

Research Article

# The Importance of the Use of Unmanned Aerial Vehicles (UAVs) in the Oil and Gas Industry

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## Abstract

The oil and gas industry, renowned for its extensive and intricate operations, confronts numerous challenges in maintaining and inspecting its infrastructure. Traditional inspection methodologies, often reliant on manual labor, are not only time-consuming and costly but also expose workers to hazardous conditions. These conventional methods necessitate the shutdown of operations, leading to considerable productivity losses and elevated costs. Over the past decade, the advent of unmanned aerial vehicles (UAVs) has introduced a transformative technology in this sector, providing a safer, more efficient, and cost-effective alternative to traditional inspection techniques. UAVs, equipped with advanced sensors and high-resolution cameras, facilitate detailed visual and thermal inspections of critical assets such as pipelines, flare stacks, and offshore platforms. These capabilities enable companies to perform routine inspections without halting operations, thereby minimizing downtime and operational disruptions. The implementation of UAV technology has notably enhanced safety by reducing the need for human intervention in perilous environments. For instance, the traditional inspection of flare stacks necessitates workers to ascend these structures, posing significant risks. UAVs obviate this requirement by delivering real-time visual data from secure distances. Moreover, the precision and accuracy inherent in UAV inspections contribute to the early detection of defects and potential issues, allowing for prompt maintenance and repairs, which further augment safety and operational efficiency. The environmental benefits of UAV technology are also noteworthy. By diminishing the reliance on heavy machinery and extensive transportation typically associated with inspections and maintenance, UAVs aid in reducing carbon emissions, thus aligning with the industry's sustainability objectives. In summary, the integration of UAVs into the oil and gas industry's inspection protocols represents a significant technological advancement. This integration aligns with the sector's goals of enhancing safety, efficiency, and environmental sustainability, marking a pivotal step forward in the industry's evolution.

## Keywords

Unmanned Aerial Vehicles (UAVs), Oil and Gas Industry, Offshore Operations, Real-Time Visibility, Flare Stack Issue, Carbon Emission

## 1. Introduction

Unmanned Aerial Vehicles (UAVs) have emerged as a pivotal technology in the inspection and detection of structural damages, both offshore and onshore [1, 8]. This ad-

vancement aligns with corporate expectations, enhancing employee safety while meeting operational demands efficiently [2]. UAV technology, equipped with high-resolution

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**Received:** 6 June 2024; **Accepted:** 5 July 2024; **Published:** 31 July 2024



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cameras and thermal detectors, significantly reduces maintenance and inspection times, offering a superior alternative to traditional methods [11].

The primary advantage of UAVs lies in their ability to capture high-quality images that allow inspectors to accurately assess the condition of structures such as flare stacks, which are prone to fatigue stress and damage. These images, characterized by their high resolution, enable the detection of even minor defects, facilitating timely and precise maintenance interventions [13]. The thermal sensors equipped on UAVs measure surface temperatures and detect subtle thermal variations, further enhancing their diagnostic capabilities.

Cost-effectiveness is another crucial benefit of UAV inspection. Unlike traditional methods that may require operations to halt, UAVs can perform inspections without disrupting ongoing activities. This continuous operation capability prevents unnecessary shutdowns and associated financial losses. Moreover, UAV inspections mitigate the risks associated with manual inspections in hazardous environments. Traditional methods often involve technicians climbing to dangerous heights under challenging weather conditions to assess structural conditions. In contrast, UAVs eliminate the need for physical human presence, allowing remote operation and monitoring [5].

This study aims to highlight the significant role of UAVs in structural inspections, emphasizing their technological advantages and operational benefits. The research provides a comprehensive review of current methodologies and their limitations, positioning UAV technology as a superior solution in the context of structural maintenance and safety [10]. The findings underscore the efficacy of UAVs in reducing inspection times, enhancing safety, and providing cost-effective solutions for ongoing and future operations [11].

## 2. Materials and Methods

In the inspection of offshore structures, both commercial and specialized drones are employed within the industry, offering advanced capabilities that enhance operational efficiency and safety. Two notable examples of drones actively used in the oil and gas industry are the Aeryon SkyRanger and the Lockheed Indago 2. Additionally, in the oil and gas industry, drone inspections are primarily conducted using two methods: Thermography Inspection and Close Visual Inspection (CVI) [1]. Each method offers unique advantages and capabilities for assessing the condition of offshore and on-shore structures [14].

### 2.1. Aeryon Skyranger

#### 2.1.1. Purpose

The Aeryon SkyRanger's operational capabilities are designed to meet the demanding needs of the oil and gas industry.

