Human Factors in Aerial Drone Operations

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Abstract
Meanwhile experiencing an industry-wide lack of regulatory adaptation and official incident/accident data, aerial drone usage is becoming increasingly popular and so the potential safety concern they pose to civil aviation and ‘ground-based objects’. Similarly to the aviation industry, its assumed Human Factors will be a proportionally increasing contributing factor in drone related incidents/accidents as drones becomes progressively more reliable. Seen as a suitable safety-related area to address, a better understanding of Human Factors in drone operations motivated the need for this project. Conducted as a qualitative interview study, gathered data from Remote Pilots/Operators was processed through the framework Evidence-Based Training (EBT). The project aimed to determine ‘how’ elements of Human Factors where incorporated into present aerial drone operations. The study found four main attributes:

1. Predominant use of in-depth pre-flight preparations.
2. Low significance of Procedures, Problem Solving and Decision-Making mid-flight.
3. High significance of Workload Management and Situational Awareness.
4. Limited applicability of Teamwork, Leadership and Communication.

Likely shaped by the nature of operation, extensive pre-flight preparations were observed to aid operational conduct in unpredictable environments, meanwhile Workload Managements and Situational Awareness was observed to be of main concern for Remote Pilots mid-flight.

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Content

1. Introduction

1.1 Background

1.1.1 Aerial Drones

During the last few years, the market has unveiled an increasing amount of civil drone solutions, varying in size, structure, endurance, purpose etc. In combination with a broad spectrum of sensor compatibility, drones have in many ways become the go-to utilitarian vehicle type for multiple industries. Ranging from forestry to power grid providers, aerial drones allow for smart adaptation and versatility in remote controlled mission conduct. Contrary to the rest of the aviation industry, aerial drones are inexpensive, portable, removes the need for an onboard pilot and often delivers similar (or better) output results to a fraction of the operational cost.

As mentined by Giones & Brem (2017), the civil drone industry was estimated in 2016 to grow from $2 billion to reach nearly $127 billion in 2020. Looking at the technical development timeline, it becomes apparent the basic concept of aerial drones has been around since the first half of the 20th century (initially as military target practice vessels) but only been commercially available for civil use since the 2000s. The main driving forces has been miniaturization of electric components, increasing computer processing capabilities and progress with lightweight advance materials, making smaller drones of fixed wing design and quadcopter type especially affordable and popular.

With regards to accessibility and prize point, the current number of registered operators are likely to increase. As of May 2022, no formal update with regards to the European market had been found published by European Union Aviation Safety Agency (EASA) or by any of the Scandinavian Civil Aviation Authorities, thus necessitating the direct request of numbers from respective national Scandinavian CAA as per Appendix D and summarized in Table 1.1.

Table 1.1 Registered Operators in Scandinavia as of Q1 of 2022

Country	Sweden	Norway	Denmark
Registered operators	~50000	~16900	17426

(Andersen Boe, personal communication, 2022-02-24; Heimro, personal communication, 2022-04-26; Stålberg, personal communication, 2022-04-25)

1.1.2 Human factors

As the interdisciplinary study of accidents and its prevention, Safety Science started to emerge as people abandon the divine as cause of accidents and shifted focus towards believing accidents could be understood scientifically. This evoked the moral responsibility to organize and engineer preventively with safety in mind, thus laying the foundation for the concept of Human Factors (Dekker, 2019).

With regards to the history of drone development and Human Factors, the amount of data/literature has been found scarce, giving a poor insight into the progress made throughout the years. In contrast, the evolution of airplanes has been well documented and came with an unfortunate extensive number of lives/airframes lost during the early years. As mentioned by Harris (2011), losses amongst US Army Air Corps pilots during World War II was evenly distributed between combat losses, operational accidents and training crashes, signaling the importance of understanding Human Limitations and Performance. The introduction of Human Factors in the civil aviation industry (initially in form of pilot selection, training and cockpit design) came to be during the late 1950s/early 1960s. As it progressed into the 1970s with the introduction of the CRM-concept (Cockpit Resource Management, later Crew Resource Management), simulator training, etc., one could argue it signaled an industry wide paradigm shift, focusing increasingly more on the human pilot.

With increasing aircraft reliability, Human Performance has played a proportionately increasing role in the causation of aviation related accidents (Harris, 2011). Traditional pilot training was widely based on evidence from accidents of early-generation jet aircraft, inadequately addressing issues with regards to Human Factors (EASA, 2016). As a response, pilot training has shifted from focusing on technical failures into a more Line Orientated Flight Training (LOFT) approach, targeting non-technical skills to a greater extent. The implementation of Evidence-Based Training (EBT) and Competency-Based Training (CBT) has allowed for a continuous improved training, equipping pilots with a relevant and updated set of competencies (EASA, 2016).

The widely recognized human error accident rate of ~75% (60,2% for aerial drones (UAS) according to Thompson (2005)) is up for debate depending on how you define human error and whether you view it as a contributing factor or part of a greater systemic error (Dekker, 2001). Regardless of exact statistics and minding the operational differences between operating a drone and an airplane, as aircrafts has become progressively more reliable, Human Performance has played a proportionally increasing role with regards to accident occurrences (Harris, 2011). Similarly, as aerial drones are becoming technically more reliable and the man-machine interactions remains, it would be wise to assume Human Factors is as applicable to aerial drone operations as it is to the rest of the aviation industry.

1.2 Problematizing

1.2.1 Delay of regulatory adaptation

Even if the rapid progress in aerial drone technology has unveiled highly competent and affordable gear within reach for the everyday consumer, its status within the field of civil aviation has been somewhat ambiguous. Carl Stålberg (personal communication, 2022-04-12), Inspector at Maritime- and Aeronautical Department of the Swedish Transport Agency (CAA Sweden), indicated that from a national authority standpoint, the expansion of the drone usage hasn’t been viewed as a ‘natural branching’ of the aviation industry per se. Rather, it has been viewed as a parallel subindustry that quickly evolved from its military/toy roots into a fully fletched category within civil aviation. With lack of regulatory adaptation, regulations have been viewed overall as inadequate to address the rapidly expanding drone industry in a suitable manner, thus failing to facilitate the safety net provided in other areas of civil aviation. Yet, with lack of transparency and communication between all the stakeholders of the drone industry, the slow progress observed could be considered a shared issue (Stålberg, personal communication, 2022-04-25).

1.2.2 Requirements for certification

The current regulation governing drone operation is currently in a transiting state and the new long-term regulation is set to be implemented by 1 January 2023 (as of 25 April 2022). With the current regulation, aerial drone operation is conducted in one of three operational categories and subcategory as per Table 1.2

Table 1.2 Operational Categories and subcategories

Category	Open	Specific	Certified
Subcategory	A1 A2 A3	PDRA (Pre-Defined Risk Assessment) SORA (Specific Operation Risk Assessment) LUC (Light UAS Operator Certificate)	N/A (adheres to normal civil aviation regulation)

An appealing factor likely contributing to the incremental numbers of Operators and Remote Pilots, is the required demonstrated level of skill and knowledge. To receive an entry level Certificate of Remote Pilot Competency (allowing for operation in Open A1/A3), current regulations requires the Remote Pilot to be familiar with the manufacturer's instructions and successfully complete a theoretical examination (40 multiple-choice questions, 75% pass mark within a 24h time limit) without any practical training (European Commission, 2019). Aerial drone missions of commercial type or at a higher complexity level (i.e. specific or certified category), requires further demonstrated skill and knowledge. In comparison, the minimum demonstrated knowledge and skill levels required to operate other types of airborne vessels (e.g. Ultralight Aircraft, Single Engine Piston aircraft, etc.) demands a substantially more complex, exhaustive and increasingly expensive process of training (initial and recurrent) and examination.

Dekker(2001) mentions how human contribution to complex systems tend to make them safer, rather than being considered as the unreliable variable of a perfectly safe system. The author concurs, yet one could argue what's the minimum required competency to be considered as a positive contributor to a dynamic and complex system.

1.2.3 Official Incident/accident data and availability

Personal communication with Swedish, Danish and Norwegian CAA may be found in Appendix D.

Even if drones mainly conduct flying at or below 120m/400ft as per regulations (European Commission, 2019), they still share the sky with the rest of the aviation industry. Further use of Geo-Awareness and the forthcoming implementation of U-space (EASA, 2021b; ECAC, 2021) will allow for increasing airspace management, tools currently lacking. From a safety perspective an airborne collision between a drone and other airborne vessel would likely lead to hull damage (Lu et al., 2020) or even loss of lives. Even if the U-space implementation allows for a large improvement, complete separation between aircrafts and aerial drone will not be guaranteed throughout European airspace. Therefore, the issue of conflict remains relevant and somewhat unresolved.

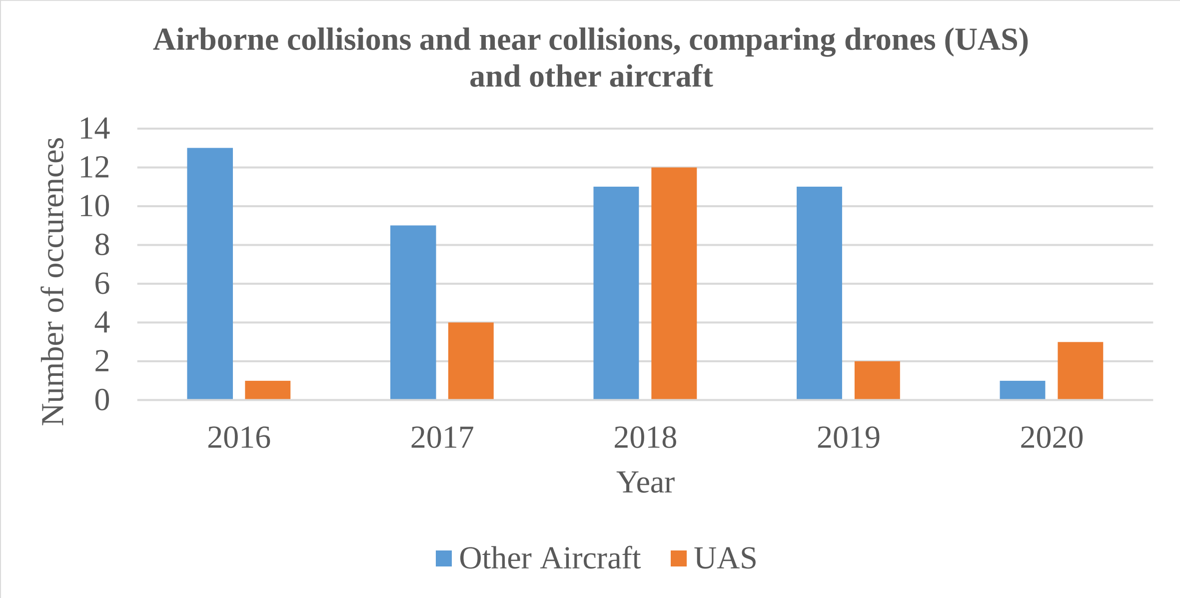

Figure 1.1 Replication of presented data by EASA (2021a, fig. 128)

Even if numbers are seemingly low as per Figure 1.1, conflicts are very much a present threat leading to EASA(2021a) voicing their concerns regarding airborne collisions between drones (UAS) and other aircraft, pointing towards the wide spread accessibility of drones as an issue. It should however be noted that current published data in Figure 1.1, is based primarily on reports from other aircraft or air traffic management (EASA, 2021a, p. 166). No data with regards to Remote Pilot actions, errors, chain of events, potential causal factors or similar has been found published in relevant reports by EASA.

On a national level the Swedish Transport Agency (CAA Sweden) only requires drone operators to submit a report whenever a drone has been involved in a situation causing serious injury, death or involvement with other manned airship (operation in category specific or certified may be subjected to further reporting requirements). According to Swedish CAA Inspector Carl Stålberg (personal communication, 2022-04-12), there is an apparent lack of overall incident/accident data with regards to aerial drone operations. On a Scandinavian level, Andersen Boe (personal communication, 2022-02-24) of the Danish CAA similarly reported a lack of a data. Heimro (personal communication, 2022-04-26) of the Norwegian CAA was the only Scandinavian CAA representative able to provide a set of data, partially presented in Table 1.3.

Table 1.3 Occurrences involving drones per year – All event types, Norway

Year	Number of total occurrences (accidents and incidents)	Number of accidents	Accidents as a percentage of total occurrences
2012	8	3	37,5
2013	4	3	75,0
2014	12	2	16,7
2015	29	7	24,1
2016	26	4	15,4
2017	45	2	4,4
2018	80	1	1,3
2019	76	No data	N/A
2020	52	2	3,9
2021	58	1	1,7

(Heimro, personal communication, 2022-04-26)

Similarly to EASA(2021a), the Norwegian data in Table 1.3 (as per Appendix D) was primarily based on reports from other aircraft or air traffic management, seemingly lacking any data with regards to Remote Pilot errors as potential causal factors.

There is undoubtedly information available to support the safety implication of aerial drones, yet accuracy in official data is debatable. As the reported data predominantly comes from other source than Drone Operators and Remote Pilots, a concern of 'hidden statistic' arises, an opinion shared by Andersen Boe (personal communication, 2022-02-24) of the Danish CAA. Data with regards to Remote Pilot performance and errors, overall chain of events, etc., would likely facilitate a better understanding of causal factors in aerial drone incidents/accidents, allowing for safety related issues to be addressed and applicable Human Factors elements to be studied further.

1.2.4 Related literature

According to Woolley (2014) academic research of arising industries tends to get unnoticed until the industry emerges fully. As varying ways of utilizing aerial drones increases steadily, one could argue the industry is far from well-defined, thus potentially explaining the existing vacuum of literature in certain areas. Still, research have been conducted in multiple scattered areas of drone operations, but the desirable holistic understanding already attained by the aviation industry is seemingly lacking

With regards to incident/accident data in drone operations, Giese et al. (2013) reported 42% of mishaps involved human error and occurred predominantly in the following error categories:

- skill-based errors
- procedural errors
- checklist errors
- inadvertent operation
- overcontrol/undercontrol (pilot control input)
- breakdown in visual scan

A similar publication widely referred to in related literature, was published by the FAA representative Williams (2004). Seemingly resting on the basis of Reason's (1987) error classification scheme, William highlighted 'unsafe acts' being the cause contributing to 61% of human error related accidents in drone operations. Both sources primarily provided data representing drones in military operations, generally omitting certain variables applicable to operators of drones with quadcopter design (Mohan et al., 2021).

Other areas of intereset was observed through an interview studdy by Ljungblad et al. (2021), highlighting the aspects of Human-Drone Interactions (HDI) and the complexity of operation.

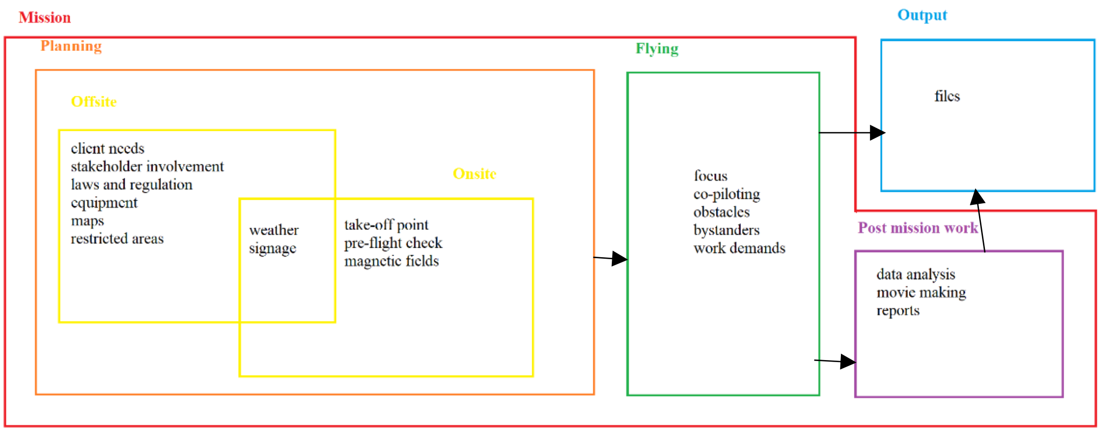

Figure 1.3 replication of Overview of a typical drone mission by Ljungblad et al.(2021, fig. 2)

Remote Pilots may use similar sources as airline pilots for weather, NOTAMs, etc., yet compared to commercial airline operations, they lack the benefit of pre-defined threat assessments, secure boundaries of airports and provided compiled information of the surrounding area (i.e. departure/arrival/approach charts). As Figure 1.3 replicates, Ljungblad et al. (2021) illustrates an comprehensible overview of aerial drone operations at large, highlighting the many areas required to be attended to in addition to piloting the drone. From a Human Factors standpoint, it becomes increasingly clear how the operational challenges in aerial drone missions differs from those in the remaining field of civil aviation, thus emphasizing the need for industry related adaptation.

Both Harris (2011) and Endsley & Jones (2004) pointed to how Human Factor elements are linked (e.g. Situation Awareness drives Decision Making and facilitates performance, etc.). Compared to manned aircrafts, drone operations face a greater issue with regards to maintaining situational awareness (Endsley & Jones, 2004) as it requires an understanding of vehicle state and the surrounding environment (Endsley, 1995). To aid future Remote Pilots and to gain a better understanding of applicable Human Factors elements, research on 'how' different elements interact and influence one another becomes imperative.

Similarly to EASA, the FAA has allowed for some Remote Pilot certification to be conducted purely on knowledge based assessments, questioning the need for practical training (initial and/or recurrent training). The presented research made by Kunde et al.(2022) highlighted the need for identifying user proficiency in manual flight to allow for system adaptation. Harris (2011) generally expressed how pilot training is of great importance to maintain aviation safety. With regards to airline pilot performance, Haslbeck & Hoermann

(2016) indicated how recency has been found to be a significant predictor of flight performance compared to time since initial flight training. It’s clearly debatable whether training should be required in a recurrent manner, only initially or even at all. Kunde et al.(2022) highlighted the need for further research on the topic, thus understanding current Operators and Remote Pilots training habits could be considered useful.

