# COMPARATIVE ANALYSIS OF RISKS IN TRADITIONAL INVENTORY METHODS AND UAV-ASSISTED INVENTORY PROCESSES

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**Abstract**

Asset inventories in both the public and private sectors play a key role in managing assets and maintaining accurate asset records. Traditional inventory methods are often associated with various risks. In recent years, unmanned aerial vehicle (UAV) systems have become increasingly popular as tools supporting inventory processes. The aim of this publication is to conduct a comparative analysis of the risks associated with traditional and UAV-assisted inventory processes.

Our research, conducted across various economic sectors, included all stages of the inventory process from data collection to analysis. The results suggest that UAV-assisted inventory may result in a lower rate of risks compared to traditional methods. We will describe factors affecting the quality and time of inventory processes, the equipment used, and identify best practices that can help minimize risks in inventory processes supported by UAV systems.

The conclusions from this analysis will be important for companies planning to introduce UAVs into their inventory processes as well as for organizations aiming to optimize the efficiency and accuracy of their existing methods. This publication provides practical guidance on selecting appropriate inventory tools and strategies to minimize risks and improve the quality of inventory data.

**Keywords:** Inventory, UAV, UAS, adverse events, risks, comparative analysis, process optimization

## 1. INTRODUCTION

In the field of logistics, new solutions and technologies have been emerging for some time. Over the years, this area has evolved from the mechanization of transportation, through the automation of handling, to the gradual implementation of information systems and the deployment of autonomous devices [1]. Various solutions in logistics are continuously developing, aiming to increase process efficiency, reduce operational costs, mitigate the risk of errors, and enhance worker safety [2].

The necessity of implementing intelligent solutions is a response to current market needs, including challenges in workforce acquisition, rising employment costs, employee turnover, and overall process uncertainty. Customers increasingly demand absolute punctuality. To systematize work and boost efficiency, various technologies are being introduced, with the most popular ones including RFID technology [1], autonomous vehicles [2], and automated shelving and transport systems [5].

One of the newest and most rapidly advancing technologies in logistics is the use of unmanned aerial vehicles (UAVs). Their application in logistics is broad, ranging from transporting small shipments, monitoring situations on highways and expressways, overseeing logistics facilities such as loading terminals and distribution centers, to fulfilling small orders [6]. UAVs are also increasingly utilized in intralogistics, including the warehouse inventory process. This process covers both daily inventory, to provide information about material stock levels, and the annual inventory, a mandatory task for every enterprise.

The use of UAVs in the warehouse inventory process not only reduces the time required but also decreases the number of personnel involved, minimizes the risk of errors, and enhances safety. UAVs offer greater flexibility as they can operate on holidays or even at night, eliminating the need to halt warehouse processes [8].

The aim of this research is to conduct a comparative analysis of the risks associated with traditional manual inventory and UAV-assisted inventory methods. This analysis will help identify best practices and countermeasures to minimize these risks.

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## 2. METHODOLOGY

The research aimed to compare the risks associated with two methods of conducting inventory: traditional manual inventory conducted by a team of people and autonomous inventory using unmanned aerial vehicles. The study was divided into two parts, each consisting of four stages:

(1) Process Analysis

(2) Process Design

(3) Process Execution and Observation

(4) Summary and Analysis of Results.

In traditional inventory, the first stage involved preparing a process map, considering the risks at each stage, scheduling activities, assigning responsibilities, and preparing a list of resources needed for the inventory. The second stage included incorporating the inventory schedule into the production and warehouse work plan, preparing a worker schedule, ordering necessary external resources such as forklifts, and printing essential documents like inventory cards. This stage also verified workers' qualifications for working at heights. The third stage involved dividing workers into counting teams, conducting the count, entering data into the system, and comparing it with the system state. Observations were made, and potentially hazardous events were identified during this stage. The fourth and final stage included preparing a report containing a list of potentially hazardous events and high-risk points related to both safety and process accuracy [18].