It is equipped with advanced navigation and control systems that ensure precise flight paths and stability even in challenging conditions. The SkyRanger can be deployed quickly and efficiently, with minimal setup time required. Its high-resolution cameras provide detailed visual and thermal data, allowing operators to conduct thorough inspections without needing to halt operations. The drone's endurance of up to 50 minutes allows for extended missions, covering large areas in a single flight. Additionally, the SkyRanger's ability to operate in a wide range of temperatures makes it suitable for inspections in various environments, from extreme cold to intense heat. The real-time streaming capabilities enable immediate data analysis and decision-making, enhancing the overall efficiency and effectiveness of the inspection process. [11].



*Figure 1. Aeryon Skyranger Drone.*

#### 2.1.2. General Characteristics

Empty Weight: 2.4 kg (5 lb.)  
 Maximum speed: 50 km/h (31 mph, 27 kn)  
 Cruise speed: 40 km/h (25 mph, 22 kn)  
 Range: 5.0 km (3.1 mi, 2.7 nmi)  
 Endurance: 30-50 minutes  
 Service ceiling: 5,000 m (15,000 ft)

### 2.2. Lockheed Indago 2

#### 2.2.1. Purpose



*Figure 2. Lockheed Indago 2 Drone.*

The Lockheed Indago 2 is another advanced drone used for inspection in the oil and gas industry. It can capture detailed images from a distance of 300 feet, allowing inspections to be conducted during regular operations without the need for shutdowns. This capability ensures continuous monitoring and reduces operational disruptions.

### 2.2.2. General Characteristics

Empty Weight: 4.4 lbs (2050 grams) with payload  
Range: 10 km (depending on the transmission system used)  
Endurance: 50-75 minutes with payloads  
Operating Altitude: 18,000 ft

These drones, with their high-resolution imaging and robust operational capabilities, provide invaluable support in maintaining the integrity of offshore structures, ensuring safety, and optimizing inspection processes [6].

## 2.3. Thermography Inspection

### 2.3.1. How It Works

Thermal imaging using small unmanned aerial vehicles (sUAVs) or drones has become increasingly popular for inspections in the oil and gas industry. Thermography, the study of heat or infrared radiation (IR) emitted by objects, leverages thermal cameras to detect and visualize heat signatures from both animate and inanimate objects. Before delving into the specifics of thermal imaging, it is crucial to understand several fundamental aspects of thermography [2].

Firstly, while humans can feel heat, they cannot see it, as heat is part of the infrared wavelength of the electromagnetic spectrum. The visible light humans perceive is only a small portion of this spectrum. In contrast, thermal cameras capture infrared energy and convert it into images that are visible to the human eye. This capability makes thermal cameras an invaluable tool for revealing heat patterns and anomalies that are otherwise invisible, thus enhancing the inspection process in the oil and gas industry.

### 2.3.2. Process of Thermography Inspection

**Preparation:** Set up the drone with an IR camera and configure the necessary settings based on the specific inspection requirements.

**Flight Execution:** Operate the drone to fly over the target structures, capturing thermal images at various angles and distances.

**Data Collection:** Gather high-resolution thermal images and videos, ensuring coverage of critical areas prone to defects or damage.

**Analysis:** Analyze the thermal data to identify hotspots, temperature differentials, and other anomalies that could indicate underlying issues [12].

**Reporting:** Compile a detailed report with annotated thermal images, highlighting areas of concern and providing

recommendations for further action or repairs.

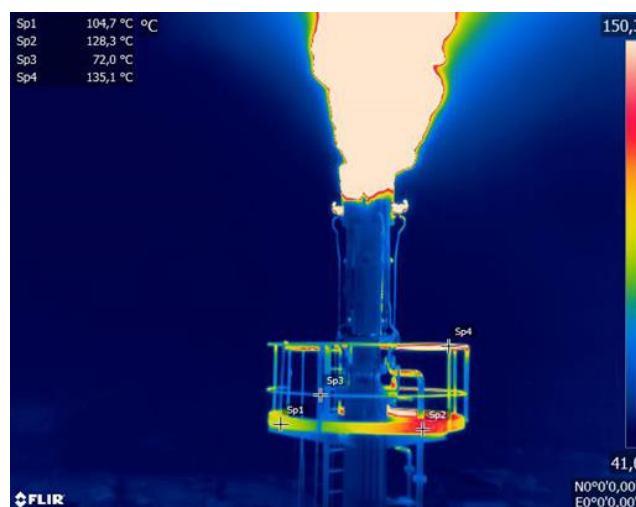
## 2.4. Close Visual Inspection (CVI)

### 2.4.1. Benefits of CVI

Unmanned Aerial Vehicles (UAVs) have revolutionized traditional flare stack inspections, significantly reducing the time and effort required for planning, preparation, and on-site work. Unlike traditional methods, UAVs do not necessitate taking the flare system temporarily offline, thereby avoiding productivity losses [9]. This approach has become increasingly common in the oil and gas industry, particularly for inspecting flare stacks, tips, and pilot ignition systems [10].

