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Military unmanned aerial vehicle operations through the lens of a high-reliability system: Challenges and opportunities

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Abstract

This study examines the impact of regulations and standard procedures on safety outcomes in unmanned aerial vehicle (UAV) operations, specifically focussing on Norwegian military UAV systems, from a high-reliability organization (HRO) perspective. By analyzing data from existing regulations, accident reports, and interviews with military drone pilots using thematic analysis, we identify key recurring themes. Our findings highlight the importance of fatigue and exhaustion due to the absence of regulations on resting time for military drone pilots. This poses substantial risks and increases the likelihood of accidents and incidents in UAV operations. Additionally, we uncover gaps in safety reporting and accountability for military UAV pilots, indicating the need for improved reporting procedures that consider the unique operational elements of UAVs. Effective communication between stakeholders, including drone pilots, ground crew, and air traffic controllers, emerges as a critical factor in maintaining situational awareness. This emphasis on communication is consistent with HRO principles and supports the essential safety tasks of UAV pilots, namely sense-making, decision making, and performance. By uncovering the impact of regulations and operational procedures on safety outcomes and addressing fatigue in UAV operations, this research contributes to enhancing the safety and reliability of Norwegian military UAV systems.

KEYWORDS
decision-making, high reliability organization (HRO), operational complexity, sense-making, thematic analysis, uncertainty, unmanned aviation

INTRODUCTION

The unmanned aerial vehicle (UAV), commonly known as drones, inaugurated a new era in the aviation industry. While the growth rate in drone use, for a wide variety of purposes, is increasing, research on the safety management for the operation of UAV, in particular in a military context, is underdeveloped (Arterburn et al., 2017; Hobbs & Lyall, 2016; Susini, 2015). Among the existing UAV safety management directives, the European Union Aviation Safety Agency provides a drone incident management guide, aiming to mitigate risks from unauthorized civilian drones (EASA, 2021). This guidance points to a collision with other manned aircraft in the air, civilian, or military, as a potential accident scenario related to drone operations (p. 4). Collision with people on the ground is also another accident scenario, addressed in a report developed by the Federal Aviation Administration, Unmanned Aircraft Systems in the United States (Arterburn et al., 2017). While these two above-mentioned scenarios are considered as major hazards, leading to loss of lives and injuries, the militarized unmanned aviation has significantly reduced airworthiness, that is, measure of an aircraft's condition for safe operation. The manual for aviation safety, developed by the Norwegian Military Aviation authority, stipulates that the acceptable risk of airworthiness accidents for unmanned aerial military aviation can be up to 10,000 times greater than that of military manned helicopters (BFL 010-1 [B], 2017). This discrepancy in acceptable airworthiness levels is a critical safety issue that requires attention.

To gain a better understanding of this phenomenon, it is necessary to explore the risk of midair collision and ground strike by military UAVs through factors beyond just technical aspects. In a similar vein, Hobbs and Lyall (2016) identify several challenges of human factors in UAV operations, including reduced sensory cues, transfer of control during ongoing operations, flight termination, unconventional characteristics of unmanned aircraft, and reliance on automation. The UAV pilot's ability to assess risks and make informed decisions during the mission is crucial in dealing with the challenges. Effective risk assessment skills are essential for identifying and mitigating potential hazards. Skilled UAV pilots can adapt to changing conditions and ensure safe and successful operation of the UAV. Bergström et al. (2015) express caution about placing too much reliance on front-line operators' adaptive capacity, such as UAV pilots, in estimating inherent risks and vulnerabilities during missions. They highlight the challenges faced by front-line operators in trying to balance conflicting goals while ensuring safety in potentially dangerous situations. In such situations, the individual's cognitive ability plays a critical role in trade-off adaptation, as described by Hollnagel (2009, p. 141) and Woods (2018).

This ability involves extracting environmental cues and adopting appropriate strategies to deal with immediate threat levels. However, the characteristics of the operational environment affect the ability of UAV pilots to control the signals overlooked and the biases of decision-making. In the realm of unmanned aviation, understanding the dynamics of human–machine safety is of paramount importance. This study aims to explore the intricate aspects of pilot tasks as defined by Lim et al. (2017), including flying, navigating, communicating, and managing. We frame our investigation around the following research question: How do regulatory norms and protocols, along with UAV pilot tasks, impact safety outcomes in Norwegian military UAV operations when viewed through the lens of HRO principles? To address this inquiry, we will explore two crucial aspects. First, we examine the existing regulatory norms in unmanned military unmanned aviation. Second, we explore how existing protocols align with the reality of the operational environment for UAV pilots and consider potential strategies to improve UAV operational reliability. This analysis contributes to the dialog on safety management in complex cyber-sociotechnical systems within the HRO framework, providing both theoretical significance and practical relevance.

This paper is organized as follows. Section 2 provides a summary of unmanned aviation in the context of the Norwegian military. Section 3 introduces the main concepts used in this study, including high-reliability organization (HRO) and the three strands of safety-critical tasks: sense-making, decision-making, and performance. Section 4 describes the methodology and data sources used to support our analysis. Section 5 presents a brief overview of our findings. In Section 6, we discuss the insights obtained from our research. Finally, Section 7 concludes with recommendations for future research.

THE NORWEGIAN UNMANNED AVIATION IN A CYBER-SOCIO-TECHNICAL SPACE

Norway was selected as a case in this study due to its unique context in military UAV operations, allowing a detailed examination of the specific challenges, practices, and outcomes associated with UAV operations within this context. Although our study does not aim to represent the use of UAVs around the world, it provides valuable information on safety dynamics and operational considerations within Norwegian military UAV operations. This choice contributes to a wider understanding of safety management in unmanned aviation by offering insights from a specific operational setting. The justification for choosing Norway as a case lies in the fact that each country regulates and authorizes its own UAV operations, including safety management, both domestically and when participating in alliance missions. For instance, when a UAV from the United States, the United Kingdom, or Germany is deployed to Norway for military exercises, it becomes subject to the Norwegian regulations and safety management system.

The operation of unmanned military aerial vehicles serves as a prime example of a cyber-sociotechnical system, as noted by Patriarca et al. (2021). In addition to its digitalized nature, UAV operations involve various social networks, such as geographically dispersed ground control stations and transmission facilities, in addition to technical systems such as displays, devices, and control systems. In Norway, national aviation regulations and safety measures are overseen by two distinct entities: the civil aviation authority and the military aviation authority. The foundation for implementing safety-promoting regulations is based on the principle that aviation comprises two separate entities, the regulator and the operator. The regulator establishes regulations, competency requirements, and approves procedures, while the operator, that is, the airline, must comply with these regulations to obtain and maintain its operating licence. However, for Norwegian military aviation,

