

## *Retraction*

# **Retracted: Construction and Research of Safety Management System for Machine Patrol Operation**

### **Mathematical Problems in Engineering**

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

### **References**

- [1] Y. Zhang, J. C. Guo, and J. D. Liao, "Construction and Research of Safety Management System for Machine Patrol Operation," *Mathematical Problems in Engineering*, vol. 2021, Article ID 4529169, 7 pages, 2021.

## Research Article

# Construction and Research of Safety Management System for Machine Patrol Operation

Ying Zhang , Jin Chao Guo, and Jian Dong Liao 

*Aircraft Patrol Management Center of Guangdong Power Grid Co., Ltd, No. 40, Dong Feng West Road, Liwan, Guangzhou, China*

Correspondence should be addressed to Ying Zhang; 13922252457@139.com

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Aiming at the flight safety problems existing in UAV power patrol inspection, this study proposes a UAV patrol inspection safety management system (SMS) scheme, which takes the safety target level specified in soar as the target management, based on safety management, modern control theory, risk management, and UAV operation regulations, combined with the actual needs of machine patrol inspection of China Southern Power Grid and the requirements of local government. The UAV SMS scheme is developed from four parts: safety policy, risk management, safety guarantee, and safety promotion, and the application analysis is carried out in combination with the Kobe accident case in 2020. The experimental results demonstrate that the implementation of SMS scheme can effectively reduce the accident risk level during UAV power patrol inspection.

## 1. Introduction

In 2016, the National Development and Reform Commission issued the “National Electric Power” 13th “Development Plan” that proposed the power development goals from 2016 to 2020. The size of the grid would continue to grow, and the special high pressure grid would be further mature, as of the end of 2017. The total mileage of 35 kV and above the overhead transmission line reached 18.3 million, nearly increasing 40% from 2015. The size of the grid ranks first in the world. During the “14th Five-Year Plan” period, China would also increase the grid to support industry, with the overall investment exceeding 6 trillion.

At present, there are few research studies on the field of electricity patrol safety management, and there existed some shortcomings in the corresponding management system. Wen-Kuei Lee developed a quantitative model for the evaluation of aviation safety risk factors, and it is a method of increasing the effectiveness of the safety risk management system by integrating the fuzzy linguistic scale method, failure mode, effects and criticality analysis principle, and as low as reasonably practicable approach [1]. A.L.C. Roelen described how a safety management system is related to a

quality management system and safety culture. Particular emphasis was placed on the difficulties for the development of safety performance indicators in an organization as part of a successful safety management system [2]. Steffen Kaspers’ respective data from 7 European airlines were analyzed to explore whether there is a monotonic relationship between safety outcome metrics and SMS processes, and operational activity and demographic data were widely used by the industry. On the contrary, they discovered that the more you do with the safety management system, the higher safety performance would not be made [3]. Olja Čokorilo developed a quantitative methodology for assessing aviation hazards during the aircraft usual daily operations. The methodology was developed by estimating all related hazardous factors by their occurrence placement, nature, and specific components related to timing, sequencing, and mutual dependency [4]. Slobodan Gvozdenović discussed items that were determined to be important to understand the risk of aircraft accident and safety appraisal, including aircraft operations/flights, crash probabilities, aircraft characteristics, costs, revenues, socio-economic benefits, and value statistical life. And those items above could be used as risk assessment tools to implement the SMS process [5].

