

BVLOS Beyond Visual Line of Sight.

CTR Control Zone.

DFO Director of Flight Operations.

ENS Faculty of Engineering and Natural Sciences.

FIZ Flight Information Zone.

FOM Flight Operations Manual.

GCS Ground Station Control.

GEC Ground Environment Controller.

GM Group Manager.

GSO Ground Station Operator.

MEL Minimum Equipment List.

PF Pilot Flying.

PIC Pilot in Command.

PNF Pilot Not Flying.

PS Payload Specialist.

RMZ Radio Mandatory Zone.

RPA Remote Piloted Aircraft.

RPAS Remote Piloted Aerial System.

RTL Return to Launch.

TAU Tampere University.

TD Technical Director.

UAS Unmanned Aerial System.

UAV Unmanned Aerial Vehicle.

VLOS Visual Line of Sight.

Contents

Chapter 1

General information

This Flight Operations Manual has been prepared by the Tampere University, Faculty of Engineering and Natural Sciences. The purpose of this manual is to provide operational procedures, limitations and guidelines for personnel conducting any RPAS operation under the Faculty of Engineering and Natural Sciences.

This manual applies to aerial work conducted with Remotely Piloted Aerial Systems (RPAS; other common definitions including Unmanned Aerial System UAS, Unmanned Aerial Vehicle UAV and 'drones') in accordance with the operational limitations listed in the section 1.2.

This manual does not apply to any operation conducted outside of Finnish territory.

1.1 Name and address of the organization

Billing address	Visiting address
Tampere University	Tampere University
Faculty of Engineering and Natural Sciences	Faculty of Engineering and Natural Sciences
P.O.Box 589	Korkeakoulunkatu 6
33101 Tampere	33720 Tampere
Finland	Finland

1.2 Operational information

Areas of operations	Types of operations
Finland	Research and development Teaching

1.3 Key people

Director of Flight Operations	Technical Director
Mr. Jouko Laitinen jouko.laitinen@tuni.fi +358 50 676 10	Dr. Jussi Aaltonen jussi.aaltonen@tuni.fi +358 40 849 0522

Part II

PERSONNEL

Chapter 2

Duties and Responsibilities of Management

2.1 RPAS Flight Operations Management

Responsibilities in RPAS operations management is divided between the Director of Flight Operations, the Technical Director, and the group-specific Group Managers.

2.1.1 Director of Flight Operations - DFO

Director of Flight Operations is responsible for

- Overseeing RPAS operations,
- Accepting personnel appointments and changes,
- Accepting changes to this Flight Operations Manual,
- RPAS related flight and safety training,

Director of Flight Operations has the right to stop and seize all RPAS flight operations for legal, safety or other reasons. Director of Flight Operations has the right to impose additional requirements for flight operations, personnel, training, and other issues presented in this document.

2.1.2 Technical Director - TD

Technical Director is responsible for

- Airworthiness of Remote Piloted Aircraft,

- Insurances related to RPAS operations,
- RPAS related technical training,
- Management of the aircraft notification collection,
- Making the RPAS notification on the use of Remote Piloted Aircraft to Trafi and any updates related to it,

2.1.3 Group Manager - GM

Any department, research group or any other group under the Faculty of Engineering and Natural Sciences that wish to conduct independent RPAS operations, is required to have a named Group Manager. Group Manager oversee that RPAS operations are conducted according to this Flight Operations Manual, the rule of law and any other relevant instructions.

Group Manager is responsible for the group specific supplement part of this Flight Operations Manual and any responsibilities related to it.

Chapter 3

Flight Crew Personnel

3.1 Pilot-In-Command - PIC

The Pilot in Command has the undivided responsibility to conduct RPAS operations according to all rules and requirements set by this Flight Operations Manual and the regulatory framework concerning RPAS operations. The Pilot in Command has the full authority to postpone, cancel or change any RPAS operation if deemed necessary in regards to safety, legal or other relevant requirements.

The Pilot in Command is responsible for the final flight plan and briefing of the flight crew, for all operations. Relevant information for flight planning is included in chapter 8 and part VIII, and instructions for flight crew and its composition is in section 3.2.

The Pilot in Command has the right to delegate tasks among the flight crew, and the person piloting the RPA can be changed during the operation. The change of role should be avoided in general to avoid any confusion in the chain of command but could be considered during training flight or when there are two sets of controls available (for example a handheld radio controller and other controls connected to the Ground Station Control). Look for more details in sections 3.2.2 and 3.3.

3.2 Flight Support Crew Roles

Additional crew members are not a requirement for all RPAS operations, but the following roles (and combinations of them) should be considered in regards

to the complexity of the flight operation, operational area and other relevant factors.

3.2.1 Spotter

Spotter is responsible for monitoring the airspace for other air traffic and the environment for other potential hazards. Spotter is also an assistive role for the Ground Environment Controller (see subsection 3.2.3 for more information).

3.2.2 Ground Station Operator - GSO

Ground Station Operator is responsible for operating Ground Station Control and interacting with the RPA via telemetry connection. Ground Station Operator role requires specific training for Ground Station Control hardware and software.