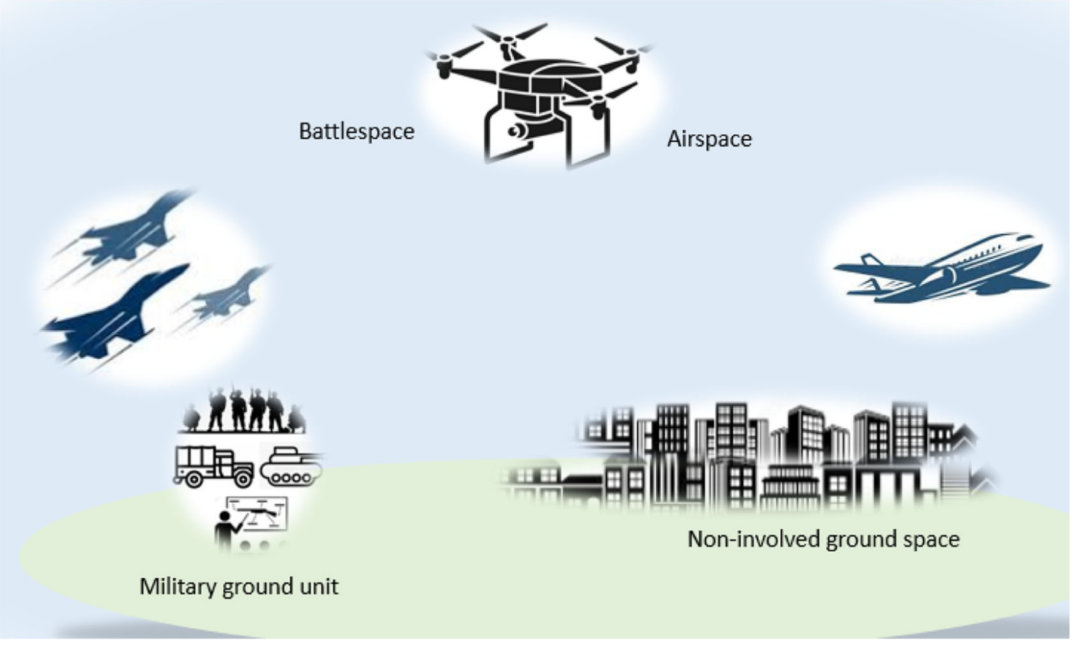

FIGURE 1 Cyber-sociotechnical system of the military unmanned aerial vehicle operation.

the roles of regulator and operator are combined under the same entity, namely the Norwegian Air Force, which oversees all military UAV operations in multidimensional spaces, including battlespace and airspace (as shown in Figure 1).

The battlespace is the primary "social system" of interaction for military drone pilots. Mini unmanned aerial systems (MUAS) provide security for the military society and respond to orders from the chain of command. Military flight operations are inherently risky and the operational environment for military UAV pilots is even more complex than in civilian settings. In addition to weather conditions, inadequate training, and technical failures, there is also the active element of the enemy that seeks to destroy the UAV. The battlespace, where the pilot confronts the enemy, is a multidimensional space with dynamic and constantly changing airspace (Wathen, 2007). Unlike a piloted aircraft, where the pilot is physically present, drone pilots rely on sensor data, cameras, and other technologies to gather information. This remote nature of control, coupled with the reliance on technology and the absence of direct sensory input, can increase cognitive load and pose challenges in interpreting complex situations. These factors can affect the pilot's ability to accurately perceive risks and make timely decisions (Hobbs & Lyall, 2016).

The safe conduct of military UAV operations in shared airspace is paramount. Military UAV operations involve the coexistence of various entities in the battlespace, including civil users, nongovernmental organizations, coalition military forces, and host nation users. In broad terms, it is categorized into three groups (Clothier et al., 2018; Wathen, 2007):

- First parties: friendly units or assets directly associated with the military UAV operations, in the air and on the ground.
- Second parties: the enemy or potential threats that seek to disrupt or deny military UAV operations in the air and/or on the ground.

- Third parties: entities that share the same airspace as the military UAV operations but are not directly associated with the operation of the UAVs. These entities can include civil users, nongovernmental organizations, coalition military forces, and host nation users.

Coordination and management of shared airspace involve considering the presence and interactions with these third parties to ensure safety and minimize conflicts. This dynamic environment requires effective coordination and management to ensure the safety and success of military UAV operations.

THEORETICAL BACKGROUND: HRO IN AN AVIATION CONTEXT

HROs: Key principles

HROs are a scientific field that emerged in the 1980s, developed by Todd LaPorte and colleagues. HROs examine how organizational structure, reporting systems, and human factors, such as individual and collective mindfulness, play a central role in supporting operational safety. In general, HROs are organizations that can carry out their operations almost without errors while operating in a complex, demanding, and uncertain operating environment. Sutcliffe (2011) emphasize that having backup systems, including human, technical, and organizational redundancy, as well as well-defined procedures for unexpected events, is essential for enhancing reliability in operational settings. They outline five characteristics of mindful HROs, including preoccupation with failures, reluctance to simplify interpretations, sensitivity to operations, commitment to resilience, and deference to expertise. The deference to expertise means that in dealing with complex and uncertain situations, the involvement of experts who have knowledge and experience of the situation is crucial for the urgent situational assessment and response of the situation. Commitment to resilience highlights the crucial role of learning from errors, making sense of emerging patterns, anticipating changes, and planning accordingly.

In addition to these elements, Frederickson and LaPorte (2002) point to internal properties of HROs, including adequate financial and human resources and a strong, shared sense of mission valence that includes a collective commitment to highly reliable operations in terms of both safety and production. The external properties of HROs, according to the same scholars, are related to the organizational hierarchy, in terms of a joint governance and decision-making system in close collaboration with stakeholder groups and the availability of credible channels to share operational information promptly. Strong and strong leadership is also considered an aspect of HROs. Accordingly, Hopkins (2021) discusses how leaders, by communicating with staff when walking around on sites, seek information and the view from the frontline operators. This type of attitude indicates leadership mindfulness, which in turn creates invaluable insights about what is happening on the front line and what the organization could do to improve operational reliability.

The principles of HRO are highly relevant to UAV operations, particularly in the military context. UAV operations require adequate resources, shared commitment to safety and mission success, and a well-functioning organizational structure. Collaborative decision-making and information-sharing processes within HROs align with the need for effective coordination and communication between stakeholders involved in UAV operations. Strong leadership and a mindful engagement with front-line operators are also crucial to enhancing operational reliability and safety. By actively seeking input from front-line operators, leaders can gain valuable insights and foster a culture of continuous learning and improvement, enhancing operational reliability and effectiveness in UAV operations.

Challenges in implementing and maintaining the key principles

Numerous scholars have identified challenges in implementing and maintaining the characteristics of HROs, as well as applying HRO principles. One study conducted by LaPorte and Consolini (1991, p. 63) highlighted a particular challenge in developing and maintaining HRO characteristics and implementing HRO principles. This challenge pertains to the decision-making process, specifically when adapting to emergent changes in operational needs. The study identified three key areas of difficulty: first, expanding cognitive and organizational capacity beyond formal calculative, programmed decision analysis, and ensuring adherence to standard operating procedures; second, remaining sensitive to operational requirements and improving performance through analysis, while also incorporating judgemental and incremental strategies in the process; and third, being fully aware of unexpected events resulting from small or large errors that could cascade into major system failures, from which organizations may not be able to recover.

Mindful organizations require the ability to make sense of their operational context, and this is particularly relevant in UAV operations. Sensemaking involves understanding the context of the operation by searching for changes, pitfalls, and signals and assessing the problem at hand while deciding how to deal with it. Pilots need to monitor their surroundings, noticing alarms, anomalies, and situations that trigger a response. This improves the ability to develop alternatives, assess conditions, and allocate resources to achieve higher priority goals (Hegde et al., 2015). The sense-making process starts with situational recognition based on existing information, knowledge, past experiences, and intuitions. The UAV operator develops a course of action by matching and evaluates it through mental simulation in the contextual condition (Klein, 2021). Detecting changes in the operating environment is related to airspace, possible exposed populations, weather conditions, technical readiness, ground topography, and battlespace. Viewed from an HRO perspective, the ability to comprehend ongoing changes and update the risk picture by expanding on 'small cues' (Weick, 1995, p. 133) is influenced by cultural attributes both individually and collectively. In this regard, pilots face several challenges when attempting to make sense of what is happening during their operations, as highlighted by Dekker (2015, p. 137):

- The dynamism and complexity of the operational environment exceed the scope of handbooks and checklists.
- Situations in which pilots may not have a well-defined diagnosis of the problem at hand.
- The side effects of pilot perceptions and assumptions when taking action.

