

Drones: Ensuring cost-effective maintenance of oil and gas pipelines

WHITE PAPER

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Executive summary

Oil and gas pipelines transport hydrocarbons around the globe. Drones, or unmanned aerial vehicles (UAVs), can help enhance the working life and operational efficiency of these important parts of the global energy infrastructure.

Pipelines are the blood veins of the global oil and gas sector. They are an established means of secure and cost-effective transport of crude oil, natural gas and other petroleum products around the world.¹ Ensuring reliable access to these energy lifelines needs systematic and continuous efforts on two primary fronts: one, higher operational efficiency of pipelines; and two, longer effective

operational lifetime of the existing pipeline infrastructure. Drones, as a subset of Fourth Industrial Revolution technologies,² are poised to play a transformational role in this sector. This paper is intended for government officials, pipeline operators and drone sector stakeholders, and has three broad objectives:



To outline how drones can make the traditional means of monitoring and managing this important segment of the energy infrastructure safer, more economical and more efficient.



To explore diverse types of drone uses in the pipeline segment that not only deliver faster returns on investment but also spur greater efficacy.



To propose a sandbox approach for accelerating the adoption of drones in the pipeline segment.

This document will serve as a starting point for a community-based approach to a broader

understanding of UAVs among pipeline operators, government agencies and drone service providers.

Introduction

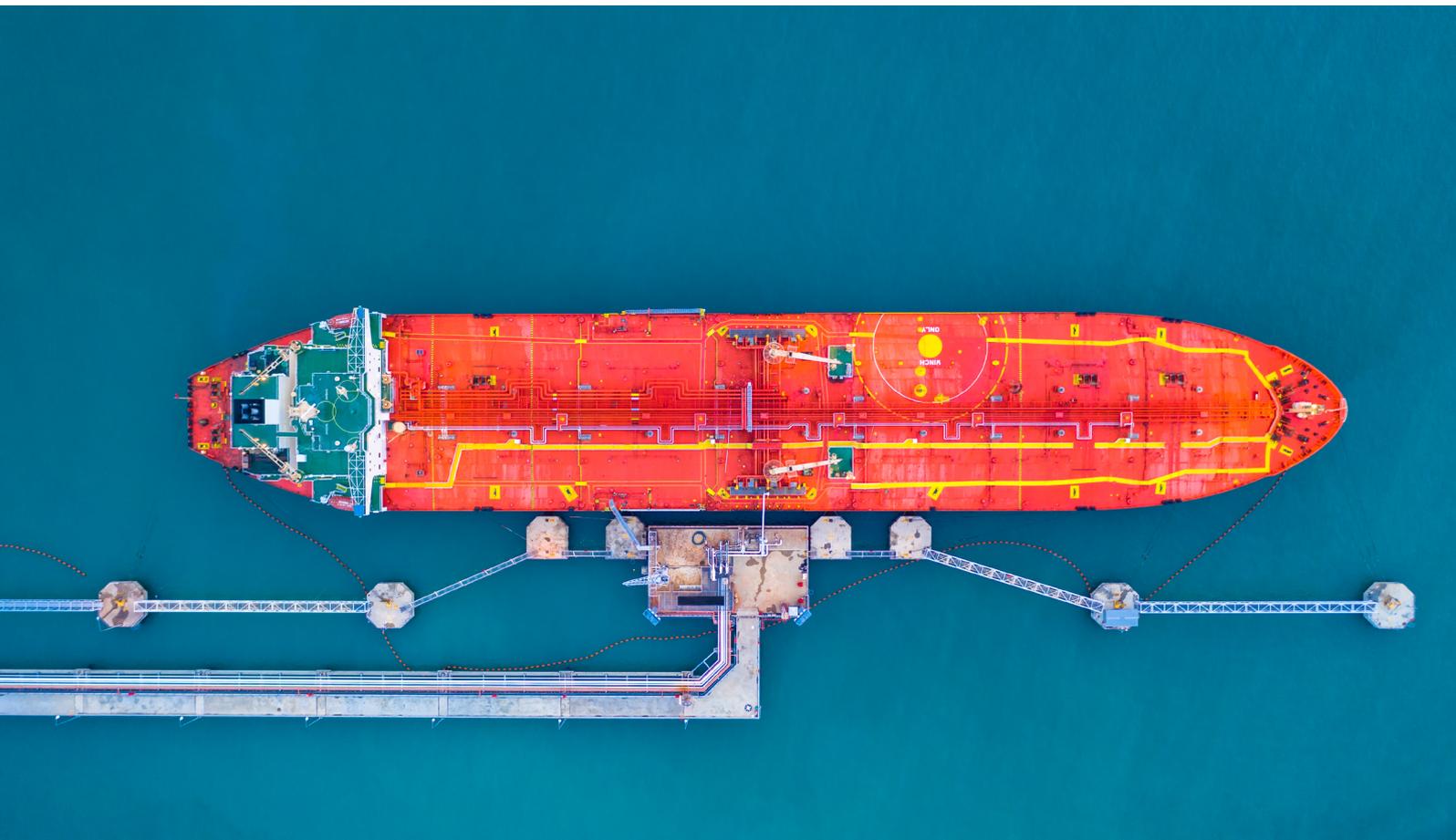
Pipelines are among the most widespread methods of transporting hydrocarbons and petroleum products worldwide.³ The overall length of the oil and gas trunk (main) pipelines globally stood at 1.89 million kilometres in 2020,⁴ that is nearly five times the distance between the Earth and the moon. North America, Asia and Africa are expected to lead global pipeline expansion for the next few years.⁵ Apart from domestic pipelines, several cross-border oil and gas pipelines operate in different parts of the world.