Huan-JyhShyur developed an analytic method that uses data on both accident and safety indicators to quantify the aviation risk, which are caused by human errors. Considering the baseline hazard function as a quadratic spline function, a specified proportional hazard model has investigated and demonstrated its applicability in aviation risk assessment. The use of the proposed model allowed the investigation of nonlinear effects on the aviation safety factors and flexible assessment of aviation risk [6]. The Civil Aviation Authority of China also established a supporting regulatory system after issuing "Management Procedures for special UAV trial Operation," using the SORA method to safely manage drones [7]. In 2010, ICAO jointly included 25 Member States and 7 industries; EASA had set up safety management group (SMP) and revised DOC9859 "Safety Management Manual." In November 2019, DOC9859 files described the risk management, safety incident report, safety incident survey, afterward summary analysis, etc., and gave the air carrier, air transport unit, airport, and aircraft manufacturing and maintenance. Flight training units implemented SMS management guidance policy to reduce security risks [8]. In addition, ICAO also requires national civil aviation management agencies to strengthen cooperation, share experiences and lessons, and combine their own actual needs to develop their own national SMS, so as to achieve acceptable security goals in the process of civil air operation. Capello et al. proposed new rules for the regulation of cloud-based remotely piloted aircraft systems (RPAS), which are operating in urban environment [9]. Afman et al. discussed the new operating environment of civil UAV, studied the meaning of safety according to this new environment, and discussed different methods to ensure system safety from the perspective of avionics [10]. CAAC has also introduced a series of related policies and measures to support SMS construction, including "Requirements for Air Operators Safety Management," "Civil Aviation Air Traffic Management Security Management System (SMS) Construction Requirements," "Civil Aviation Information Security Event Classification Guide," and "Transportation Airport Safety Management System (SMS) Construction Guide" [11]. Kurdel P et al. studied the flight technical safety of UAV in the vertical direction when flying through mountains and formulated a series of flight technical requirements, which can effectively avoid obstacles in mountainous terrain [12]. Black et al. studied the classification of UAVs and the formulation of rules related to tasks, supervision and safety, certification, and air traffic management when UAVs are integrated into national airspace (Europe and the United States) [13]. Jeelani I. et al. examined UAV integration in construction workplaces from a health and safety perspective, categorized the potential ways UAVs might affect the construction workers' health and safety, and provided a roadmap for future research in this area [14]. The fusion of UAV multimedia situational awareness sensor and artificial intelligence is also a main means to reduce collision risk [15–17].

Through the above relevant literature, it can be concluded that there is a lack of the safety management scheme for UAV power inspection in China. According to the safety

management requirements of UAV power patrol, based on the UAV airworthiness management regulations, this study will propose a set of "professional, accurate, and full coverage" UAV power patrol SMS scheme, which will greatly improve the safety management efficiency of UAV power patrol.

## 2. SMS Framework Analysis of UAV Patrol Operation

The basic goal of the operation is to integrate the SMS advanced structured management system into the operation control of the organ to achieve effective control operation.

First, through the risk management function, the risk source in the operating system and the work program is identified by the operation safety analysis, after which the risk matrix method is used for the risk analysis and evaluation. The corresponding risk control measures and the continuous tracking mechanism will be used. Risk control is in the acceptable range.

Second, based on modern control theory, closed-loop control is implemented throughout the running process, and the operational process is monitored by running the feedback mechanism. Safety assurance feedback to risk management feedback from the new risk source and the risk management are evaluated and analyzed. It acts on security promotion and profile acts on security guarantees, thus correcting poor run safety status, so that the operating security state is always in an acceptable range. Through closed-loop management and its continuous improvement, the security system has been continuously improved.

By deeply understanding the characteristics of the machine, combined with the PDCA cycle theory, modern control theory refers to the requirements of the public air carrier and the requirements of the International Civil Aviation Organization "Safety Management manual." This study works the SMS content that is divided into four modules: security policies, risk management, security assurance, and security promotion. The above constitutes the minimum safety management requirements for the SMS of the machine.

The operation SMS is based on security policies, risk management, security guarantee as the core function, and security promotion. Through security assurance, the operations in the actual operation are within the standard range. Invalid risk management measures and new hazardous sources can promptly feedback to risk management, and overall operational risks are always acceptable. When certain factors are safe, the security policy should be given to the security policy. For the problem whether the security policy needs to be modified, the security policy needs to feedback policy changes to risk management, thereby triggering the revision of risk management. Through safety promotion and the establishment of a positive and fair safety culture, employees can voluntarily participate in SMS, thus laying the foundation for reducing unsafe events. The relationship among various components of the safety management system is shown in Figure 1.

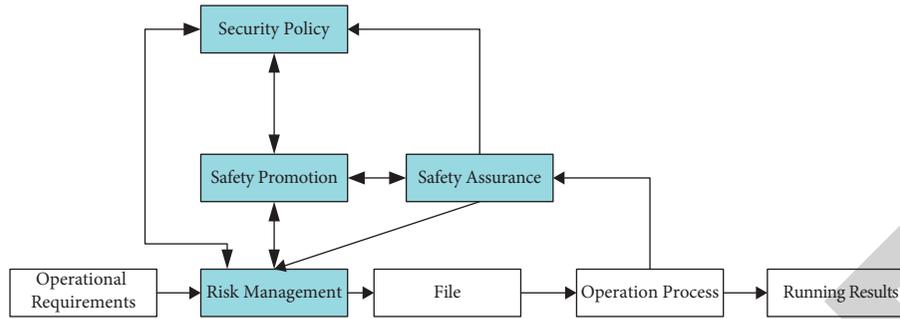


FIGURE 1: Software structure map.