1.3 Purpose

From a safety standpoint the implementation of U-space (EASA, 2021b; ECAC, 2021) will likely be a significant contributor to increased safety in aerial drone operations by imposing limitations and providing transparency, yet it does not address the potential performance shortcoming of humans as Remote Pilots. As the potential safety implications of aerial drones grows, the apparent lack of data remains and regulatory minimum requirements for practical training of entry level Remote Pilots remains non-existent, it complicates a purposeful systemic change. A more stringent regulatory implementation could suppress the current issue to some degree by making it substantially harder to become a certified Remote Pilot, but without mindful implementation the industry would run a risk of consequently stifling development and at worst break down 20 years of useful progress of serious operators. Accurate data allows for a better understanding and for thoughtful measures, thus highlighting the necessity to fill the current vacuum of information (both accident data and academic literature).

Until then, since human performance has been established to play a proportionately increasing role in the causation of aviation related accidents (Harris, 2011), attending to Human Factors at large would seemingly be a sensible way to contribute to safety. Rather than applying the complete and non-adaptive set of the aviation industry understanding/standards/regulations of the subject ‘Human Factors’, identifying key elements in aerial drone operation would facilitate a tailored and likely more suitable approach.

1.4 Issue

The project intended to explore how Human Factors elements were incorporated into aerial drone operation by evaluating gathered data from interviews through the framework of Evidence-Based Training.

1.5 Demarcation

As operation of interviewee’s where confined primarily to flights within Sweden, the results presented in this report mainly reflects aerial drone ops within Sweden. Due to lack of data published by the Swedish CAA, inputs from neighboring Scandinavian CAA’s was considered. As aerial drone operation on a national level is subject to regulatory governance on a European level, subordinate publications by the International Civil Aviation Organization, the regulatory holistic perspective including all levels must be considered.

As this report is aimed toward civil and commercial use of aerial drones, the reader benefits from general knowledge about the aviation industry and drone operations. Likewise, a basic understanding of Human Factors will aid the readers understanding of the report.

1.6 Definitions

1.6.1 Abbreviations

BVLOS	Beyond Visual Line of Sight
CBT	Competency-Based Training
CTR	Controlled Traffic Region (control zone)
EBT	Evidence-Based Training
LOS	Line of Sight
OM	Operations Manual
RPAS	Remotely Piloted Aircraft Systems
RTH	Return-To-Home
UA	Unmanned Aircraft
UAS	Unmanned Aircraft System
UAV	Unmanned Aerial Vehicle
VLOS	Visual Line of Sight
VO	Visual Observer

1.6.2 Explanations of expressions and terminology

Atti-mode or attitude mode, being a mode of revertial e.g. during loss of GPS-signal stabilization

Civil Aviation, being flights and aircraft intended for personal or business purposes (e.g. cargo or passenger transport) and excluding flights of military purpose.

Human Factor Element is used to describe parts of a concept, factor, segment, component, behavioral indicator or information of similar kind, relevant to the field of Human Factors.

RPAS is a subcategory of UAS, which includes both RPAS and fully autonomous UAS. Fully autonomous UAS fly completely by themselves without the need for any pilot intervention (EASA, 2020).

Unmanned Aerial Vehicle (UAV), or as EASA stipulates **Unmanned Aircraft (UA),** is referring to all types of aircraft without a pilot onboard. UA may be of remote radio-controlled vehicle types, including gliders, powered fixed wing and helicopters. The vehicle could potentially be controlled by a ‘Remote Pilot’ (European Parliament and Council of the European Union, 2018).

Unmanned Aircraft System (UAS) refers to a UAV and the equipment used to control it (European Commission, 2019)

1.6.3 Use of terminology

For the sake of simplicity, the terminology ‘aerial drone’ or ‘drone’ will hereby be used primarily to describe UA, UAV, UAS and RPAS unless context require a more detailed wording.

Aerial drone operations has grown into a separate branch and is recognized to be part of the Civil Aviation Industry. However, for the purpose of this report, the main use of 'Civil Aviation' will be used mainly to compare drones to the remaining industry. Therefore, the use of the term 'Civil Aviation' should be interpreted as the full civil industry excluding drone operations.

In the context of EBT, ICAO(2013) defines 'competency' as a combination of **knowledge**, skills and attitudes required to perform a task to the prescribed standard. In addition, the author had prior experience of the EBT-concept in pilot training with multiple airlines, all implementing 'Knowledge' as an additional competency category. As a result, this project will recognize 'Knowledge' as a separate standalone competency category and the use of the terminology 'EBT competency categories' should therefore consider knowledge as included.

2. Method

2.1 Pre-study description

A literature pre-study was conducted to search for academic litterateur with regards to the Human Factors topic in aerial drone operations. The Lund University Libraries LUBsearch function and Google Scholar was the primary method of accessing academic literature

Several combinations of the following words were used during the pre-study phase when researching current published literature:
Human, Factors, Performance, Errors, Drones, UAV, UAS, RPAS

To gain a better understanding of aerial drone operations, the author attended a 5-month Higher Vocational Education (HVE) program orientated towards Remote Pilots and Drone Operators (in addition to previous experience and training as a commercial airline pilot).

2.2 Main study description

2.2.1 Scientific method selection and conduct

For this project Semi-Structured Interviews (SSI) was selected as a preferred basic method for data gathering. As can be seen in Appendix B, preparations (mainly in form of a survey orientated interview guide) carried a slight offset towards an agenda-led structure, intended to facilitate a useful path throughout the interview and act as a general support for the interviewer. The use of other methods and interview structures was considered, but it was the opinion of the interviewer/author that SSI had the most favorable potential to benefit the project at large.

Interviews were conducted using online video conference calls by services such as Zoom Meetings and Teams. Each interviewee was scheduled for a 1-hour session.

2.2.2 Sampling and participating profiles

As drone operation vary significantly, it was highly desirable to find interviewees that represented a variety of operational categories and types of operation. Trough purposeful/convenience sampling, 9 potential candidates were contacted with 3 declines, thus initially attaining the recommended minimum sample size of 6 interviewees (Mann, 2016).

However, as the study required the interviewees to be operationally active, data from 1 out of 6 interviewees was unfortunately removed as this person mainly had experience from drone development. The remaining 5 profiles are presented in Table 2.1

The use of purposeful/convenience sampling (either through direct ties to the interviewer/author or through personal recommendations) served multiple purposes. Beyond the timesaving aspect of finding candidates, Mann (2016) highlighted the benefit of a potential ’insider-status’. Being considered as a ‘prior known person’ had the advantage of adding a greater richness to the sampled data as interviewees might have felt more relaxed speaking frankly about their prior experience. This was considered highly desirable, since talking about Human Error may touch on sensitive subjects of personally experienced incidents etc. Yet, the close ties might have been grounds to question the authenticity of some answers as there was a potential risk of interviewees telling the author what they thought he wanted to hear rather than what they really thought. Similarly, participants (interviewer and interviewee) could suffer from mutually shared assumptions as mentioned by Mann (2016) and thus being further grounds to criticize the validity of the study.

Demographical details such as gender, age, etc. was deliberately omitted as non-aviation related information was considered to bear little importance to the research being conducted. A strict aviation ops related profile was therefore created. All interviewees operated aerial drones in a non-leisure manner.

Table 2.1 Information of participants

			Experience of participants			
Alias (ID)	**Operative position**	**Time (Years/ hours or flights)**	**Civil aviation license type**	**Nature of operation**	**Operative category (Open, Specific, Certified, or equivalent of)**	**Weight range (gram)**
Alfa (A)	Remote Pilot/ operator	11/ 12500h	N/A	Surveillance, inspections, photogrammetry, forestry (inventory), SAR	Open, Specific	3600 – 34000
Charlie (C)	Remote Pilot/ operator	5/ >1000h	N/A	Photo, video	Open, specific (small amounts)	249 – 1380
Echo (E)	Remote Pilot/ operator	8/ ~27000 flights	N/A	Training, mine inspections, general inspections, mapping, videography	Open, Specific	200 – 23000
Golf (G)	Remote Pilot/ operator	5/ ~650h	ATPL	Real estate photo/video, surveillance, Management eVTOL producer	Open, Specific, Certified	250 – 28000
India (I)	Flight systems manager fire services	6/ No data	N/A	Rescue Services (fire service)	Specific (note, rescue services are subject to separate regulation)	Ca 250- No data

As an underlying friction exists between airline pilots and Remote Pilots, the implication of the issue was considered with regards to influence and presumptions/bias between interviewer and interviewees. As the interviewer/author was a former airline pilot himself, it had the potential of insinuate an unspoken feeling of 'we against them'. The indirect benefit of purposeful/convenience sampling was the ability to vouch for the good intension of the project without any intension to miscredit participants. However as a precaution, a section about the interviewer was included in the Interview Pre-brief (see Appendix A, presented to all participants prior the interview), dedicated to facilitate transparency in accordance with Mann (2016) recommendations. Additional benefits of attending a drone related HVE-program, was the ability to create a sense of mutual grounds.

2.2.3 Language and transcripts

Transcripts were produced in plain text format together with timestamps and profile designator ('J' or 'Joakim' indicating the author). Except for longer pauses (mid-text indicated by …), likely intended words missing in incomplete sentence (indicated by (intended word)) and exclamations, any indirect communication (laughter, body language, stress/intonations, etc.) was omitted due to the vast amount of processing capacity required. It would likely have provided further richness to the data, however, the potential gain was not in proportion to the effort required.

As the interviews were conducted in Swedish, the transcripts were completed in a Swedish colloquial manner. Selected excerpts were thereafter translated into a more formal English presentation and sorted with regards to applicable EBT competency category as can be observed in Appendix C.

Sharing mother tung doesn't remove all hinderance of communication by any means, as Mann (2016) mentions several other challenging factors (e.g. dialects, experience, perspective, etc.). However, as all participants were native Swedish speakers, certain ques and traits of the language was considered more likely to be picked up on by the interviewer (native Swedish), thus facilitating for broader data collection.

With regards to translation, the need for word-to-word translation accuracy was not considered as important as context, thus allowing for representational adjustments (Mann 2016).

Minding the need to observe interviewee's 'data privacy and protection' called for personal and company related details to be removed or replaced from the transcripts. Sensitive details mentioned during the interview was omitted.

2.2.4 Data processing

Due to the broad spectrum of the field of Human Factors, it necessitated a way of processing the data into something operationally relatable. Therefore, the interview transcripts were processed in a heuristic manner through the framework of the industry acknowledged concept of EBT and its competency categories found in Table 2.2.

Table 2.2 Evidence-Based Training (EBT) Competency categories and descriptions

Competency	**Competency description**
1. Application of Procedures	Identifies and applies procedures in accordance with published operating instructions and applicable regulations, using the appropriate knowledge.
2. Communication	Demonstrates effective oral, non-verbal and written communications, in normal and non-normal situations.
3. Aircraft Flight Path Management, automation	Controls the aircraft flight path through automation, including appropriate use of flight management system(s) and guidance.
4. Aircraft Flight Path Management, manual control	Controls the aircraft flight path through manual flight, including appropriate use of flight management system(s) and flight guidance systems.
5. Leadership and Teamwork	Demonstrates effective leadership and team working.
6. Problem Solving and Decision Making	Accurately identifies risks and resolves problems. Uses the appropriate decision-making processes
7. Situation Awareness	Perceives and comprehends all of the relevant information available and anticipates what could happen that may affect the operation.
8. Workload Management	Manages available resources efficiently to prioritize and perform tasks in a timely manner under all circumstances.
9. Knowledge[a]	Refers to recurrent training (practical and theoretical), experience and understanding of limitations

[a]Added by the author as indicated in 1.6.3

(IATA, 2013; ICAO, 2013)

Inspired by Magnuson (2015, Chapters 8, 12) as a primary reference for basic data processing, the following steps were conducted:

1. Whilst listening through the actual interviews, transcript text was tagged with EBT competency-based markers.

2. Tagged text was divided into 9 separate files with regards to each separate EBT competency area.
3. A search for commonalties with regards to EBT behavioral indicators (ICAO, 2013, Appendix 1) and other Human Factors elements created topics within the competency area. Text relating to the topic from each participating interviewee was clustered together.
4. Excerpts of interest were marked, translated and compiled into Appendix C**.**
5. Marked excerpts fully relevant to the issue and reoccurring in multiple interviews were finally presented in the result section.

3. Results

The project intended to explore how Human Factors elements were incorporated into aerial drone operation by evaluating gathered data from interviews through the framework of Evidence-Based Training.

Some EBT competency categories have been combined due to observed attributes in the interview material during aerial drone operations. Presented competency categories are outlined in a suitable order with regards to the result rather than regulatory publications.

Within each EBT competency category, observed (partially, fully or with regards to) behavioral indicators are presented with regards to relevant ICAO(2013) *publication.*

3.1 Application of Procedures

Indications of the following EBT behavioral markers were observed:

- Identifies the source of operating instructions
- Complies with applicable regulations.
- Follows SOPs unless a higher degree of safety dictates an appropriate deviation
- Identifies and follows all operating instructions in a timely manner
- Complies with applicable regulations.

3.1.1 Procedural use

All participating interviewees indicated implementation of Procedural use or structure of similar kind.

> *No, but we have created an SOP, standard operational procedures for how we should act and how we should secure airspace at a tactical and strategic level in order to minimize air risk and ground risk. Absolutely, that's what we have done. So we have daily checklists and checklists (specific) for flights (India)*

Beyond the use of Standard Operating Procedures and checklists, interviewees indicated use of a specific 'start-up sequence', active use of Operations Manuals and recurring flight preparations (checking weather, NOTAM and Drone map service (provided by Swedish CAA) and actively informing responsible units for relevant control zone (CTR, if applicable).

4 out of 5 participants indicated use of checklists, yet an alternative approach utilizing a 'mind-based flow scan' was observed in addition.

> *I do not really use any checklists except the ones I have in my head, but I check all the gear properly before each flight, check so that everything looks good and that everything works. (Charlie)*

4 out 5 participants indicated procedural use was primarily applicable during the pre-flight stage, yet profile Echo indicated an emphasizes on procedural practice throughout all stages of flight.

> Joakim: *"But where do you put most effort (procedural practice)? Is there a lot of focus on pre-flight or is it something that is used during the whole (flight)?"*

> Echo: *"It's the entire flight. It is before (preparations), prior flight(pre-flight) and during the flight(mid-flight) and after(post-flight)"*

3.1.2 Non-normal/emergency procedures or structure

All participant indicated being actively mindful about non-normal/emergency procedures and two distinct mid-flight approaches were observed:

1. Actively planning for failures.

> Alfa: *"That's kind of the limitation of the drone concept, you have no options. If you fly a quadcopter with four propellers and one is damaged while being airborne, well then you can hopefully trust that it falls straight down and that you are within your buffer zone. If you have a hexacopter, well then you can do more and continue to fly and make a safe landing"*

> Alfa continuing: *"We are not pilots in that sense, we are navigators. It's the Flight Controller that takes care of everything (control inputs etc.). Therefore, it is not possible to take such extra measures to have more awareness up in the air, for emergencies or (use) emergency protocols."*

2. Active us of emergency procedures

> *Yes, there are procedures available depending on the equipment of course and it differs. (Echo)*

Regardless of approach utilized, all participants seem very aware of the potential threats associated with a drone in a non-normal state.

3.2 Situational Awareness

Indications of the following EBT behavioral markers were observed:

- Anticipates accurately what could happen, plans and stays ahead of the situation
- Identifies and assesses accurately the general environment as it may affect the operation
- Maintains awareness of the people involved in or affected by the operation and their capacity to perform as expected

3.2.1 Pre-flight preparations to facilitate Situational Awareness

All 5 interviewees indicated great emphasis on Pre-flight preparations to facilitate Situational Awareness.

> *If I come to a completely new area, I check maps. I check how it looks in the surrounding area. The drone map service (by Swedish CAA). Then when I get to the location, I usually drive (by car) around a bit just to get a feel. (Charlie)*

Applying the reoccurring procedures of checking maps, NOTAM, weather, etc., seemed to facilitate Situational Awareness offsite. Onsite preparations included active scouting for threats and obstacles in the area intended for the flight. Active considerations of pilot state (fit to fly or not) was additionally indicated by multiple participants.

3.2.2 Mid-flight Strategy aiding Situational Awareness

All participants indicated an active use of mid-flight strategies to further facilitate Situational Awareness.

> Alfa: *"To avoid it from flying entirely autonomously, as you lose the sense of 'if the wind is correct', 'if I have done everything correctly', I sense it through my fingertips"*

> Alfa continuing: *"I start and fly out to the first waypoint where it should start the autonomous procedure, just to get a sense of the surroundings."*

In addition, the most common way of gaining awareness while being airborne was the use of 360° rotations (3 out of 5), facing inwards or outwards depending on the mission type. Additionally, Alfa and Echo indicated use of technology (e.g. big screens for monitoring purposes, etc.) as a supplement.

3.2.3 Use of applicable scanning technique

The use of an applicable scanning techniques was indicated by 4 out 5 participants.

> *We teach our pilots that we divide it into two segments. One segment is pure transport, when you are going to take it from point A to point B, and meanwhile you don't look down at the screen even once. If you want to look down at the screen, you should select a reference point before you do so, so that you can find it mid-air. If we are 300-400 meters away, it can be difficult sometimes, so we should always select a reference point. A treetop for example, I stop above that treetop and then I look down. When we look down it is for a maximum of 5-10 seconds. Once you arrive at the destination and it starts to approach a safe environment, then we commence detail flying instead and that's when we use the screen (India)*

The use of a sweeping scan technique of surrounding airspace and alternating focus between drone and controller screen was observer in addition.