As the world endeavours to arrive at pre-pandemic levels of economic activity, the promise of long-term growth and accelerated infrastructure expansion suggests that global energy consumption will increase. With the enhanced focus on non-conventional energy sources, the oil and gas transit infrastructure will need to deliver higher-than-normal operational efficiency while extending the lifespan of existing pipelines. These imperatives open up significant opportunities for the use of drones to support such initiatives.

While the upkeep of pipelines is essential for global economic growth, the threat emanating from natural disasters and other external factors, etc. is omnipresent. Drones can act as a critical cog in the response machinery for each of these challenges, thereby ensuring smooth energy trade across regions and around the world.

To understand the scope of drones' applicability in the pipeline segment, it is essential to understand energy supply chains. Considering that global energy reserves are unevenly concentrated,⁶ their transport involves primarily pipelines, in addition to shipping.⁷

Cross-country and cross-border pipelines transport crude oil, petroleum, gas and other associated products across long distances. In countries that import crude oil, pipelines transport imported crude to dedicated storage areas, and then to refineries to be converted into finished products.⁸ After processing, the finished products are re-transported through a product pipeline to designated end-users.⁹ In case of natural gas, the liquefied gas is re-gasified at dedicated plants and transported further via pipelines.¹⁰ In some instances, oil and gas reserves are concentrated in offshore areas, requiring their transport via undersea pipelines.¹¹



Drone use cases for pipelines

Drones can play an important role in ensuring safe operation of pipelines at different stages in the energy supply chain. The world over, experts have discussed leveraging drone technology to plan pipeline projects, carry out route surveys and perform regular inspections to ensure safety and security.¹²

Combined with advanced software, drones can deliver superior analysis and insights based on high-resolution images, videos and associated geospatial data on pipelines. This can assist project planners, implementation agencies and pipeline operators in making more informed decisions. Conventionally, the task of performing pipeline surveys is carried out by deploying human resources on foot, using vehicles or helicopters.¹³ These tasks involve considerable human effort and expenditure. However, with developments in drone technology and associated visual intelligence tools, these tasks can be performed more efficiently and at

relatively lower costs.¹⁴ In some instances, industry data indicates that drones could slash the costs of inspection of energy infrastructure by nearly 50%.¹⁵

