Abstract
Risk Considerations for Vertiport Planning at Airports: An integrated Approach to Safety, Security, Environment, and Privacy

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The integration of vertiports at existing airports represents a key challenge for the innovative air mobility (IAM) of the future. Safety-related, infrastructural and operational risks must be systematically identified and assessed in the early planning phase in order to ensure safe and efficient integration into airport operations.

Four key focus areas are essential for safe, sustainable, and socially accepted vertiport operations: Safety (SF), Security (SC), Environment (EN), and Privacy (PV). Based on these areas, a qualitative risk assessment was conducted, with key risk indicators (KRIs) defined for each category to identify representative hazards relevant to vertiport safety, environmental impact, security, and data protection.

Each KRI is assessed in terms of its probability of occurrence and extent of possible damage. The results are then classified using the ICAO risk matrix, which enables a transparent prioritization of mitigation measures and supports informed decision-making in the vertiport planning process [1]. The following ten indicators were initially examined.

The safety-related KRIs address key operational hazards associated with vertiport integration. SF1 (see Table 1) considers the risk of crashes, both midair and on the ground, which, although extremely improbable, could have catastrophic consequences. SF2 covers physical interferences on the ground, such as conflicts with infrastructure or personnel, posing a high risk due to their frequency and severity. SF3 highlights GPS jamming as a growing threat to navigation reliability in dense airspace environments. SF4 evaluates the importance of maintaining obstacle clearance to ensure safe take-off and landing procedures within constrained airport surroundings.

Environmental risks, though not predominant, are relevant in vertiport planning. EN1 addresses weather hazards like high winds, fog, and icing, which can impair the performance of an electric vertical take-off and landing (eVTOL) aircraft by reducing visibility and affecting flight stability. While infrequent, these conditions have operational implications. EN2 evaluates pollution risks such as noise emissions and potential chemical leaks from charging or maintenance as extremely improbable with negligible severity. In contrast, EN3 highlights animal strikes involving birds or wildlife as more

significant, with remote probability but major severity, potentially damaging rotors or sensors and requiring evasive action.
Security risks address potential disruptions to vertiport operations through unauthorized access (SC1) or cyberattacks on digital systems (SC2). Although these events are considered improbable, their potential impact ranges from hazardous to catastrophic, especially in highly automated environments [2]. Early implementation of physical and digital safeguards is therefore essential.

Privacy concerns focus on data theft (PV1), involving unauthorized access to passenger or operational data. While the severity is assessed as minor, such incidents can undermine user trust and regulatory compliance.

Table 1: Risk Assessment of Vertiport Hazards Based on ICAO Matrix [1]

Probability of occurrence	**Extent of possible damage**				
	Catastrophic A	Hazardous B	Major C	Minor D	Negligible E
Frequent 5					
Occasional 4			**SF2**	**PV1**	
Remote 3			**EN3**	**EN1**	
Improbable 2		**SC1**	**SF3**		
Extremely Improbable 1	**SF1** **SC2**	**SF4**			**EN2**

The assessment demonstrates that a wide range of potential hazards spanning safety, environmental, security, and privacy domains can significantly influence the future operation of vertiports. Addressing these risks early in the planning phase is essential to ensure not only operational safety, but also regulatory compliance, environmental sustainability, and public acceptance. Future work will incorporate qualitative and quantitative risk analysis validation to assess the effectiveness of mitigation strategies at an early stage.

[1] INTERNATIONAL CIVIL AVIATION ORGANIZATION (2013), "Safety Management Manual (SMM)" (Third Edition). Quebec, Canada
[2] BUNDESAMT FÜR SICHERHEIT IN DER INFORMATIONTECHNIK (2024) "IT-Grundschutz-Profil für kleine und mittlere Flughäfen". Bonn, Germany

Biography

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I studied Safety and Hazard Defense in Magdeburg and currently work as a research assistant at the German Aerospace Center (DLR) in Cochstedt. My work focuses on operational safety and risk assessment in the context of new aviation technologies, including vertiport integration and unmanned aircraft systems.