2.1. *Characteristics of Patrol Operation.* Part of the mechanical patrol operation in the power patrol is strictly in the field of general aviation, but universal aviation operations, such as traditional photography, exploration, and rescue, are significant. The main characteristics of the machine patrol are as follows:

- (1) The size of the fleet is different and the types are diverse. The operating fleet usually includes helicopters, fixed wings, and multirotor operating fleet [18]. There are performance differences among different aircraft types. Moreover, when performing different patrol tasks, the meteorological conditions, geographical environment, operating load, operating distance, and other conditions at that time also have greater impacts on the performance and operation effects on the fleet.
- (2) Work scene: electricity patrol operation is carried out around the grid. Meanwhile, the geographical environment of the grid is complex, including mountains, lakes, and population intensive districts. In the helicopter, you can inspect the road section using a helicopter to conduct refined inspections and channel inspections, and the fixed wing or multirotation is refined and channel patrols for the helicopters cannot be patrolled.
- (3) Work airspace: most power patrol operation is performed below 100 meters. In complex and variable environments, the low-altitude flight collision, low-air wind cut, and probability of signal occlusion interruption are higher than other navigation works.

2.2. *Security Policy.* As the specific embodiment of the SMS concept, security policy is the foundation of SMS effective operation [19]. It includes security policies, including security commitments and philosophy formulated for this policy. The security policy is the planning phase of the operation SMS (Plan), mainly including safety commitments and ideas, security regulations, and other requirements, five aspects of document record and management, and emergency preparation and response.

Safety policy requires managers to formulate quantitative security objectives for implementation. Managers should clarify the overall security objectives in which they are located. According to the management methods,

business models, and workflows of the departments, the overall safety objectives are split into multiple subobjectives, and the security objectives and corresponding assessment systems of each sector are formulated as well.

Managers need to commit to establish and implement SMS, integrate safety management into the overall production operation through risk management, and ensure operational processes to comply with civil aviation laws and regulations and continuous improvement for safety levels. As for employees, to implement safety is the basis of survival and development.

When developing security policies and objectives, managers should comply with various regulations, including national regulations, industries, and local regulations and civil aviation regulations, and establish the development, revision, and improvement of SMS-related documents.

Record is a special file that confirms the SMS running process and results and manages the record control program: SMS required records should be established and held in the form that can be archived and controlled, which provides SMS operation, implementation, and evidence of their implementation results.

Managers should establish emergency preparation and response policies, including emergency organization, emergency supplies, and emergency plans, regularly organize emergency drills and emergency treatment, and improve the emergency power of all members.

2.3. *Risk Management.* Risk management is one of the cores of the operation SMS, analyzes each workflow through system and work analysis, identifies the dangerous source, and uses risk assessment matrix quantitative risks. Risk control measures are developed to reduce risk to an acceptable level, and the module is the execution phase of SMS, as shown in Table 1.

Matrix evaluation method is displayed in Figure 2.

White section: is acceptance risk. Risk level is 1. Green part can be accepted after relief and corresponding measures need to be taken to rectify, and risk level is 2. Blue part can be accepted after the risks, with the risk level of 3. The corresponding measures are rectified. The purple part: the risk level is 4. You need to take enough measures to reduce the risk to the acceptable level. Red part: unacceptable risk (risk level is 5). You need to take enough measures to reduce risk reduction to the acceptable level, as shown in Table 2.

TABLE 1: Risk management worksheet.

Information	Hazard identification	Hazard association	Risk analysis and assessment	Risk control measures	Tracking verification	Status
Information sources	Number		Possibility	New risk control measures	Implementation	
	Description		Seriousness	Time limit for completion	Reasons for noncompletion	
	Classification	Hazards relate	Risk level	Person liable	Stalker	If turn off
	Associated event		Acceptability	Implementation effect	Evaluation of implementation effect of measures	
	Entry date		Existing control measures	evaluation standard		
	Consequence					