3.3 Workload Management

Indications of the following EBT behavioral markers were observed:

- Plans, prioritizes and schedules tasks effectively
- Manages and recovers from interruptions, distractions, variations and failures effectively
- Develops effective contingency plans based upon potential threats[a]

[a]refers to Behavioral Indicators associated with Situational Awareness (ICAO, 2013, Chapter Appendix 1)

3.3.1 Workload mitigation

With regards to workload management and the mid-flight segment, participants indicated use of technical solutions, overall Situational Awareness, training and application of knowledge, use of secondary operative person (e.g. visual observer (VO) or sensor operator) and reverting to basic flying as ways of reducing workload in specific operations. Yet, the predominant use (5 out of 5) of flight planning and pre-flight precautionary measures was observed to be the primary strategy to reduce potential workload by all participants.

> Alfa: *"Especially if I do wall inspections, I normally implement limitations (seemingly referring to area access, use of fence and area of operation). For wall inspections, it is usually the ground risk that is the major one"*
>
> Alfa continuing: *"it's the ground risk I attend to and thus the use of roadblocks. That's when I need extra staff like an VO or someone that scans the airspace"*

This indicated that management of workload relied heavily on the ability to foresee and mitigate threats while airborne.

3.3.2 Known operative conditions with high workload

4 out 5 interviewees indicated a clear understanding for reoccurring operative conditions associated with a higher level of workload.

> *For me, it's the moment when I fly and record videos at the same time. Then I have to keep full focus on the drone and how it moves. Especially when I'm flying in cramped spaces or in an apartment area where it is tight between the walls. Then additionally I have to maneuver it nicely while I avoid flying into buildings to get a nice shot. This is where the highest workload is (experienced), absolutely. (Charlie)*

Compared to workload peaks found during takeoff and landing in commercial aircraft operation, it was observed that workload exerted on the Remote Pilot would primarily increase during certain maneuvers or mission types midst the flight.

That is as soon as the drone disappears from the visual spectrum for me as a remote pilot. That is where the workload increases, so to speak. It's quite the opposite to normal aviation (refereeing to takeoff and landing as segments of higher workload rather than mid-flight/enroute). (Alfa)

3.3.3 High workload strategy

5 out of 5 interviewees indicated use of a high workload strategy.

So, I am a formerly trained military clearance diver and there we learned one thing quite quickly. Stop - Breathe - Think - Act. (Alfa)

Others mentions where 'stop and hover', maneuver repeat if possible or full mission abort (with potential use of automatic Return-To-Home feature).

3.3.4 Considers environmental stressor (e.g. cold temperature)

Even if applicable environmental stressors (i.e. primarily temperature) have little impact on the human cognitive system (Harris, 2011), it can have a negative physiological effect that may impair operational conduct.

to sit in a warm cockpit versus to stand in the woods and freeze during a cold winter. It affects a lot ... It affects the assignment, the quality of the assignment. When you are standing there cold and freezing, then you really just want to get inside (quickly) and get the job done. Less caring. If you sit in a fairly pleasant environment being in a little more relaxed environment, then there will be more focus at work. If you stand there and shiver, you lose a lot. (Golf)

All interviewees indicated a mindful approach to the effect of temperature and generally showed an understanding of the negative impact it may exert on the operational conduct.

3.4 Problem Solving and Decision Making

Indications of the following EBT behavioral markers were observed:

- Identifies and verifies what and why things have gone wrong
- Employ(s) proper problem-solving strategies

3.4.1 Active approach to Problem Solving while airborne

All 5 participants indicated some degree of active approach to Problem Solving while flying.

when situations have occurred with magnetic interference while airborne, I've lost control for a while and maybe forced me to rearrange the antennas or change position depending on where/how you're flying, (e.g.) if you're using Cendence on the (DJI) Matrix or similar so try to regain control again. And also when you see that it has switched to 'Atti-mode' (attitude mode), quickly escalating, and so becoming the biggest factors to why you start thinking like 'ohh, how should I solve this now?' (indicating an initial level of hopelessness to regain control). Like I said, I just continue calmly and relax. Release the control levers, observes what it's *doing (the drone) and then take care of the situation and bring it back. That is, so to speak, the peak of trouble when I fly, a lost signal or something that forces it into 'atti-mode' and then stars drifting with the wind or something similar. (Alfa)*

Mentions of 'antenna redirection', 'Remote Pilot repositioning', 'stop and hover', 'Return-To-Home' was indicated examples of ways to facilitate problem-solving meanwhile airborne.

With regards the use of Return-To-Home a clear reservation was expressed by profile India.

You should also know about the dangers, for example inside central Stockholm, it can be directly inappropriate to use Return-To-Home because of phone towers other things that the sensors might not pick up on. While over a forest environment with an open field to land on, absolutely, Return-To-Home works great. In an urban environment, we use 'hover' for example (rather than the RTH land feature). (India)

This seemingly reaffirms the need to utilize proper planning, as one would need to foresee threats and designate an appropriate maneuver for RTH/signal lost/battery low action (e.g. hover on the spot, land at nearest suitable area, return to pilot and land/hover), as a miscalculation would rather increase workload

As indicated by lack of evidence and expressed by profile Echo and Golf, no use of a Decision Making Model or similar was found.

Joakim: *"Is there no decision-making model that explicitly help you 'these are the considerations...', step by step, to diagnose?"*
Echo: "*No"*
Joakim: *"Rather, you try to identify the problem 'as you go' and then work towards trying to solve it?"*
Echo: *"These are very unpredictable environments"*

3.5 Aircraft Flight Path Management, Manual Control and Automation

Indications of the following EBT behavioral markers were observed:

- Maintains the desired flight path during manual flight whilst managing other tasks and distractions
- Selects appropriate level and mode of flight guidance systems in a timely manner considering phase of flight and workload
- Effectively monitors flight guidance systems including engagement and automatic mode transitions

3.5.1 Purposely use manual flight or applicable automatic mode depending on operational conditions

All interviewees indicating a purposeful consideration with regards to level of automation for the intended operation.

Yes, automation in the sense that I usually program the UAV before the mission and then I concentrate on keeping track of the drone while its flying and the data I've collected. On the other hand, during a search (and rescue) mission, well then I approach it differently since it is not possible to automate everything there. You have to fly into a forest, follow a stream of water or similar. But if I do photogrammetry assignments and similar, well, then it's completely automated. (Alfa)

Joakim: *"So as long as it is quite monotonous maneuvers, well then it feels relevant to use automation."*
Golf: *"Absolutely"*

Almost all flights are conducted manually. (Charlie)

Note: As most aerial drones are using computer assistance to control and position of the vessel (similar to fly-by-wire), the remote pilot will generally be subjected to some level of automation at all times.

As drone missions vary greatly, indicated level of automation utilized ranged from 'all manual flight', to certain use of automatic features (such as RTH) and all the way to full autonomous flight utilizing/requiring Ground Stations (i.e. computer planner) for prior planning. As briefly mentioned in section 3.3.1, reverting to basic flying when deemed appropriate was a seemingly common practice amongst the interviewees (4 out of 5).

With regards to mindful use of automatic modes and features, 3 out 5 interviewees indicated they would prepare more thoroughly when flying missions including (for them) 'uncommon elements' (i.e. new mode or similar).

Joakim: *"The few times you were mapping, did you spend more time preparing to understand the automation you would use on that particular occasion?"*
Charlie: *"Absolutely. It was very difficult, because there I just couldn't (interrupt the flight)... Of course I could interrupt the operation and maneuver the drone myself, but yes I thought it was uncomfortable. Because I'm used to having one hundred percent control"*

3.6 Knowledge

As there are no specific EBT behavioral markers published, the following areas were considered to be of interest:

- Recurrent training (practical and theoretical)
- Experience
- Understanding limitations

3.6.1 Recurrent training theoretical and practical

All participating interviewees were found to use reoccurring theoretical updating and practical training of some kind.

Golf: *"We have 8 occasions annually where we show proficiency of flight. We perform different flying exercises."*

Golf continuing: "*Abnormal flight attitudes and how to recover your drone if it starts to run away (not respond to commands). Or if you get an engine failure on one of... Well, then it practically falls out of the sky, but you should be able to quickly assess what is wrong with the machine.*"

Examples of indicated amount and interwall of practical training:

- 4h/week
- 8 annual proficiency check flights
- Min 30min/month + annual check

3.6.2 The effect of currency and experience on limitations, resilience and threat management

All 5 participants indicated a mindful approach of how previous experience and currency would influence pilot limitations, resilience and threat management.

It depends on the situation that arises that forces me to make adjustments. And to some degree it has to do with how we use our own autonomous system (refereeing to experience), it becomes second nature. It's about what we have practiced and how its configured that creates a sense of 'this is something I have no control of'. (It triggers you) to then immediately stop, bring it back, restart and then observe what happens. I think there are many who needs to practice this (approach) and you do so by gaining experience. (Alfa)

In the winter it's like that, then it's less flying for me. So I'm always a little nervous when I takeoff with the drone again before missions, to come back (to flying). And as you say, gradually build it up and increase the complexity of the flights more and more, when I feel I can trust the drone. Absolutely step by step and if you look at my material, for example, on a broker filming from January vs now, there is a big difference. I remain (distance from drone) much closer, I make much less movements and there you can see that I am much more comfortable now when I have started flying again and have a lot of assignments. (Charlie)

Echo: *"There are significantly more risks when you are indoors. It's more to consider and you also need a little more experience to be able to do it."*
Joakim: *"Is there anything specific that you find is really the main point, a specific key point where it differs?"*
Echo: *"It's the risk of something happening. You don't have GPS that you can rely on to keep the drone in place. Should the sensor stop working, the one that prevents it from colliding with anything, if it stops working then it will probably slip into a wall, floor or ceiling. Or something else if you are not fast enough to fly it out yourself and be able to fly in such an environment. In some cases there is not much distance between the propellers (and wall), it can be half a meter on either side."*

Experience and currency seemed to be of significance, aiding safe flight.

3.7 Communication, Leadership and Teamwork

Note: The interviewees had a mixed experience from working with others operationally, varying from 'seldomly occurring' to 'daily operational reoccurrence'. No specific consideration was given to the varying experience levels in the results presented.

With regards to EBT behavioral indicators (ICAO, 2013), indication of elements in following areas were observed:

- Adheres to standard radiotelephone phraseology and procedures
- Conveys messages clearly, accurately and concisely
- Listens actively and demonstrates understanding when receiving Information
- Confirms that the recipient correctly understands important information

3.7.1 Effective communication

There is no standardized phraseology specific for aerial drone operations, yet interviewees (4 out of 5) indicate use of short and direct phrasing during operations requiring other operative personnel (e.g. Visual Observer).

> *if you fly with dual controls or in a two-pilot system, regardless of whether it is a drone or if you have one who operates drones and one who operates the cameras, it's good to use 'call outs', something predetermined according to a certain template. Just like you have in an airplane. (Golf)*
>
> *I usually give the directive to say as short commands as possible. If you see a helicopter, say 'helicopter'. If you want me to stop, say 'stop!'. (Charlie)*

Communication structure utilized by interviewees bear a seemingly close resemblance to the structured communication found in civil aviation (cockpit/cockpit, cockpit/ground, cockpit/ATC, etc.).

3.7.2 Importance of communication made by other operational participants

4 out of 5 interviewees indicated they put great emphasis by any communication made by additional operative person.

> Joakim: *"If the person who is an observer were to shout something to you, or inform you in any way, how do you consider it (the information)?"*
> Charlie: *"Take it very seriously! They become like an extended eye."*
> Joakim: *"But do you see it as a recommendation or do you see it as something you act on directly?"*
> Charlie: *"I probably act on it immediately."*

Rather than consider it as a hint or suggestion, interviewees placed great value at any expressed communication by other operative personnel, often acting on it in a direct manner rather than viewing it as recommendations. One interviewee indicated that certain emphasis was placed on any communication at times of lost visual contact with the drone.

3.7.3 Use of closed loop communication and feedback

All but one participant indicated the use of briefs, de-briefs or other type of 'feedback-loop' orientated communication structures during aerial drone operations.

> *We go through the mission type. Are we taking photographs or are we doing surveillance? And then I fly a certain flight plan and he/she takes care of the camera. It has been discussed, and just like you have onboard aircrafts, 'I'm flying and you take care of other things' (refereeing to roles of pilot flying/not-flying). (Golf)*

Certain emphasis was indicated with regards to post-flight clarification of decisions made throughout the flight.

3.7.4 Designated leaders and hierarchies

All interviewees recognized the clear presence of a structure with regards to leadership and different roles in their operation.

> *And if we also put it in the aspect that we have a 'command of chain', then it's always the question of who is responsible for discovering these things? Who is responsible so nothing happens? Yes, it falls in the hands of the remote pilot. But the only difference is that of what the operator has done prior in the preparatory work, before handing over to the remote pilot. (Alfa)*

Additionally, if being subjected to the influence of others in a greater hierarchy (e.g. rescue unit or similar), the option of refusal to operate in perceived unsafe conditions remained a recurringly consideration for both profile Golf and India

> *We train our pilots to dare to say no to rescue leaders. A rescue leader might order "you're going to fly!", but if the pilot does not feel safe, then they should say no. Just like with smoke diving, you can be told to go inside but if the whole apartment is on fire, I will refuse. We are always our own safety representatives. (India)*

Overall, the privilege of a pilot in command was seemingly recognized and honored in a similar manner to what has been observed in the remaining civil aviation industry.

4. Discussion

4.1 Result outcome

4.1.1 Review

The results indicated several areas of incorporated Human Factors Elements in aerial drone operation.

Four main attributes were observed:

1. The limited use of procedures (normal and non-normal), problem-solving techniques and an active decision-making whilst flying (mid-flight segment).

2. The applicability of workload management and situational awareness with regards to the nature of operation.
3. The limited yet focused applicability of communication, leadership and teamwork.
4. The use of planning and in-depth pre-flight preparation to facilitate safe flight, influencing the majority of EBT competency categories.

4.1.2 Procedures, emergencies, problem solving and decision making

Even if results suggested all participants used some sort of procedural structure, it was predominantly associated with the pre-flight segment. Some drone manufacturers have implemented a system logic similar to that of a dark cockpit concept (in simple terms, the system only display errors when or if deemed necessary for the current phase of flight) and most drones require few or no steps to reconfigure between phases of flight. Consequently, there seems to be very little mandating procedural use (e.g. a checklist or similar) during the mid-flight segment. Yet, as profile Echo solely states in section 3.1.1, procedures may be useful at every stage of the flight, potentially depending on mission type and suggesting the need to tailor procedures with regards to mission conduct.

As most of the flight are being conducted at 120m/400ft or bellow, it leaves little margin when non-normal events unfold. All participating interviewees indicated a mindful approach (as per section 3.1.2) to non-normal situations, yet with regards to emergencies and engine failures in particular, procedures were confined primarily to planning and executing flights within pre-defined buffer zones, accounting for potential breakdowns of equipment leading to a crash. As indicated by Alfa and Echo in section 3.1.2, the only time airborne emergency procedures seem applicable, was during flights with a copter-type drone with a sufficient number of engines (often 6 or more) to support a fail-safe redundancy operation. One should also note that the use of fixed wing drones or VTOL (Vertical Take-Off and Landing) with wing profile, would potentially allow the Remote Pilot to utilize any gliding distance for some purposeful maneuvering after suffering an engine failure, a feature lacking for most copter type drones.

Some occurrences (e.g. signal interference, loss of GPS leading to a subsequent automatic revertial into ‘atti-mode’, etc.) may allow the Remote Pilot sufficient time to process and respond to an arising situation. However, during rapidly unfolding events, the overall nature of drone operation allows the Remote Pilot very little room for an analysis to facilitate an appropriate response. Therefore, it constitutes at large the need for planning of accidents to occur rather than to try to fully avoided them.

Beyond the scope of non-normal situations, the application of problem-solving techniques and an active decision-making process is rather limited as seen in section 3.4.1. Remote Pilots may face an undesirable state, yet the nature of operation and current industry wide battery endurance would seldomly allow for an exhaustive process to diagnose problems and make subsequent well-informed decisions.

> *This necessitated the use of heuristics to reduce cognitive load and speed up decision making. As a result decision makers often sought satisfactory solutions rather than trying to make optimal decisions. Human beings have bounded rationality. When pursuing a satisfactory decision, a full review of alternatives is not made (Harris, 2011, p. 73)*

One could therefor argue the applicability of a Naturalistic Decision Making as the prime 'method', as aiming for a satisfactory outcome rather than the optimal could be considered desirable with the general nature of drone operation in mind. As indicated multiple times by the interviewees the use of 'stop and hover', 'maneuver repeats' and 'mission abort' was a seemingly recurring strategies both with regards to high workload and problem solving (potentially as you preferably attend to the problem after landing rather than whilst airborne).

A noteworthy detail was the significant effect of inputs from additional operative personnel on Remote Pilots decision-making process, as most interviewees acted on call outs/communication rather than observing them as recommendations.

Implementing full-scale problem-solving strategies and decision-making models similarly to those used in commercial aviation could therefore be seen as redundant in aerial drone operations.

4.1.3 Workload management and Situational Awareness

Similarly to Endsley & Jones (2004), Harris (2011) pointed to how Human Factor elements are interconnected and how they affect one another (e.g. a higher workload state impose a potentially higher error rate, thus information passed in a correct format and time could aid and enhance the pilot Situational Awareness. Poor Situational Awareness leads to poor Decisions Making and vice versa). At the center of aerial drone flights, elements related to Workload and Situational Awareness seem to be key categories impacting the operation.