Dekker (2015, p. 141) stresses the importance of coping resources, such as experiences, knowledge, workload management skills, and organizational support, to handle poorly structured problems, goal conflicts, and high uncertainty levels during operations. He suggests that organizations should focus on improving resilience, rather than absolute reliability, by promoting the ability to anticipate and respond to potential failures instead of solely relying on preventing them. Organizational support can be provided through technological and informational aid, policy and compliance guidance, prioritization of goals, and training programmes.

UAV operations face two significant challenges: First, the operational environment of UAVs exceeds the scope of standard handbooks and checklists. Pilots must navigate through dynamic and complex situations that may require decision-making beyond predefined procedures. Second, pilots face situations in which they may not have a clear and well-defined diagnosis of the problem at hand. This uncertainty can pose challenges in understanding and responding effectively to operational issues. UAV pilots must balance their sensitivity to operational requirements while incorporating judgemental and incremental strategies to address uncertain and evolving circumstances.

The UAV context (Section 2) is characterized by uncertainty and challenges that affect information sharing, efficient work, and response strategies. In addition, factors such as fatigue resulting from inadequate sleep, extended wakefulness, and excessive workload can decrease the required performance levels of operators and their operational sensitivity, which is the third principle of HRO. Response-ability in UAV operations depends on various factors, including timing, communication, priorities, information sharing, and coordination. Studies have shown that a poor operational environment can lead to decreased performance quality (Sugiarti, 2022). In the context of UAV operations, factors such as unsafe supervision, preconditions for unsafe actions, and specific unsafe acts, including skill-based errors, perceptual errors, and violations in routine and exceptional situations, as identified by Li (2011), remain relevant. These elements highlight the potential challenges and risks associated with decision errors and unsafe performance in UAV operations. Thus, it is crucial to address these factors to ensure the safety and effectiveness of UAV operations.

METHODOLOGY

In an interpretative paradigm (Babbie, 2010, p. 53), this explorative study has a deductive nature, since we use our theoretical foundation (Section 3) to interpret and analyze our findings. Four research phases were carried out, illustrated in the following figure (Figure 2).

In the initial phase, as outlined in the introduction section, we identified the research interest, recognized the research gap, developed research questions, and delineated the scope of the study. Once we have conducted preliminary research through literature review, focussing on pertinent topics, we initiated the data collection process (Section 4.1).

Data collection

In this study, triangulation was employed as a methodological approach to gather comprehensive and diverse data from multiple sources, allowing a deeper understanding of the research topic, including human–machine safety dynamics in unmanned aviation. We sought to specifically examine pilot tasks where the research question guided our investigation of how regulatory norms, protocols, and UAV pilot safety tasks impact safety outcomes in Norwegian military UAV operations. To understand it, we need data on what regulatory norms and protocols concern UAV operation consist of and how they reflect HRO principles.

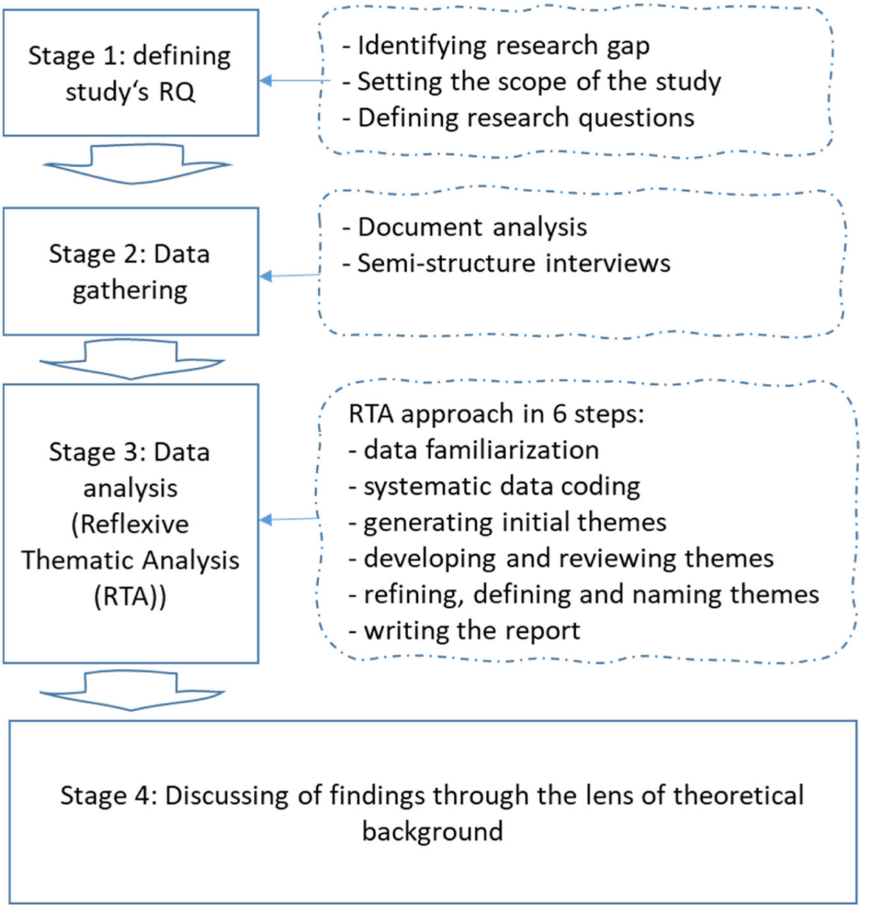

FIGURE 2 Research methodology—four phases.

Document analysis

We conducted a comprehensive analysis of various reports, operational manuals, and standard procedures developed by the Norwegian Air Force to understand the design and coordination process of UAV operations. Our research involved examining 36 incident reports from 2016 to 2021 and studying incident report templates used in manned and unmanned aviation contexts. We focus on identifying the initial design of UAV operations, the organization of the coordination process (centralized or decentralized), the defined roles and activities, and their interplay. In addition, we examine the reporting system and the requirements for incidents, near-misses, and accidents.

Semistructured interviews

After employing a purposive sampling strategy to recruit participants, we conducted five semistructured interviews in October 2021. Participants were selected based on their knowledge and experience with the phenomenon of interest, as recommended by Etikan (2016). Our participants consisted of individuals from various parts of the safety

TABLE 1 Interviewees and their background.

Role	Responsibility area	Time
Station Safety Officer (inf. 1)	Review and respond to incident reports and make recommendations, develop manual, creating new technique and tactics procedure	01.10.2021 1.45 h
Military flight operator's safety officer (inf. 2)	Review and respond to incident reports and make recommendations, conduct regular meetings with the flow safety organization, assume responsibility for training activities, and updating information	01.10.2021 1.30 h
Drone operator (Pilot) (inf. 3)	Drone operator in Norwegian Armed Forces	01.10.2021 Ca 1 h
Drone operator (Pilot) (inf. 4)	Drone operator in Norwegian Armed Forces	01.10.2021 Ca 0.8 h
Staff officer, military air authority (MAA) (inf. 5)	Governing air defense flight backup services. MAA constitutes the highest professional level with respect to: Tactical development (Aircraft), coordinated air operations, and air surveillance and combat management.	25.10.2021 Ca 1.5 h

management of the military's UAV systems, including different roles and areas of responsibility. The rationale behind involving participants with a range of internal variation was twofold: first, to gather data with rich and detailed descriptions of contextual issues and second, to uncover important common patterns across different roles. In this way, we attempted to cover different perspectives in the operational context. The following table provides a summary of nonsensitive data on our interviewees and their backgrounds (Table 1).

To create meaningful data, we followed Jacob and Furgerson (2012) suggestion to let the research guide our questions. We prepared a list of guiding questions based on the study scope and theoretical background. During the interview process, our objective was a in-depth discussion rather than a direct question-and-answer format, so we did not strictly follow our list of questions. We used an open-ended question style and linked our topics of interest to the interviewees' context, seeking additional information provided by participants. If necessary, we adjusted our questions to further investigate the issues commented on by the respondents. The following set of trigger questions was used during the interviews to explore contextual elements in military UAV operations, challenges, and opportunities.