Ground Station Operator role requires good communication and coordination with the Pilot in Command. Ground Station Operator role may include flying the RPA with GCS connected controls and additional Pilot Flying (PF) and Pilot Not Flying (PNF) role terms should be used, but this kind of operation and crew organization is recommended only for experienced flight crews.

3.2.3 Ground Environment Controller - GEC

Ground Environment Controller is responsible for controlling ground environment and coordinating the spotters to aid this task. The tasks of GEC for example include measures to avoid public incursion and other ground hazards.

3.2.4 Payload Specialist - PS

Payload Specialist is responsible for managing and operating the scientific payload on the RPA in coordination with the PIC.

3.3 Flight Crew Organization

The Pilot in Command is responsible for organizing the flight crew in regards to the mission complexity, area of operation and other relevant items.

Flight crew should be organized according to the instructions in chapter 8

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Part III

SAFETY MANAGEMENT SYSTEM

Chapter 4

Safety Policy and Objectives

4.1 Management commitment and responsibility

The organization management according to the section 1.3 is committed and responsible to be in compliance to rules and regulations, managing and implementing the changes in the relevant regulatory framework safety related education, and continuous improvement in all safety related aspects.

4.2 Safety accountabilities

The Pilot in Command is responsible for any individual flight operation the he or she conducts. The Pilot in Command answers to the relevant Group Manager, Technical Director or directly to Director of Flight Operations.

Group Managers are responsible for PIC qualifications and airworthiness of the RPA within their respective groups. Group Managers answer to Technical Director or Director of Flight Operations.

Director of Flight Operations and Technical Director are responsible for the compliance with the regulatory framework.

4.3 Appointment of key staff members

Key staff members in safety issues are the members of the management according to the section 1.3. Director of Flight Operations or Technical Director have the right to appoint additional staff members with specific roles and responsibilities at their discretion.

4.4 Emergency response planning

Emergency response planning is a part of mission planning (section 8.1) and mission briefing (section 8.2) process. It is also closely related to safety risk management (chapter 5).

Common rules for emergency response planning are the following

- Respect the Minimum Equipment List according to the chapter 21, as it includes the required safety equipment.
- Include persons with skills in first aid and first extinguish in the flight crew.
- Be aware of the location where operation is conducted, so additional help may be directed to the scene.
- Call 112 when in emergency. It is recommended to install the 112 application on phones of the crew, as it automatically sends location data to the emergency services.

4.5 SMS documentation

The current SMS documentation is limited to this Flight Operations Manual and occurence reporting according to the chapter 12. Additional documentation practices may be imposed by Director of Flight Operations if deemed necessary.

Chapter 5

Safety Risk Management

Every flight operation should include a written description of the operation, including hazard identification, risk assessment and operational instructions.

Trafi has published a set of guidelines for hazard identification and risk assessment. Instructions (currently only available in Finnish) may be accessed from here:

`https://www.droneinfo.fi/fi/lentotyo/rpas_lentotyo`

Appendix of this document also includes a template for a mission plan. This mission plan includes risk and safety assessment section. See more information in part VIII.

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Chapter 6

Safety Assurance

6.1 Safety performance monitoring and measurement

The primary safety performance monitoring is conducted through accident and incident reporting (see chapter 12). All reports are analyzed for implications of errors in training, instructions, or any other relevant part in the organization.

6.2 Management of change

The management according to the section 1.3 is responsible for making the changes for any safety related practices and instructions. They are also responsible for educating and informing the relevant personnel according to the chapter 7.

6.3 Continuous improvement

The management is committed to make changes on the organizational level whenever a safety related issue is discovered.

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Chapter 7

Safety Promotion

7.1 Training and education

There are no compulsory training or education requirements at the time being, but the Director of Flight Operations has the right to impose them, if deemed necessary.

Flight crew personnel should be informed about common flight safety issues, especially including human factors. Relevant information and training is available through Director of Flight Operations or Technical Director.

First aid and first extinguish training is recommended for all flight crew members.

7.2 Safety communication

The management according to the section 1.3 is responsible for informing about any new safety related requirements, instructions, or other relevant information.

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Part IV

OM-A GENERAL

Chapter 8

Flight operations

8.1 Mission planning

Every RPAS mission is required to be planned in advance. Mission may be prepared by any qualified person, but the final mission plan is required to be accepted by the Pilot in Command.

Mission plan template is included in the appendix and additional information is presented in the part VIII.

8.2 Mission briefing

The Pilot in Command is responsible for mission briefing before any RPAS mission. The briefing should contain (at minimum) the following items

- Mission plan and area of operations
- Flight crew composition, including individual roles, responsibilities, and the chain of command
- Risk assessment and mitigation plan
- Safety, security and emergency procedures

8.3 Flight crew communication

Flight crew members are required to use common language during the whole operation. Whenever crew members are beyond the speaking distance, radios or designated hand signals are required to be used.

Designated words and phrases should be used in critical phases of the flight operations. This organization does not have a standardized communication protocol at the time being, but for example the following items should communicated among the crew

- Power on and power off
- Takeoff and landing
- Deviations from a normal flight operations, including emergencies
- Mission specific commands

Chapter 9

Operational control system

Remote Piloted Aircraft should always be connected to the controller operated by the Pilot in Command, to the ground station operated by Ground Station Operator, or both, during any flight, including fully autonomous operations. The responsibilities of Pilot in Command and the flight crew are shared according to the chapter 3.