For inventory conducted using unmanned aerial vehicles, the first stage was identical to traditional inventory. In the second stage, a review of the warehouse conditions was conducted to adjust UAV parameters. The third stage involved inventory conducted by unmanned aerial vehicles, including observations of potentially hazardous situations. The last stage, as in the first case, involved preparing a report with a summary of all potentially hazardous situations and high-risk points [6].

## 3. TRADITIONAL INVENTORY

To determine the actual inventory of materials in the warehouse, an annual inventory is conducted. The process of annual inventory can be divided into four stages, as shown in Figure 1.

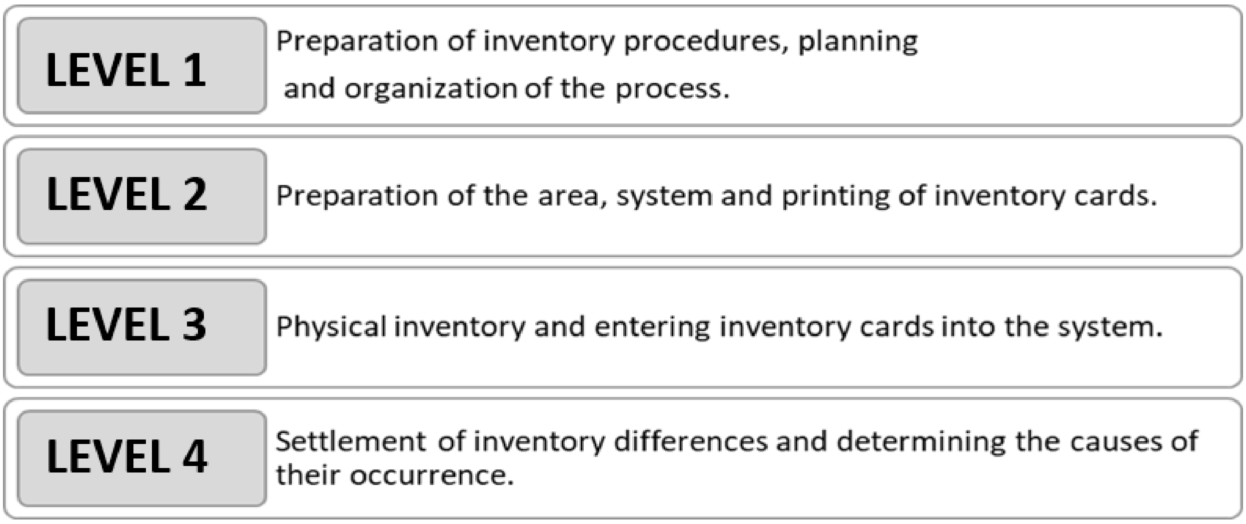


**Figure 1** Annual Inventory Process Stages

At each stage of the annual inventory, various risks are present, categorized based on their causes. The causal division of risks during the annual inventory process is categorized into four groups, as presented in Figure 2.