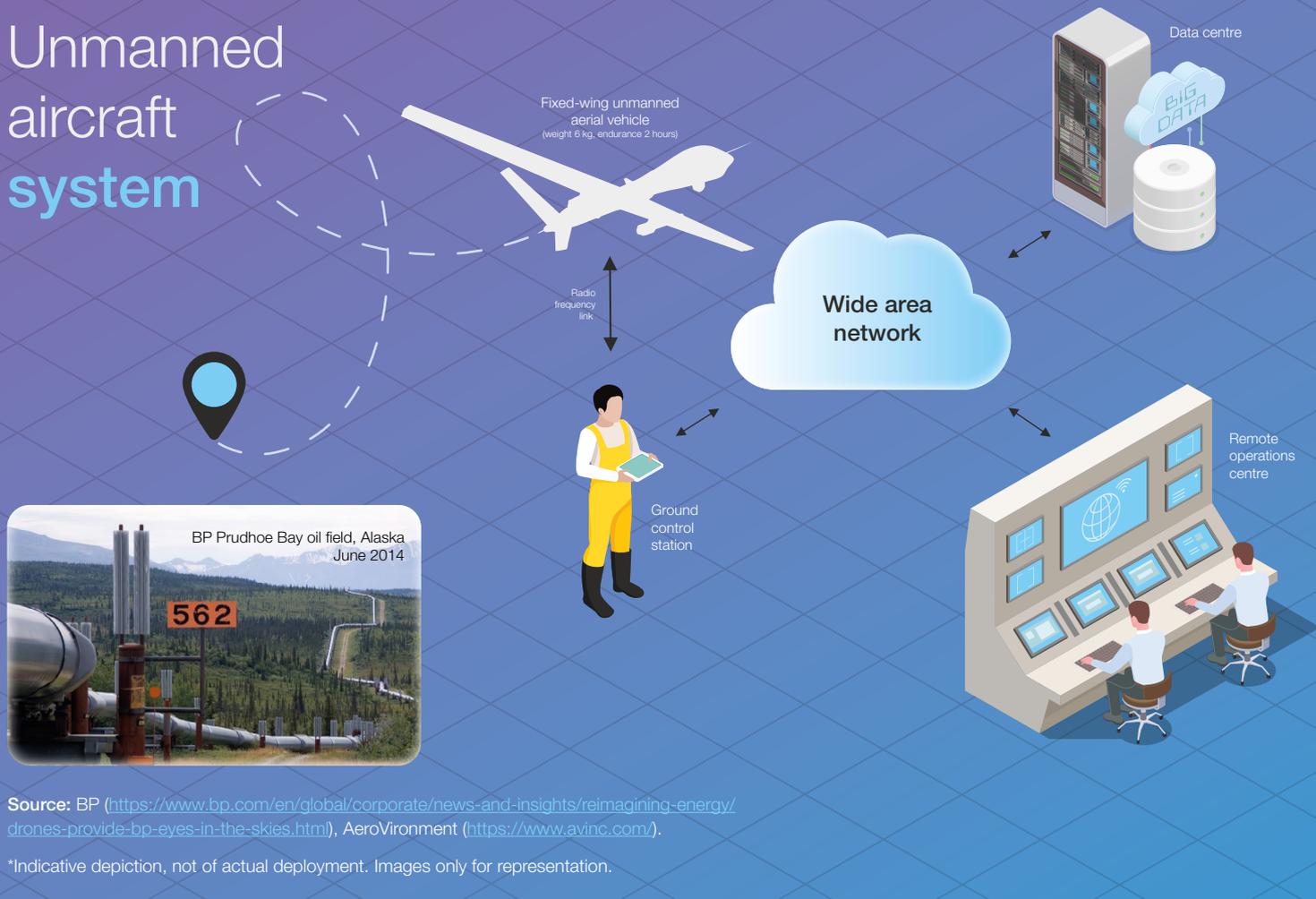
From the perspective of saving costs and resources, generating accurate data¹⁶ and ensuring safety and security of personnel,¹⁷ the case for deploying drones is strong. As the regulatory regime worldwide eases in coming years, more and more drone companies are expected to show interest in participating in pipeline projects and operations. Drones can be used in many ways across a range of pipeline activities including project planning and design, construction and operations.¹⁸

The next section examines the most impactful use cases in which drones would not only justify the investment but also deliver benefits difficult to achieve by other means.

1.1 Construction

1. **Progress monitoring:** Construction of a new cross-country or international pipeline involves substantial investments and is an activity spread over long distances. Often, multiple stakeholders are involved, including lenders and investors in pipeline infrastructure assets. Drones can be used to capture high-quality images and video footage for planning pipeline routes and enhancing the investment pitch to potential investors. Once construction begins, drones can take similar footage at regular intervals to generate visually appealing data about the progress of construction activity for investor briefings.¹⁹
2. **Real-time remote instructions:** Drones mounted with high-resolution cameras and loudspeakers can assist project managers to remotely perform real-time monitoring of actual work progress²⁰ and relay specific instructions to site supervisors²¹ based on their visual assessment from thousands of kilometres away.
3. **Transport of material:** Logistics drones offer the unique proposition of lifting and transporting equipment and materials to aid construction activity²² in challenging terrains. They can also be used to drop emergency supplies to workers during extreme weather events and other contingencies.²³
4. **Inventory management:** Drones can perform on-site inventory management²⁴ of construction material and equipment using radio-frequency tags and readers, especially when material and equipment are spread across vast terrains and have to be moved frequently.
5. **Safer blasting operations:** Drones mounted with high-resolution optical and thermal cameras can assist construction²⁵ and safety managers in performing blasting operations safely by ensuring no human being is present within the radius of the blast effect.²⁶ Moreover, drones can help clear people from areas adjacent to the blast site by announcing the risk to trespassers unaware of the risk to their lives.