- Can you describe your role and responsibilities within the military UAV system?
- What do you believe are the key factors that contribute to successful UAV operations and what are the main challenges and opportunities?
- How are the data collected and integrated into the aviation safety management system (SMS) for UAV operations?
- What indicators are used to ensure that UAV operators are fit to carry out operations safely?
- What factors do you think influence the sense-making process of a UAV pilot during an operation?
- How would you define the concept of “Just Culture” in the context of military aviation and how is compliance with this concept ensured?

- In your opinion, what are the similarities and differences between the regulations for manned and unmanned aircraft regarding resting hours and training activities?

The interviews were conducted through Microsoft Teams and lasted 60 to 90 min. We recorded and transcribed each interview, resulting in approximately 25,000 words of data. Before the interviews, we obtained the consent of the participants and assured them that their information would remain confidential and anonymous.

Data analysis

Our data analysis relies on coding, a process of breaking down transcriptions into smaller pieces of data, "capturing meaning relevant to the research question" (Braun & Clarke, 2021, p. 52). We began by carefully reading our transcriptions of all the data material and wrote memos. In our reflections, we sought to identify the patterns in our transcriptions and to make sense of them, through the lens of the study's research question. Then, we highlighted phrases, repeated topics, and assigned initial codes to articulate their content. The codes included uncertainty, workload, human error, improvisation, communication, tacit knowledge, resources, training activities, etc., and were iteratively refined and restricted. The following table presents examples of excerpts from interviews and derived codes (Table 2).

TABLE 2 Examples of excerpts from interviews and derived codes.

Excerpt from interviews	Initial codes
And as a culture [the way we work here], it is the pilot who is in command. It is the pilot who decides whether he is fit to fly. (Inf. 2)	Decision making structure
In my opinion, it can be difficult "to say" when it comes to being "fit to fly." You don't want to slow down your own unity and operations. (Inf. 3)	"Unspoken" expectation
I believe that the checklists & procedures that we have, before and during the flight, cover all the safety measures that are necessary. When an incident occurs, it is probably a human error rather than something related to the procedures that you follow (Inf. 5)	Human error
I want to point out that there will be challenges for a long time in relation to flight time limitation and rest requirements for UAV pilots. (Inf. 5)	Rest requirements
[...] Things that are discovered along the way, while the mission is carried out according to plan, are not reported.	Reporting
It is hard to check that the pilots actually record and report everything because we cannot be at all places at all times. (Inf. 5)	Reporting requirement
So, we are getting some reports there, it is starting to "go well." But it has been slow because they don't yet have that 'organizing system' in place. (Inf. 2)	Reporting system
After all, we are small units and will operate vehicles, plan missions, and actually perform the flight. So even if there had been a [rest time] requirement, I don't think it would have been feasible. (Inf. 3)	Workload
A lot of the risk you might face during operations is about risk to mission that you might not be able to complete your assignment. And it is clear that rest time will affect that. Also, for drone operators.	Rest time requirements

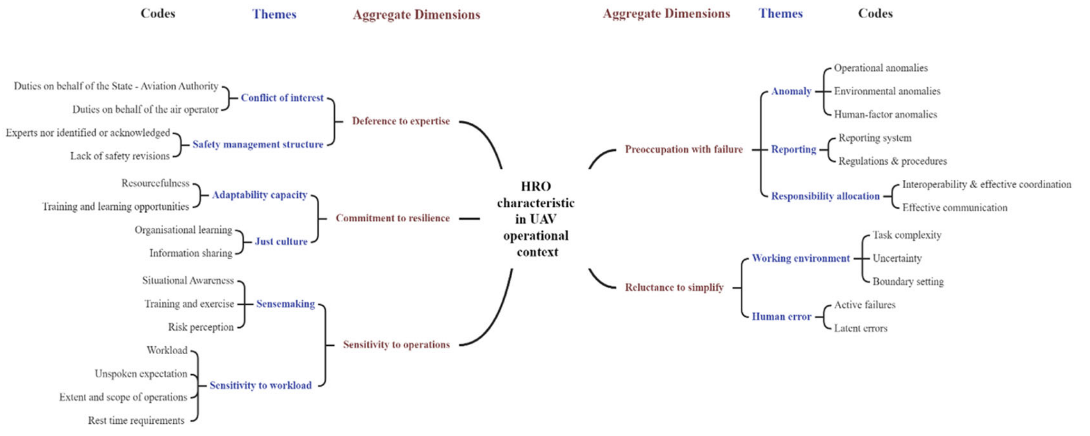

FIGURE 3 The Structure of the high-reliability organization characteristic in the operational context, using thematic analysis.

Once the 27 initial codes were established, we proceeded to categorize them into 11 distinct themes. These codes served as a valuable analytical tool, briefly encapsulating notes from the documents studied and observations made during the interview process, including participant comments, which were then assigned corresponding labels (codes). After developing the set of themes, they were categorized at an aggregated level, using five principles of HRO as the main dimensions (see Figure 3). This sorting process was iterative, as we found that some themes were relevant to two HRO principles, such as the theme "responsibility allocation." The placement of themes under the aggregated level was determined by an analytical process considering the essence and relevance of each theme, where we perceived it to naturally belong. This part was somewhat subjectively assessed, as it required careful consideration of the context and relevance of each comment to ensure appropriate categorization.

FINDINGS

Qualitative analyzes conducted in the UAV domain revealed significant findings on the enhancement of safe and reliable operations. These findings are further categorized into four key areas, using the main principles.

Preoccupation with failure

In military UAV operations, adopting a learning-orientated mindset with operational transparency and active learning from incidents and near misses is crucial. Through a systematic analysis of these events, potential risks and areas for improvement can be identified. The interviews highlighted the vital role of reporting in the promotion of a learning culture. An interviewee emphasized:

> [...] I sincerely think that everyone understands the importance of reporting, both for their personal learning and for the Air Force's progression. (Inf. 2)

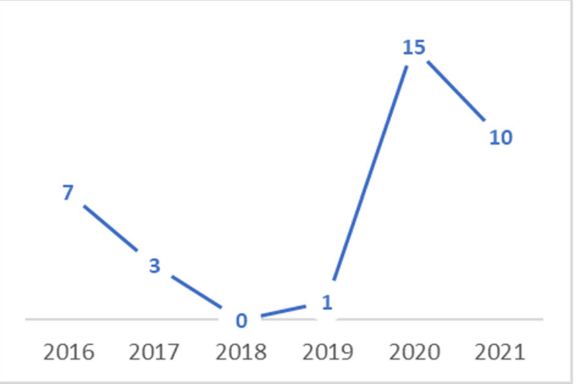

FIGURE 4 Number of accidents/incidents reported 2016–2021.

Reporting is vital, but effectively utilizing the outcomes to enhance reliability is equally crucial. Analyzing 36 reports from 2016 to 2021 involving four types of unmanned aircraft revealed considerable fluctuations in reported incidents (see Figure 4). However, our study had limitations due to the classified nature of assignment and flight hour details. These protected data, governed by the Security Act, were absent from incident reports, possibly leading to the omission of vital contexts in our analysis.