The high-resolution images captured by UAVs offer numerous advantages for accurate issue detection. These images can reveal fatigue failures and other stress-related deformations, providing detailed insights into the condition of the structures. By analyzing these high-quality images, operators can make informed decisions on whether to shut down the flare for maintenance [7].

Furthermore, UAV inspections allow for the assessment of structure status without the need for cooling down periods or assigning personnel to climb the flare tower, thereby enhancing safety and efficiency.



**Figure 3.** Thermal Image of a Flare Stack Captured by UAV during Inspection.

**Figure Description:** The thermal image shows the temperature distribution on a flare stack, with key points (Sp1, Sp2, Sp3, Sp4) indicating specific temperature readings. The highest temperature recorded is 135.1 °C at Sp4, highlighting the areas of intense heat. This image was captured using a UAV equipped with a FLIR thermal camera, demonstrating the capability of UAVs in detecting thermal anomalies and ensuring efficient inspection of offshore structures.

### 2.4.2. Process of CVI

**Preparation:** Equip the drone with high-resolution electro-optical (EO) cameras and configure the settings for optimal image capture.

**Flight Execution:** Pilot the drone to perform close-up inspections of the structures, capturing high-quality images from various perspectives and distances.

**Data Collection:** Acquire a comprehensive set of visual images, focusing on critical areas that require detailed examination.

**Analysis:** Review the collected images to detect any visible defects or anomalies, documenting their locations and severity.

**Reporting:** Generate a detailed report with annotated images, describing the identified issues and suggesting necessary maintenance or repairs.



**Figure 4.** Visual Inspection of Flare Stack Damage Captured by UAV.

**Figure Description:** The images show visible damage and deformation on a flare stack, including heat-induced warping and burn marks, captured by a UAV during an inspection. The use of UAV technology allows for detailed close-up visual assessments of structural integrity without the need for manual inspection, enhancing safety and efficiency offshore.

**Table 1.** Comparison of UAVs Tech & Traditional Methods.

Aspect	UAVs Technology	Traditional Methods
Flare Stack Shutdown	No shutdown required: %0	Approx. 2 days: 100%
Number of Required Labour	Experts for UAVs: 17%	Operators, Engineers, Technicians for Traditional Methods: 83%
Cost Associated with Flare Stack Shutdown	\$5,000 (2%)	250,000 (98%)
Required Time for the Inspection	4 hours (2%)	168 hours (98%)

\*The table highlights the substantial advantages of using UAV technology over traditional methods for inspecting flare stacks. UAVs minimize downtime, reduce the number of required labors, lower costs, and drastically cut down inspection time. These benefits make UAVs a more efficient and cost-effective solution for the oil and gas industry.

## 3. Results

### 3.1. The Time Savings

The study demonstrated that utilizing UAVs for inspection purposes leads to significant time savings. Traditional methods require extensive planning, preparation, and on-site time, often extending the inspection process to weeks. In contrast, UAV inspections drastically reduce this timeframe. The data indicated a 97% saving in total operation time when UAV technology is employed compared to only a 3% saving using traditional methods. This remarkable reduction in inspection time highlights the efficiency of UAVs in streamlining maintenance operations.

### 3.2. Cost Savings

The cost-effectiveness of UAV inspections is another major finding of this study. Traditional inspection methods often necessitate operational shutdowns, leading to substantial financial losses. The study revealed that UAV technology mitigates these costs by allowing inspections to be conducted without halting operations. Specifically, the cost associated with flare stack shutdowns using traditional methods was approximately \$250,000, whereas UAV technology reduced this cost to just \$5,000. Overall, UAVs offered a 78% saving in inspection costs compared to 22% for traditional methods, emphasizing the economic advantages of adopting UAV technology.