Unmanned aircraft system



1.2 Safety, operations and maintenance

- 1. Detecting leakages and spills:** Gas leaks and oil spills from pipelines pose the risk of damage to the environment, property and human life in adjacent areas.²⁷ Timely containment of such leaks and spills can prevent financial loss and reputational damage to pipeline operators. Using specialized sensors, drones can detect such gas leaks and oil spills²⁸ and the extent of their spread. Further, drones can send live feeds to aid disaster management authorities in containment operations.
- 2. Safety audits:** Drones can be used to perform comprehensive inspections and safety audits of pipeline infrastructure²⁹ to assist with pipeline failure investigation, compliance with personal protective equipment norms, etc.
- 3. Preventive inspection:** Drones mounted with specialized cameras and payloads can be used to carry out regular inspection activities³⁰ like checking the structural integrity of pipelines³¹ and the condition of compressor stations to pre-empt maintenance issues and damage.³²

1.3 Security

- 1. Risk assessment:** Pipelines often pass through sensitive areas. To overcome vulnerabilities³³ in such areas, regular risk assessment exercises are essential.³⁴ Drones with special sensors can assist security managers in performing surveys in such areas.³⁵

2. **Replacing foot patrolling:** Regular drone flights can replace conventional forms of surveillance such as foot patrolling.³⁶ This could avert unnecessary safety risks to patrolling personnel such as from snakebites, slips and falls, and unsafe night patrols.

3. **Incident management:** Globally, pipeline maintenance has been a challenging task.³⁷ When any incidents are anticipated or have occurred, security managers can rapidly deploy drones for live tracking of intruders and relay their precise location to law enforcement authorities.³⁸

1.4 Managing contingencies

1. **Assisting in disaster management:** Drones can aid the authorities in carrying out damage assessment and in delivering essential equipment and emergency medical supplies.³⁹ They can also assist first responders with more comprehensive situational awareness in the affected areas of a pipeline.⁴⁰ After disasters, drones can assist company personnel in performing repairs.

2. **Extinguishing fires:** Drones equipped with special hosepipes can spray extinguishing foam in case of a fire.⁴¹

3. **Telecom connectivity:** Telecommunications companies are carrying out trials to provide short-term wireless internet connectivity using drones in areas with limited communication infrastructure during pipeline construction or during contingencies.⁴²

4. **Insurance claim verification:** Insurance companies can harness drone technology to verify damage when settling insurance claims.⁴³

1.5 Environmental gains

1. The downstream segment of the energy supply chain, of which pipelines are an important part, is responsible for methane emissions.⁴⁴ Drones mounted with specialized sensors and cameras⁴⁵ can assist pipeline operators in environmental monitoring and in addressing emissions-related challenges.⁴⁶

2. By replacing traditional foot patrolling, vehicular and aerial surveillance methods, drones can reduce operators' carbon footprint.

1.6 Global deployments

In various parts of the globe, drone companies have been roped in for pipeline inspection and monitoring. For instance, a few entities in the USA have received permission on a case-by-case basis from the Federal Aviation Administration to perform tasks pertaining to pipeline monitoring in the beyond visual line of sight (BVLOS) mode.⁴⁷ A leading energy entity in Europe has reportedly begun using drones for performing surveillance of its pipeline infrastructure.⁴⁸

Interestingly, the pipeline segment in India has already shown foresight in realizing the potential of drone technology. For instance, the Gas Authority of India had placed an order in 2016 for conducting a drone-based aerial surveillance pilot project on two of its gas pipelines.⁴⁹ Recently, it was reported that the Indian Oil Corporation is working on drone-based monitoring of one section of a trunk oil pipeline.⁵⁰

2

Accelerating drone adoption

2.1 Policy

Globally, governments are making rapid progress in creating enabling policy frameworks to maximize the potential of drones. India, for example, has significantly reformed its drone regulations starting with the notification of new Drone Rules in August 2021 to ensure greater adoption of the technology. Almost the entire country, excluding sensitive locations (red zones) and urban areas around airports (yellow zones), has been opened up for commercial use of drones (green zone) up to a height of 400 feet.⁵¹ Most of the cross-country onshore trunk pipelines, falling in the green zone, are beginning to adopt drones faster under the simplified rules.

