ENHANCING ELEVATOR DOOR MANUFACTURING WITH AUXILIARY DRONES

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Abstract:

The rapid development of industry equipment at the end of the 20th and the beginning of the 21st century caused the development of unmanned aircraft vehicles, whose application began at the end of the 20th century. Nowadays, unmanned aerial vehicles are used for different purposes, although their development was intended for defence and security. Drones have a broad spectrum of possibilities; therefore, they have unlimited usage for both commercial and country-wide defence and security purposes. Drones have become an unavoidable part of the arming of police and military units in the world, and their versatile usage has classified them as the most important combat means without which modern operations are unthinkable. The possibilities of using drones in the vertical transportation industry in urban environments are presented and explained in this paper. The focus is on the analysis of the characteristics of drones in terms of their ability to be used in an urban environment with restrictions dictating urban space and the modern way of conducting combat operations.

Keywords:

Drones, Manufacturing, Drone application.

INTRODUCTION

Incorporating drones or unmanned aerial vehicles into elevator manufacturing is a new milestone, demonstrating the industry's readiness to modify its operation and improve quality. Beyond their conventional military use, drones have become integral to various sectors today. In the elevator manufacturing field, integrating robotics into assembly and inspection streamlines production and offers an entry point into the high-technology era [1], [2], [3]. This article discusses how drones can improve efficiency, maintain quality assurance, and enhance safety protocols, proving that they are responsible for the uninterrupted progress of elevator manufacturing.

Drones are operated remotely, and there are ongoing discussions regarding their impact on warfare, technology detachment, and more casual methods of killing individuals [4]. Their use for military purposes during the tenures of George W. Bush and Barack Obama,

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DOI: 10.15308/Sinteza-2024-199-205

especially in Iraq, Afghanistan, and Pakistan, suggests a significant rise in the use of drones and highlights their role in the present political and military doctrines. The shift towards remote surveillance and warfare demonstrates both a technological advancement and a tactical reorientation in the utilization of drones, highlighting the increasing significance of drones in the tactical realm, where constant monitoring and precise actions are imperative. Despite their benefits, the ethical and civil consequences remain a tangible stress, adding to the difficulties of using military robots for warfighting. The complexity of modern warfare is clearly shown in modern warfare.

The elevator manufacturing industry, which plays a pivotal role in the advancement of urban infrastructure, is currently experiencing a significant demand for innovation in light of evolving construction dynamics and technological advancements. With an estimated market value of $134.46 billion in 2021 and an anticipated compound annual growth rate (CAGR) of 6.3% through 2030, the industry is poised for significant expansion [5]. The expansion is fuelled by the implementation of modern safety features in escalators, technological advancement, and the burgeoning construction industry [5]. Elevator and escalator upgrades, including emergency systems and the development of energy-efficient alternatives, are currently being implemented to meet the escalating standards of living and sustainability objectives in urban areas. Concurrently, the attainment of green building certification and the utilization of low energy consumption demonstrate convincingly that innovative elevator technology holds significance and will be demanded in the construction industry. The emergence of digitalization trends, as exemplified by the introduction of digitally driven elevators such as KONE's DX Elevators, has demonstrated the industry's readiness to integrate intelligent technologies to enhance user experience and operational efficiency [5] While the infrastructure sector could benefit from these new technologies, maintenance, and inspection costs could pose challenges that could slow market growth. Undoubtedly, the demand for elevators and escalators remains substantial, particularly in residential sectors and high-rise constructions, as a result of urbanization in emerging economies [5], [6]. Therefore, this paper examines the impacts of drones on the elevator manufacturing industry, particularly spaces where they can enhance safety processes and reduce operational costs. Through investigation of the implementation of drones for inspections, maintenance activities, and installation, we aim to illustrate the significant gains in efficiency and safety that drones can bring to this vital field. Overview of drones in industrial applications.

1.1. GENERAL USES

- Drones are becoming an essential tool for inspection across different areas, providing cost savings, efficiency, and safety. For example, in offshore wind turbines, drones are transforming how inspections are carried out by mitigating the requirement for technical to engage in risky climbs and reducing both the operational downtime and the heavy lifting equipment needed for inspections [7]. Drones have also significantly improved structural health and worker safety by replacing multiple inspection techniques for industrial site inspection [8]. Similarly, the energy sector derives advantages from the utilization of drones, particularly to inspect transmission infrastructure. Drones offer detailed 3-D asset comprehension, which translates into improved asset health comprehension, cost savings, and heightened safety and compliance [9]. In the field of construction, drones offer significant benefits in the inspection of aged or decayed structures. The need for risky hand-operated inspection is substituted with a swift and secure alternative that reduces the expense, facilitates instantaneous data transmission, and aids in the planning of subsequent diagnostic procedures [10]. Such applications highlight the revolutionary role of drones among sectors, bringing safer, more effective, and more economical solutions.
- Drones play a significant role in surveillance operations, such as urban development, public health, and border security. Smart cities employ drones in diverse research areas such as transportation, environment, infrastructure, and disaster management [11]. The primary areas of application for these applications are air pollution and traffic monitoring. The ability to operate UAVs as single or multiple vehicles, combined with more advanced technologies such as IoT, AI, and machine learning, provides more intelligent and sustainable solutions among the traditional surveillance methods [11], thus enhancing living standards. UAVs are becoming an essential tool for mosquito surveillance and control, addressing the spread of vector-borne ailments such as dengue and malaria. UAVs facilitate the identification of breeding locations and the mapping of micro-environmental compositions, thereby contributing to the efficacy of control programs [12].