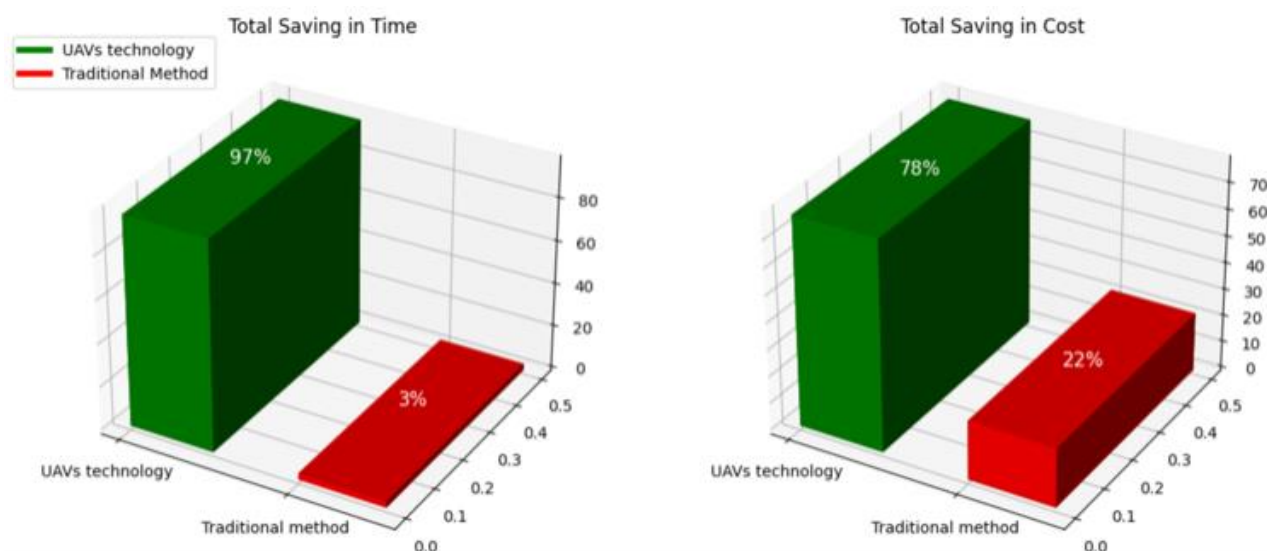


Figure 5. Saving in Time and Cost Compared to UAVs and Traditional Application.

The left 3D bar graph demonstrates that utilizing UAVs results in a substantial 97% saving in time for the entire operation. In contrast, traditional methods only achieve a 3% time-saving. This significant difference highlights the efficiency of UAV technology in reducing the duration of inspection processes, allowing for quicker and more streamlined operations.

The right 3D bar graph illustrates that UAV technology is far more economical, offering a 78% saving in costs compared to traditional methods, which provide only a 22% cost saving. This notable cost reduction underscores the financial benefits of employing UAVs for inspections, making it a more cost-effective solution for the oil and gas industry.

### 3.3. Safety Improvements

One of the most critical aspects of UAV technology is its impact on safety. Traditional inspection methods often involve hazardous conditions where technicians must climb flare stacks or work in dangerous environments. The study highlighted that UAVs eliminate the need for such risky activities, as inspections can be performed remotely. This not only ensures the safety of personnel but also minimizes the likelihood of accidents and fatalities associated with manual inspections. The deployment of UAVs, therefore, represents a significant advancement in enhancing worker safety in the oil and gas industry [15].

### 3.4. Operational Efficiency

The study also highlighted the operational efficiency brought about by UAV inspections. UAVs can capture high-resolution images and thermal data, enabling precise detection of structural defects such as fatigue failures and thermal anomalies [4]. This capability allows for more accurate assessments and timely maintenance decisions, ensuring

the structural integrity of offshore and onshore facilities. Additionally, UAVs provide continuous real-time visibility into systems and sites, facilitating better monitoring and management of assets [3].

## 4. Discussion

The implementation of UAV technology in the inspection of offshore and onshore structures in the oil and gas industry represents a significant advancement over traditional methods. The results of this study underscore the numerous benefits of UAVs, including reduced inspection times, enhanced safety, and cost savings. These findings align with existing literature that highlights the effectiveness of UAVs in various industrial applications.

A key advantage observed is the ability of UAVs to capture high-resolution images and thermal data, which are crucial for identifying structural defects such as fatigue failures and thermal anomalies. This capability has been corroborated by other studies, which emphasize the precision and reliability of UAVs in detecting minor defects that might be overlooked by manual inspections [1, 2]. Furthermore, the ability to conduct inspections without shutting down operations aligns with findings from prior research, demonstrating significant cost savings and operational efficiency [3, 4].