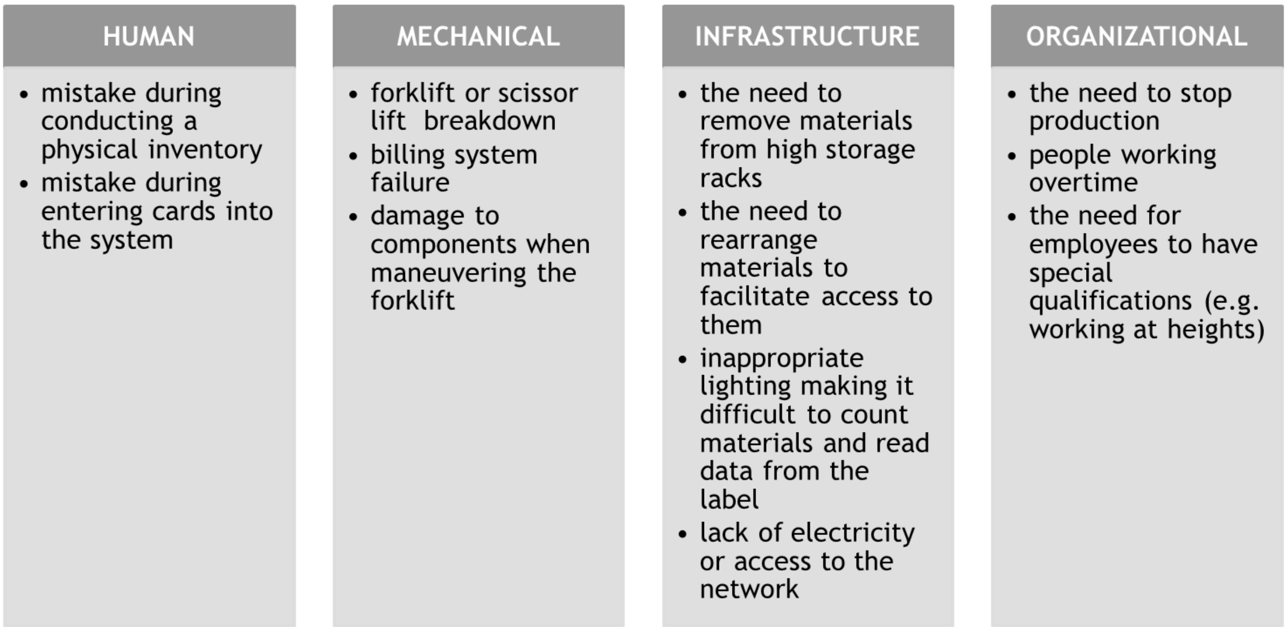


**Figure 2** Causal division of risks occurring during the annual inventory in the warehouse of production materials

During the first stage of the annual inventory, the highest number of organizational risks is encountered. This is because this stage involves planning and organizing the entire process. Choosing a suitable date, often on weekends or holidays when production is inactive, requires planning workers' schedules beyond their standard working hours, incurring additional costs and higher hourly rates. It is also crucial for the appropriate number of workers to have the required qualifications, such as forklift operation or authorization to work at heights.

The second stage may encounter risks from the infrastructure group, as preparing the inventory area may reveal that some material storage locations are inaccessible, necessitating the rearrangement of materials to facilitate worker access. Additionally, inadequate lighting in some areas may make counting materials difficult [10].

However, the highest risk occurs in the third stage, where problems from all groups can arise. Organizational challenges may include the absence of planned workers or a shortage of personnel with the required qualifications. It is also possible that some rented equipment may not arrive in full, extending work time. Infrastructure-wise, issues such as lighting, power, or network failures may arise. Mechanical risks involve potential failures of equipment such as forklifts, scissor lifts, or the settlement system [4]. Moreover, there is a significant risk of damaging counted components during warehouse movements. The third stage is also characterized by the highest risk of human error. Mistakes often occur during component counting, leading to the need for a recount when compared to the system, and errors may arise during data entry into the system. Mistakes can be made by both counting teams and data entry personnel, leading to the need for a recount until at least two values match.

The lowest risk occurs in the final stage of the annual inventory. Despite being the last stage, the inventory committee responsible for conducting the inventory must determine the causes of inventory differences based on document analysis and discussions with individuals responsible for stored materials. Although it is the final stage of the entire process, a decision may be made to conduct another physical inventory entirely or in selected sections. The official conclusion of the inventory process is the preparation of a protocol by the inventory committee, containing the inventory results along with detected inventory differences, their reconciliation method, justification, and submission to the unit manager [18].

## 4. INVENTORY WITH USING UAV SYSTEMS

There are the following types of risks occurring during inventory missions using UAVs. When planning and conducting inventory missions with UAVs, it is essential to consider these various types of risks and develop appropriate risk management strategies. Implementing safety measures and monitoring the process can significantly minimize potential threats.