Liu et al.(2016) mentioned how the lack of the human presence onboard the flying vessel creates a certain disconnect, out of the loop unfamiliarity, bearing an negative impact on Situational Awareness. To counteract this whilst airborne, interviewees indicates that the most common practice to improving Situational Awareness was the use of a 360° maneuver (ref 3.2.2). Yet, even if it gives an overall picture of the surroundings, it requires a side-step from the intended operation and allows for little room of periodical update during mission conduct. As counteracting the disconnect requires an understanding of vehicle state in the surrounding environment (Endsley, 1995), the use of a scanning technique between remote controller/screen and drone (during VLOS ops) seemed to be the primary method of creating an updated awareness.

For Remote Pilots flying near ground/obstacles with relatively low endurance (i.e. battery capacity), maintaining an awareness level sufficient to predict performance becomes an additional important aspect. As mentioned by Stark et al. (2012) projecting the near future (Situation Awareness Global Assessment Technique level 3) allows the Remote Pilot to anticipate certain areas that could induce a high level of workload (e.g. battery endurance remaining) if not attended too.

As mentioned by Harris(2011), the cognitive activity of a person and their readiness to engage in activity, Arousal, is believed to be derived from the human primitive fight or flight response. Arousal tend to generally increases with stressful situations, preparing the body's ability to respond. A well-established way of understanding how human performance varies with levels of arousal, is presented in Figure. 4.1 by Nixon (1976), with origins from Yerkes & Dodson (1908) Inverted 'U' Hypothesis of arousal and performance.

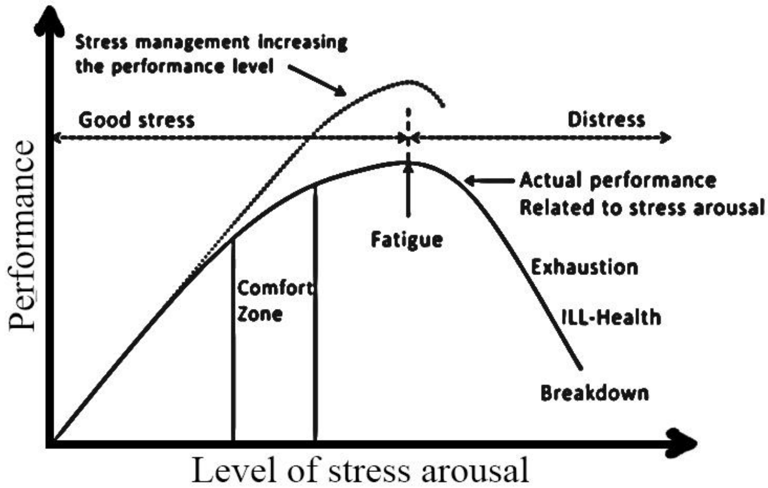

Figure 4.1 Replication of 'The human function curve' by Nixon (1976)

As operational conduct often occurs in close proximity to obstacles/ground, Remote Pilots may find themselves in a need to act quickly on situations requiring immediate actions.

> *It's the risk of something happening. You don't have GPS that you can rely on to keep the drone in place. Should the sensor stop working, the one that prevents it from colliding with anything, if it stops working then it will probably slip into a wall, floor or ceiling. Or something else if you are not fast enough to fly it out yourself and be able to fly in such an environment. In some cases there is not much distance between the propellers (and wall), it can be half a meter on either side. (Echo)*

This necessitates 'readiness' management as it will likely be needed during the entire flight, thus requiring a high level of focus for pro-longed durations. This underlines the importance of being fit-to-fly and proper planning of duty periods as no regulation currently governs this aspect.

The following excerpt (presented in section 3.3.2) is a good example of how arousal may enhance performance, likely whilst being exposed to a high level of stimulus:

> *For me, it's the moment when I fly and record videos at the same time. Then I have to keep full focus on the drone and how it moves. Especially when I'm flying in cramped spaces or in an apartment area where it is tight between the walls. Then additionally I have to maneuver it nicely while I avoid flying into buildings to get a nice shot. This is where the highest workload is (experienced), absolutely. (Charlie)*

It also shows how an awareness of the surroundings environment influences the Remote Pilot during a high workload maneuver in a complex surrounding.

This additionally highlights ambiguity connected to the use of automatics, as it allows for some rest and the ability to scan the area/airspace more widely (potentially increasing Situational Awareness) whilst potentially reducing the level of arousal and ‘readiness’. With regards to automation, Liu et al.(2016) pointed to the difficulties in anticipating the workload during some drone missions, stating that the operationally induced workload could shift quickly between ‘too low to remain vigilant’ to ‘excessive to a degree that cause performance degradation’. The impact from these extreme points can be visualized through Figure 4.2 and to some extent Figure 4.1.

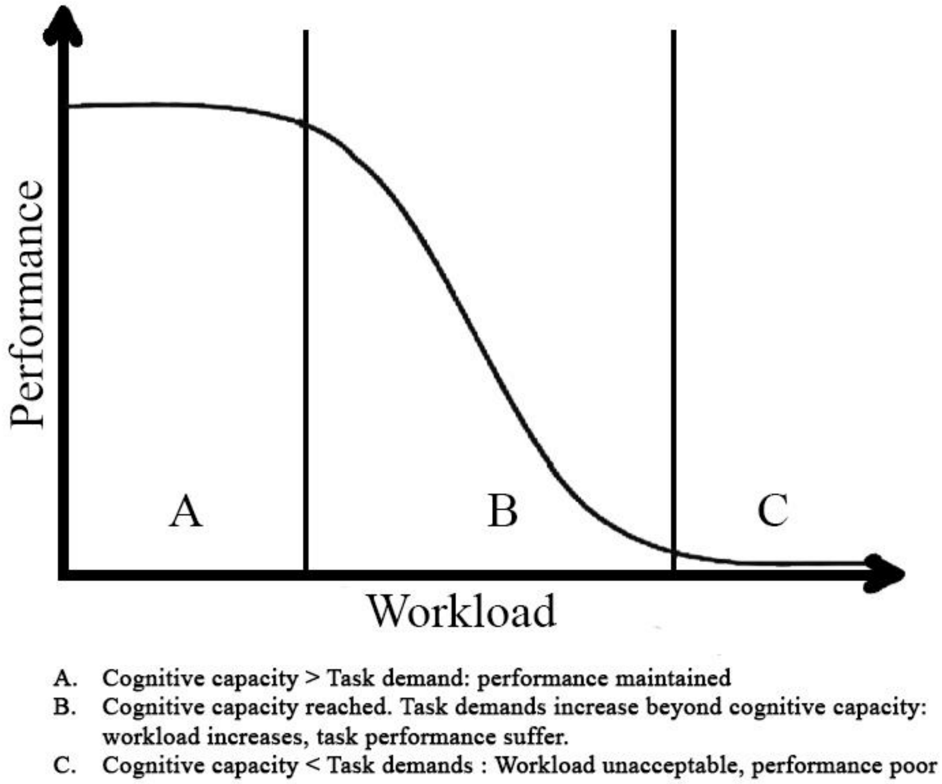

Figure 4.2 Replication of The hypothetical relationship between workload and performance by Harris (2011, fig. 3.1)

Airline pilots are often seen as capable of coping with quite high levels of anticipated workload, from the authors experience relying on training, planning and experience to create a level of resilience to withstand events imposing high levels of workload. A reasonable assumption would be that similar strategies are as applicable to Remote Pilots as to airline pilots.

Contrary to airline operations however, aerial drones do not operate from a (somewhat) controlled environment (i.e. airport), with a pre-defined threats analysis completed and with published explanatory departure/approach/airport charts, etc. “These are very unpredictable environments” (Echo)**,** minding that Echo is referring to their operation in tunnels used for mining specifically, the unpredictability is still applicable to most aerial drone flights. The emphasis on pre-flight preparations to foresee and mitigate situations of high workload was indicated by all interviewees, yet as the dynamic environment is hard to fully predict, precautionary measures may not be sufficient at all times.

Even if the effect is not prolonged, Remote Pilots would additionally need to consider the effect of surprise and startle. Landman et al.(2017) indicated both will temporarily increase arousal beyond peak performance and thus momentarily have a degrading effect similar to what can be observed in figure 4.1.

The saying 'Sit on your hands' is an adopted concept with regards to the initial response in non-normal situations amongst commercial airline pilots. It emphasizes on regaining an understanding for the situation at hand before acting, allowing the effect of the startle/surprise to dissipate by regaining awareness through a situation analysis. In turn this increases the likelihood of appropriately responding to the situation (Harris, 2011) as the risk of rushed actions may increase the risk for errors (Moriarty, 2015).
As mentioned in section 3.3.3, similar approaches ('Stop - Breathe - Think – Act' and 'stop and hover') was seemingly used by the interviewees to counteract high workload and potentially startle or surprise. Yet, Moriarty(2015) goes on to say how the level of urgency for the specific situation sets the tone for how to deal with the unfolding events, thus e.g. instantly releasing the controls in close proximity to obstacles without consideration for current inertia and direction of the drone, may prove to be detrimental.

Landman et al.(2017) continued to indicate that variable and unpredictable training may improve resilience to counteract the effect of both startle and surprise.

For as long as the human participates actively in aerial drone operations, there will be a need to consider our limitations. To accommodate for our information processing bottlenecks (Resource limited processing, Data limited processing, Resource competition), Harris (2011) advocated the need to design systems around the pilot, facilitating safe operational conduct whilst accounting for our human limitations. The author concurs, yet the lack of data is likely to complicate any tailored drone development with regards to Human Factors. For now, appropriate training seems to be the sensible way forward, as it creates awareness and aids resilience.

Finally with regards to environmental stressors, Harris (2011) mentions there is little evidence of temperature impairing cognitive functionality, yet it may impose significant physiological impairment. The interviewees indicated a mindful approach to the effect of temperature as per 3.3.4 and a seemingly clear understanding of its impact on flight performance. Other environmental stressors should be considered in future research, as it may affect the cognitive system and the human ability to manage workload.

4.1.4 Communication, Leadership and Teamwork

According to the current regulation (European Commission, 2020) and similarly to the airline industry, the operator bears a general responsibility for the operation and thus being in charge of appointing a Remote Pilot for the intended flight. If the operator has taken correct actions to facilitate safe operational conduct, much of the responsibility of the flight ends up with the Remote Pilot. Currently, some technical systems support multi-pilot operation, allowing for handover of flight between pilots and/or division of roles (e.g. Remote Pilot and separate Sensor Operator). Additionally, a Remote Pilot may be assisted by a Visual Observer.

The results indicated a beneficial use of closed-loop communication (e.g. briefs and feedback) and a clear recognition of hierarchies and leaders. Yet, inputs from additional operative personnel (e.g. Visual Observer, etc.) carried a surprising significance during flight. With regards to the author's experience of multi-pilot systems in airline operations, the proximity to the ground would decide level of urgency and required appropriate action ('hint', 'suggest', 'direct' or 'actively takeover controls') in response to an undesirable state such as being incorrectly configured for the specific flight segment (e.g. no flaps selected for the approach). With similar logic and as indicated by the results, direct action seems appropriate if a call of ‘greater urgency’ is made to the Remote Pilots whilst operating in low level conditions/close proximity to obstacles. However, this mandates accuracy in communication and operation would benefit from commonality (i.e. standardized communication) amongst all operative stakeholders. There is no regulation mandating the use of callouts or similar standardized communication (unless using 2-way VHF-COM with ATC), yet the concept still seemed to be adopted as the majority of interviewees indicated use of short and direct phrasing when operating with others.

The overall use and implementation of Communication, Leadership and Teamwork in aerial drone operation seemed to be functional, limited and simple. Throughout the course of this project, the use of implementing ‘airline based’ Crew Resource Management (CRM) has been somewhat of an internal debate, as the author has found it to be a useful e.g. to highlight barriers of communication and subsequently how to overcome these.

> *We keep being told that CRM is vitally important but this is not backed up by any meaningful or structured guidance for individuals and organizations about how these principles can be best implemented (Moriarty, 2015, p. 269)*

Being mindful of the words of Captain David Moriarty, the applicability of such a CRM-program is debatable. Targeting key aeras affecting drone operation would add meaning, thus it’s hereby suggested to further investigate the need for a tailored and purposeful implementation of CRM in aerial drone operations.

4.1.5 Planning and Pre-flight preparations

The results suggest that for the majority of the EBT competency categories, an emphasis on in-depth pre-flight preparation allowed for the facilitation of safe flight in a preventative manner. Referring to Figure 1.3, Ljungblad et al.(2021) visually highlighted the extent of planning and preparations required by most Operators. Airline operation requires a vast amount of planning, yet it assumes much of the work has been prepared beforehand by each responsible stakeholder. For aerial drone operation this responsibility mainly falls in the hands the Operator and the Remote Pilot, thus necessitating thorough planning for each and every flight. Still minding the issue of unpredictability in flight, the use of in-depth pre-flight preparations seemed to be a useful tool to increase operational safety. Yet, it reduces the quick and effortless launch of a drone that we have become so conveniently accustomed to seeing worldwide.

As stated in 4.1.3, the structures implemented in airline operations are far from available to drone operators. It should be mentioned however that several applications are available for pre-flight assistance. Yet, as seen in the summary in Appendix D with inspector Stålberg (personal communication, 2022-04-25), legalities are problematic when using third party information. Additionally, it’s hardly so that current applications may forsee or highlight all the aspects necessary to address in an dynimaic enviroment open to the public.

As indicated by multiple interviewees in 3.1.1, the use of procedures during the pre-flight stage looks to be indications of a structured recurring preparatory approach to how to incorporate important aspects of the flight prior mission start. Rather than arguing for specific details or discussing further aspects and angles (as drone operations will vary greatly), the author elects to underline the observed importance of pre-flight preparations with regards to safety.

4.2 Result Conclusion

As the field of Human Factors has been found applicable in countless industries, varying from healthcare to nuclear power plants, the need to account for industry variation becomes imperative. The variables of operation should be defined and addressed accordingly, as the limitation of the human body remains the ‘constant common denominator’. Therefore, understanding the unique specifics of drone operation will allow for necessary adaptation of relevant Human Factors concepts. Even if drone operations share some commonality with operations in the remaining civil aviation industry, the contrast between them stands out as they differ in several ways. However, parallels of Human Factors concepts can be observed, current knowledge studied and applied with mindful modification.

The width of this project was far from exhaustive enough to make any major conclusions, yet the results evidently pointed to the applicability of Human Factors in aerial drone operations at large. By observing the results 4 main attributes emerged, likely shaped by the nature of operation. Out of the 4 main attributes, 2 seemed to be out of greater importance:

- Workload Management and Situational Awareness
- Pre-flight preparations

The elaborate discussion conducted in section 4.1 intended to consider potential aspects applicable to the results. As the results indicated great significance of Workload Management and Situational Awareness in drone operations, it motivated the relevance of addressing related areas such as arousal, cognitive capacity, startle/surprise and training. At large sought to benefit Remote Pilots understanding of performance and limitations in unpredictable environments.

As a seemingly major contributing factor facilitating safe operational conduct with regards to nature of operation, the importance of pre-flight preparations is recognized as a tool allowing for precautionary measures facilitating overall safe flight including Workload Management, Situational Awareness, etc.

4.3 Project conduct

4.3.1 Method

The use of Semi-Structured Interviews was purposely selected as an appropriate method for the project, but the number of interviewees failed to cover the full operational spectrum of aerial drone flights.

Purposeful/convenience sampling was considered necessary for the completion of the project and added potential for a more in-depth data collection, yet risked corrupting/distorting the sampled data as indicated in section 2.2.2. Any replication of a similar project should therefor consider the use of another main method and sampling method.

The use of EBT Competency categories with corresponding behavioral indicators might be widely recognized and implemented throughout the civil aviation industry. Yet, it’s not entirely clear whether it sufficiently identifies Human Factors elements solely applicable to aerial drone operations. Future research should therefore aim to assess if a more suitable basis for data evaluation exists.

4.3.2 Interviews

As interviews had to be scheduled with a reasonable time limit, certain areas received more attention than others. The interview guide (see Appendix B) allowed for a pre-planned structure with initial open-end questions for each competency area, followed by more direct follow up questions. To facilitate the progress of the interview in a useful direction, the use of leading questions occurred multiple times. This unfortunately came with the price of potential unwanted influence, bias and reduction in data accuracy and validity.

The conduct of this project aimed to achieve as much transparency as possible, meanwhile maintaining the integrity of the interviewees. In order to facilitate any detailed future comparison of data during a replication, the author considered including the full transcripts in the report. Yet, minding good ethics of research conduct, it was opted not to disclose such in-depth documentation with regards to interviewee anonymity. However, the decision reduced transparency and there subsequently becoming a potential concern of report validity.

4.3.3 Result

As the result presented in the report was subject to the data processing and sampling by the sole author of this project, 'personal coloring' to some extent was unenviable.

As this project didn't account for the full operational spectrum of aerial drone operation, the results provided are likely to be contested and reliability disputed. Future research should aim to include the vast variety of aerial drone operation to adequately address any inaccuracies presented in this report.

Constructive criticism or opinions about the project in future research is highly welcomed.

4.4 Suggestion

This report has by no means enough substance to facilitate proper recommendations for a useful systemic improvement (Dekker, 2001). However, with the growing numbers of sold aerial drones and with the increasing threat they potentially pose, the lack of official data is worrisome. As aerial drones become more technically reliable, it would be wise to look to history and consider lessons already made by the civil aviation industry. Properly educating Operators and Remote Pilots about applicable areas of Human Performance and Limitations may help to further increase safety. Furthermore, as 5 out 5 interviewees, Harris (2011), Haslbeck (2016) and Landman et al. (2017) indicated the use of 'training' in any type or form, neglecting its benefit would be unfortunate.

> *Training is at the very core of Human Factors and was one of the starting points for the discipline in World War II (Harris, 2011, p. 125)*

As the current regulation for an entry level A1/A3 certificate mandates no practical training (initial or recency), a final urge to implement a minimum requirement for training goes out to all applicable legislators.

