

Drone Usage in Industrial Surveillance From Local Hero to Enterprise Champion

Összefoglalás: Az ipari drónok lehetőséget biztosítanak az üzemek és ipari berendezések működés közbeni állapotvizsgálatára. A drónokra szerelhető érzékelők széles választéka, a begyűjtött adatok gépi tanulási és hagyományos módszerekkel történő hibrid feldolgozása együttesen növeli a drónokkal elvégzett roncsolásmentes vizsgálatok hatékonyságát. A cikk bemutatja a drónok ipari alkalmazási területeit, részletezi – a szerzők által meghatározott - nagyvállalati szintű, ötfokozatú drónprogram-bevezetési modellt, és jövőbeli kitekintést nyújt az ipari drónhasználat kapcsán.

Kulcsszavak: Drón, ipari felügyelet, nagyvállalati drónprogram-bevezetés, AI automatizáció.

Abstract: Industrial drones offer the opportunity to inspect the condition of plants and industrial equipment during active operation period. The wide range of sensors that can be mounted on drones, combined with the hybrid processing of collected data using machine learning and traditional methods, increases the efficiency of non-destructive testing. This article presents the industrial applications of drones, details the five-stage implementation plan for a corporate-level drone program, and provides a future outlook on drone usage.

Keywords: Drone, industrial monitoring, corporate drone program roadmap, AI automation.

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[1] Masoni, I.–Pagliccia, B.–Thalmann, G. (2019): *The Use of Drones for Innovative Seismic Acquisition: A Change of Paradigm for HSE*. International Petroleum Technology Conference, Beijing, China, 26–28. March 2019.

Introduction

High altitude, confined spaces and narrow passages are equally hazardous environments for operators at industrial operation units. Traditional inspection methods in many cases could be performed only during the scheduled turnover or during some unplanned shutdown when the unit is partially or entirely out of operation. From an economic point of view any shutdown means production loss, and production loss means direct impact on the company balance sheet.

Drones equipped with the latest industrial surveillance tools are a potential solution to perform inspections during normal operation period, assumingly all HSE, operational safety, unit regulations and legal requirements are met. Drones operate at various altitudes, while the operator safely stays at the ground. According to Masoni et al. [1] drone usage significantly decreases not only the HSE risk but the environment footprint too.

However, drone inspection is not simply flying the drone around the operation unit. Drone operation has serious legal preconditions defined by law, that differ from country to country. There is an EU level regulation package aiming to have the same frame at each member state of the EU. Safe drone operation requires cautious preparation from the operation unit and the company's HSE team, resulting the site and case specific risk evaluation, permitting process and operational safety process descriptions. Moving beyond drone proof of concept attempts, any enterprise scale drone program requires the related legal, security, HSE, competency and technical processes to be developed and embedded into the enterprise regulation framework and ingested into the companies' culture.

Drone inspection can provide a proven alternative for some of the current inspection methods, even under heavy cost scrutiny, offering new horizons in inspection methodology. This article presents the industrial application areas of drones, proposes a five-step framework to introduce drone inspection at enterprise grade, and describes the inspection process and anomaly detection methods in practice.

Drones in Industrial Applications

Drones mounted with surveillance kits could provide benefits in most of the major segments of industrial non-invasive inspections. Drones are utilised in most cases as carriers of specialised tools that provide the monitoring, inspection and surveillance capabilities. Drones provide the flexibility to reach hard-to-access points at various altitudes and the mounted tools provide the data gathering and analysis capabilities required for inspection processes. Infrastructure monitoring capability could be one of the reasons why energy industry companies are the major commercial drone customers. Inspection purposed drone usage, including industrial and construction infrastructure inspections and imagery capture, are observed as one of the leading application areas of drones across industries, besides media and logistics.

The authors categorized the drone usage along two dimensions which give the most insight into the wide variety of application areas by highlighting the category relevant value creator potentials. One dimension is the economical areas with special details on different segments of industry where the highest drone utilisation potential is considered. The other dimension is the major direct functionalities of the drones and the related indirect functionalities by the mounted equipment and the collected data utilisation. Each industry can leverage benefit from all of the functional areas. There are cross domain utilisation opportunities such as the monitoring and surveillance capability that can be applied segment independently. Surveillance functionality can be further specialised to the given industry by mounting the purpose-oriented equipment onto drones.