1) Technical Risks:
- Equipment Failures for UAV, sensor, or other technical component failures during inventory mission;
- Power Issues means risks associated with UAV battery performance, especially during prolonged missions [18].
2) Safety and Legal Aspects:
- Collisions with objects, mostly risks of collisions between UAVs and other objects in the warehouse, leading to damages to both the UAV and the surroundings;
- Regulations and permissions, when risks of violating regulatory provisions regarding UAV usage and the necessity of obtaining appropriate permissions [24].
3) Cybersecurity like hacking attacks, when risks of unauthorized access or hacking attacks on UAV systems, leading to a loss of control over the UAV [11].
4) Environmental Hazards such a structural damage, which means risks of structural damage to buildings or warehouse structures due to UAV operations [21].
5) Communication Issues connected with signal interferences, possibility of communication disruptions between the UAV and the control system, leading to a loss of control over the device [22].
6) Data-related concerns for example data loss and Risks of losing inventory data due to equipment failures or issues with recording [23].
7) Weather Conditions, so inappropriate weather conditions created risks associated with operating in unfavorable weather conditions such as strong winds, rain, or fog [19].
8) Machine Learning and Artificial Intelligence issues, algorithm errors are responsible for risks of errors in machine learning algorithms used for analyzing inventory data collected by UAVs [20].

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## 5. COMPARATIVE ANALYSIS CONCLUSION AND TOP REMARKS

Based on the comparative analysis of traditional inventory methods and stock-taking with the use of UAVs, several key conclusions can be drawn:

1) Efficiency and Speed - UAVs offer a significant advantage in terms of speed and efficiency compared to traditional inventory methods [7]. The ability to rapidly scan large areas and access hard-to-reach places enhances the overall speed of the inventory process [6].
2) Accuracy and Precision - The precision and accuracy of inventory data improve when using UAVs. Advanced sensors and technology eliminate human errors, ensuring a more reliable dataset for inventory management [8].
3) Cost-Effectiveness - While the initial investment in UAV technology may be higher, the long-term cost-effectiveness becomes evident through increased operational efficiency and reduced labor costs [9].
4) Safety and Risk Mitigation - UAVs minimize risks associated with traditional inventory methods, especially in hazardous or hard-to-access environments [12].
5) Data Integrity and Real-time Monitoring - UAVs provide real-time monitoring capabilities, allowing for immediate identification and response to any irregularities during the inventory process [15].

6) Flexibility and Adaptability - UAVs offer flexibility in adapting to various inventory scenarios and environments. Their ability to navigate complex spaces makes them suitable for a wide range of industries and warehouse configurations [16].
7) Regulatory Compliance - Adherence to regulations and permissions for UAV usage is crucial. Proper compliance ensures the legal and ethical deployment of UAV technology in inventory management, addressing potential regulatory challenges [17].

In conclusion, the integration of UAVs in stock-taking and inventory management presents a transformative shift towards efficiency, accuracy, and safety. While challenges such as initial costs and regulatory considerations exist, the long-term benefits in terms of operational excellence and risk reduction make UAVs a compelling choice for modernizing inventory processes.

## CONCLUSION

In conclusion, the integration of UAVs in inventory processes presents a significant advancement towards improving efficiency, accuracy, and safety. The comparative analysis of traditional inventory methods and UAV-assisted inventory highlights several key benefits of using UAVs, including enhanced speed, precision, and cost-effectiveness. UAVs reduce the risks associated with manual inventory, particularly in hazardous or hard-to-reach environments, and offer real-time monitoring capabilities that ensure data integrity and situational awareness.

However, it is important to address the initial costs and regulatory challenges associated with UAV implementation. Ensuring regulatory compliance and proper risk management strategies are crucial for the successful adoption of UAV technology in inventory processes.

Future research should focus on long-term impacts of UAV integration on inventory management, exploring advancements in UAV technology, and developing comprehensive guidelines for organizations considering the transition to UAV-assisted inventory methods.

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