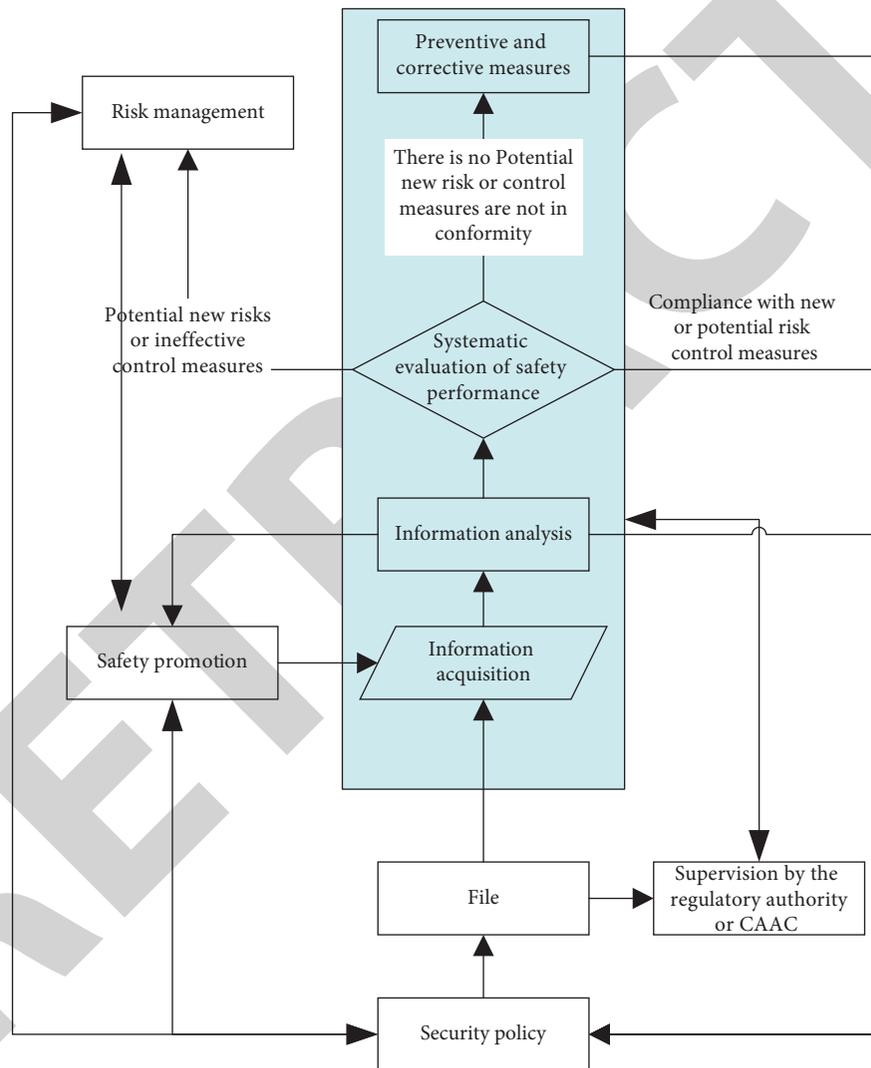


FIGURE 2: Safety assurance flow diagram.

The combined mechanism is characterized by the operation, and the risk management of the machinery assignment is divided into two parts. Part of the day-to-day operation safety risk management mainly includes the annual machine patrol operation plan, running weather environmental assessment, operation aircraft functionalization modification, driver operator business training, helicopter

driver flight training, and ground security service. Another part is the risk management of the machine patrol, mainly including the airspace application and stopping using the application notification program, the takeoff release evaluation procedure for helicopter operation, the transportation of the drone operation, and the emergency response procedure for emergency states.

TABLE 2: Matrix evaluation method.

		Gradually increase →				
		seriousness possibility	1	2	3	4
Gradually decrease ↑	5					
	4					
	3					
	2					
	1					

**2.4. Safety Assurance.** As another core of SMS, security assurance aims to realize the closed-loop management of company operation safety. Safety assurance is composed of information acquisition, information analysis, system evaluation, safety performance, and prevention and corrective measures, and each link is indispensable. In order to effectively play the function of safety assurance in SMS, we establish an information driven active safety management mode and achieve the expected goal; the operation methods and implementation standards of each link must be strictly implemented.

Security assurance completes the situation awareness of the operation state through the information acquisition link, analyzes the operation state in the information analysis link, confirms the deviation between the actual operation state and the expected safety goal through the system evaluation, analyzes the causes of these deviations, and finally confirms the ways and methods to implement the adjustment. Safety assurance is the check stage of SMS in patrol operation.

Figure 2 exhibits the relationship between each link of safety assurance and the relationship between safety assurance and various components of safety management system, such as operation process, risk management, safety policy, and safety promotion.