Incidents in UAV military operations have been reported extensively, including near-accidents, accidents, and incidents leading to material or personnel injuries. Of the 36 incident reports we received, 16 were closed at the time of this study, covering incidents between 2016 and 2020. The remaining 20, pertaining to incidents from 2019 to 2021, are still under investigation. The average investigation time for closed reports was approximately 962 days, with a range of 64–1722 days. The Air Force provides a template to facilitate this reporting process. However, our findings suggest that there is no universal reporting approach across all entities involved in UAV operations. One respondent remarked:

> […] It is probably different from department to department. But for us, as soon as we see that there is someone who can learn from it or that there will be harm, it can be useful for other departments, and we choose to report. (Inf. 3)

Despite this, there is uncertainty about the criteria for reporting incidents in military drone operations. For example:

> […] In many cases, we have experienced that the flying machine has descended to the flight altitude, returned, and crashed into a mountain or something higher than the altitude set. In these cases, something physical has happened, yet things such as where the assignment is carried out according to plan, it is not an incident that is reported. (Inf. 1)

Our findings suggest that the decision on what incidents should be reported is based on individual interpretation of procedures. For example, two respondents admitted to falling asleep during assignments while in charge of operations. They chose not to report it as it did not lead to any incident. One respondent stated:

> […] f you encounter an error during a mission and it resolves along the way, then there is no need to report it. (Inf. 4)

The lack of interoperability and effective coordination are identified as incident causes. In one case, an investigation report highlighted the issue when an air ambulance flew in an area where the UAV was authorized to fly. The report stated:

> [...] XX is the new operator of the UAV in these areas, and other actors such as the YY are not used to the Armed Forces using such systems in these areas. XX must establish contact with other actors who use the lower airspace for their operations and inform about the Armed Forces' activity. Furthermore, XX must coordinate with other actors' operational staff to continuously coordinate activity. (Report #15, 2020)

Clear communication ensures that team members are aware of potential risks and vulnerabilities, crucial for forecasting and managing incidents. Assigning responsibilities provides clarity in roles and functions, enabling accountability to identify and addressing failures. These factors collectively embody the principle of preoccupation with failure in the HRO, where failures are anticipated, documented, and mitigated. The importance of effective communication is highlighted in various incident reports. For instance, one report specifically states:

> [...] UAV operators should coordinate directly with other flying departments that will operate within the relevant airspace and seek for the longest time to avoid an "intermediate," to avoid missing, imprecise, or misunderstood information. Such direct communication is carried out normally but was not used on this occasion when XX had a coordination role for several actors. (Report #16, 2020)

Another recurring theme in our data is related to operational procedures and pushing boundaries. Several statements indicate a tendency to prioritize mission completion over strict adherence to regulations. For example:

> [...] If one can distinguish in practise between war and peace operations, commanders strive to carry out their tasks regardless. The principle is followed, "train as you fight." To create robust soldiers with years of experience in various combat operations, one often has to push some boundaries. (Inf. 2)

Reluctance to simplify

An aspect related to the second principle of HROs, the reluctance to simplicity, is the recognition of the inherent complexity and uncertainty within UAV operations. Our findings highlighted the challenges posed by the unpredictable and dynamic nature of the UAV operating environment. Informants emphasized the need for thorough understanding and management of this complexity to ensure safe and effective operations. As one informant expressed:

> [...] Military aviation is not risk-free and should not be. But we are going to regulate it. By regulation, our objective is to manage risk at an acceptable level. A large part of the risk that we deal with is related to the loss of human life, in peacetime, also own, as well as loss of expensive material. (Inf. 5)

The focal point of risk management in UAV operations is the potential damage to third parties. However, when the potential risks are not identified and actively managed by the Air Defense due to simplification, there is a risk of adverse outcomes. Cost may serve as an indicator of simplification in some cases. As one informant expressed:

> [...] You could say that the primary motivation for having rest time regulations is to prevent the loss of people aboard aircraft and to avoid losing highly expensive equipment. Unmanned military aviation holds a unique position here because there are no individuals sitting inside the aircraft, and until now, the equipment has often been relatively less costly compared to a fighter jet or maritime patrol aircraft. (Inf. 5)

The principle of reluctance to simplify is closely linked to the process of incident reporting and learning. Investigation reports should embrace complexity, avoiding oversimplification that might mask critical details. This depth enables a more nuanced understanding of incidents, fostering richer learning and more robust preventive measures. Analysis showed that 27 incidents occurred during daylight hours, five in darkness, and 4 were unspecified. Among the 16 closed reports, the identified causes were distributed as follows: 6% unknown; 44% due to technical factors; 19% due to human factors; 6% organizational factors and 25% due to external environmental factors. However, these data should be interpreted with caution given the classified nature of some pertinent information, as previously noted. In addition to human error and technical malfunctions, atmospheric conditions, specifically icing—were identified as potential causes of the reported incidents. The complexities involved in UAV operations, particularly nonquantifiable human factors like fatigue, are significant. One of our informants expressed this complexity:

> [...] I have briefly lost focus on the control panel on the way back from a mission when tired and weary. (Inf. 3)

Momentarily losing focus, as mentioned in the citation, underscores another crucial aspect: the impact of pilot fatigue. This aligns with the principle of reluctance to simplify, urging a comprehensive exploration of all contributing factors to operational failures, including those that may not be immediately obvious or easily measured.

Sensitivity to operations

Two main themes emerged from the data, sensemaking and sensitivity to workload. Situational awareness is a key component of the sense-making process, enabling pilots to quickly identify and address anomalies, and potential or actual errors. Turbulent environments and fluctuating circumstances, underscored in investigation reports, act as risk factors that affect the pilot's ability to assess situations and determine appropriate actions. As illustrated in Report #26, 2020:

> [...] The correct course of action in this case would have been autolanded, but the incident happened so quickly that the operators were unable to identify the condition and take the correct action.

Pilot risk perception, as shared by our respondents, can influence their sensitivity to operations. For example, they pointed out that possible in-air events, such as a collision between a military UAV and a military or civilian helicopter, do not pose significant danger to the military drone pilot.

> [...] It is not that dangerous for us if they collide with us, because then there are no lives lost. At the same time, we should also be fit enough to fly in terms of being able to operate in the same airspace to avoid the major incidents that could possibly happen (Inf. 4).

Sensitivity to workload surfaced as a theme in our data. When examining rest time in the context of unmanned aviation, the following legislation is applicable to military manned aviation.

> [...] The air department chief shall ensure that crew members are not required to work such long hours or so much flight time that it compromises the safety of the air service. The minimum rest time before a work session containing flight should be 10 h and allow for 8 h of continuous sleep. (BFL-100-1 [G], 2017)

Although our informants emphasized the importance of training exercises and their effect on sharpening situational assessment, the demand they place on UAV pilots should not be overlooked. One drone pilot recounted his experience with extended exercises:

> [...] There is an operational requirement if you want to perform in exercises. The exercises usually last three days, and there is no time allocated for rest. Because you are on work hours and you have to push through regardless. (Inf. 4)

A notable pattern in our data is the impact of workload and exhaustion on the operational capabilities odrone pilots:

> [...] With little sleep, you slow in perception. Things are slowing down. You can forget to set a height to stay at or one within the box restrictions you get. (Inf. 1)

> [...] The reaction ability decreases significantly with fatigue. Working continuously for 10 h straight affects not only the ability to fly safely but also the quality of work and the ability to provide precise reports when fatigue sets in. (Inf. 2)

Recognizing and effectively managing workload demands is essential to maintain operational effectiveness and safety. By being sensitive to workload considerations, UAV organizations can ensure that individuals are not overwhelmed or fatigued, thus promoting a balanced and manageable work environment.