Table 1. Insight into application areas of drones. Source: own

SECTOR	MONITORING & SURVEILLANCE	ACTIONS	ANALYTICS ON DRONE-COLLECTED DATA
Agriculture	<ul style="list-style-type: none"> · Crop and livestock · Pest control 	<ul style="list-style-type: none"> · Fertilization · Irrigation management · Seeding 	<ul style="list-style-type: none"> · Predict crop & livestock growth · Pest detection and mitigation plan
Mining	<ul style="list-style-type: none"> · Mining areas' inspection 	<ul style="list-style-type: none"> · Surveying and mapping · Operation support 	<ul style="list-style-type: none"> · Volumetric prediction
Oil and gas	<ul style="list-style-type: none"> · Integrity · Emission · Leakage 	<ul style="list-style-type: none"> · Infrastructure assessment · Seismic support · Surveying and mapping 	<ul style="list-style-type: none"> · Failure prediction
Utility and power	<ul style="list-style-type: none"> · Integrity · Emission 	<ul style="list-style-type: none"> · Infrastructure assessment 	<ul style="list-style-type: none"> · Failure prediction
Construction	<ul style="list-style-type: none"> · Inventory · Progress 	<ul style="list-style-type: none"> · Ensure workers' safety 	<ul style="list-style-type: none"> · Completion data prediction · Plan vs fact comparison
Logistics	<ul style="list-style-type: none"> · Inventory 	<ul style="list-style-type: none"> · Parcel, sample, equipment delivery · Reach extreme locations · Navigational aid 	<ul style="list-style-type: none"> · Plan oversized shipment route · Optimise delivery routes
Insurance	<ul style="list-style-type: none"> · Natural disaster monitoring 	<ul style="list-style-type: none"> · Accurate property assessments · Damage assessment 	<ul style="list-style-type: none"> · Fraud prediction
Media & telecom	<ul style="list-style-type: none"> · Transmission and connectivity monitoring 	<ul style="list-style-type: none"> · Cinematography, photography · Broadcasting sports 	<ul style="list-style-type: none"> · Transmission entities optimisation
Entertainment	<ul style="list-style-type: none"> · Participants 	<ul style="list-style-type: none"> · Replace firework · Drone racing · Drone shows 	<ul style="list-style-type: none"> · Crowd movements

Many companies and countries are committed to getting closer to or reaching carbon net-zero operation. This initiative can be largely supported by drones because leakage and emission anomalies can be successfully discovered and tracked by drone technology in many cases. The combination of drones' capabilities with the mounted equipment's data gathering capabilities and the related data processing capabilities are increasing the return on investments, assuming that all relevant regulations are created and the needed technological advancements are developed. AI advancement also provides great value for the analysis of drone captured data and leads us towards autonomous drone operation, which was only a great idea a couple of years ago and nowadays the technology is ready for it in many cases.

Table 2. Drone industry market size forecast and reality comparison, future outlook



Source: Own analysis based on data from Drone Industry Insights (2020, 2025). Revenue in bn. US dollars. The 2020 forecast did not cover years beyond 2025.

[2] Insider Intelligence (2021): *Drone market outlook in 2021: industry growth trends, market stats and forecast 2021*. <https://www.businessinsider.com/drone-industry-analysis-market-trends-growth-forecasts?IR=T> (Downloaded: 16. 05. 2021)

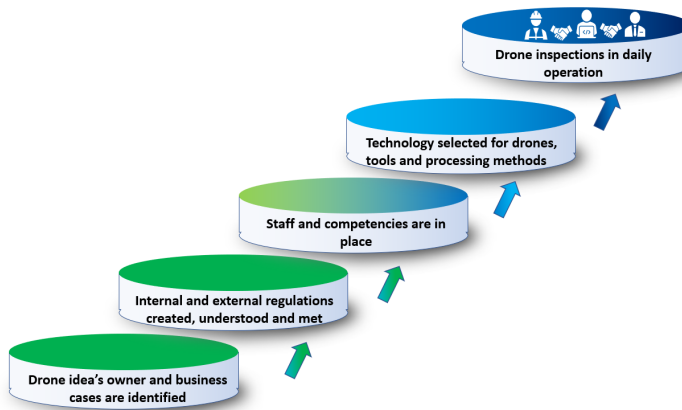
[3] Drone Industry Insight (2025): *Total Global Drone Market Size*. <https://droneii.com/wp-content/uploads/2025/04/Drone-Market-Growth-2025-2030.jpg>