**2.5. Safety Promotion.** Although safety policy, risk management, and safety assurance have formed part of the closed-loop control logic of SMS, a rigid management system that lacks the ability to enhance employee safety awareness does not enhance safety risk identification and control and employee participation in SMS construction aggressiveness, and it fails to chronically make risk control within acceptable limits.

Safety promotion mainly consists of safety culture, safety training, and safety education. A positive safety culture can effectively complement deficiencies in current safety policies, manuals, rules, and regulations to set up a good job style within employees. Safety training and safety education are primarily aimed at raising employees' safety awareness and increasing their ability to analyze problems, ask questions, and solve problems when encountering safety issues. Security promotion is the processing stage (action) of the machine tour job SMS.

### 3. SMS Application Analysis of UAV Patrol Operation

Equations and mathematical expressions must be inserted into the main text. Two different types of styles can be used for equations and mathematical expressions. They are in-line style and display style.

The machine tour operation SMS contrasts with other general-purpose aviation SMS, the most major differences of which are as follows:

- (1) The safety policy differs: tour operations have a large number of line tour operations per year, and they have a diverse operating model and complex operating locations, so the safety policy differs with related  $e$  to other general-purpose aviation.
- (2) Security guarantees differ: unlike other general-purpose airways where there is only one model or group, the tour operation center includes helicopter, fixed wing drones, and multirotor drones, with multiple models being potentially subdivided under each model. The tour tasks charged also vary among different models, which have led to the need for a system for the targeted development of preventive corrective actions and safety performance evaluations for each condition.
- (3) Different risk management: due to different security assurances, risk management measures in each case need to be formulated individually. The overall risk management is more complex than other general aviation.

**3.1. Case Analysis.** On January 26, 2020, basketball player Kobe Bryant's private helicopter flew into the clouds causing a "spatial orientation obstacle," lost its way in the fog, and finally crashed. The flight plan is similar to the helicopter power line patrol, so the following analysis is performed.

In 2015, the pilot was punished by the local civil aviation administration for violating the safe flight terms during the flight. The scheduled departure time was 9:45. Due to the user's request, the departure time was advanced to 9:00, and the fog weather of the day was not fully evaluated before takeoff. After taking off, the pilot chose to hover instead of alternating to other airports. Then, the fog gradually increased. At this time, the pilot had hovered in the fog for about 25 minutes and trapped in the space orientation obstacle. The pilot flew in the mountain area to the south in the fog, which eventually led to the crash.

**3.2. Accident Results.** The SMS analysis results are as follows:

- (1) In 2015, pilots violated safety regulations. According to the SMS requirements of patrol operation, effective control measures should be formulated for the hazard source. On the contrary, the effectiveness

of the control measures should be determined in the process of safety assurance. However, the pilot still violated the safety regulations once again, which indicated that the control measures were invalid.

- (2) It is one of the most basic and important contents to evaluate the weather of the day before the aircraft takes off. However, pilots still take off in foggy weather, which is not in line with the safety concept that SMS is the basis of survival and development.
- (3) After the plane took off, the fog gradually increased, and the pilot did not choose to alternate, but continued to hover. In this process, pilots failed to operate in strict accordance with the method of system evaluation in safety assurance, thus resulting in insufficient safety risk prediction and spatial orientation obstacle.

If the helicopter company can conduct SMS-related training for pilots in accordance with SMS requirements, such as safety policy and risk management, the crash would have not occurred. The implementation of SMS can promote the operation safety of low-altitude UAV, reduce the accident rate of power grid inspection, and more effectively implement the relevant national standards and recommended measures of UAV and realize effective supervision while maintaining the public safety and national security of local low-altitude airspace. SMS also contributes to the development, utilization, transmission, and communication of UAV operation safety information and realizes the sharing of safety information resources.

#### 4. Conclusion

As an advanced security management system in the world, SMS has been successfully applied in various fields. Although China's Civil Aviation Administration has always attached great importance to safety work, there is still a lack of SMS for general aviation, especially in cruise operations. The patrol operation SMS proposed in this paper studies the safety patrol inspection of UAV from the aspects of policy, UAV classification, and airworthiness standards, plays a certain guiding role in the safety work in the following related fields, and can effectively provide safety guidance for relevant personnel in the implementation of UAV power patrol inspection. However, SMS cannot fully cover all potential risks. Under the background of socialized production, aircraft patrol work should be completed in many fields, such as civil aviation regulations and policies, aircraft manufacturing, civil aviation employee training, air traffic management, and development direction of power industry; each field should have its own SMS to ensure the safety of patrol operation.