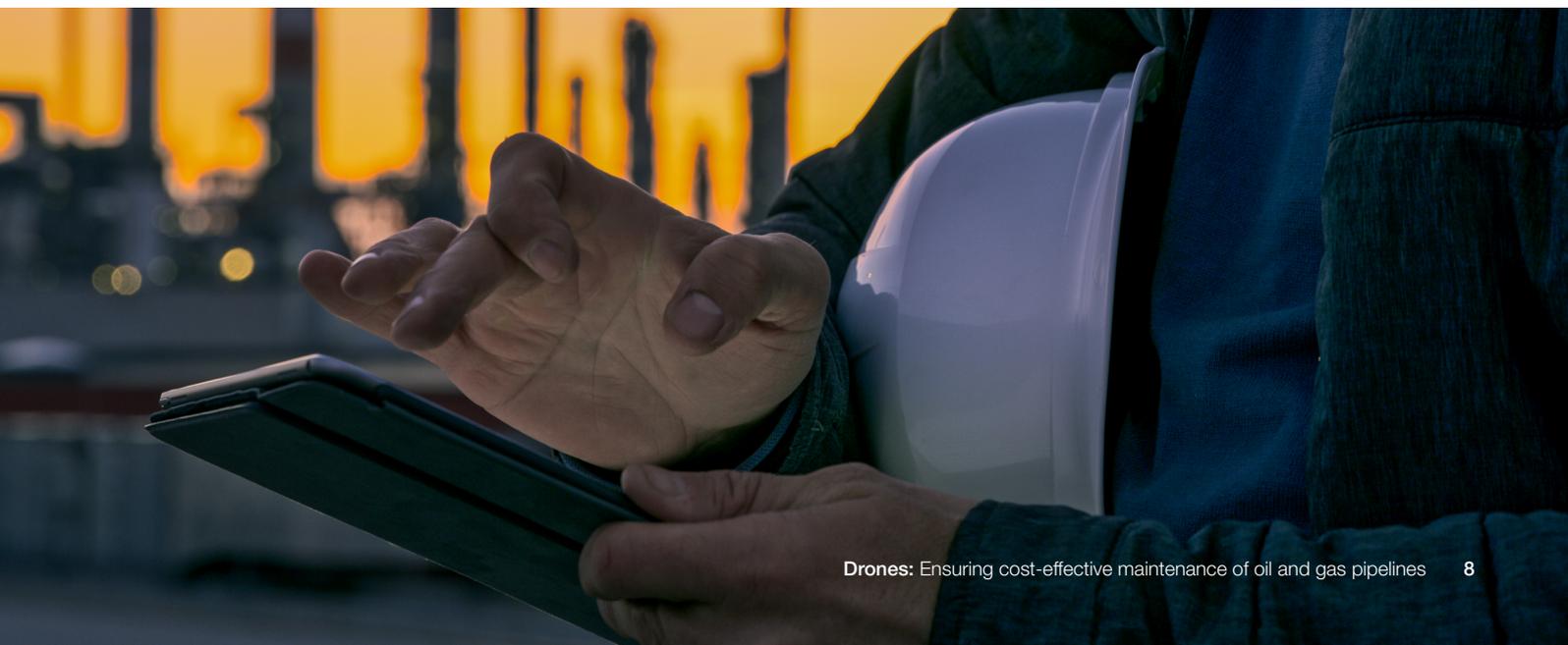
The traditional, labour intensive means of performing pipeline surveys are yielding dwindling profits even as end users expect superior results.⁵² With respect to pipelines, drones are uniquely positioned to perform these tasks with limited human intervention, using innovative tools to generate accurate data at lower costs, identifying pain points along the right-of-way and enabling optimal decision-making for constructors and operators.⁵³

To assess and prioritize various drone use cases in the oil and gas pipelines segment, each region or country can set up a regulatory sandbox in collaboration with all stakeholders. This would help regulators **derive key learnings to prepare**

suitable flight standards and operating procedures, while pipeline operators and drone service providers could test the robustness of drone use in meeting the pipeline segment's needs under varying conditions. Sector-specific experiments with the participation of different stakeholders and nationalities would induce more thoroughness and interdisciplinarity to help formulate more informed regulations. This will also enable innovators to gain insights **on process design, product value chains, product development and key industry expectations**.