Failsafe systems and mechanisms should always be used when available, and they should be configured for every individual flight operation. Common failsafe options are the following:

- RTL - Automatic return to launch site along a straight flight line
- SmartRTL - Automatic return to launch site by back tracing the flight route
- RTL or SmartRTL with rally points - automatic return to the closest preconfigured landing site
- Automatic landing
- Parachute launch

Failsafe mechanisms can usually be configured for radio, battery, and Ground Station Control failures and be coupled with geofence functionality.

9.1 Failsafe examples

Choosing a suitable failsafe mechanism is usually self-explanatory, but decisions should always be made based on the flight mission and area of operation. Following examples demonstrate specific cases, where extra effort is required.

9.1.1 Flight operation above water

If the RPA used for flight operations above water is not equipped with flotation devices, the landing mode should be avoided. The RTL and smartRTL modes with additional pre-configured rally points are recommended.

9.1.2 Flight operation above crowds of people

Flight operations above crowds of people should not use the automatic landing mode as a failsafe, as it imposes the obvious hazard for the health and safety of the people. RTL or smartRTL modes are preferred and may be coupled with additional rally points.

Flight operations above crowds of people are not allowed in this organization.

9.1.3 Flight operation with a grid pattern

Depending on the ground features of operational area, the RPA should be configured for RTL or landing modes in a case of radio or battery failure. SmartRTL mode should generally be avoided with grid patterns, as it may result a longer flight distance to the launch site.

Additionally, flight operations in grid patterns should always be started from the furthest end of the grid. This practice will ensure the maximum available battery power and a safe return to the launch site in a case of an insufficient radio range.

9.1.4 BVLOS flight operations

Failsafe mechanisms for Beyond Visual Line of Sight flight operations are extremely critical and should be included in the mission planning process. For example, GCS failure can lead to a total loss of a situational awareness of the aircraft. The GCS failure should be coupled, for example, with RTL or smartRTL modes and with rally points within the visual line of sight of the Pilot in Command.

Chapter 10

Flight and duty time limitations

This organization has no fixed flight or duty time limitations. Flight crew experience, environmental conditions and mission complexity are the factors that decide the practical limits during pre-flight planning process.

More important than the fixed limits are that missions are planned beforehand, their duration are known for the whole flight crew, and any personal limitations are respected. Long missions should be broken down for smaller flight segments whenever possible.

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Chapter 11

Weather limitations

All RPAS operations should be conducted according to the manufacturers instructions and limitations. Weather conditions may be estimated on site and following primary items should be considered.

- Wind speed (hand held wind meter is recommended)
- Visibility
- Cloud ceiling
- Rain, snow or other precipitation

For pre-flight planning purposes, the aviation weather service and relevant instructions can be accessed through the following address:

`https://www.ilmailusaa.fi`

RPAS operations in unsuitable weather are forbidden. These operations should be postponed, cancelled or done in limited fashion. The Pilot in Command is responsible for any weather related decisions in accordance to the responsibilities laid out in section 3.1

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Chapter 12

Occurrence reporting

In a case of accident or incident, a report should be made to Trafi and a copy sent to the organization management. Practical instructions and link to the reporting service may be accessed through the following link:

`https://www.trafi.fi/en/aviation/unmanned_aviation/incident_and_occurrence_report`

When filling the form, the box for "Send a copy of this flight safety report to my e-mail" should be ticked and the resulting email should be forwarded to the management. Contact information for the management can be found in section 1.3.

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Chapter 13

Security procedures

To avoid unlawful interference with RPAS operations all connections should be encrypted, whenever possible. Setting up proper failsafe mechanisms according to the chapter 9 is an important security procedure.

Informing the public about RPAS operations should also be considered as a safety procedure. Public access to active operations or any equipment is required to be controlled at all times.

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Chapter 14

Airworthiness and maintenance

All Remote Piloted Aircraft and any equipment which has an effect on flight safety needs to maintained. All equipment needs to be maintained according to the manufacturer maintenance intervals and instructions.

In a case of an incident, accident or any other type of abnormality, the RPA and other relevant equipment is effectively grounded until the contributing technical issues have been discovered and corrected.

All RPA should be properly tested after every significant maintenance task or modification. These include software updates, extensive disassembly and assembly, component changes, wiring tasks and other similar items.

Compliance with sections V and VIII in this Flight Operations Manual is also considered as an airworthiness requirement.

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Chapter 15

Special operations

Special operation is any flight operation, that is not covered in this Flight Operations Manual. Anyone wishing to conduct such operation, should contact either Director of Flight Operations or Technical Director. Contact information for the relevant personnel can be found in section 1.3.

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Part V

OM-B AIRCRAFT OPERATIONS

Chapter 16

Introduction to OM-B

This part of the Flight Operations Manual defines the general rules and requirements for any RPAS operated by the Faculty of Engineering and Natural Sciences in Tampere University. The rules and requirements apply to all aircraft, ground control stations, documentation, safety equipment and other operational items.