#### Data Availability

The data are provided by the machine patrol management center of Guangdong Power Grid Co., Ltd. and can be obtained upon request (xmfch1@126.com).

#### Conflicts of Interest

The authors declare that they have no conflicts of interest.

#### References

- [1] W.-K. Lee, "Risk assessment modeling in aviation safety management," *Journal of Air Transport Management*, vol. 12, no. 5, pp. 267–273, 2006.
- [2] A. Roelen and M. B. Klompstra, "The challenges in defining aviation safety performance indicators," *Psam & Esrel*, vol. 12, 2012.
- [3] S. Kaspers, N. Karanikas, and S. Piric, "Measuring safety in aviation: empirical results about the relation between safety outcomes and safety management system processes," *Operational Activities and Demographic Data*, vol. 14, 2017.
- [4] O. Cokorilo and G. Dell'Acqua, "Aviation hazards identification using safety management system (SMS) techniques," in *Proceedings of the 16th International Conference on Transport Science ICTS*, Mohali, India, March 2013.
- [5] O. Cokorilo, P. Miroslavljevic, and S. Gvozdenovic, "An approach to Safety Management System (SMS) implementation in aircraft operations[J]," *African Journal of Business Management*, vol. 5, 2011.
- [6] H.-J. Shyur, "A quantitative model for aviation safety risk assessment," *Computers & Industrial Engineering*, vol. 54, no. 1, pp. 34–44, 2008.
- [7] Civil Aviation Administration of China, *Management Procedures for Special UAV Trial Operation*, Civil Aviation Administration of China, Beijing, China, AC-92-2019-01, 2019.
- [8] T. T. Zhang, R. S. Sun, and J. J. Liu, "Study on building test flight safety management system of civil aircraft[J]," *China Safety Science Journal*, vol. 23, no. 10, pp. 152–157, 2013.
- [9] E. Capello, M. Dentis, and L. N. Mascarello, "Regulation analysis and new concept for a cloud-based uav supervision system in urban environment," in *Proceedings of the 2017 Workshop on Research, Education and Development of Unmanned Aerial Systems (RED-UAS)*, pp. 90–95, IEEE, Linköping, Sweden, October 2017.
- [10] J. P. Afman, L. Ciarletta, and E. Feron, *Towards a New Paradigm of Uav safety*, <https://arxiv.org/abs/2108.05542>, 2018.
- [11] ICAO, *Safety Management Manual, Doc9859*, ICAO, Montreal, Canada, 2018.
- [12] P. Kurdel, A. N. Sedláčková, and J. Labun, "UAV flight safety close to the mountain massif," *Transportation research procedia*, vol. 43, pp. 319–327, 2019.
- [13] G. T. Black, K. Cohen, and C. Ronflé-Nadaud, "Integration in the national airspace (europe and USA)–UAV classification and associated missions, regulation and safety, certification and air traffic management," in *Multi-Rotor Platform-Based UAV Systems*, pp. 1–25, ISTE, Eugene, OG, USA, 2020.
- [14] I. Jeelani and M. Gheisari, "Safety challenges of UAV integration in construction: conceptual analysis and future research roadmap," *Safety Science*, vol. 144, Article ID 105473, 2021.
- [15] S. Liu, S. Wang, and X. Liu, "Fuzzy detection aided real-time and robust visual tracking under complex environments[J]," *IEEE Transactions on Fuzzy Systems*, vol. 29, no. 1, pp. 90–102, 2020.
- [16] S. Liu, S. Wang, and X. Liu, "Human memory update strategy: a multi-layer template update mechanism for remote visual monitoring," *IEEE Transactions on Multimedia*, vol. 18, 2021.

- [17] S. Wang, X. Liu, and S. Liu, "Human short-long term cognitive memory mechanism for visual monitoring in iot-assisted smart cities," *IEEE Internet of Things Journal*, vol. 22, 2021.
- [18] L. Ren, M. Castillo-Effen, H. Yu et al., "Small unmanned aircraft system (sUAS) categorization framework for low altitude traffic services," *2017 IEEE/AIAA 36th Digital Avionics Systems Conference (DASC)*, 2017.
- [19] E. Batuwangala, J. Silva, and G. Wild, "The regulatory framework for safety management systems in airworthiness organisations," *Aerospace*, vol. 5, no. 4, p. 117, 2018.

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