With advanced technologies, drones can accurately carry out surveillance, assess habitat suitability for mosquitoes, and implement targeted interventions, presenting an innovative approach to managing public health problems [12]. EU border surveillance of the EU has witnessed a multitasking drone tool, facilitating the security function at EU borders [13]. UAVs provide excellent performance and precision, even in the worst conditions and places where borders are not predictable and an unknown element exists [13]. However, using drones for border surveillance carries unclear aspects and pitfalls, even though they have proven helpful. Therefore, it is essential to take a responsible approach to their use in sensitive areas.

- Drones are exerting an impact on logistics in numerous domains, and among the innovations they are generating are medical deliveries, production logistics, and social logistics. The utilization of drones in medical logistics provides an efficient and accessible distribution platform for essential supplies such as medications, vaccines, and testing kits to the rural populace [14]. The creation of optimization models will lead to greater logistical efficiency in drone delivery to remote and suburban clinics, which will significantly reduce total completion times and improve healthcare logistics for such areas, especially for regions with limited access [14]. Production logistics necessitates supply chains that manage diverse dynamics through self-adaptive and self-directed systems [15]. The utilization of drone transport in the three-dimensional blank spaces of manufacturing facilities has the potential to enhance logistics efficacy, particularly in situations where space is constrained. Despite their promising prospects for implementation, they remain in the experimental stage owing to both financial constraints and safety considerations, as well as the necessity for their compatibility with existing logistics systems [15].

  In social logistics, particularly in response to natural disasters, UAVs are critical in delivering humanitarian aid and conducting aerial assessments of disaster-affected locations. UAVs provide fast, flexible, and efficient solutions for examining damage, issuing relief materials, and assessing post-disaster requirements [16]. The effectiveness of UAVs in disaster response underscores their likelihood of improving logistical operations in critical periods, balancing technological advances with the necessity for expert operation.

1.2. CASE STUDY DRONES' IMPACT ON THE CONSTRUCTION INDUSTRY

Haloti Bros., Inc., a general contractor based out of San Rafael, California, which has been operating for over 100 years, demonstrates the impact UAVs have on the construction sector by way of major construction projects [17]. GBI has implemented UAV integration into its ground surveying, estimation phase, and onsite project management functions. UAVs facilitate the construction management process by providing real-time surveys and precise measurements that can be utilized for precise site planning, deployment, and traffic management [17]. This technology surpasses conventional methodologies, such as utilizing outdated satellite images in Google Earth, which are employed for project design and evaluation purposes.

One notable benefit of GBI's experience is that UAVs are capable of automating surveying tasks, accurately capturing millions of data points to survey sites without manual piloting [17]. This data collection increases efficiency and precision and supports better decision-making throughout construction [17]. Moreover, the UAVs have served as an instrument for legal documentation, providing tangible evidence to support GBI in legal disputes by providing clear, date-stamped pictures of site conditions. Another critical benefit emerged from the replacement of manual grade checks with the GPS software, namely the Trimble Propeller, which saved time and labour costs [17]. Specifically, unmanned aerial vehicles (UAVs) enabled communication among clients regarding crucial aspects of the contract, thereby generating additional revenue for the company in terms of returns.

Despite these benefits, GBI encountered challenges in adopting drone technology, such as the learning curve associated with drone software and the required pilot certification [17]. Obstacles on the job site, such as foliage, also posed problems to the drone's surveying abilities, though these were trivial and manageable problems. The case study demonstrates that drones are highly effective in increasing operational efficiency, accuracy, and cost-effectiveness in construction. Therefore, the digital transformation of the industry is taking shape [18].