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Chapter 17

General information

Aircraft specific operation manuals are required to contain general information of the aircraft. This information contains (at minimum) the following items.

- Manufacturer of the aircraft
- Type of aircraft
- Number of identical aircraft
- Dimensions of the aircraft
- Diagrams and/or photographs of the aircraft
- List of components installed (manufacturer, type, software version) for aircraft built by Tampere University
- System diagrams for aircraft built by Tampere University

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Chapter 18

Normal procedures

Aircraft specific operation manuals are required to contain comprehensive information of normal operating procedures. At the minimum, every aircraft is required to have a checklist of all critical items for a safe and controlled flight. A condensed checklist may be used by an experienced RPAS crew.

Documentation provided by manufacturer of commercial aircraft, creators of used software or other relevant source may be used as is if deemed suitable and accepted by Technical Director or Director of Flight Operations.

Normal procedures do not overrule aviation law or any safety related rules laid out in this manual. The Pilot in Command is responsible for that all the rules and regulations are followed during the normal operations.

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Chapter 19

Emergency procedures

Aircraft specific operation manuals are required to contain comprehensive information of emergency procedures. At the minimum, every aircraft is required to have an emergency checklist for all potential situations, in which there is a threat to human life, aircraft, infrastructure or any other property.

Documentation provided by manufacturer of commercial aircraft, creators of used software or other relevant source may be used as is if deemed suitable and accepted by Technical Director or Director of Flight Operations.

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Chapter 20

Performance and operating limitations

The nature of RPAS operations conducted by the Faculty of Engineering and Natural Sciences at Tampere University is experimental and research orientated. This means, that performance and operating limitations for different aircraft are subject to a constant change.

The following items should be known (or at least estimated) for any operation outside of purely experimental activities.

- Mass and balance of the aircraft
- Mass and shape of external cargo
- Maximum take-off mass of the aircraft
- Performance limitations
- Power supply and its limitations
- Weather limitations
- Temperature limitations
- Wind limitations
- Visibility limitations
- Precipitation limitations
- Limitations related to icing conditions
- Limitations related to thunderstorms
- Airspace limitations
- Altitude restrictions
- Obstacle limitations

- Limitation for flights over populated areas
- Communication and control limitations

Chapter 21

Minimum equipment

Every aircraft is required to have a Minimum Equipment List (Minimum Equipment List). This list includes all items required for a safe and controlled flight, and also any limitations set by inoperable items. The Pilot in Command is responsible, that the RPAS is operated in the required configuration. The Minimum Equipment List also includes all the relevant emergency and safety equipment.

The Minimum Equipment List should be updated whenever a risk and safety assessment impose additional requirements. More information in chapter 5 and part VIII.

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Chapter 22

Flight data

In case of any incident or accident the RPA and any flight data needs to be secured for investigation purposes. The procedure for extracting flight data should always comply with manufacturers instructions, but the following priorities should generally apply in a case of an accident:

1. Download log files over telemetry radio before turning off power from the RPA, if allowed by the GCS. Skip this step if the RPA is on fire and start first extinguish measures instead.
2. Download log files over a wired connection, for example USB, if possible. Skip this step if flight controller or other component containing the memory device is damaged.
3. Remove the SD card or other memory device from the RPA and make backups of the content.

Save a local copy and a cloud back up (use cloud services offered by Tampere University) in case the organization management or accident investigation authorities request the information.

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Part VI

OM-C AREAS OF OPERATION, ROUTES AND CHARTS

Chapter 23

Airspace and areas of operation

Common altitude restriction (above ground or water) is 150 meters. This altitude restriction not apply to operations near fixed objects, if permission is obtained from the owner of the objects in question.

RPAS operations are allowed in a Control Zone, a Flight Information Zone or a Radio Mandatory Zone with following rules

a) Flying is allowed near fixed objects, when the horizontal distance to an airport is more than 1 kilometer, but less than 3 kilometers.

b) The altitude restriction is 50 meters, when the horizontal distance to an airport is more than 3 kilometers.

c) All operations in the vicinity of airports Jyväskylä (EFJY) and Utti (EFUT) require a permission from the airport authorities.

d) The altitude restrictions may be extended with 15 meters, when operated near fixed objects while following the rules a) and b).

These instructions are available in OPS M1-32 and should be the primary information source.

Information about the airspace structure, restricted areas and other relevant information may be accessed through the following address:

`https://www.ais.fi/aip/en/`

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Chapter 24

Airports and other aerodromes

Tampere and Pirkanmaa region contains multiple airports, including commercial, general aviation, and RC airfield. These airfields may be used as a base for operations, but they should also be taken into account when planning RPAS operations.

Tampere-Pirkkala airport is a combined commercial and military airport. It is highly unlikely that Tampere-Pirkkala airport is used as a base for RPAS operations, but as it is located close to Tampere city center and Tampere University campus in Hervanta, it is essential to include the airport in risk assessments concerning the relevant operational areas.

Teisko airfield north of Tampere city center is a general aviation airfield, that may also be used for RC aviation and therefore also for RPAS operations.Aviation radio is a recommended item.