When comparing our results with those of other studies, it is evident that the integration of UAVs into inspection protocols offers a superior alternative to traditional methods. For instance, a study by [1] highlighted the limitations of manual inspections, including the risks associated with climbing structures and the inability to detect subtle defects. Our findings support these observations, illustrating how UAVs can overcome these challenges by providing safe, remote, and detailed inspections.

The safety benefits of UAVs cannot be overstated. Tradi-

tional inspection methods often place technicians in hazardous environments, such as high flare stacks or extreme weather conditions. UAVs mitigate these risks by enabling remote inspections, thereby protecting personnel from potential accidents and injuries. This aspect of UAV technology is particularly relevant given the increasing focus on occupational safety in the oil and gas industry [5].

Future research should focus on further enhancing the capabilities of UAVs through the integration of advanced technologies such as Machine Learning (ML) and Artificial Intelligence (AI). These technologies can improve the analysis and interpretation of the data collected by UAVs, leading to even more accurate and efficient inspections. For example, AI algorithms can be trained to identify specific types of defects from thermal and visual data, thereby automating the inspection process and reducing the reliance on human expertise.

Additionally, the development of more robust and weather-resistant UAVs will expand their applicability in harsh offshore environments. Research into improving battery life and range can also enhance the operational efficiency of UAVs, allowing for longer and more comprehensive inspection missions.

In conclusion, the use of UAVs for inspection in the oil and gas industry presents a transformative approach that addresses many of the limitations of traditional methods. The findings from this study, supported by relevant literature, highlight the significant benefits of UAV technology in terms of safety, efficiency, and cost savings. Future research should continue to explore and refine UAV capabilities, ensuring that this technology remains at the forefront of industrial inspection practices.

## 5. Conclusions

The utilization of UAV inspection techniques is critical for ensuring the maintenance and operational safety of offshore and onshore platforms in the oil and gas industry. The advantages of UAV technology are undeniable, offering significant benefits such as reduced inspection and maintenance times, cost savings by eliminating the need for operational shutdowns, and enhanced safety for crew members who no longer need to perform dangerous climbs or work in hazardous areas.

Looking ahead, the application of UAVs in the oil and gas sector is expected to expand significantly. The integration of Machine Learning (ML) and Artificial Intelligence (AI) techniques will further enhance the capability of UAVs, allowing for more precise analysis and interpretation of the high-resolution images and data they collect. This advancement will lead to more accurate and reliable inspection results, driving efficiency and safety improvements across the industry.

In conclusion, companies that choose to invest in UAV technology or are currently employing UAVs in their operations are likely to see substantial benefits. The ongoing advancements in UAV capabilities promise to make these sys-

tems even more integral to the oil and gas industry's inspection and maintenance processes, ensuring safer, more efficient, and cost-effective operations.

## Abbreviations

CVI	Close Visual Inspections
UAV	Unmanned Aerial Vehicle
FLIR	Forward Looking Infrared
ML	Machine Learning
AI	Artificial Intelligence
EO	Electro-Optical
IR	Infrared Radiation

## Acknowledgments

The authors would like to express their gratitude to the Turkish Petroleum Corporation for providing the financial support and resources necessary for this research. Special thanks go to the technical team for their assistance in data collection and analysis, and to the management for their unwavering support. The authors also acknowledge the contributions of their colleagues and peers who provided valuable feedback and insights during the course of this study.

## Author Contributions

Taha Enes Kon is the sole author. The author read and approved the final manuscript.

## Conflicts of Interest

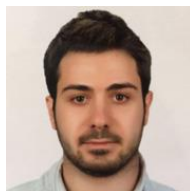
The authors declare no conflicts of interest regarding the publication of this paper.

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## Biography



**Taha Enes Kon** has been working as a Sr. Mechanical Engineer at Turkish Petroleum Corporation for six years. He earned his bachelor's degree in mechanical engineering from Erciyes University in Turkey and a second bachelor's degree in business administration from Anadolu University.

During his undergraduate studies, he participated in an exchange program at Széchenyi Istvan University in Hungary, where he studied and analyzed the Audi TT's engine design. His bachelor's dissertation focused on creating and analyzing a model airplane using SolidWorks CAD software. After completing his bachelor's degrees, Taha received a scholarship from Turkish Petroleum Corporation to pursue a master's degree in the USA. He completed his master's in mechanical engineering at Drexel University, PA, with a dissertation on improving maneuverability in jet fighters. He then enrolled in a second master's program in Computer Science at Georgia Institute of Technology. Currently, he continues to contribute to the Turkish Petroleum Corporation as a Sr. Mechanical Engineer.