2. DRONES IN ELEVATOR DOOR MANUFACTURING

2.1. SITE SURVEYS AND INSPECTIONS

UAVs are increasingly acknowledged for their critical contribution to the construction sector, particularly when angular spreading is involved in elevator door installation. These correspond naturally and give rapid and uniform rates to previously time-consuming jobs that require accuracy and complex jobs like geometric measurements of elevator shafts. The same checks happen when performing complete validation statement forms for technology and field inspection [19]. Drones utilize their adaptability and sophisticated photo-taking capabilities to facilitate work in these areas. Through the ability to quickly and accurately collect data and visualize where potentially installed installations cannot be accessed previously or would be unsafe to do so, drones are the best tools that not only make informed decisions faster but also boost the precision of the installations [19]. Compared to conventional systems, their use is expected to reduce installation periods by 21 to 26 percent and reduce costs by 11 percent [19]. Furthermore, these savings are not limited to direct financial savings but also minimize the chances of delay and errors, thus benefiting the whole project [19]. The adoption of drone technology for elevator door installation is a sign that the construction industry is moving towards more innovative technological options to overcome long-term challenges, thereby making the processes more affordable, efficient, and reliable.

2.2. SAFETY ENHANCEMENTS THROUGH DRONES

The installation, maintenance, and repair domains of elevator door manufacturing have suffered from high-risk factors, as demonstrated by the statistics on injury in the past (Figure 1). Working in these sectors often entails working at heights, in restricted spaces, and near moving machinery, which are innately risky activities. The Department of Labour in the United States has observed an increasing incidence of elevator and escalator incidents that result in severe harm; in fact, elevators are responsible for approximately 90% of the deaths and 60% of severe injuries that occur annually [20]. This includes the elevator maintenance and installation crew as well as those working near or inside the elevator shaft, where most of the yearly deaths due to falls into the shafts occur – around half of the annual figures [20]. Workers caught between moving parts or struck by elevators or counterweights are more common occurrences.

Figure 1 depicts the fatal work injury rates per 100,000 workers, categorized by selected occupation, during 2020-2022 [21]. The installation, maintenance, and repair categories have a consistent rate of occupational fatalities, highlighting the inherent risks linked to these professions. These statistics emphasize the significance of enhancing safety measures in these industries to safeguard employees.

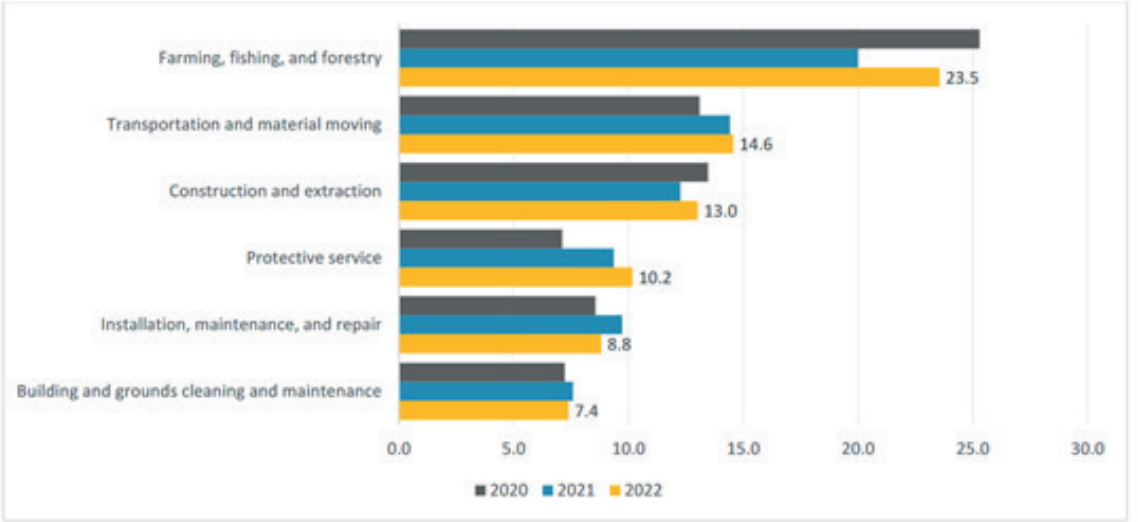

Figure 1. Fatal work injury rates per 100,000 full-time equivalent workers by selected occupation, 2020-22 [21].

The utilization of unmanned aerial vehicles (UAVs) can significantly mitigate these hazards by automating and executing risky tasks that would otherwise be performed by human workers [22]. Drones can conduct site surveying and structural checks thanks to their aerial ability, without putting workers in danger. This eliminates the need for technicians to reach restricted or high-up areas physically [22]. Furthermore, by utilizing advanced imaging and data-capturing technologies, drones possess the capability to generate comprehensive visual data, thereby aiding in preliminary assessments before the necessity of human intervention [22]. For fabrication, drones can help define exact dimensions and operations, which will help the mechanics carry out their work with a precise understanding of the situation. This will prevent mistakes that lead to accidents. Lastly, drones can routinely scan the integrity of the elevators and their components for inspection operations, indicating possible problems on time [22]. This proactive approach enables scheduled maintenance to be executed without the unforeseen circumstances that typically result in accidents [22]. Additionally, using drones can speed up the inspection process and reduce elevator time; so that repairs can be performed promptly and accurately.