Pinsiö airfield is a privately owned grass strip dedicated for RC aviation and therefore is suitable for RPAS operations. If the pilot in command or other relevant person wishes to use the airfield, he or she should contact Tampere RC pilots chairman to obtain permission:

`http://www.trerc.fi/yhteystiedot/`

Pirkanmaa region and surrounding areas also contain other airports and aerodromes, for example, Halli military airport in Jämsä or Jämijärvi general aviation airfield in Jämijärvi. The contact information and other relevant information may be accessed through the following links:

`https://www.ais.fi/aip/en/`

`https://lentopaikat.fi/`

Special consideration should be applied to the Tampere University Hospital helipad near the city center, as low flying helicopters pose a significant risk.

Chapter 25

Populated areas

Important distinction should be made between crowds of people and populated areas. The definition for a crowd of people is a gathering of people, where RPAS could be considered to add a direct hazard to human life and health (in practice any RPAS flight operation within 50 meter radius from the crowds of people). The insurances purchased by the Faculty of Engineering and Natural Sciences does not contain protection for operations above crowds of people and therefore they are forbidden.

The definition for densely populated area is an area with 800 or more residents or place of work per square kilometre, but it could be considered to be any area where RPAS operations could express significant level of hazard, direct or indirect, against people, property or other important infrastructure. There are no comprehensive instructions for operations around populated areas, but all operations should be carried out following rules of the section III. The maximum takeoff weight for a RPA in densely populated areas is 3 kg.

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Part VII

OM-D PERSONNEL QUALIFICATIONS AND TRAINING

Chapter 26

Qualification and training requirements

The Faculty of Engineering and Natural Sciences does not have official qualification or training requirements for any personnel. Pilot in Command may be considered qualified, if he/she can express the knowledge and comprehension of following items, when they are relevant to the conducted operation:

- Content of this Flight Operations Manual
- Technical and operational knowledge of the used aircraft
- Aviation law and other applicable regulations*
  - Use of remotely piloted aircraft and model aircraft (OPS M1-32)
  - Commission Implementing Regulation (EU) No 923/2012 on the common rules of the air (SERA)
  - Finnish Aviation Act (864/2014) - relevant parts: 2 § (Definitions), 9 § (exemptions from the rules of the air), 11 § (airspace restrictions), Chapter 5 (requirement for a commander, responsibilities of the commander, flight planning and performance), 76 § (use of aerodromes and other areas), 136 § (liability for damages), 159 § (activities causing danger to flight safety)
  - Government Decree (930/2014) on areas where aviation is restricted
  - Regulation (EC) No 785/2004 of the European Parliament and of the Council on insurance requirements for air carriers and aircraft operators
  - Act on plant protection products (1563/2011) - 20 § (air spraying of plant protection products)
  - Other regulations that may be specific to the conducted operation
- Aeronautical Information Publication (AIP)

*Latest information should be retrieved from the official sources, that are listed on this website by the competent authority - Traficom:

`https://www.droneinfo.fi/en/unmanned_aviation`

For any flight operations with more than minimal risk, the Pilot in Command is required to have recent flight experience, including experience with the relevant safety and emergency procedures. Recent flight experience is defined by the discretion of Director of Flight Operations, Technical Director or the relevant Group Manager. In case of an insufficient recent flight experience, the pilot should conduct training flights (that include both normal and emergency procedures) in a safe environment.

Director of Flight Operations or Technical Director will organize training events if required. Director of Flight Operations and Technical Director also have the right to set additional training requirements at any point, if deemed necessary for safety or other reasons.

Chapter 27

Training records

Training flights are required to be logged in personal and aircraft specific log books, as any other flight operation, and saved for at least 3 years. Flight are logged according to the regulation OPS M1-32. The following items are required to be logged for any remotely piloted flight, including training flights:

- Date
- Location
- Pilot in Command
- Manufacturer and model of the aircraft
- The start and end times of the flight, or series of flights
- Type of flight (VLOS or BVLOS)
- The type of flight operation

More information about flight logging is presented in the part VIII of this document.

At the time being there is not any compulsory training for RPAS pilots and crew, but if Director of Flight Operations or Technical Director exercise their right to impose additional training requirements, a documentation practice is also created and implemented.

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Part VIII

OM-E DOCUMENTATION

Chapter 28

Supplement for the Flight Operations Manual

Supplement is the group specific part of the Flight Operations Manual that includes the relevant information about personnel, remotely piloted aircraft and other equipment. Supplement can also be used to describe any other unique information related to the group and their RPAS operations.

28.1 Group specific supplement for RPAS Flight Operations Manual

Group specific supplement is a form, that also act as a cover for the group specific part of the Flight Operations Manual. The form includes general information about the group and contact information for the relevant personnel. An example of the form with instructions is included at the appendix. Digital form is available from the document bank.

Any group wishing to commence RPAS operations under this organization, should fill this form and contact the Technical Director for further processing and istructions.

28.2 Aircraft information notification for RPAS operations

Any aircraft used for RPAS operations is required to have an information notification.

Aircraft information notification is required to be filled, delivered to the Technical Director and allowed to be processed before the aircraft is used for aerial

work. The process needs to be repeated for any changes related to the items in the aircraft information notification.