4.5 Recommended reading

During the pre-study phase some competent academic publications were observed, but was later found to be beyond the scope of this project. As future research into the field of Human Factors may require further in-depth focus into certain areas of aerial drone operations, a list of suggested reading has been provided:

FPV-flights	Human-Piloted Drone Racing: Visual Processing and Control by Pfeiffer & Scaramuzza (2021) https://doi.org/10.1109/LRA.2021.3064282
	The Effects of Visual and Control Latency on Piloting a Quadcopter Using a Head-Mounted Display by ZHAO et al.(2018) https://doi.org/10.1109/SMC.2018.00505
Haptic feedback	Effect of Haptic Feedback on Pilot/Operator Performance during Flight Simulation by Malik et al.(2020) https://doi.org/10.3390/app10113877
Head Up Display	Impact of Heads-Up Displays on Small Unmanned Aircraft System Operator Situation Awareness and Performance: A Simulated Study Rebensky et al.(2021) https://doi.org/10.1080/10447318.2021.1948683
Simulators	Physiological Data Models to Understand the Effectiveness of Drone Operation Training in Immersive Virtual Reality by Sakib et al.(2020) https://doi.org/10.1109/SMC.2018.00505
	Workload perception in drone flight training simulators by De la Torre et al.(2016) http://dx.doi.org/10.1016/j.chb.2016.07.040

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Appendix A – Interview Pre-brief

LUND UNIVERSITY
School of Aviation

TFHS SEDE2020
FLYL01
2022-03-01

Interview pre-brief
'Human factors in drone operations'

Joakim Albihn

Då studien presenteras på engelska, så kommer innehållet i denna intervjuförberedande text fortsatt att vara på engelska för att enkelt kunna inkluderas som bilaga i slutrapporten. Intervjun kommer utföras på ***svenska.*** *Frågor och förtydligande av dokumentet kan göras innan intervjusessionen påbörjas eller via email i förväg.*
As the study is presented in English, the content of this pre-interview information will follow in English to facilitate inclusion as an appendix in the final report. The interview will be conducted in ***Swedish.*** *Questions and clarifications about this document can be made before the start of the interview session or via email beforehand.*
Note: ***Your attention to page 4 Data collection and data storage is required***
A copy of this document will be sent out to each participating interviewee for your convenience, it is however not individually tailored.

Thank you for your upcoming participation as an interviewee in this qualitative study on 'Human factors in drone operations'. In the following pages you will find some additional information useful before the interview session.

Purpose:

This interview is conducted as a part of a bachelor thesis at Lund University School of Aviation. The interview is conducted in order to add valuable data, knowledge and further understanding about human factors withing the field of drone/UAV/UAS/RPAS operations. You have been purposely selected, being one out a diverse group of other remote pilots/operators, thus your contribution is of great value.

As a separate and in some ways less regulated branch within the field of aviation, drone operations have made a major leap in progress over a very short time span (compared to civil aviation). Research about human factors within the overall field of aviation has been conducted widely, yet this is not entirely the case with regards to drone operations specifically.

Interviewer:

To focus more on the topic of the interview (rather than getting to know each other further), it might be useful for you as an interviewee to gain a slight insight into the professional background of the person conducting your interview.

You'll be talking to Joakim Albihn, 30. Introduction to aviation started in 2010 at Svensk Pilotutbildning, followed by a cadet program with Ryanair during 2013. After serving as a First Officer on the Boeing 737 with Ryanair (short to medium haul), career progressed to Qatar Airway in 2017, flying again as a First Officer on the Boeing 777 (long haul). Attendance to this related bachelor program at Lund School of Aviation commenced in 2020. After leaving Qatar Airways in 2021, a short HVE-program (focused on remote pilots and drone operators) was completed at YrkesAkademin, open category A1/A3+A2 certification was finalized and a small "drone ops" start-up company launched as a side project.

Conduct of interview:

The interview will be conducted as a one-to-one video conference call. After established connection is satisfactory and general greetings completed, you'll be informed that the subsequent parts of the conversation will be recorded. Formalities regarding consent of data storage and use of interview for data gathering will be handled first (more information is provided on page 4).

The interview will then commence and use a set of basic questions as a foundation, adding relevant follow-up questions as the interview progresses. Even if the main focus will remain on the interviewee, it should be considered as a conversation rather than a hearing.

Consider the following:

- You as an interviewee are allowed to ask questions and seek further clarification during the interview if necessary.
- You are encouraged to answer in a way that suits you and feels comfortable. However, mind that a broader/in-depth answer allows for more data to be collected. Your input matters!

- Aviation related terminology will be used by the interviewer from time to time and any clarification will be made as required. However, you as interviewee are not expected to use any (for you) unknown terminology when responding to asked questions.
- Personal involvement in any prior unsafe operation and/or incident/accident is understandably a delicate matter to mention. The study does NOT seek to judge, frame or assign blame of any personal operational conduct, human factor related practice or lack thereof!

Data collection and data storage– See page 4

Data collection and data storage
Consider the following:

- **<u>The interview will be recorded and transcribed</u>** - The interviewer will inform you **prior** to commencing the recording.

  Note: Any mentioned irrelevant (for the topic or context) name or other personal data of people, companies or similar, will be crossed out or substituted in the transcript.

  The following sequence will follow:

  1. As soon as the recording starts, you'll be asked for a verbal consent to data collection and data storage using the following phrase:

     Tillåter du användning och lagring av data enligt den information som presenterats på sida 4 i tidigare tillhandahållet dokument 'Interview pre-brief.pdf'?
     (Do you consent to use and storage of data according to the according to the information presented on page 4 of previously provided document 'Interview pre-brief.pdf'?)

  2. You'll be asked a couple of initial questions to identify your professional profile. The questions will strictly be related to drone and civil aviation operations. Together with a random assigned alias, this will form your profile for the transcribing process.

- Any audio, video or shared on-screen content will be recorded
- For the purpose of redundancy there will be 2 recordings in progress at the time of the interview, one primary and one backup.
- The recorded material will be stored locally on 2 separate data storage devices
- An excerpt of the verbal consent will be kept for future reference. All remaining recorded material will be stored until final submission of thesis is accepted, approved and disputation completed, but no later than 31 December 2022. Thereafter, recorded material (except verbal consent excerpt) will be deleted permanently.
- Privileges granted by your consent can be revoked at any point and all data with reference to the particular interview will be deleted immediately.
- Any participating interviewee may request a copy of the final report prior final submission. Please note this requires you to provide the interviewer/author with an email address. The email address will be locally stored but NOT published in the report

Note: ONLY upon request from the interviewee, you will be provided with a copy of page 4 to sign as an alternate procedure of consent. A copy with your name and signature will be required to be sent back prior to engaging in the interview. The signed copy will be stored similarly as the video consent excerpts. Name and signature will NOT be included in the final report.

Additional information:
You as an interviewee are required to prepare the following beforehand:

- Access to stable internet connection
- Access to computer or PED able to run video call software

- Available video call software

    Preferred: Teams, Zoom

    Additional (for your convenience): Skype, Whatsapp, Facetime, Facebook Messenger
- Access to microphone
- Preferably access to webcam

As the interview will be transcribed, it would be highly appreciated if the interview session is conducted in a quiet room with minimal background noise and disturbance.

If you have ANY question beforehand, don’t hesitate to contact the interviewer/author in a returning email.

Appendix B – Interview Guide (Swedish)

Intervjuguide

Tilltänkta forskningsfrågor:

- What elements of Human Factors (9 core competencies) are present within todays drone ops?
- How are these elements present (e.g.procedures, is it written in a manual (flight as imagined) or is it practiced (flight as done))?

START

- **<u>Informera att du kommer starta inspelning</u>**
- **<u>Starta inspelning på båda enheter</u>**
- **<u>Dela sida 4</u>**
- **<u>Be om tillåtelse för datahantering och lagring genom följande mening:</u>**

  Tillåter du användning och lagring av data enligt den information som presenterats på sida 4 i tidigare tillhandahållet dokument 'Interview pre-brief.pdf´

  Notera: vid frågor om oönskat flygtillstånd, incident eller olycka – fråga alltid om hur current piloten var vid tillfället

Erfarenhet

1. Vad för operativ roll har du störst erfarenhet av (fjärrpilot/operatör/båda/annan (redogör))?
   a. Är det samma roll som du innehar vid nuvarande verksamhet?
2. Hur många års/uppskattad mängd loggade timmars erfarenhet av ”drönaroperationer” har du?
3. Har du någon tidigare utbildning med anknytning till civil luftfart?
   a. Om JA, hur många år/vilken licenstyp innehas?
4. Vilken typ av verksamhet har du primärt utfört under dina år som operativ med drönare (ex. foto/videoflyg, skogsbruk, lantbruk etc.)?
   a. Är det samma verksamhetstyp som nuvarande du utför?
5. Inom vilken operativ kategori har du primärt flugit under (öppen, specifik, certifierad, eller uppskattad motsvarande)?
   a. Är det samma kategori som nyttjas i nuvarande verksamhetsutförande?
6. Vilken typ av utrusning har du nyttjat mest (segment eller modell)?

Här följande kommer du ombes svara på frågor kring det operativa utförandet inom den verksamheter där du förnuvarande är aktiv eller som du ser som ”huvudmässig”. Huvudfokus kommer vara ”nutid”, men du får gärna referera till gamla/parallella erfarenheter. Tänk bara på att gärna förtydliga detta om sådant är fallet.

Frågorna som ställs är baserade på det underlag som nyttjas för återkommande träning inom civil luftfart. Frågorna avser att fastställa om området är relevant och i sådant fall på vilket sätt. Du kan säkerligen känna att vissa frågor är ”upprepande”, du är då högst välkommen att själv koppla ihop ett svar med ett tidigare svar, så att sambandet förtydligas extra.

Procedurer

Vägledning genom forskningsfrågor:

- Finns procedurer i deras verksamhet?
- Verkar procedurerna relevanta för just deras verksamhet?
- Hur används procedurer i deras verksamhet, verkar de existera för att de enbart ”ska finnas” eller finns de för att hjälpa till operativt?

7. Hur jobbar du/ni med procedurer operativt inom er verksamhet (ex. har ni egna, nyttjar ni bara tillverkarens inbyggda checklistor, etc.)?

   Vägledning:
   Verkar något extra intressant be dem utveckla det området
   Vidare
   Finns uttalade procedurer? Om uttalade procedurer FINNS -> 7A, annars 7B

   7A Om uttalade procedurer FINNS

   a. Hur relevanta/anpassade/välförankrat upplever du att procedurerna är för det faktiska operativa verksamhetsutförandet?
   b. Anser du i största allmänhet att du/ni har nytta av procedurerna?

      Om JA

      i. I vilket skede anser du att de har störst vikt/gör störst nytta (pre-flight, mid-flight (start, ”enroute”, landning), post-flight? (**fler segment kan väljas**)
      ii. Hur strikt anser du att dessa procedurer efterföljs?
      iii. Finns det en återkommande anledning till att ibland inte efterföljs? (ex. vissa delar är inte applicerbara på alla typer av flygningar)
      iv. Upplever du att procedurerna någon gång bidragit till en icke-önskvärd/förvirrande/osäkert operativt tillstånd?

      Om NEJ

      i. Förklara varför inte?
      v. Hur strikt anser du att dessa procedurer efterföljs?
      vi. Finns det en återkommande anledning till att ibland inte efterföljs? (ex. vissa delar är inte applicerbara på alla typer av flygningar)
      vii. Upplever du att procedurerna någon gång bidragit till en icke-önskvärd/förvirrande/osäkert operativt tillstånd?

   c. Finns procedurer för både normaloperation och non-standard/nödprocedurer?

      Om JA

      i. Hur är non-standard/nödprocedurer uppbyggda?

   7B Om uttalade procedurer INTE FINNS

   a. Följs någon återkommande struktur (ex. finns något flöde/mönster som tydligt praktiseras vid varje flygning)?

      Om JA

      i. Berätta om strukturen
      ii. Hur strikt efterföljs dessa strukturer (vägledning: är den fast eller ganska flytande)?
      iii. Vad skulle vara en anledning till att du/ni inte följer de strukturer som finns? (ex. vissa delar är inte applicerbara på alla typer av flygningar)
      iv. Upplever du att strukturen någon gång bidragit till en icke-önskvärd/förvirrande/osäkert operativt tillstånd?

      Om NEJ

      i. Finns en avsikt att skapa procedurer eller en ofta praktiserad struktur?
      ii. Upplever du att avsaknaden av procedurerna någon gång bidragit till en icke-önskvärd/förvirrande/osäkert operativt tillstånd?

Automation

Vägledning genom forskningsfrågor:

- Nyttjas automation i deras verksamhet?
- Verkar det relevant att automation nyttjas i just deras verksamhet?

- Hur nyttjas automation?

8. Berätta om hur du/ni nyttjar automation inom ert operativa utförande/verksamhet?
   Vägledning:
   Verkar något extra intressant be dem utveckla det området
   Vidare
   I hur stor utsträckning nyttjas automation? Mycket 8A, lite 8B, inte alls 8C

   8A Automation verkar nyttjas i STOR utsträckning
   a. Vilka fördelar ser du att automation har på ditt/ert operativa utförande?
   b. Hur nyttjas ev. frigjord kapacitet av automation inom ert operativa verksamhetsutförande?
   c. Uppskattar du att er operativa verksamhet till stor del är beroende av automation för det operativa utförandet?

      Om JA
      i. På vilket sätt?
      ii. Finns en strävan mot full autonomi?

      Om NEJ
      iii. Finns en önskan/strävan att implementera mer automation?

   d. Under vilka segment nyttjas automation mest i ert operativa utförande (pre-flight (planning), mid-flight (start, ”enroute”, landning))? (**Fler segment kan väljas**)
   e. Nyttjas oftast samma typer av ”automatiska mode”/funktioner inom er verksamhet?
      i. Om ett sällan använt ”mode”/funktion behöver nyttjas, görs någon extra förberedelse/ansträngningar i samband med detta?
   f. I det operativa verksamhetsutförandet, uppfattar du att fokus på drönarens ”flight-path” ökar eller minskar när automation används?
   g. Har automation varit bidragande till att du/ni hamnat i en oönskad situation (den gör inte som tänkt, incident, olycka)?
      i. Om JA - Berätta

   8B Automation verkar nyttjas i MINDRE utsträckning
   a. Vilka fördelar ser du att automation har på ditt/ert operativa utförande?
   b. Vilka automatiska funktioner används mest?
      i. Vad är oftast syftet med detta (ex. Return-To-Home säkerhetsrelaterat)?
   c. Under vilka segment nyttjas automation mest i ert operativa utförande (pre-flight (planning), mid-flight (start, ”enroute”, landning))? (**Fler segment kan väljas**)
   d. I det operativa verksamhetsutförandet, uppfattar du att fokus på drönarens ”flight-path” ökar eller minskar när automation används?
   e. Har automation varit bidragande till att du/ni hamnat i en oönskad situation (den gör inte som tänkt, incident, olycka)?
      i. Om JA - Berätta

   8C Automation verkar INTE nyttjas alls
   a. Varför? (det kan finnas goda skäl att inte nyttja det)
   b. Finns en önskan om att börja nyttja automation framöver?
      i. Om JA - Vad krävs för att det ska implementeras? (ex. önskemål om utbildning, övning, etc)
   c. Ser du/ni några nackdelar med att automation inte nyttjas i dagsläget?

Manuell flygning

Vägledning genom forskningsfrågor:

- Nyttjas manuell flygning i stor utsträckning inom deras verksamhet?
- Har manuell flygning relevans för deras specifika verksamhet?
- Hur nyttjas manuell flygning?

9. Hur använder du/ni manuell flygning operativt inom er verksamhet? (ex. enbart vid start och landning eller mer omfattande? Berätta)

   Vägledning:

   Verkar något extra intressant be dem utveckla det området

   Vidare

   I hur stor utsträckning flyger man manuellt under en flygning? Mycket 9A, lite 9B, inte alls 9C

   9A Manuell flygning förekommer MYCKET

   a. Om tekniken hade tillåtit, hade du/ni föredragit att reducera mängden manuell flygning till förmån för automation?
   b. I vilket skede av flygningen nyttjas manuell flygning primärt (pre-flight, mid-flight (start, ”enroute”, landning))? **Du kan välja fler**
   c. Uppmuntrar ni till manuellt flygande och återkommande övning?

      Om JA

      i. Övar ni på manuell flygning utanför verksamheten?
      ii. Hur övar ni?

      Om NEJ

      i. Varför?
   d. Vilka risker har upplevt med manuell flygning inom verksamheten?

   9B Manuell flygning förekommer LITE

   a. Om karaktären på det operativa utförandet hade tillåtit mer manuell flygning än vad det gör idag, hade detta varit att föredra?
   b. I vilket skede av flygningen nyttjas det primärt (pre-flight, mid-flight (start, ”enroute”, landning))? Du kan välja fler
   c. Uppmuntrar ni till manuellt flygande och återkommande övning?

      Om JA

      i. Övar ni på manuell flygning utanför verksamheten?
      ii. Hur övar ni?

      Om NEJ

      i. Varför?
   d. Vilka risker har upplevt med manuell flygning inom verksamheten?

   9C Manuell flygning förekommer INTE ALLS

   a. Varför? (ex. om autonomi är eftersträvat så är det naturligt inte relevant med manuell flygning)
   b. Hade det funnits en poäng med att introducera något manuellt segment i er operativa verksamhet?

      Om JA

      a. Vilka risker skulle du se associerat med detta?

Situationsmedvetenhet/rumsuppfattning

Vägledning genom forskningsfrågor:

- Läggs någon vikt vid att utvärdera och aktivt bygga upp en situationsmedvetenhet?

- Verkar det relevant att för deras typ av verksamhet?
- Hur?
- Uppdateras den under flygningens gång?