> Response capacity decreases significantly when one starts to fatigue. It is mainly about the need for rest that affects us, especially me, not so much about sleep. Continuous workload, having to keep going for 10 h straight, hinders our productivity. Although it may not necessarily affect our ability to fly safely, it can impact our accuracy in reporting when we start to get tired. (Inf. 3)

During our investigation of rest time in the context of unmanned aviation, we came across the following legislation on rest time that pertains to military "manned aviation":

> The air department chief shall ensure that crew members are not required to work so long hours or so much flight that it compromises the safety of the air service. The minimum rest time before a work session containing flight should be 10 h and allow 8 h of continuous sleep. (BFL 100-1G)

The legislation on rest time for military manned aviation emphasizes the importance of setting boundaries for crew safety. However, in UAV operations, our investigation revealed discrepancies in adhering to these limits. One pilot highlighted the challenges faced during assignments, where the role of the UAV operator goes beyond flying and includes communication and information delivery. The pilot expressed the need for recovery time, stating:

> For the actual assignment, the UAV operator is not necessarily just flying and having it in the air. You must deliver something in both communication and you will deliver something by text. And personally, I think if we have 3 longer missions and start approaching 7 to 8 h continuously, you are quite boiled and you need a couple of hours to recover before you can drive again. (Inf. 4)

Promoting awareness and understanding of unspoken expectations within the operational environment, particularly regarding the need for rest and self-care, is crucial to sensitivity to workload. Encouraging individuals, especially young and promising personnel, to assert their need for sleep or rest without fear of negatively impacting the entire unit, helps reduce the threshold for communication, and fosters a supportive and understanding culture.

> So now it is up to the individual to say, "Hey, I cannot continue flying anymore." It is a bit sketchy, in my opinion. It is challenging for someone young and promising to speak up and say, "Now I need sleep or rest," because it would halt the entire unit. I think the threshold is quite high for some people to speak up. (inf. 1)

The aspect of boundary setting, which emerged as a significant finding from our data, is indeed a vital component of the principle of sensitivity to operations. It emphasizes the importance of establishing clear boundaries within the operational environment, allowing individuals to assert their needs for rest, self-care, and overall well-being.

Commitment to resilience

The commitment to resilience, a key principle of HROs, stresses the implementation of redundancy measures to enhance operational reliability and mitigate failures. This includes using backup systems for UAVs. However, our findings highlight challenges due to the lack of an appropriate information system. As one informant stated:

> [...] The absence of information from the UAV overwatch makes the battalion commander defensive, leading to pushing the limits to restore

> the drone systems to obtain required information. This creates a vicious circle that continues. (Inf.1)

Ensuring the availability of robust backup systems enables organizations to maintain operational continuity and respond effectively to unexpected events or failures. Challenges related to organizational factors, such as resource allocation, decision-making hierarchy, and task organization, were identified during the interview process. Among these challenges, the informants highlighted feeling pressured to conduct flights that might deviate from regulations due to high management pressure. Addressing this issue poses a significant difficulty, as one informant expressed.

> [...] I have felt pressured to carry out flights that may be outside the regulations due to high management pressure. And I can be honest about that, it is not easy to sit as a sergeant alongside a lieutenant colonel and say that the UAV capacity is being deployed despite not having had sufficient sleep for 6 or 8 h, for example. (Inf. 1)

The cause of exhaustion among UAV pilots was identified as the need to operate for extended periods without adequate rest and manage a heavy workload, placing significant demands on military drone pilots. Commitment to resilience involves fostering the so-called "just culture," focussing on learning from previous mistakes and using that knowledge to improve safety practises rather than assigning blame or punishment for errors. One of our informant's highlighted the efforts made to maintain a strong reporting culture where individuals are encouraged to report safety incidents, thereby fostering continuous learning and improvement in safety measures within the organization.

> [...] We talk extensively about culture. People are encouraged to report. That is why we aim to anonymise as much as possible. We can see in some units that there is a high level of reporting, but currently, we do not have the means to get an overview and see which pilots have access and how many are actually reporting. (Inf. 5)

This citation underscores the ongoing focus on the concept of just culture, emphasizing the importance of encouraging open reporting within the organization. On a related note, another informant points to some inconsistencies in the required compliance versus what the crew understands about it. This is explained by the informant as follows:

> We have received a Defense Investigation Act, which provides some basis and outlines the obligations one has. It states that one is obligated to disclose everything, even if it may incriminate oneself. We do not have such a basis in other investigations. And that means that one could be subject to prosecution if they say something in the investigation. [...] There is a risk that people may become reluctant to share information as a result. (Inf. 5)

The citation highlights the hesitancy to share information due to fear of prosecution, hindering the learning process. By promoting open communication, organizations can empower individuals to raise concerns, including fatigue issues.

However, the study finds challenges in speaking up about tiredness or exhaustion, as pilots fear slowing down their unit or team:

> [...] And as a culture, we have the principle of 'pilot in command.' It is the pilot who decides whether they are fit to fly. If one says no, there is room for that. [At the same time], it is my claim that it can be difficult to speak out in such situations. I don't think one wants to slow down their own unit. (Inf. 1)

The informant highlighted the importance of information sharing to foster resilience within UAV operations. He pointed out that the lack of timely and comprehensive information could lead the battalion commander to adopt a defensive approach, prompting efforts to reinstate drone systems for gathering vital data.

> [...] Then the battalion commander becomes defensive due to the lack of information previously provided, and this pushes the boundaries to get the drone systems back in the air to gather that information. It becomes a vicious cycle that continues. [...] it is not easy to be a sergeant, and then there is a lieutenant colonel saying that the UAS capacity needs to be in the air, and you have to say no because we have not slept for 6 or 8 h, for example. It is extremely challenging. (Inf. 1)

Our findings highlight the importance of resourcefulness in accordance with the commitment to the resilience principle. An informant's statement illustrates the challenge of managing limited capacity to meet the varying demand for UAV operations.

> [...] With a small number of operators and a high demand for UAV capabilities, this provision becomes an exercise. [...] A commander is always responsible for his own readiness and ability to fly. In 9 out of 10 cases, a department manager will continue the operation to safeguard the integrity of his department. (Inf. 1)

An informant highlighted the significance of adaptive capacity in the context of UAV operations by stating the following.

> [...] We had a small unit that was supposed to support a battalion. If we had divided it into two teams with equipment and sensor materials, there would have been less overuse, and we could have provided continuous support with two teams (one off-line and one team on). (Inf. 3)

When we asked our informant what you mean by overuse, he explained:

> [...] trying to maximize sensor time and get the most out of something that has very limited capacity. It was a bit of an exaggeration to call it overuse, but it emphasized the idea of pushing for maximum sensor utilization. (Inf. 3)

These statements highlight the need for adaptive capacity in resource utilization and operational reliability. The study emphasizes the lack of a dedicated role for managing risks during exercises or similar situations in UAV operations.

> [...] We don't have a dedicated person for this; we don't have enough personnel to assign someone specifically to it. We don't even have a position for it; we borrow a position from the Army when we need it. (Inf. 1)

This statement underscores the importance of establishing a permanent and specialized role to ensure safety and resilience in UAV operations during exercises and other scenarios. The absence of a dedicated position for this critical responsibility raises concerns about the consistency and effectiveness of risk mitigation efforts.

Deference to expertise

Recognizing and entrusting decision-making to individuals with relevant expertise is crucial to effective problem-solving. Two notable themes that emerged from the data regarding the deference to expertise were the structure of safety management and conflict of interest. The safety management structure, centralized or decentralized, was identified as a factor that contributes to the uncertainties in UAV operations.

> [...] We have two lines in military aviation: the mission line and the authorization line. The mission line is where the assignment comes from, while the authorization line should be separate and provide an outsider's view of the assignment's feasibility, considering factors such as personnel rest and safety. (Inf. 4)

The increasing use of UAVs in military operations demands a holistic safety approach. The deference to expertise stresses trusting the knowledge of key stakeholders. Integrating operational aspects is vital, clarifying roles within the Norwegian Air Force and the Air Force chief's responsibility. However, uncertainty remains:

> [...] Things have progressed rapidly, and not everyone has yet fully understood their role [...]. The operational aspects are not involved in this, so, for now, it is only about airworthiness, focussing solely on the technical aspect. (Inf. 5)

In UAV operations, collaboration and understanding of roles are vital for a robust safety framework. However, the principle of deference to expertise can be challenging due to the system's complexity. The informant, a staff officer in the military air authority (MAA), faces a dual responsibility in acknowledging expertise: a professional versus supervisory role.