Group Managers are required to keep an up-to-date collection of aircraft information notifications for their group and Technical Director is required to keep a collection of all active aircraft under the organization. The definition for an active aircraft is any aircraft, that may used for aerial work.

An example of the form with instructions is included at the appendix. Digital form is available from the document bank.

28.3 Additional information for the supplement

All groups are encouraged to include additional sections and information to the supplement part. This information could include items such as specific skills of the personnel, specific operational instructions, or specific safety instructions.

Group Manager is responsible that all information up-to-date, correct, and relevant to the specific group.

Chapter 29

List of flight crew qualifications

List of Pilot in Command qualifications includes the people, that are qualified to conduct flight work according to the current requirements.

Group Managers are responsible to keep their list up to date. Group Managers are also responsible to make sure, that the organization management (section 1.3) have an access to the list.

As qualification requirements are subjects to change, it is recommended to have the list in electronic form, for example in an Excel file. Any changes to the requirements should be implemented to the list and enforced without a delay.

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Chapter 30

Risk and safety assessments

Risk and safety assessment is a part of any complex RPAS operation. Complex operation is defined to be any of the following:

- Operations above densely populated areas.
- Operations in 50 meter radius from crowds of people
- Beyond visual line of sight operations
- Operations with an exemption from mass, altitude or other limit

Risk and safety assessment is recommended for all RPAS operations, but the scope and broadness of the assessment should be proportional to the size and inherit complexity of the operation itself. A template (with example information) of a flight planning and briefing form, which includes risk and safety assessment, is included at the end of this document.

The included template is designed for highly complex operations. The template can and should be tailored for each group conducting RPAS operations. For example, any repeating information (such as operational area, technical details etc.) specific to the group, can be included in the template. Some sections may be removed, if deemed unnecessary. For example the route section could be removed by the groups, that only conduct local flight in small range. Editable template is available from the document bank.

Risk and safety assessments (chapter 5), along with other flight planning documents should be stored for at least 3 months.

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Chapter 31

Log books

31.1 Flight log book

All flights are required to be logged in aircraft specific log books and saved for at least 2 years. Flight are logged according to the regulation OPS M1-32. The following items are required to be logged for any remotely piloted flight:

- Date.
- Location (of takeoff and landing).
- Pilot in Command.
- Manufacturer and model of the aircraft.
- The start and end times of the flight, or series of flights.
- Type of flight (VLOS or BVLOS)
- The type of flight operation

A digital template for the flight log book is available from the document bank. Physical log books can be requested through the Technical Director. The decision between digital and physical should be made from the practicality viewpoint.

Any aircraft used for RPAS operations is required to have its own flight log book. Flight log book is required to be available before, during and after for any conducted RPAS operation.

31.2 Personal log books

Using a personal log book is not a strict requirement defined in the relevant regulatory framework or by the organization, but it is highly recommended to do so. Personal log books may be used to demonstrate relevant flight experience for flight crew licences, if licence requirements are defined in the future.

All flights should be logged in personal log books and saved for at least 2 years. Any person who is qualified to work and is conducting RPAS operations in the role of Pilot in Command, should use a personal log book. The following items are required to be logged for any remotely piloted flight:

- Date
- Location
- Manufacturer and model of the aircraft
- The start and end times of the flight, or series of flights
- Type of flight (VLOS or BVLOS)
- The type of flight operation

A digital template for the personal log book is available from the document bank. Physical log books can be requested through the Technical Director. The decision between digital and physical should be made from the practicality viewpoint.

Appendix A

Group specific supplement for RPAS Flight Operations Manual

Appendix A

GROUP SPECIFIC SUPPLEMENT FOR RPAS FLIGHT OPERATIONS MANUAL

Organization

Name of the group Name of the group e.g. Mechatronics Research Group.
Position in the faculty Position of the group in the faculty e.g. ENS - TAU

Group Manager

Name of the Group Manager e.g. John Doe
Email e.g. john.doe@tuni.fi
Phone number e.g. +3581234567

Other personnel with specific roles (optional)

Role	Name, email, phone number
Additional roles e.g. Flight Instructor.	

Description of operations

General description of the type of operations conducted e.g. Aerial photography and bridge inspections.

Instructions

1. Any department, research group or any other group under the Faculty of Engineering and Natural Sciences that wish to conduct independent RPAS operations, is required to have a named Group Manager. Group Manager oversee that RPAS operations are conducted according to the Flight Operations Manual, the rule of law and any other relevant instructions.
2. The form needs to be filled by the named Group Manager before commencing RPAS flight operations. Fill the form, export it as PDF and use it as a cover page for the supplement part of the Flight Operations Manual.
3. Send a copy of the form to Director of Flight Operations (jouko.laitinen@tuni.fi) and Technical Director (jussi.aaltonen@tuni.fi).
4. Wait until the form is processed and answer possible enquiries from the directors.
5. Repeat process whenever there are changes to the supplied information.