Drone industry and related services provided significant growth potential [2], [3] from the year 2020 and the new regulations about beyond visual line of sight operations could be a further exponential boost for the industry. *Table 2* shows a retrospective comparison of the 2020 industry forecast against 2025 reported actuals and the revised forward-looking outlook. A moderated future growth can be expected, which might be explained by the establishment and harmonisation of drone specific regulatory and airspace control management frameworks ensuring safe operation across application areas.

The Five-Step Enterprise Adoption Framework

The authors defined five major steps that are enabling to scale up drone inspection from local hero level to enterprise grade solution. The five steps represent the major stages of drone usage evolution within a company who has limited exposure to this technology. The authors believe that this approach is also applicable for those companies who have experience with drone usage, however intend to scale it up into daily operation at most of their operation units.

Figure 1. Roadmap to apply drones in enterprise grade standard operation. Source: own



Step 1 – Opportunity identification and business case

The initial trigger to deal with drones could come internally or externally from any of the suppliers. This trigger shall be channelled into the opportunity evaluation channel of the company and the owner of the idea has to be nominated and authorised with relevant resource to run an initial series to identify potential business cases. The business cases shall be adjusted with value calculations. It is worth to make a sense check about the identified use cases, either by examining the relevant literature or running discussions with the spotted business unit leaders, engineers and operators. The possible next step is to run pilots on the identified business cases to validate the idea in the reality of the given operation unit. All these pilots must have the approvals from the relevant internal and external organisational units.

Step 2 – Regulatory and compliance foundations

Assumingly pilot drone inspections confirmed some of the business cases that make economical the further investments in drone inspection technology, the external regulations must be understood. External regulatory environment could accelerate the penetration of the drone inspection, but at first, it must be completely checked, understood and applied. There could be cases when an attractive business case cannot be put into daily operation due to the external regulations. To comply with external regulations is a must to have a safe daily operation. Relevant teams from the company shall deal with authorities and meet the regulation requirements. The internal regulations are also as important as the external ones and the teams shall consider the potential changes in the internal regulations and the creation of a companywide drone regulations section in order to ensure safe and transparent drone inspection operation. Depending on the planned drone operation model, internal regulations shall consider the case if a third-party drone service provider would be involved in the process.

Step 3 – Operation model decision

Properly communicated decision about operation model increases the transparency about drone inspections and starts to penetrate the idea within the company. The original teams who delivered the first and second steps might be adjusted with newly joining operation team members or a completely new team can be created who will deal with building up the necessary competencies and technological background. The operation model can have three major approaches: internal drone team with own equipment, external drone team with equipment, or a hybrid solution as a mix of the above two. All operation models could deliver the required benefits, assumingly the components are properly planned and applied. An intercompany drone inspection service catalogue creation could help the internal customers to use the regular work order channels if they want to apply drone inspection in operation.

Step 4 – Technology and competency buildup

The authors propose a purpose-oriented technology selection that serves the realisation of the drone business plan or even the drone strategy of the company if such was created. Depending on the industry where the drones are applied there are special equipment options but there are general ones such as thermographic camera that can be successfully applied in drone driven inspection processes. The parameters of the selected equipment have to comply with the safety regulations at the sites. A professional, experienced pilot with certified licences is a critical factor to manage unexpected situations safely during operation. However, the success of a drone based industrial inspection nowadays depends rather on the data capturing and analysis technology than on the carrier unit itself. Inspection data capturing, geolocation, equipment tagging, time and relevant metadata capturing, analytical software capabilities and AI backed automation opportunities are increasingly the decisive factors in securing top management or budget owner commitment to an enterprise scale, AI blended drone adoption program.

Step 5 – Scale up to enterprise grade

Growing from local hero initiative to a group level daily operation process is hard and, in many cases, can happen only if the relevant managerial support is backing the idea. Same goes for drone inspection as well, a powerful coalition is required to successfully apply the drone idea on enterprise grade level. In order to use the results of drone inspection in the regular decision-making processes the new way of inspection shall be communicated within the organisation and the relevant processes have to be put in place.