> [...] We (MAA) can only observe and provide advice, since we cannot report deviations. We have professional responsibility only, not supervisory responsibility. (Inf. 5)

The Norwegian Military Aviation Authority (MAA) is responsible for airworthiness decisions based on specialized knowledge. The deference to expertise applies as the MAA focusses on technical aspects, while the Air Force chief handles operational risks during flights. This ensures comprehensive and balanced aviation safety standards in military operations. One of our informants stated that:

> [...] We (MAA) do not have the same role as, for example, the Safety Inspector in the Navy, who has the authority to say "I am putting this boat to dock." We cannot say that. However, for airworthiness reasons, the Norwegian Military Aviation Authority can say "This aircraft should not fly due to this and that." But then the operator, the Norwegian Air Force, with the Air Force chief at the forefront, can step in and say "I will take this risk." (Inf. 5)

Our informant pointed to the issue of conflict of interest with respect to the regulatory authority, the Air Force Operations Inspectorate (AOI), and raised concerns about impartiality and objectivity in enforcing regulations, as the regulatory body may have a vested interest in the outcomes.

> [...] Here, the Air Force Operations Inspectorate) comes into the picture. They are the regulatory authority, while they also hold the regulations themselves. It is a bit of a fox in the henhouse situation. (Inf. 5)

> [...] But it is not us who want to regulate [rest time]; it is the operational or mission giver who regulates it. So, we regulate what concerns flight safety versus what concerns the impact of force production. (Inf. 1)

Our informant addressed an operational environment overshadowed by a struggle. He mentioned that the military aviation authority has been delegated from the Chief of Defense to the Air Force chief and from there to the Norwegian Defense Materiel Agency (NDMA) for technical matters. As a result, the Air Force chief can take the operational risk. This situation generates a dilemma, as our informant put it:

> [.] NDMA can say: the aircraft is not airworthy because the radar is not working, but then the Norwegian Air Force can respond, "We will not use the radar, so we can still fly." (Inf. 5)

Deference to expertise also requires a collaboration between the operators, who possess specialized knowledge and experience in UAV operations, and the regulatory authority:

> When you are out conducting field inspections, is there something you report to the regulatory authority, a report that goes from you to them—there is no system for that; usually, it is a verbal or written report that we produce and send to them. (Inf. 1)

Citation refers to a wide range of activities and interactions related to aviation operations. Covers aspects such as obtaining permission to fly, reporting incidents, and participating in discussions and feedback processes concerning the development and revisions of regulations and handbooks. The context suggests that it pertains to the various interactions and collaborations between the regulatory authorities and the aviation organization, where both parties work together to ensure compliance, safety, and effective operations in the aviation industry. Our informant pointed to the two lines of communication in military aviation: the mission line and the authorization line.

> [...] You can say that we have two lines that go down to those who are going to carry out missions in military aviation. One is the mission line, and

> it is through this line that the mission arrives. But for all military aviation, we also have something called the authorization line. (Inf. 1)

The authorization line in this citation represents a clear example of deferring to the expertise of personnel who are responsible for granting permission for military aviation missions. These individuals are likely to have in-depth knowledge of the operational requirements, safety protocols, and technical aspects necessary to assess the feasibility and safety of each mission.

DISCUSSION OF RESULTS AND IMPLICATIONS

Having outlined the primary results of the research in the preceding section, we identified key themes associated with operational procedures, decision-making hierarchy, demanding workloads, limited resources, and goal conflicts. Fatigue has emerged as a significant impediment within the UAV military operational context. In this section, we discuss these findings through the lens of HRO principles to gain deeper insight into the identified challenges and potential avenues for improvement.

In safety-critical environments, such as military UAV operations, the principle of "preoccupation with failure" is founded on the belief that learning from mistakes and close calls and analyzing each event can lead to system-wide changes aimed at mitigating the occurrence of similar errors (Yip & Farmer, 2015). Our findings indicate the importance of a learning-orientated mindset, promoting operational transparency and active learning from incidents and near misses. Reporting is crucial in cultivating a learning culture, as it allows for valuable lessons to be drawn from these events and provides insights to enhance future operations (LaPorte & Consolini, 1991; Sawyerr & Harrison, 2020). However, despite the importance of reporting, effectively utilizing the outcomes of incident reports remains a challenge for Norwegian military UAV operations. Based on our analysis of incident reports covering 2016–2021, we observed fluctuations in the number of reported incidents in military UAV operations. In addition, the use of diverse reporting approaches by different entities involved in UAV operations creates uncertainty about which incidents should be reported and what specific details should be included in the reports. A crucial factor influencing reporting is the interpretation of procedures, since individual discretion shapes the criteria for reporting incidents. Subjectivity can lead to variations in reporting decisions, which impact the overall quality and consistency of incident data. This highlights the need for clearer guidelines and consensus on reporting criteria to ensure a more consistent reporting culture in UAV operations. To address these challenges and promote a more effective learning culture, we propose:

Proposition 1. Standardizing reporting practices and providing clear guidelines fosters a more comprehensive understanding of incidents and near misses, enhancing operational reliability and safety for UAV operators. Through this approach, consistent reporting enables the identification of patterns, trends, and systemic issues, empowering UAV operators to proactively respond to potential hazards. This heightened awareness, being preoccupied with failure, fosters a safety culture that is highly sensitive to early warning signs, ultimately reducing the likelihood and impact of critical failures.

The principle of "reluctance to simplify" in the UAV domain emphasizes the importance of understanding the complex dynamics involved in operational processes rather than oversimplifying them. The operation can be viewed as a complex adaptive system, comprising UAVs, operators, air traffic control, ground crews, weather conditions, and other airspace users. Each element within this system interacts and adapts to the dynamic environment, leading to emergent behaviors and patterns (Colchester, 2016, p. 38). Embracing this principle means that UAV operators and authorities proactively investigate incidents and near-misses, aiming to identify both active and latent errors (Reason, 2000). The application of the principle "reluctance to simplify" faces challenges as organizations prioritize strict adherence to rules, potentially leading to "cutting corners" and negative outcomes (Reason, 1990). Corner cutting refers to shortcut behaviors that consume less time compared to usual or standard procedures (Beck et al., 2017). Through our analysis (Section 4), we identified instances where Air Force operators and military aviation authorities overlooked minor deviations in procedures and attributed accidents to external factors. Several incidents were noted involving civilian helicopters and air traffic services entering areas with military unmanned aerial systems. Allocating resources to identify root causes and contributing factors could have led to the development of preventive measures. However, some reports concluded with less relevant factors, such as Armed Forces' administrative decisions and discontinuation of unmanned aircraft systems. Additionally, the inexplicable closure of incident reports on the same day of reporting raised questions about workload or time constraints during investigations.

This simplification approach ignores the potential systemic roots of small errors, regardless of the type of UAV used. A concerning tendency to shift blame to other parties was observed, contradicting the principles of a HRO emphasizing open reporting, just accountability, and continuous learning (Dekker, 2012, p. 11). Consequently, understanding and learning from incidents become challenging for aviation safety personnel within the Armed Forces. Scrutinizing the underlying assumptions in the operational environment that contribute to incidents is crucial, recognizing the significance of coupled performance variability (Hollnagel, 2014) and attributing responsibility appropriately.

Proposition 2. Embracing the principle of "reluctance to simplify" in UAV operations by proactively investigating incidents and near misses to identify both active and latent errors, including momentary lapses due to UAV pilot fatigue and coordination breakdowns, enhances the potential for more effective risk management and improved operational excellence for the Norwegian Armed Forces.