10. Hur bygger du/ni upp en bild av-, och medvetenhet kring-, där drönaren ska flyga/flyger?
    Vägledning:
    Är det primärt i pre-flight skedet de gör en aktiv ansträngning till att bygga en ”överblicksbild”? Hur? (Är det genom NOTAM och väder, kontrolleras området även via Google Maps, besöks du området aktivt inför en flygning?)
    På plats, används några medel för att hjälpa till att bygga situationsmedvetenhet? (Observatör, uppdelning pilot + sensoroperatör)
    Vidare
    Verkar största vikten ligga på att bygga en god rumsuppfattning innan flighten eller är den delad/största vikten under flighten? Innan 10A, delad/under 10B, inget aktivt arbete kring SA 10C

    10A Huvudfokus verka ligga på att bygga upp medvetenhet INFÖR flygning

    a. Skulle du säga att det finns en uttalad struktur som nyttjas för att bygga rumsuppfattning eller är den adaptiv/flytande inför varje uppdrag? **Berätta**

       Om UTTALAD struktur verkar nyttjas

       i. Skulle du säga att du/ni anpassar strukturen? (ex. lägger till/tar bort punkter på en checklista som känns relevanta/irrelevanta)

       Om ADAPTIV/FLYTANDE approach verkar användas

       i. Vad ser du som största fördelen med att ha en lite mer varierande approach till förberedelserna? (ex. bättre anpassat till uppdragets utformning)
       ii. Hade det funnits någon relevans i att ha en mer uttalad grundstruktur att följa som sedan anpassas till uppdraget? (ex. lägger till/tar bort punkter på en checklista som känns relevanta/irrelevanta)

    b. Uppfattar du att det återkommande uppkommer inslag av oförutsedda händelser relaterat till situationsmedvetenhet eller rums/flygområdesuppfattning?

       Om JA

       1. Tror du att vidare påbyggnad av ”rumsuppfattning” av området du/ni opererar inom hade kunnat öka situationsmedvetenheten på ett sådant sätt att det hade gjort en positiv skillnad? I kort, ger ytterligare ”effort” på detta område en tillräckligt stor ”gain” för att vara värt det? (det är inte helt säkert att uppdragets natur tillåter att bygga vidare på SA, det är inte en säkert att det är önskvärt (spana efter helikoptrar på horisonten varannan minut hade kunnat göras, men vad är vinsten? Troligen bättre med implementering av transponderteknik som synliggör varandra)

    c. Har du upplevt att det finns något i er verksamhet som återkommande sänker situationsmedvetenheten? (trötthet/ljus - tunnelseende, störningsmoment/människor, miljö/kyla, etc.)

b. Tror du att ytterligare tekniska hjälpmedel såsom ex. head up display, haptik (skakande kontroll), ljud/call outs, etc, hade bidragit till en ökat situationsmedvetandet eller tvärt om, genom möjlig distraktion eller informationsöverflöd?

10B Fokus verkar vara delad mellan att bygga medvetenhet <u>både före och/eller under flygning</u>

a. Skulle du säga att det finns en uttalad struktur som nyttjas för att bygga rumsuppfattning eller är den adaptiv/flytande inför och under varje uppdrag?

Om UTTALAD struktur verkar nyttjas

i. Skulle du säga att du/ni anpassar strukturen? (ex. lägger till/tar bort punkter på en checklista som känns relevanta/irrelevanta)

Om ADAPTIV/FLYTANDE approach verkar användas

i. Vad ser du som största fördelen med att ha en lite mer varierande approach till förberedelserna? (ex. bättre anpassat till uppdragets utformning)

ii. Hade det funnits någon relevans i att ha en mer uttalad grundstruktur att följa som sedan anpassas till uppdraget? (ex. lägger till/tar bort punkter på en checklista som känns relevanta/irrelevanta)

b. För att tydligt konkretisera, kan du peka ut exempel på vad du/ni gör för öka situationsmedvetens och rumsuppfattning under pågående flyguppdrag? (ex. större skärm, flertalet kamerasensorer, kontrollera distanser till hinder, etc.)

c. Ser du några nackdelar med hur ni bygger denna medvetenhet? (ex. förlust av tid, mer komplext uppdrag som kanske skapar andra sekundärproblem, etc)

d. Har du upplevt att det finns något i er verksamhet som återkommande sänker situationsmedvetenheten? (trötthet/ljus - tunnelseende, störningsmoment/människor, miljö/kyla, etc.)

e. Tror du att ytterligare tekniska hjälpmedel såsom ex. head up display, haptik (skakande kontroll), ljud/call outs, etc, hade bidragit till en ökat situationsmedvetandet eller tvärt om, genom möjlig distraktion eller informationsöverflöd?

10C <u>INGEN</u> aktiv ansträngning verkar göras för att bygga rumsuppfattning/medvetenhet inför eller under en flight?

a. Varför?

b. Uppfattar du att det återkommande uppkommer inslag av oförutsedda händelser som påverkar det operativa utförandet negativ?

Hantering av arbetsbelastning

Vägledning genom forskningsfrågor:

- Fastställ om det finns en uppfattning hos piloten/operatören kring upplevd arbetsbelastning?
- Hur arbetar man i den operativa verksamheten för att hantera ökad belastning?
- Verkar området relevant för den operativa verksamheten?

11. Inom den civila luftfarten ser man ganska tydligt att arbetsbelastningen ökar ganska markant under vissa segment av en normaloperativ flygning och hålls betydligt lägre under andra segment. Hur ser fördelningen av arbetsbelastningen ut genom spannet av ett helt normalt operativt förförande för dig dig/er? **Berätta!** (Vägledning: pre-flight (planning), mid-flight (start, ”enroute”, landning))?
    a. Har du/ni någon dagligt nyttjad struktur/taktik för att hantera en ökad arbetsbelastningen under vissa moment under en normal flygning?
        Om NEJ
        i. Anser du att det finns behov av någon specifik strategi för flygningar inom vad som operativt kan klassas som normala?

Vägledning:
Finns det en tydlig uppfattning om hur arbetsbelastningen påverkar den operativa verksamheten?
Finns en antydan på strategi kring hur man bemöter en ökad arbetsbelastning?
Vidare
Uppvisas medvetenhet kring hantering av arbetsbelastning? JA 11A, annars 11B

11A Det verkar <u>finnas</u> en medvetenhet kring hantering av arbetsbelastning
a. Om arbetsbelastningen oväntat skulle öka, finns det någon strategi på hur man bemöter detta (load shead, prioritering av tasks, akronymer, Return-To-Home – avbryt, etc)?
b. Har du någonsin bevittnat att en operativ överbelastning eller mättnad lett till en icke önskvärd situation?
    i. Vad hände?
    ii. Hur återtogs den operativa kontrollen (om det lyckades)?

11B Det verkar <u>INTE</u> finnas en medvetenhet kring hantering av arbetsbelastning
a. Om något oväntat skulle inträffa som tydligt kommer påverka flygning, hur hanteras det oftast? (det är inte helt otänkbart att man i de flesta fallen avbryter flygningen om något oväntat sker)

Ledarskap och lagarbete

Vägledning genom forskningsfrågor:
- Fastställ om det finns en uppfattning hos piloten/operatören kring hur ledarskap och lagarbete fungerar inom deras operativa verksamhet?
- Verkar området relevant för den operativa verksamheten?
- Hur är det relevant?

12. Hur ser du på ledarskap och lagarbete inom er operativa verksamhet?
    a. Finns det moment som återkommande tydligt innefattar koordination med andra personer inom den operativa verksamheten?

Vägledning:
Finns det återkommande moment där ledarskap och lagarbete har relevans inom deras operativa verksamhet?
Vidare
Om JA 12A, annars 12B

12A JA, det verkar finnas återkommande moment där ledarskap och lagarbete har relevans
a. Finns det segment av er verksamhet som där ledarskap och lagarbete har extra stor betydelse för det operativa utförandet? **Berätta!** (ex. dubbelkommando, uppdelat mellan pilot och sensoroperatör, etc?)

b. Inom civil luftfart är det ganska uttalat med roller, kanske extra tydligt i tvåpilotsystem. En pilot kan inneha flera roller såsom Kapten, Styrman, designerad Pilot In Command (blir högst relevant om två kaptener flyger tillsammans), Pilot Flying, Pilot Monitoring, Left hand seat pilot, Right hand seat pilot, etc. Trots att ledarrollen kan ses som ganska uttalad, så kan den för vissa situationer ändå skifta mellan deltagande individer momentant, t.ex. om styrman har en temporärt bättre uppfattning av pågående situation. Vid varje drönarflygning så väljs en designated remote pilot ut. Trots det, ser du att ni rent operativt kan **flyta** mellan rollerna lika det som förklarades innan? (ex. arbetsledare ger direktiv om vad som ska kontrolleras vid en byggarbetsplats och piloten följer strikt efter, en observatör ser en fara och piloten agerar på uppmaning av denne)

Om JA

i. Brukar det finnas något uttalat kring ledarfrågor, ansvarsfrågor, etc. innan flygningen börjar? **Berätta**

ii. Hur inkluderas andras input i ditt eget beslutsfattande? (ex. ser du det som tips, är det något du direkt plockar in och överväger, följer du ”order”, spelar operativt segment roll för hur du behandlar det som framkommer från andra individer, vilken inverkan kan tidspress och nivå på uppdrag?) (Delas med kommunikation och beslutsfattning)

iii. Finns en strategi kring hur och när andra kan ge sin input? (ex. säger du till när du är mottaglig för info)

iv. Finns det något tillfälle där du märkt att ineffektivt ledarskap eller icke-funktionellt lagarbetet lett till ett oönskat operativt tillstånd?

Om NEJ

i. Nyttjas trots detta inputs från andra under flygningens gång? På vilket sätt?

ii. Hur inkluderas andras input i ditt eget beslutsfattande? (ex. ser du det som tips, är det något du direkt plockar in och överväger, spelar operativt segment roll för hur du behandlar det som framkommer från andra individer, vilken inverkan kan tidspress och nivå på uppdrag?) (Delas med kommunikation och beslutsfattning)

iii. Finns det något tillfälle där du märkt att ineffektivt ledarskap eller icke-funktionellt lagarbetet lett till ett oönskat operativt tillstånd?

12B NEJ, det verkar <u>INTE</u> finnas återkommande moment där ledarskap och lagarbete har relevans

a. Har det funnits enstaka tillfällen då du ändå har fått inkludera andra i ditt flygande? (ex. någon som velat agera ”instruktör” och lära dig en viss manöver etc.)

Om JA

a. Hur?

b. Har det funnits tillfällen då du sett behovet av hjälp från en funktionell grupp eller tydligt ledarskap för att potentiellt underlätta för det operativa utförandet?

Kommunikation

Vägledning genom forskningsfrågor:

- Fastställ om det finns en uppfattning hos piloten/operatören kring vikten av kommunikation inom deras operativa verksamhet (har detta element någon faktiskt inverkan)?
- Verkar området relevant för den operativa verksamheten?
- Hur är det relevant?

13. Finns det någon del av ert operativa utförande där kommunikation har stor betydelse? **Berätta!** (ATC, dubbelkommando, uppdelat mellan pilot och sensoroperatör, crowd control under flygning, etc)?
    Vägledning:
    Är ett kommutativt element relevant för deras operativa utförande?
    Vidare
    Om JA 13A, annars 13B

    13A Kommunikation <u>har relevans</u> för det operativa utförandet

    a. Inom civil luftfart ligger stor fokus på bl.a. effektiv-, direkt- och standardiserad kommunikation. Anser du att ert operativa utförande kräver en specifik disciplin eller struktur kring kommunikation?
        Om JA
        i. Vad för strategi/strukturer/liknande nyttjar ni kring kommunikation? (ex. standardiserat språkbruk, akronymer, briefer, etc.)
        ii. Finns det kritiska moment, ex. tidskritiska, där du anser att du/ni kommunikation spelar en synnerligen viktig roll?
        iii. Har du noterat att ineffektiv kommunikation, misskommunikation eller liknande haft en operativ påverkan som försatt flygningen i ett oönskat tillstånd?
        Om NEJ
        i. Finns det kritiska moment, ex. tidskritiska, där du anser att du/ni kommunikation spelar en synnerligen viktig roll?
        ii. Har du noterat att ineffektiv kommunikation, misskommunikation eller liknande haft en operativ påverkan som försatt flygningen i ett oönskat tillstånd?

    b. Vad för kommunikativa barriärer/hinder ser du inom er operativa verksamhet?
        i. Finns struktur eller återkommande lösningar som används för att överkomma dessa?

    13B Kommunikation ses <u>INTE ha relevans</u> alt. <u>mycket liten relevans</u> för det operativa utförandet

    a. Har du noterat att avsaknaden av kommunikation haft en operativ påverkan som försatt flygningen i ett oönskat tillstånd?
    b. Ser du potentiellt ett framtida behov av att utveckla den kommunikativa grenen inom den operativa verksamheten?
        i. Vad hade krävts för att uppnå denna utveckling (ex. infrastruktur, ett välfungerande team)

Problemlösning och beslutsfattande

Vägledning genom forskningsfrågor:

- Fastställ om det finns en uppfattning hos piloten/operatören kring en struktur-, eller om det aktivt resoneras kring problemlösning och beslutsfattande?
- Hur är jobbar man kring problemlösning och beslutsfattande, vilka typer av strukturer finns?

14. Om ett problem med operativ inverkan uppstår, hur jobbar ni då?
    Vägledning:
    Verkar man aktivt resonera kring-, alt. det finnas struktur kring-, problemlösning och beslutsfattande?
    Vidare

Om JA 14A, annars 14B

14A Det verkar finnas ett aktivt resonera kring-, alt. det finnas struktur kring-, problemlösning och beslutsfattande

a. Finns det en uttalad struktur kring hur man bemöter och löser problem? **Berätta** (ex. akronymer, bryter ner problem i beståndsdelar-prioritering, fokusområdet, aviate-navigate-communicate, etc.)
b. Har ni någon beslutfattandemodell eller struktur ni använder (akronym, inhämtning av information inför beslut, etc)?

Om JA

i. Hur fungerar den

Om NEJ

i. Hur sker den största mängden (problemlösning och framförallt) beslutsfattande?

c. Under vilket segment sker största delen av all problemlösning och beslutfattande (pre-flight (planning), mid-flight (start, ”enroute”, landning))? (**Fler segment kan väljas**)
d. *Har du stött på några scenarion där en beslutsfattandeprocess och/eller problemlösning **TYDLIGT** varit nyckeln till en fortsatt säker flygning? **Berätta**
e. *Brukar du/ni återkommande på bekostnad av t.ex. marginaler lösa uppkomna problem eller ta operativa beslut (ex. kan ni tänka er att gå under er satta batterireserv för att göra klart ett uppdrag)?

14B Det verkar <u>INTE finnas</u> ett aktivt resonera kring-, alt. det finnas struktur kring-, problemlösning och beslutsfattande

a. OM ett problem skulle ändå skulle uppkomma under flygning, hur bemöts det? (ex. RTH, pausa flygningen, avbryter flygningen direkt)

Kunskap

Vägledning genom forskningsfrågor:

- Fastställ om det finns en uppfattning hos piloten/operatören kring sin egen kunskap inom området
- Hur är jobbar man kring att bibehålla/uppdatera kunskap?

15. Regler kring drönare uppdateras just nu med högt tempo. Finns det ett aktivt arbete kring att bibehålla och uppdatera kunskap?
    a. Om JA hur? **Berätta**

Vägledning:
Verkar man aktivt arbeta kring att bibehålla och uppdatera kunskap?
Vidare
Om JA 15A, annars 15B

15A JA, det verkar finnas ett aktivt arbete kring att bibehålla och uppdatera kunskap?

a. Hur jobbar ni kring att bibehålla och uppdatera er kunskap (ex. finns återkommande bolagstest, läser man igenom nya regler när det kommer nya publiceringar, etc)

b. Har du sett att bristfällig kunskap försatt den operativa verksamheten i ett oönskat tillstånd? (antingen vid själva flygningen eller efter)
    i. Hur bemöttes detta och vilka korrigeringar vidtogs?

15B NEJ, det verkar INTE finnas ett aktivt arbete kring att bibehålla och uppdatera kunskap?

a. Har du återkommande sett att bristfällig kunskap försatt den operativa verksamheten i ett oönskat tillstånd? (antingen vid själva flygningen eller efter)

Avvägning av EBT-kategorier mot Miljö/omvärld

Undersök deras synsätt

Appendix C – Translated transcript excerpts

Application of Procedures

<table>
<tr><td colspan="7">Procedural use</td></tr>
<tr><td rowspan="2"></td><td colspan="5">Profile</td><td>Note</td></tr>
<tr><td>A</td><td>C</td><td>E</td><td>G</td><td>I</td><td></td></tr>
<tr><td>Element present (Y, N, -)</td><td>Y</td><td>Y</td><td>Y</td><td>Y</td><td>Y</td><td></td></tr>
<tr><td colspan="7">00:04:08
I: No, but we have created an SOP, standard operational procedures for how we should act and how we should secure airspace at a tactical and strategic level in order to minimize air risk and ground risk. Absolutely, that’s what we have done. So we have daily checklists and checklists (specific) for flights
00:00:57
A: …I make notes if I do things that require extra safety (precautions). So I have it in the process to really think about all the things that I have to bring with me. I will also be alert and well rested when I go and fly, when I’m the remote pilot for the flight I’ve prepared. So I do a lot of preparational work in front of the computer and prepare data and weather, the whole kit. NOTAM’s amongst other thing and (check) the weather. I contact, even if I’m not in a CTR area but during a forest inventory where I am near a CTR area, I always contact those responsible for the CTR area and tell them
00:19:00
E: … And then you have a start-up procedure that you follow, it’s the same every time.
00:19:13
J: But is it still adaptive in the way that you modify it for the environment you are in? Do you add additional steps?
00:19:22
E: No, it's the same start-up sequence wherever you go. Even if you fly indoors above ground, it is the same procedure for that (specific) system. Then it is varying depending on different system (drone system used), but then it is usually adaptive while flying. Things may not go according to plan and then you have to rethink and change.</td></tr>
<tr><td colspan="7">Related Material</td></tr>
<tr><td colspan="7">00:00:34
C: I do not really use any checklists except the ones I have in my head, but I check all the gear properly before each flight, check so that everything looks good and that everything works.
00:01:41
J: I’ve had some (interviewees), who perhaps have used a more relaxed approach. And they may not have written procedures, they are a little more fluid ... Rather you have a mindset (mental flow) that ‘this is what I will do before this flight’. Would you say that yours are more pronounced (fixed in writing) in such cases?
00:02:01
E: It will become like that too, if you follow a certain procedure all the time, you will get that mindset as well.