Drone Inspection in Practice

Drone inspection has the purpose to safely and quickly identify potential anomalies in complex industrial infrastructural systems. Additionally, a photogrammetric 3D model can be created about the inspected objects by utilising the gathered pictures and videos, serving as the foundation for a digital twin. Multiple software is on the market which can be used for creating photogrammetric 3D models from captured photos. It is important to properly set the reference point in the model and then the created photogrammetric 3D model will be a solid and measurable building block of the digital twin ecosystem.

The inspection needs to be properly planned. The first step is to define the purpose of the actual surveillance. Most widely used inspection goals cover areas such as visual inspection or thermographic inspection. Having agreed the purpose, the inspected area's hazardous ranking shall be identified. Generally, the operation units have their own rule book about the applied safety requirements. The drone flight planning team must carefully examine this rule book and make the necessary steps to comply with the requirements.

Technical preparation comes after the understanding of the hazardous environment and conditions to be met such as ATEX related conditions. The drone and the equipment must be selected accordingly.

Drone inspection must be carefully planned and executed. This is a multidomain task where the most visible role is the drone pilot's one. In many cases the drone inspection is done by minimum two, and generally three persons: the pilot, the drone equipment operator and the observer. Major risks are related to heat, wind, confined spaces, hidden or barely visible objects. Prior take off the pilot has to investigate the visible obstacles and potential hazardous factors and collect all relevant information from the operation unit safety leader. The weather forecast has to be checked prior the take off and regularly monitored during the flight.

The process of the drone inspections starts with legal, security and HSE processes. If all three are in place, then the scheduling with the operation unit leader, maintenance, process engineer and service providers can commence. Performing the flights is the most visible part of the process and especially at the beginning it could be an attraction for people around, therefore safety measures have to consider how to handle viewers. During the flight the main activities are photo and video capturing.

Anomaly inspection part of the process starts as soon as the first photos are available at the ground either on the control panel or at the place equipped accordingly. The photos and videos have to be transferred for the processing unit, where the pictures and videos are checked either by man or by algorithms to retrieve information from the raw datasets. The scale of the inspection and the available budget define in many cases the image processing technologies. Process is continued with creating the documentation of the anomaly detection and triggering potential anomalies explicitly georeferenced in the material. The photogrammetric 3D model of the inspected areas is created by a selected software using the captured photos and videos in a parallel process with the anomaly detection process.

On-the-spot evaluating method is very fast and gives the opportunity to real time physical counter-check of the potential anomaly spot. From accuracy point of view the inspector group heavily depends on the screen resolution of the control panel, and on the bandwidth for the transmitted information between the drone and the control screen. Not all inspections have this technology in place and even having the latest technology the weather conditions can significantly influence the effectiveness of the inspection. One could pose the question: what else can be done? The potential answer is the semi-automatic or autonomous image and video processing capabilities, tools and processes – a direction that AI advancement is now making increasingly feasible.

Summary

This article spotted the potential of drone usage in industrial inspections and provided an insight about the wide range of existing and future application areas of drones. The article defined the building blocks of a process to scale up drone usage from local hero level to enterprise grade solution. Based on the research work and applied literature the conclusion is that drone usage will indicate many changes in the existing structures and companies could benefit the most of drone usage if technical and cultural aspects are equally handled during the drone usage establishment.

Drones can deliver benefits in multiple ways and this article highlighted the monitoring and surveillance capabilities of drones. To maximise the benefit of drone usage, companies might consider automatizing the processing of drone captured information. Automated image processing increases the speed and accuracy of inspections and could contribute to discovering hidden correlations.

Drone usage blended with automatized data processing opens new horizons for companies to increase value creation and reach net-zero targets. Autonomous drone operation combined with near-real time anomaly detection has already arrived, the relevant technologies are available and the regulatory framework is actively framing the opportunity landscape to harvest the benefits from AI strengthened drone operation. Companies interested in heavy infrastructure operation or logistics are seeing growing evidence that drones equipped with proper tools are valid answers to increase operation efficiency and operational safety.