The Armed Forces Safety Rules and Regulations (UD 2-1 [U], 2022) designate risk acceptance and risk decisions as a leadership responsibility (p. 33). This mandate also describes operational risk management (ORM) as the preferred methodology for Air Force departments at all levels and across all security classifications. Two crucial factors that influence the acceptability of risks are the potential loss of human life aboard military aircraft and the loss of valuable material. However, we observed less highlighted explicit references to third parties, such as the risk of colliding with other aircraft in airspace, as a risk factor for military unmanned aircraft when reviewing incident reports, standard procedures, and other relevant documents. Furthermore, we explore the regulation of working hours, flight time, and rest for military UAV pilots compared to manned aviation. At the time of this research, there are no specific regulations for UAV pilots regarding rest and working hours, unlike manned aviation. The definition of a crew member crucially affects the application of these regulations. UAV operators do not fall under the category of crew members as per armed forces regulations (BFL 100-1[G], p. 11).

Since military drone pilots are not subject to rest time provisions specified in BFL 100-1(G), organizations emphasizing operational sensitivity must accurately perceive situational realities and adapt for risk management (Long, 2019, p. 15). Compliance should be viewed as nuanced, requiring a deep understanding and strategies to align behaviors with rules' expectations. Regulators should focus on effective compliance, ensuring service providers achieve the intent of the rule as an effective control for risk situations. Despite the expected outcomes of adversity, stress, and reduced functionality associated with uncertainties (Steen & Pollock, 2022), standard operating manuals for UAVs do not explicitly consider these factors. Interviews (Section 4) and previous research (see, e.g., Østby et al., 2016) reveal that military drone pilots face challenges related to workload in their daily lives, leading to exhaustion and subsequent unsafe behaviors. Theoretical research suggests that fatigue weakens pilot sense-making abilities in three dimensions: perceptual (i.e., how pilots perceive the situation), cognitive, and physiological. As a result, individuals may be inclined to accept the first available explanation of a situation (Boin & Renaud, 2013, p. 42).

Just as HROs in complex environments, like hospitals, rely on coordinated multiteam systems for patient safety (Baker et al., 2006), military UAV operators must prioritize effective coordination and collaboration among pilots, ground crews, air traffic control, and other key stakeholders. Acknowledging pilot risk perception about colliding is crucial, but understanding the broader implications of such incidents on mission success, systemic integrity, and public perception is equally important. Integrating these aspects will ensure that risk management in UAV operations goes beyond physical danger to encompass operational readiness and comprehensive risk assessment. Thus, the principle of sensitivity to operations and continuous learning will drive military UAV operators toward becoming highly reliable, safe, and efficient.

Proposition 3. By adopting proactive and real-time identification and prevention of defects and harm, UAV operators can maintain vigilance in detecting errors and taking corrective action before they impact the mission. Prioritizing proactive approaches over reactive ones will foster a reliable culture, incorporating continuous feedback loops for data and insights that trigger action, learning, and improved outcomes.

In military UAV operations, the commitment to resilience emphasizes the importance of proactively responding and adapting to unexpected events and challenges. By learning from past incidents, fostering a just culture, and promoting resourcefulness, military UAV operators can improve their capacity to withstand and recover from failures. Our findings indicate a lack of adequate resources in military UAV operations (Section 5.4), factors such as pressure to make decisions outside of military aviation regulations, and heavy workload as significant risk contributors. In particular, the safety barrier related to fatigue verification, designed to ensure pilots' fitness for flight, may not always function as intended due to the complexity of authorization processes. This highlights a critical safety barrier in the Air Force's safety management system, particularly concerning the authorization for flight irrespective of the mission line. Additionally, while the majority of military drone pilots are affiliated with operational units outside the Air Force, the latter is overseen by the military supervisory authority, raising the importance of inter-service collaboration (Haun, 2020). Encouraging a collaborative culture among different operational units within the Armed Forces can optimize resource allocation and utilization. In the military UAV context, strict adherence to "fit to fly" status (Johansson & Melin, 2018) for drone pilots is crucial. Rigorous and regular evaluations can ensure pilots' physical and mental readiness, reducing the risk of fatigue-induced errors (Bendak

& Rashid, 2020). Open communication channels facilitate shared decision-making, leading to more informed risk assessments and effective resource management (Mosier et al., 2018). This ultimately improves the resilience of UAV operations.

Proposition 4. Prioritizing strict adherence to "fit for flight" status (physically and mentally) checks for drone pilots and encouraging interservice collaboration will optimize resource allocation and utilization, further enhancing the overall resilience of military UAV operations.

The current organizational structure of Norwegian military aviation is a critical factor that directly impacts the management of safety risks associated with unmanned military aviation. Adopting a policy of "deference to expertise" creates room for vulnerabilities arising from differences in capability (Malish & Sargent, 2019). In the face of a novel threat, HROs implement mechanisms to pinpoint the people with the most relevant expertise to handle the situation. Subsequently, they entrust decision-making authority to these qualified individuals or groups, without relying on organizational hierarchy or assuming that rank automatically equates to the most effective problem-solving abilities (Chassin & Loeb, 2013).

When the military supervisory authority issues orders for remediation or the establishment of new safety barriers, they are directed to the head of the operating unit responsible for the military airline or, in this case, the Air Force. The respondent's comment on the situation, where the supervisory authority and operator in the Air Force are led by the same person and funded from the same budget, implies that there is a conflict of interest in the current setup and it might not be ideal for ensuring effective safety management in military unmanned aviation. The lack of an independent control and instructional authority role, as established in the Civil Aviation Act, further highlights the need for a more independent and objective supervisory authority in military aviation. Deference to expertise means that decision-making authority and responsibility are given to those with the most relevant knowledge and experience. In the case of regulating rest periods for UAV operators, experts in the field can assess the impact of different rest period scenarios on safety and operational effectiveness. They can provide valuable information on how rest periods can be effectively managed to maintain operational readiness and ensure safety without compromising the well-being and performance of UAV operators.

Drone pilots are responsible for critical tasks during flight, as traditional pilots. However, when they are on the ground, they may also have additional technical responsibilities related to the maintenance and preparation of the UAVs. In this situation, experts in the field, such as experienced UAV operators, flight crew members, and technical personnel, are better equipped to understand the nuances and intricacies of the operational and technical aspects involved. They have first-hand experience and knowledge of the specific challenges and requirements faced by UAV operators during both flight and ground activities.

Proposition 5. The principle of 'deference to expertise' offers a potential path to mitigate resource constraints and the pressure observed in Norwegian military. By entrusting decision-making authority to individuals with relevant expertise, regardless of organizational hierarchy, the safety and operational efficiency of UAV operations can be improved. This strategic elevation of authority can help mitigate fatigue-induced risks and manage the weight of workload demands, thus enhancing overall safety and operational effectiveness.

CONCLUSION

As UAV use of UAVs continues to evolve, the principles offer adaptable and relevant tools for navigating the dynamic and challenging environment of military UAV operations. By embracing these principles and integrating them into operational practises, the Norwegian Armed Forces can strengthen their position as leaders in safety and operational excellence in the UAV domain. However, there are potential blind spots in the current regulation and oversight of military drone pilots, which could hinder situational awareness and effective risk management. The combination of regulator and operator roles raises concerns about safety management from a national perspective, indicating the need for a more independent and organized supervisory authority.

Significant work pressure experienced by military drone pilots, leading to fatigue, poses risks to timely and accurate information delivery to ground units. More research is essential to determine workload thresholds and their impact on information quality, ensuring the strength and effectiveness of supported ground forces. Further exploration into the application of "just culture" within the Armed Forces is warranted. Strengthening the commitment to "just culture" can be achieved by establishing clear reporting requirements for incidents, undesirable events, and system failures among front-line operators. The resulting knowledge can be used to assess the extent to which risks are effectively managed. Furthermore, it is recommended to examine procedures related to incident reporting and develop effective electronic reporting and information sharing mechanisms to promote learning.

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