Therefore, it is important to use drones in an elevator factory to create a safer working environment. This is a broader industry movement toward worker safety by utilizing technological tools that minimize direct human interaction with the unsafe environment. Hence, it is imperative to consider drones as the embodiment of economic gains and as safeguards for those aspiring to enhance safety in the elevator industry.

2.3. COST SAVINGS AND EFFICIENCY GAINS

The adoption of drone technology has been documented to heavily reduce labour costs for industrial operations, potentially reducing labour by up to 50% and overall costs by up to 11% [23]. These savings are mainly due to the speed with which drones can complete jobs that previously required scaffolding, cranes, or bulky equipment. The efficacy of drones in air monitoring and inspection enables inspectors to perform their tasks from the air without requiring heavy equipment or labour to operate them [23]. This implies that drones' agility and reach can facilitate access to volatile areas, a factor that must be taken into account. It significantly reduces the process and the resources that might have been taken as input parameters. This progress will have an operational benefit within the company, including financial savings.

Furthermore, using UAVs for routine inspections and maintenance activities reduces downtime. By expeditiously accessing and evaluating sites requiring repair or maintenance, unmanned aerial vehicles eliminate the lengthy preparations and setups commonly associated with such activities [23]. The UAVs facilitate a quick reaction, which allows for a faster start of repair work. This increased efficiency can significantly reduce downtime, as shown by a potential 21% to 26% reduction in installation time [23]. Prompt and frequent inspections have the potential to address potential issues proactively, thereby preventing prolonged periods of inactivity and ensuring that systems remain operational.

3. CHALLENGES AND CONSIDERATIONS

The practical implementation of drones in elevator manufacturing presents numerous regulatory, technical, and prospective development obstacles. Commercial and industrial use of UAVs is heavily regulated by national and local aviation bodies on the regulatory front [24]. The legal regulation of drones is currently under development to keep pace with rapid technological advancements. Firms face the problem of air traffic control regulations, which are compounded by privacy laws and airspace regulations, which may differ from jurisdiction to jurisdiction [24]. The rules and regulations change from country to country and depend upon the state and city-level requirements. Therefore, manufacturers should be aware of the new laws and sometimes incur costly legal counsel to ensure the product complies with all the regulations.

Technologically, UAVs are limited in their industrial utility through their limits. The issue of battery life is still a significant obstacle to overcome [24]; since prolonged monitoring and tasks like extensive site inspections are essential for elevator manufacturing. This means that such capabilities should be provided. Existing drones currently require periodic replacement of the batteries or frequent recharging, which interrupts the workflow [24]. Moreover, the lifting capacity of drones, another critical factor [25], will not allow them to carry heavy equipment and materials, as it is physically impossible for most commercial drones to do so. Therefore, there is a restriction on their use only for surveillance and light-duty tasks. Highly specialized operation training is an additional factor to be considered in the integration process, where these highly advanced drones utilize highly skilled operators only, thus adding more financial burden to the issue.

4. CONCLUSION

Today, drones represent aircraft that have the potential to transform the business landscape, enhance productivity, and find applications across numerous industries. The future of the advancement of drones lies ahead, as the production of drones steadily increases from year to year and is becoming more accessible to all. They vary in shape, purpose, and size, but the basic aircraft components, from the battery to the motor, are identical for all models. Due to the simple components of the aircraft being easily accessible, the price of drones has declined significantly over the last decade due to the widespread availability of drones. The classification of drones is contingent upon a particular set of criteria, drone characteristics, and their impact on the execution of urban operations. Based on the content analysis, the following conclusion is reached:

- Rotary – wings drones are more efficient for use in urban environments than fixed-wing drones. Smaller drones are more suitable for use in urban operations;
- One of the most effective sources of energy for the launch of drones is fuel cells. However, when utilized, there is a limitation that the drones must be larger;
- Depending on the type of additional payload, the efficiency of drone use in urban operations also depends on the efficiency of drone use;

This paper examines the use of drones in the elevator door industry, focusing on their characteristics and capabilities, as well as the limitations that arise during their utilization in urban operations. Also, demonstrates the significant potential advantages of incorporating auxiliary drones into elevator doors. Drones offer a multifaceted solution to long-standing challenges. The advantages of drones are reflected in the increased security, reduced risk, and improved efficiency of work, which in turn leads to an increase in economic aspects of business. Based on the characteristics of drones, it is possible to perform various high-risk tasks with minimal human risk. This justifies using drones in operations.

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