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Appendix B

Aircraft information notification for RPAS operations

AIRCRAFT INFORMATION NOTIFICATION FOR RPAS OPERATIONS

Notification

Type of notification	New aircraft ☐	Update for an existing notification ☐
Date of notification	YYYY-MM-DD	
Entry into service	YYYY-MM-DD	Removal from service YYYY-MM-DD

Group information

Name of the group: Name of the group operating the aircraft e.g. Mechatronics Research Group.
Group manager name, email & phone number: John Doe, john.doe@tuni.fi, +3581234567.
Storage location of the aircraft: Room number e.g. K1234.

Technical details of the aircraft

Manufacturer: Name of the manufacturer e.g. DJI.		
Model: Model of the aircraft e.g. Mavic Pro 2.		
Description (required for self-built aircraft and modified commercial products, optional for commercial products): General description of the airframe e.g. Electric quadcopter intended for aerial photography.		
Unique ID (will automatically add unique footer for this document)	e.g. DJIMP2_1	
MTOW (kg): MTOW in kg e.g. 0.25 kg.	Number of identical aircraft: e.g. 2.	
Aircraft is equipped with a parachute	Yes ☐	No☐
Aircraft is visibly marked with contact information (required by law)	Yes ☐	No☐

Intended tasks for the aircraft

☐ Photography, videotaping

☐ Press, media

☐ Powerline inspection

☐ Gas pipe inspection

☐ Inspection of masts or wind power plants

☐ Inspection of buildings or roofs

☐ Inspection of other construction e.g. bridges

☐ Logistics

☐ Ship emission measurements

☐ Measurement of radiation or other emissions

☐ Measurement of mobile phone networks or other telecommunication networks

☐ Agricultural work

☐ Forestry work

☐ Providing an overall situation picture for an entity in command of other operations

☐ Aircraft external inspections

☐ Mapping or charting

☐ Lidar or other sensor

☐ Test flights for development of new devices or functions

☐ Search and rescue services

☐ Surveillance

☐ Ore prospecting or other soil survey

☐ Scientific research

☐ Tasks using thermographic camera

☐ RPAS flight training

☐ Other, specify*

*if other, specify: Describe the intended tasks not included in the list.

Area of operations

Intend to operate over densely populated area/settlement	Yes ☐	No☐
Intend to perform BVLOS operations	Yes ☐	No☐
Intend to operate over an open-air assembly of persons	Yes ☐	No☐

Supplemental information

Include additional information if necessary.

Notification filled by

Name, email & phone number (required if not filled by the group manager): John Doe, john.doe@tuni.fi, +3581234567.

Instructions

1. Fill this form for any remotely piloted aircraft intended for aerial work under the Faculty of Engineering and Natural Sciences, in Tampere University.
2. Update the fields in footer (double-click footer, right-click on ID and Date fields, choose 'Update Field')
3. Export the form as PDF and include it in the group specific supplement of the Flight Operations Manual.
4. Email the PDF to the Technical Manager for processing: jussi.aaltonen@tuni.fi
5. If the supplied information changes, then fill the form again. Replace the pages in the group specific supplement and email the updated version to the Technical Manager. Archive the old notification according to the documentation guidelines in the Flight Operations Manual.
6. If the remotely piloted aircraft is removed from use, fill the removal date to the latest notification. Remove the notification from the supplement, archive it according to the documentation guidelines and send a copy to the Technical Manager.

Appendix C

Flight planning and briefing form

Appendix C

FLIGHT PLANNING AND BRIEFING FORM V1.0

1. MISSION PLAN

GENERAL INFORMATION

Mission goal and description General description of the mission e.g. Water area segmentation with a mapping gimbal equipped hexacopter. Try to include any unique details that may require further analysis from the safety and risk assessment viewpoint.
Description of aircraft General description of the type of aircraft intended to be used e.g. multirotor with a MTOW of 10 kg. Include description of any configuration changes required for this specific mission.

AREA OF OPERATION, ALTITUDES, SEPARATION AND TIMES

General description of the route / area of operation Rough estimate of the operational area e.g. lake Pyhäjärvi limited by Ratina-Hatanpää-Viikinsaari triangle with a landing zone and ground support in the boat harbor
Local airspace, relevant airports/heliports and other air traffic Airspace and airport information for the operational area e.g. lake Pyhäjärvi is in EFTP CTR zone - airspace class D, which extends from surface to 2000 feet. Altitude limit for RPAS operations is 50 meters. It should be noted that the operational area is on the direct line from VFR point PALLO to EFTP and near the line from EFTP to Tampere University Hospital heliport
Other infrastructure or items of concern Description of any additional infrastructure such as masts, power lines etc.
Flight altitudes and lateral separation from airports/heliports and other significant obstacles Intended flight altitudes and lateral separation from airports e.g. Maximum altitude of 50 meters and lateral separation of 10km from Tampere Airport and 5km from TAYS heliport
Starting and ending time of operation Click or tap here to enter Starting (local) and estimated ending time of operations e.g. 9:00 – 13:00. Also make a notice if the planned times include changes in lightning conditions

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Mark all applicable (include details in the 'Other information' field below) ☐ Operations above densely populated areas ☐ Operations above crowds of people (**NOT CURRENTLY ALLOWED**) ☐ Beyond visual line of sight operations
Other information Any additional information. This is a required field, if any of the options from the previous box is checked

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2. RISK ASSESSMENT

2.1 POSSIBLE CONSEQUENCES

Possible consequences for the aircraft List all possible consequences that the operation may cause to the aircraft e.g. structural damage, fire, crash.
Possible consequences for people List all possible consequences that the operation may cause to people e.g. death and other bodily harm.
Possible harm for other aircraft List all possible consequences that the operation may cause for other aircraft e.g. divert from flight plan, structural damage, crash.
Possible harm for infrastructure List all possible consequences that the operation may cause to infrastructure e.g. structural damage, fire.