00:02:11
J: But where do you put most effort (procedural practice)? Is there a lot of focus on pre-flight or is it something that is used during the whole (flight)?</td></tr>
</table>

00:02:26 *E:* It's the entire flight. It is before (preparations), prior flight(pre-flight) and during the flight(mid-flight) and after(post-flight)

Non-normal/emergency procedures or structure						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	N[a]	Y[b]	Y	Y	N[a]	[a]Actively plans for a potential crash rather than implementing emergency procedures (with regards to the quadcopter type utilized, it's unable to maintain flight after engine failure). [b]Use of 'mind- based flow/checklist'.
00:05:30 *J:*…are there non-standard or emergency procedures that you work with actively if something goes wrong? Or how does it work? 00:06:13 *E:* Yes, there are procedures available depending on the equipment of course and it differs. 00:10:44 *A:* That's kind of the limitation of the drone concept, you have no options. If you fly a quadcopter with four propellers and one is damaged while being airborne, well then you can hopefully trust that it falls straight down and that you are within your buffer zone. If you have a hexacopter, well then you can do more and continue to fly and make a safe landing… …We are not pilots in that sense, we are navigators. It's the Flight Controller that takes care of everything(control inputs etc.). Therefore, it is not possible to take such extra measures to have more awareness up in the air, for emergencies or (use) emergency protocols. 00:04:33 *G:* Yes, I have been involved in developing parts of the emergency procedure for drones that are becoming uncontrollable. 00:04:53 *G:* We prioritize human life. If there is danger to other humans, we fly away from people (considering risk of ground impact). 00:11:37 *I:* Yes, but it's impossible to have margins for everything and some things you can't even foresee. But again, it's based on the safety of the pilots and that's something you follow up ongoingly, so you make continuous risk assessments.						

Situational Awareness

Pre-flight preparations to facilitate Situational Awareness						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	Y	Y	Y	
00:20:12 *C:* If I come to a completely new area, I check maps. I check how it looks in the surrounding area.						

The drone map service (by Swedish CAA). Then when I get to the location, I usually drive (by car) around a bit just to get a feel. 00:17:53 *E:* …you need to plan ahead. Then in many cases, in these spaces (mine shafts), the ones the customers want you to fly into, places where they don't know themselves what it looks like. Then you don't even know how to get in and what route to fly. That's something you have to deal with as you go, but as long as you have a good plan when you start, you'll adapt it. 00:18:20 *J:* Is there anything relevant to include, such as maps of tunnels and so on before or? 00:18:25 *E:* If we have access to such, we always use it.

Mid-flight Strategy aiding Situational Awareness						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	Y	Y	Y	
00:20:10 *A:* …To avoid it from flying entirely autonomously, as you lose the sense of 'if the wind is correct', 'if I have done everything correctly', I sense it through my fingertips… ... I start and fly out to the first waypoint where it should start the autonomous procedure, just to get a sense of the surroundings. 00:32:58 *G:* If you fly in the same area, then I have notes in the debriefing from the first flight… … For the first flight I do one or two 360's. I go from point A and make a 360, check and then go to point B and I do the same, then fly back to A and pack up. Then I have a basic picture of what everything looks like. 00:25:02 *I:* …Then we do as you said, we do a 360. We fly around the area, a house for example with the camera facing inwards… …then another lap with IR.						

Use of applicable scanning technique						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	-	Y	Y	
00:36:55 *J:* Does it feel like your general scan has a pattern, like how you look at your basic T (reference to General Aviation) when scanning during an IFR-flight, is there any such method? 00:37:06 *G:* Yes absolutely, sure there it is. I scan all the time. I keep the focus on approximately where the drone is at, and it also applies when I fly airplanes, you look outside. You look around a bit, sweeping the airspace when you operate. 00:23:59 *C:* But it's probably 50/50 and my eyes quickly shifts back and forth all the time, which means that I often lose sight of the drone with my eye and then have to fly back to locate it again.						

00:17:14 *I:* We teach our pilots that we divide it into two segments. One segment is pure transport, when you are going to take it from point A to point B, and meanwhile you don't look down at the screen even once. If you want to look down at the screen, you should select a reference point before you do so, so that you can find it mid-air. If we are 300-400 meters away, it can be difficult sometimes, so we should always select a reference point. A treetop for example, I stop above that treetop and then I look down. When we look down it is for a maximum of 5-10 seconds. Once you arrive at the destination and it starts to approach a safe environment, then we commence detail flying instead and that's when we use the screen

Workload Management

Workload mitigation						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	Y	Y	Y	
00:03:46 *A:* …Especially if I do wall inspections, I normally implement limitations (seemingly referring to area access, use of fence and area of operation). For wall inspections, it is usually the ground risk that is the major one… … it's the ground risk I attend to and thus the use of roadblocks. That's when I need extra staff like an VO or someone that scans the airspace 00:40:31 *G:* …will the workload be too high? Let's say I've flown two or three flight, no matter how much I've flown I'm still looking after myself. Is this safe, could the workload be a problem? And if there is any (anticipated) problem, there is only one thing to do then, it's to refuse the flight.						

Known operative conditions with high workload						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	Y	-	Y	
00:33:53 *A:* … That is as soon as the drone disappears from the visual spectrum for me as a remote pilot. That is where the workload increases, so to speak. It's quite the opposite to normal aviation. 00:25:38 *C:* For me, it's the moment when I fly and record videos at the same time. Then I have to keep full focus on the drone and how it moves. Especially when I'm flying in cramped spaces or in an apartment area where it is tight between the walls. Then additionally I have to maneuver it nicely while I avoid flying into buildings to get a nice shot. This is where the highest workload is (experienced), absolutely.						

High workload strategy						
	Profile					**Note**
	A	C	E	G	I	

Element present (Y, N, -)	Y	Y	Y	Y	Y	

00:38:10
A: …So, I am a formerly trained military clearance diver and there we learned one thing quite quickly. Stop - Breathe - Think - Act.
00:26:30
C: I practice a lot and I'm not hard on myself so do it all over again and do it right. To make it safe. So I might make the same maneuver ten times to try it out as many times as necessary to make it safe, correct and (video) looking good.
00:42:20
G: …It's about safety. No, I wouldn't compromise it. I would abort.

Considers environmental stressor (e.g. cold temperature)						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	Y	Y	Y	

00:45:19
C: …I'm with the drone outside amongst people, exposed to the elements, so it has an extreme impact.
00:46:10
C: I always try to plan my flights with regards to daily conditions. from the outside, based on what it looks like that day. What conditions are present? What factors affects me right here, right in this place? Weather and wind. I always try to adapt, but it's something you have to do almost at the last second. You have to be very adaptable.
01:12:01
G: …to sit in a warm cockpit versus to stand in the woods and freeze during a cold winter. It affects a lot ... It affects the assignment, the quality of the assignment. When you are standing there cold and freezing, then you really just want to get inside (quickly) and get the job done. Less caring. If you sit in a fairly pleasant environment being in a little more relaxed environment, then there will be more focus at work. If you stand there and shiver, you lose a lot.

Problem Solving and Decision Making

Active approach to Problem Solving while airborne						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	Y	Y	Y	

00:36:27
A: … when situations have occurred with magnetic interference while airborne, I've lost control for a while and maybe forced me to rearrange the antennas or change position depending on where/how you're flying, (e.g.) if you're using Cendence on the (DJI) Matrix or similar so try to regain control again. And also when you see that it has switched to 'Atti-mode' (attitude mode), then quickly, it is the biggest threshold that makes you think 'how should I solve this now?'. Like I said, I just continue calmly and relax. Release the control levers, observes what it's doing (the

drone) and then take care of the situation and bring it back. That is, so to speak, the peak of trouble when I fly, a lost signal or something that forces it into ‘atti-mode’ and then stars drifting with the wind or something similar.

00:36:52

C: But I always pause the flight. It depends on the situation, but if the airspace is empty and there is no apparent threat, remaining hovering above the same position is what I’ll do. Otherwise, if something is obstructing my view, then I’ll bring the drone closer to me.

00:36:51

J: Is there a hierarchy or in any way someone way, an acronym or similar that you are working with to try to restore the situation to its origin (ops normal) or to process it further?

00:37:08

E: Try to work out the situation, whatever may have happened, and bring it back. You would probably try to bring the drone back and check that everything is okay.

00:37:25

J: So Return-To-Home is a pretty good feature?

00:37:25

E: Yes and check what could have caused the error. And then we try again if something went wrong while airborne, we try to investigate why it went wrong

00:37:47

J: Is there, is there no outspoken decision-making model that allows for ‘we think like this about ...’, step by step, that allow one to diagnose?

00:37:58

E: No

00:37:59

J: So rather, you try to identify the problem as you go and then work on a solution.

00:38:07

E: These are very unpredictable environments

Related Material

00:14:44

I: ...You should also know about the dangers, for example inside central Stockholm, it can be directly inappropriate to use Return-To-Home because of phone towers other things that the sensors might not pick up on. While over a forest environment with an open field to land on, absolutely, Return-To-Home works great. In an urban environment, we use ‘hover’ for example (rather than the RTH land feature).

00:37:47

J: Is there no decision-making model that explicitly help you ‘these are the considerations...’, step by step, to diagnose?

00:37:58

E: No

00:37:59

J: Rather, you try to identify the problem "as you go" and then work towards trying to solve it?

00:38:07

E: These are very unpredictable environments

Aircraft Flight Path Management, Manual Control and Automation

Purposely use manual flight or applicable automatic mode depending on operational conditions						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	Y	Y	Y	
00:12:05 *A:* Yes, automation in the sense that I usually program the UAV before the mission and then I concentrate on keeping track of the drone while its flying and the data I've collected. On the other hand, during a search (and rescue) mission, well then I approach it differently since it is not possible to automate everything there. You have to fly into a forest, follow a stream of water or similar. But if I do photogrammetry assignments and similar, well, then it's completely automated. 00:13:16 *I:* …We try as much as possible to fly manually only, but one exception for example is Return-To-Home. We see it more as an extra safety layer if something were to happen, then this becomes the following (automated) response (hover present position, hover above 'home position', lands at nearest suitable area, lands at 'home position', etc.). For example we never put 'landing'-mode on, so if you lose the signal, as we never know where the drone will land, then it considered quite inappropriate. 00:21:37 *G:* … I fly 85 percent of my drone flights manually 00:22:51 *G:* If you are flying in a grid pattern I'll let it go automatically or if it's supposed to follow a fence three kilometers around an industrial area for example. Then I let it fly automatically, it's simply following the fence. I have already entered the flight pattern. Same thing when it comes power lines inspections… 00:23:43 *J:* So as long as it is quite monotonous maneuvers, well then it feels relevant to use automation. 00:23:54 *G:* Absolutely 00:09:04 *C:* … Almost all flights are conducted manually.						
Related Material						
00:11:49 *J:* The few times you were mapping, did you spend more time preparing to understand the automation you would use on that particular occasion? 00:12:04 *C:* Absolutely 00:12:09 *C:* It was very difficult, because there I just couldn't (interrupt the flight) ... Of course I could interrupt the operation and maneuver the drone myself, but yes I thought it was uncomfortable.						

Knowledge

Recurrent training theoretical and practical						
	Profile					Note
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	Y[a]	Y	Y	[a]Echo was the only participant who indicated current or prior use of simulators for recurrent training.

00:21:47
A: … I do at least four hours of flying a week. Pure practice.
00:25:28
G: ...we have 8 occasions annually where we show proficiency of flight. We perform different flying exercises.
00:25:43
G: …Abnormal flight attitudes and how to recover your drone if it starts to run away (not respond to commands). Or if you get an engine failure on one of... Well, then it practically falls out of the sky, but you should be able to quickly assess what is wrong with the machine.
00:21:00
I: ...Then we have periodic flight training where the pilots must achieve 30 minutes of effective flight time a month. Then we also have an annual quality assurance where we check theory and practice. And case studies and night flights again. So it's recurring.

The effect of currency and experience on limitations, resilience and threat management						
	Profile					Note
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	Y	Y	Y	

00:26:36
A: …It depends on the situation that arises that forces me to make adjustments. And to some degree it has to do with how we use our own autonomous system (refereeing to experience), it becomes second nature. It's about what we have practiced and how its configured that creates a sense of 'this is something I have no control of'. (It triggers you) to then immediately stop, bring it back, restart and then observe what happens. I think there are many who needs to practice this (approach) and you do so by gaining experience.
00:16:51
C: In the winter it's like that, then it's less flying for me. So I'm always a little nervous when I takeoff with the drone again before missions, to come back (to flying). And as you say, gradually build it up and increase the complexity of the flights more and more, when I feel I can trust the drone. Absolutely step by step and if you look at my material, for example, on a broker filming from January vs now, there is a big difference. I remain (distance from drone) much closer, I make much less movements and there you can see that I am much more comfortable now when I have started flying again and have a lot of assignments.
00:16:31
E: There are significantly more risks when you are indoors. It's more to consider and you also need a little more experience to be able to do it.
00:16:42
J: Is there anything specific that you find is really the main point, a specific key point where it differs?

00:16:52 *E:* It's the risk of something happening. You don't have GPS that you can rely on to keep the drone in place. Should the sensor stop working, the one that prevents it from colliding with anything, if it stops working then it will probably slip into a wall, floor or ceiling. Or something else if you are not fast enough to fly it out yourself and be able to fly in such an environment. In some cases there is not much distance between the propellers (and wall), it can be half a meter on either side.

Communication, Leadership and Teamwork

Effective communication						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	Y	Y	-	
00:34:00 C: I usually give the directive to say as short commands as possible. If you see a helicopter, say 'helicopter'. If you want me to stop, say 'stop!'. 00:37:44 G:…if you fly with dual controls or in a two-pilot system, regardless of whether it is a drone or if you have one who operates drones and one who operates the cameras, it's good to use 'call outs', something predetermined according to a certain template. Just like you have in an airplane. 00:48:03 G: It's sterile. Yes, you as a pilot (knows), it's like a sterile cockpit. 00:47:48 A: …as we have a predefined language, as an example if someone in a situation when using both a fence guard and a Visual Observer, shouts "ABORT!" then there is nothing else for me to do than to bring the drone down immediately.						

Importance of communication made by other operational participants						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	Y	Y	-	
00:22:44 *J:* So when you fly as a (remote) pilot, you still emphasize on observing the other person's point of view? 00:22:53 *E:* Yes 00:42:00 *A:* …if I do not have visual contact, then I put a lot of emphasis on what they say or if they say something. 00:31:12 *J:* If the person who is an observer were to shout something to you, or inform you in any way, how do you consider it (the information)?						

00:31:26 *C:* Take it very seriously! They become like an extended eye. 00:31:36 *J:* But do you see it as a recommendation or do you see it as something you act on directly? 00:31:45 *C:* I probably act on it immediately.

Use of closed loop communication and feedback						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	-	Y	Y	
00:46:59 *G:* We go through the mission type. Are we taking photographs or are we doing surveillance? And then I fly a certain flight plan and he/she takes care of the camera. It has been discussed, and just like you have onboard aircrafts, 'I'm flying and you take care of other things' (refereeing to roles of pilot flying/not-flying). 00:30:42 *J:* Do you feel that you get feedback from that person, that he/she understands what his/hers duty is? 00:30:51 *C:* Yes. 00:45:52 *A:* Always feedback on things, and especially if I have made a decision that they may find strange for that situation, I'll tell them why I made this decision, why I flew the way I did. 00:09:13 *I:* …we have a method that we always do, which is called an 'aerial flight overview'. And it's also quite a bit just for us to have a common language in our organization, so everyone knows what you're talking about.						

Designated leaders and hierarchies						
	Profile					**Note**
	A	C	E	G	I	
Element present (Y, N, -)	Y	Y	Y	Y	Y	
00:53:25 *A:* …And if we also put it in the aspect that we have a 'command of chain', then it's always the question of who is responsible for discovering these things? Who is responsible so nothing happens? Yes, it falls in the hands of the remote pilot. But the only difference is that of what the operator has done prior in the preparatory work, before handing over to the remote pilot. 00:00:19 *A*: …if I'm the operator for the mission, we must make sure that the remote pilot and those who are out in the field, perform their duties in a correct manner 00:22:26 E: It is the pilot flying who is responsible for the drone itself						

00:46:36 *G:* …When I operate drones (myself), I'm definitely the Pilot In Command and also even if I have a camera operator who photographs or operates the camera separately 00:29:58 *J:* Do you feel that your role in its entirety, that it's quite clear you are the leader? 00:30:10 *C:* Yes
Related Material
00:40:08 *G:* It has been some days, some moments, when there has been a very high workload. But I deal with it by saying 'no'. 00:40:22 *J:* It's a recurring strategy then? 00:40:28 *G:* Absolutely. 00:29:51 *I:* We train our pilots to dare to say no to rescue leaders. A rescue leader might order "you're going to fly!", but if the pilot does not feel safe, then they should say no. Just like with smoke diving, you can be told to go inside but if the whole apartment is on fire, I will refuse. We are always our own safety representatives.