2.1 POSSIBLE DANGERS

Technical problems (aircraft) List all possible technical problems with the aircraft, that may lead to an accident or other incident
Technical problems (external items, such as ground station and connections) List all possible technical problems with the external items and connections, that may lead to an accident or other incident
Human factors List all possible human factors, that may lead to an accident or other incident
Other air traffic List all possible problems with other traffic, that may lead to an accident or other incident
Weather List all possible problems with weather, that may lead to an accident or other incident

Other List any other possibly problems, that may lead to an accident or other incident

2.3 RISK ASSESSMENT

List all items that may trigger a dangerous situation, any preventive measures that you can use to reduce the risk and/or recovering measures that you can use to reduce further consequences after an accident or incident. Insert more rows if necessary (right-click on the bottom row, choose 'insert' and 'Insert Rows Below'.

Trigger	Preventive measures	Recovering measures

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3. FLIGHT PLAN AND OPERATIONAL INSTRUCTIONS

AIRCRAFT

AIRCRAFT TYPE	SPECIFIC AIRFRAME
Model and type of the aircraft	Unique identifier for the airframe, if multiple similar in use

BATTERY/FUEL CAPACITY – SINGLE FLIGHT	ENDURANCE - SINGLE FLIGHT
Fuel or battery capacity e.g. 10 000 mAh	Endurance for a single flight in HH:MM format
BATTERY/FUEL AVAILABLE - TOTAL	ENDURANCE - TOTAL
Number of batteries or total amount of fuel available e.g. 4 batteries	Total endurance with available fuel/batteries in HH:MM format

Describe the available radio equipment and the reported range. Insert more rows if necessary (right-click on the bottom row, choose 'Insert' and 'Insert Rows Below'.

RADIO EQUIPMENT	RADIO RANGE

DESCRIPTION OF ANY ADDITIONAL EQUIPMENT INSTALLED IN THE AIRCRAFT

MAXIMUM ENDURANCE AND RANGE AVAILABLE FOR THE MISSION

MAXIMUM ENDURANCE (by the limiting factor)	MAXIMUM RANGE (by the limiting factor)
e.g. HH:MM by the battery capacity	e.g. 10km by the telemetry radio range

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ROUTE

TYPE OF FLIGHT ☐ Local ☐ Long-range ☐ Within visual range ☐ Beyond visual range	
POINT OF DEPARTURE	POINT OF ARRIVAL
e.g. Hatanpää harbour	e.g. Viikinsaari
ELEVATION FROM MSL	ELEVATION FROM MSL
Elevation from mean sea level, if significant and relevant	Elevation from mean sea level, if significant and relevant
DATE AND TIME OF DEPARTURE (PLANNED)	TIME OF ARRIVAL (PLANNED)
Planned date and time of departure in YYYY-MM-DD and HH:MM formats.	Planned time of arrival in HH:MM format

Describe route in more detail below if necessary. Insert more rows if necessary (right-click on the bottom row, choose 'Insert' and 'Insert Rows Below'.

You can also include a map as an attachment to this document, with the relevant information.

ROUTE POINT	ALTITUDE	TASK/ACTION

FAIL-SAFE SETUP

Add fail-safe scenarios (e.g. radio link lost, low battery etc.) specific to the aircraft and describe the fail-safe method (e.g. land, return to launch). Insert more rows if necessary (right-click on the bottom row, choose 'Insert' and 'Insert Rows Below'.

FAIL-SAFE SCENARIO	FAIL-SAFE FUNCTION

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FLIGHT CREW

You can assign multiple people to one role (excluding Pilot in Command). Insert more rows if necessary (right-click on the bottom row, choose 'Insert' and 'Insert Rows Below'.

ROLE	PERSON	SPECIFIC TASKS
Pilot in Command		

FINAL CHECK

FILLED BY	DATE
Name of the person that has filled and checked this document	Date of the final check of this document

Inputting the name and date is an assurance by the person that all the details are correct and deemed suitable for this specific operation on the specific date.

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4. OPERATIONAL NOTES

It is recommended to print this page and fill it during the operation, if possible. Transfer this information to personal and aircraft specific logbooks

CHANGES TO THE ORIGINAL FLIGHT PLAN

Fill the departure and arrival times (for a single flights or a series of flight) and calculate the duration. Use HH:MM format for times and write the total duration in minutes.

TIME OF DEPARTURE (ACTUAL)	TIME OF ARRIVAL (ACTUAL)	DURATION

OTHER NOTES (for documentation purposes such as incidents, accidents, technical failures etc.)