Appendix D – Personal Communication

Note: All personal email addresses and phone numbers have been omitted.

Publication authorized 2022-04-25

The following text is constructed from annotations following personal Skype call with Carl Stålberg, Inspector at the Maritime- and Aeronautical Department of the Swedish Transport Agency, 2022-04-12 10:30. It serves as compilation of information touched upon during the call and allowed the author to derive minor conclusions. A draft was submitted to Inspector Stålberg (2022-04-19) for review to allow for comments and corrections, before settling with a granted finalized version for publication (2022-04-25).

Since 1956, Sweden has been a "contracting state" as its own Aviation Legislation Publication is resting on the 19 published ICAO annexes. In 1978 Sweden implemented a unified (civil + military) airspace, that's however not the case for all other states of the EU.

As drones emerged primarily from military usage, every nation has implemented their own national regulations for authorizations of operations. Hence, for example, flying drones across borders is still a complex matter compared to civil aircraft's. Yet, the membering states of the European Union still shares common regulations regarding airworthiness and air operations, working towards a unified airspace - Single European Sky. Arriving at a fully functional operational implementation, including drones additionally, is taking its time to be actualized even though progress is being made. Contrary to the author's beliefs, ADS-B is not implemented in Europe as of today according to Inspector Stålberg.

From an authority standpoint (perceived by the author), the expansion of the drone usage hasn't been a "natural branching" of the aviation industry per se, but rather a parallel subindustry that quickly evolved from military usage and toys into a fully fletched category within the field of civil aviation. Inspector Stålberg concludes that "the drones are here to stay" and during the autumn of 2021 a rounded figure of some 45000 drone operators were registered at the Swedish Transport Agency, a number expected to rise further.

Legislators and authorities may have fallen behind on regulatory adaptation and implementation as the technology has progressed in an extraordinary rapid pace, but blaming them solely for being unable to keep up is to oversimplify things. It looks to be a case of "growing pains" and Inspector Stålberg sees an industry asking for certification standards and regulatory guidance, but failing to provide equipment to initiate a certification process with.

> Another complaint often leveled against regulators is that they collude with those they are supposed to regulate, but this is largely a red herring (and, interestingly, almost universally disagreed with by those who are regulated. Independent of claims to collusion, they often see regulators as behind the times, intrusive and threatening). To get the information they need, regulators are to a large extent dependent on the organizations they regulate, and likely even on personal relationships with people in those organizations. The choice, really, is between creating an adversarial atmosphere in which it will be difficult to get access to safety-related information, or one in which a joint investment in safety is seen as in everybody's best interest.
>
> (Dekker, 2001, p. 147)

Dekker's (2001) focus on air crash investigations may not be applicable as such, but the relations between all stakeholders is well described in the previous section. From the authors standpoint, Inspector Stålberg's kind but somewhat puzzled request of "give us something to certify", comes meanwhile as users asks for certified equipment at the other end. It is true however that certain details of the new C-classification have been delayed going public, but it looks like the industry is facing some sort of a "catch 22" loop, highlighting the need for a functional and transparent channel of communication/feedback loop of data between legislators - authorities – users – manufacturers.

Even though the lack of fully functional communication is apparent on a national level, initiatives are being taken in various ends:

- Swedish Transport Agency is inviting operators and pilots to participate in reoccurring informative seminars
- Users are moving towards a national recognized industry organization (confirmed by phone with independent drone operators 2022-04-13)
- Developers/manufacturers are yet to be heavily regulated and seem keen on providing swift solutions requested by users (DJI Matrice 30 series being a good example)

Additionally, Inspector Stålberg welcomes further research into the field of drone operations, praising the initiative by TFHS to create the first European ADS. Drone related schooling operated at a university level adds potential for further research, knowledge, and at best, allowing legislators to target and focus on key areas to improve safety.

Contrary to the more "liberal" neighboring countries, the Swedish approach has been pragmatic but cautious, especially when authorizing new permissions for operators in the specific category as it's associated with certain level of risk taking. As today's regulation is rather general and "undetailed", much is left for the operators applying for permissions "to figure it out". It requires the operator to possess a certain level of knowledge within the field, noticeably lacking by some operators, especially by those buying into pre-constructed solutions. For those operators able to navigate the regulatory requirements, carefully analyzing the inherent risks seem to be a somewhat successful way to define and demarcate associated hazards, especially since a regulatory balanced composition between drone mass, speeds and energy is seemingly yet to be established. As a strategy the Swedish Transport Agency is appearing to rely on risk analysis submitted by operators, to allow them to authorize operative permissions with gradual steps with regards to risk taking, allowing supervision of ops and required feedback data from operators to facilitate an "evaluation loop".

From an authority point of view, the drone community is perceived as unaware of the fact that the current aeronautical informative systems implemented (NOTAM, AIP etc.), is designed and scaled primarily for the usage of the civil aviation. This as they are the primary financial contributor for the current system. A simplification of how drone pilots access information (e.g. a more user-friendly NOTAM format or a service compiling a briefing pack) could potentially be considered beneficial from a operational standpoint, but would still come at a cost likely impacting the drone community. To the knowledge of Inspector Stålberg, no such development is currently taking place, thus refereeing to third party services like SkyDemon (planning tool). From a pilot point of view however, that raises the question of liability, as any third-party service provider would need to assure quality of service (likely combined with a matching price tag).

As of today (2022-04-19), the minimum mandatory requirement for drone pilots to report to the Swedish Transport Agency is whenever a drone has been involved in a situation causing serious injury, death or involvement with other manned airship (lack of separation, mid-air collision, etc.). Additionally, if the operation requires additional authorization by the authority (i.e. specific or certified, an operational category of higher complexity than open), further reporting may be required and is currently one of few source of data for the Swedish Transport Agency (in combination with Air Traffic Management Service and insurance companies). The agency is however encouraging further reports beyond mandatory items as accident/incident and other data is (by author perceived) scarce, allowing for little overall feedback to authorities of actual operational conditions, etc. Additionally, as consequence very little is known about applicable human factors, shortcomings and necessary focus areas.

The current human factors- and recommended reading material provided by the Swedish Transport Agency prior to undertaking the certification process for open category, is focusing primarily on rather rudimentary items according to Inspector Stålberg. From the author's viewpoint, intended to create a general awareness rather than further in-depth understanding of human performance and limitations. For operations in open category there might be little use of a full in-depth course, but rather a need for progressive and adaptive material and tests, targeting relevant areas of human performance and limitations as the industry progresses. However, for operations in the specific category still requires further in-depth understanding and requires a "proof of competency". Additionally, the whole operation in specific category comes with a whole other level of structure, stretching from simpler pre-defined scenarios to the use of SORA (Specific Operations Risk Assessment).

Publication authorized 2022-04-25

Från: Stålberg Carl
Skickat: den 25 april 2022 13:13
Till: Joakim Albihn
Ämne: SV: TFHS - Ex.arbete Drönare - Human Factors

Hej Joakim,

Jag har inget att kommentera eller lägga till.

Mvh
Carl Stålberg

Från: Joakim Albihn
Skickat: den 19 april 2022 10:51
Till: Stålberg Carl
Ämne: Sv: TFHS - Ex.arbete Drönare - Human Factors

Hej Carl,

Ursäkta dröjsmålet, här kommer en bifogad draft från vårt samtal. Du är välkommen att kommentera, lägga till och markera sådant du anser inte ska vara med.

Mvh
Joakim Albihn

Publication authorized 2022-02-24

Från: Troels Emil Andersen Boe
Skickat: den 24 februari 2022 13:08
Till: Joakim Albihn
Ämne: SV: Lund University School of Aviation - Human Factors, Drone ops - Request

Dear Joakim,

If you want to use parts of this correspondence for your report, I see no problem in citing the number of registered drone pilots.

The rest can be validated through open sources such as the EU regulation or guidelines from EASA that might prove more useful for academic citation.

Regards,

Troels Emil Andersen Boe
Drones

Danish Civil Aviation and Railway Authority
Carsten Niebuhrs Gade 43
1577 København V

www.tbst.dk

-----Oprindelig meddelelse-----
Fra: Joakim Albihn
Sendt: 24. februar 2022 11:13
Til: Troels Emil Andersen Boe
Emne: Re: Lund University School of Aviation - Human Factors, Drone ops - Request

Dear Troels,

Thanks a million for your help!

May I cite parts of this email in my official report (beyond the numbers/data you provided)?

Regards
Joakim Albihn

> 24 feb. 2022 kl. 10:27 skrev Troels Emil Andersen Boe
>
> Dear Joakim,
>
> In response to your questions I have searched what data we have available:
>

Publication authorized 2022-02-24

> - Number of accidents/incidents involving drones: The Danish Civil Aviation and Railway Authority does not have complete data on this, but we assume such a number would be relatively large, given that even a small drone flying into an object, such as a tree, can be considered an unexpected termination of a drone flight.
>
> - Number of registered drone operators: There is a total of 17.426 registered drone pilots in Denmark.
>
> - Requirements for categories and exams: The Danish Civil Aviation and Railway Authority comply with the requirements for competent authorities set out in EU Regulation 2019/947 of 24 May 2019 on the rules and procedures for the operation of unmanned aircraft
>
> I hope that these answers are useful to you and hope that they might encourage you to look further into the European regulations regarding the categories and exams, as well as the guidelines and specific requirements for SORA's.
>
> Regards,
>
> Troels Emil Andersen Boe
> Drones
>
> Danish Civil Aviation and Railway Authority
> Carsten Niebuhrs Gade 43
> 1577 København V
>
>
> www.tbst.dk
>
>
>
>
>
>
> -----Oprindelig meddelelse-----
> Fra: Joakim Albihn
> Sendt: 15. februar 2022 09:46
> Til: ts Info
> Emne: Lund University School of Aviation - Human Factors, Drone ops - Request
>
> Dear CAA representative,
>
>
>
> As part of my bachelor thesis at Lund University School of Aviation, I m writing you with a kind and formal request for relevant data available with regards to drone operations. With the intention to map human factor elements within drone operations, I m currently in the process gathering data for an analysis with regards to the progress of the last 5-10 years.
>

> My initial promise by the Swedish CAA got cancelled short noticed due to a sudden loss of manpower. As this data will serve as a backbone for the thesis, I⊠ m kindly looking for alternative ways, explaining why I⊠ m reaching out to you as of now.
>
> Understanding that you have your main tasks to attend, I realize it might be difficult to process my full request. Therefore, I⊠ ve lined up the requested data points in order of importance:
>
> " Number of accidents/incidents involving drones (highlighting not only aircraft/drone, ANY drone accident/incident. If possible divided by year and operational category)?
>
> " Number of accidents/incidents involving drones deemed related to human factors/errors (if possible divided by year and operational category)?
>
> " Number of registered drone operators (if possible divided by year and operational category)?
>
>
>
> " Requirements for category Open, Specific, Certified (as local variations may apply to the best of my understanding)
>
> " Exam for open category, how many questions are related to human factors?
>
> " Human factors related elements to consider for Specific ops approval (e.g. SPECIFIC OPERATIONS RISK ASSESSMENT)
>
>
>
> In no way I⊠ m expecting you to summarize all the data for me, rather I expect minimum effort from you and further in-depth work by me to sum it all up.
>
>
>
> I really do hope you could consider my kind request, either way I⊠ ll like to wish a great day ahead!
>
>
>
> Best Regards
>
> Joakim Albihn
>
> Remote pilot | Drone operator |ex. F/O B737 B777/B787
>
>
>
>
>
>
>

Publication authorized 2022-04-26

Från: Heimro, Hans Petter
Skickat: den 26 april 2022 01:17
Till: Joakim Albihn
Ämne: SV: Lund University School of Aviation - Human Factors, Drone ops - Reply

Yes you may cite my answers!

Best regards
Hans Petter Heimro
Inspector
Section for unmanned aviation
Phone
E-mail:

CAA Norway

Fra: Joakim Albihn
Sendt: mandag 25. april 2022 12:06
Til: Heimro, Hans Petter
Emne: Sv: Lund University School of Aviation - Human Factors, Drone ops - Reply

Yet again, thank you for your kind help!

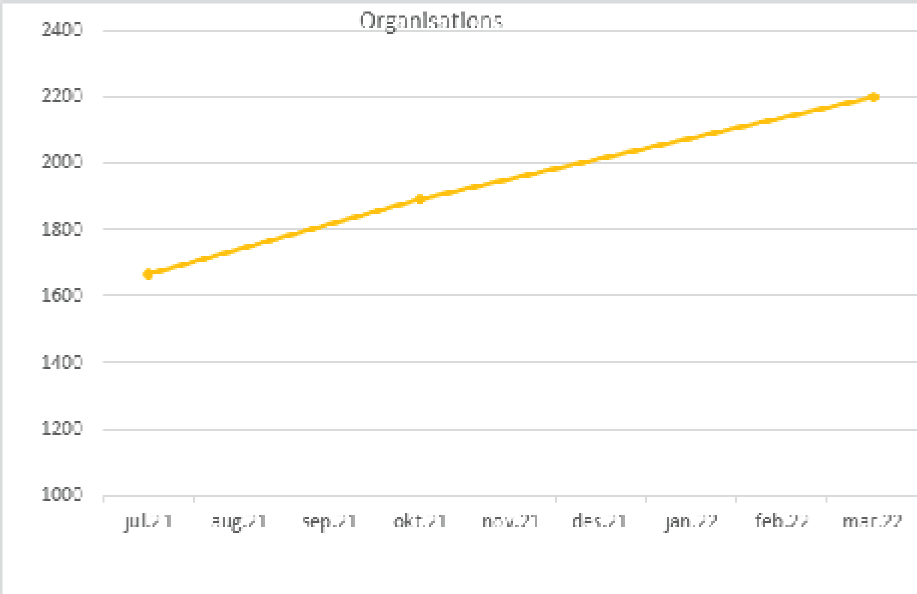
I just want to confirm that I may cite your answers and the data you have provided in previous email?

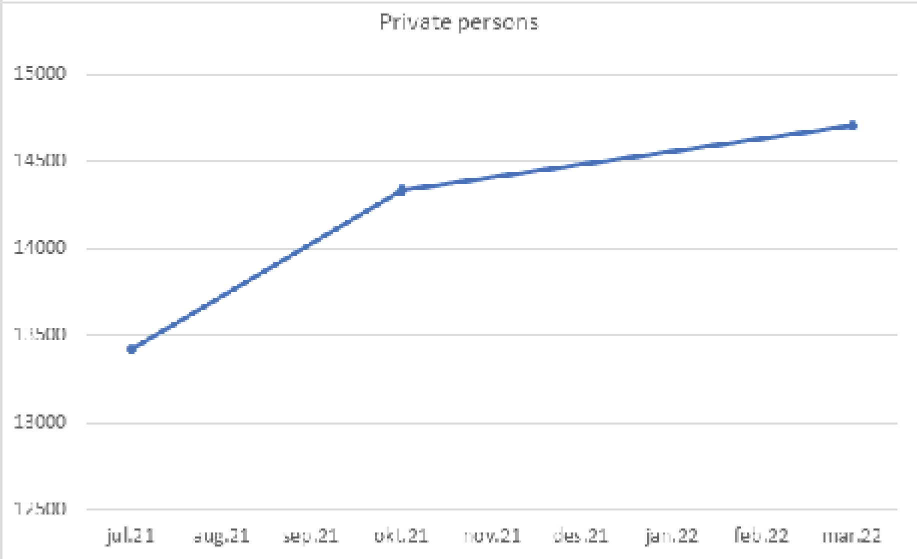
Regards
Joakim Albihn

Från: Heimro, Hans Petter
Skickat: den 8 april 2022 15:31
Till: Joakim Albihn
Ämne: Lund University School of Aviation - Human Factors, Drone ops - Reply

Numbers regarding accidents and incidents are attached. Let me know if you have questions.

Registered operators:





There are 38 operators in the specific category in Norway today.

Requirements for category Open, Specific, Certified:

Publication authorized 2022-04-26

These are mostly the same in Norway as in other EASA-member states.
In Norway insurance is always a requirement, and the minimum age in open category is 16 years.

Exam for open category, how many questions are related to human factors?
Out of 40 questions in the A1/A3 exam:
4 are related to human performance limitations
2 to insurance
7 to UAS general knowledge
4 to aviation regulations
7 to airspace restrictions
4 to air safety
7 to operational procedures
2 to privacy and data protection
2 to security
1 question is given from one of the subjects at random

Human factors related elements to consider for Specific ops approval
Operational Safety Objectives (OSO) #14-20 are related requirements.
You find them in Easy Access Rules for Unmanned Aircraft Systems from page 98.

Let me know if you have further questions or need clarifications.

Best regards
Hans Petter Heimro
Inspector
Section for unmanned aviation
Phone
E-mail:

CAA Norway

-----Opprinnelig melding-----
Fra: Joakim Albihn
Sendt: tirsdag 15. februar 2022 09:48
Til: postmottak
Emne: Lund University School of Aviation - Human Factors, Drone ops - Request

Dear CAA representative,

As part of my bachelor thesis at Lund University School of Aviation, I m writing you with a kind and formal request for relevant data available with regards to drone operations. With the intention to map human factor elements within drone operations, I m currently in the process gathering data for an analysis with regards to the progress of the last 5-10 years.

All occurrences (accidents and incidents) involving drones per year

Year	Count
2012	8
2013	4
2014	12
2015	29
2016	26
2017	45
2018	80
2019	76
2020	52
2021	58

Accidens involving drones per year

Year	Count
2012	3
2013	3
2014	2
2015	7
2016	4
2017	2
2018	1
2020	2
2021	1

Keep in mind that reporting from the drone operators themselves are in the early stages.
We receive some reports from drone operators, but the majority of occurrences involving drones in our
database are reported by other operators in the aircraft industry, for example by airline pilots or ATS personnel.