At the same time, the sandbox approach would enable stakeholders to anticipate and plan for potential risks or downsides such as privacy considerations, safety concerns due to malfunction or hacking, and security threats from rogue drones. Regulators, manufacturers and service providers have a range of options to address these, including tracking of drones in real-time; training and certification of pilots; registration of users; and monitoring of drone flights.

After obtaining learnings from the proposed trials and conducting industry consultations, **regulatory authorities could consider making drone deployment mandatory for pipeline construction, rehabilitation and monitoring, as the National Highways Authority of India has done for all national highway projects.**⁵⁴



2.2 Stakeholders

This table lists the stakeholders who need to play a role in the evaluation and adoption of drones in the pipeline segment.

TABLE 1 **Community of stakeholders**

Entity	Role
Energy ministry	<ul style="list-style-type: none"> Derive insights from sandbox trials for policy planning and formulation Provide guidance on safety and security standards Promote the use of drones for cross-country pipelines
Civil aviation authorities	<ul style="list-style-type: none"> Formulate UAV policy; monitor and ensure compliance Obtain insights; provide support to overcome drone operation challenges
Pipeline asset owners and operators	<ul style="list-style-type: none"> Curate experiments for use of drones in wide variety of use cases Define key functional expectations and outcomes required Scope out drone missions and conduct cost-benefit analysis Adapt potential use cases and define data repository and governance parameters
Project management, planning and consulting agencies	<ul style="list-style-type: none"> Understand potential drone applications relevant for each customer Support customers in preparing requests for proposals for inviting bids Conduct technical evaluations and manage deployments
Engineering, procurement and construction (EPC) contractors	<ul style="list-style-type: none"> Evaluate and adopt use of drones during planning and implementation stages of new greenfield pipeline projects Transfer unmanned aircraft systems as core sub-systems for operations and maintenance to the pipeline operators
Drone service providers	<ul style="list-style-type: none"> Demonstrate drones' capabilities in the pipeline segment Gauge operational, environmental and technical challenges Understand pipeline operators' expectations Engage with all stakeholders to deliver end-to-end drone-as-a-service
Drone manufacturers, payload original equipment manufacturers (OEMs), training organizations	<ul style="list-style-type: none"> Deliver drone and sensor capabilities matching customer needs Support delivery of generic and sector-specific training of drone pilots
Unmanned traffic management and digital platform providers	<ul style="list-style-type: none"> Provide tracking and traffic management especially for BVLOS operations Contribute towards safe drone usage in the pipeline segment
Telecom service providers	<ul style="list-style-type: none"> Offer telecom coverage in remote areas to support drone operations and traffic management Support proof-of-concept and sandbox trial environments; provide technical guidance
Insurance companies	<ul style="list-style-type: none"> Evaluate use of drones for insurance surveys Incentivize drone usage by offering premium discounts
Local government officials	<ul style="list-style-type: none"> Survey pipelines after construction to address local issues Sensitize the community on the benefits of drone use
Law enforcement and disaster management agencies	<ul style="list-style-type: none"> Communicate key expectations for response to incidents and disasters Engage during trials to provide inputs and drive buy-in

2.3 Product development and co-innovation

Pipelines often crisscross large distances with varying environmental conditions. Building drones with high margins of safety and greater endurance and robustness requires a collaborative approach towards innovation and product-market fit.

Moreover, considering the substantial number of use cases, such collaboration between pipeline operators, drone service providers and startups is critical to develop user-friendly software and advanced data analytics solutions.

2.4 Skills development and training

Studies have already highlighted the need for a skilled workforce to handle drones for monitoring pipelines, especially in risky environments.⁵⁵ Remote pilot training organizations must work closely

with pipeline operators, regulatory authorities and drone manufacturers to create standard operating procedures for drone surveys of pipelines and to train drone pilots.



3 Way forward

Considering countries' mutual dependencies for energy security, and in the interest of existing and future energy security cooperation, countries must undertake joint trials, knowledge sharing and capacity building in the use of drones in the pipeline

segment. The exchange of data and sharing of regulatory insights are necessary to generate interest and promote interoperability, while boosting demand across different countries.

Conclusion

While the pipeline segment has a favourable safety record, the potential for pipeline failures cannot be ignored – be it a case of blockage or fires that adversely impact the surrounding habitation, flora and fauna,⁵⁶ or post-construction concerns raised by local populations. With the complex and dynamic nature of safety, security and operational risks, the deployment of drones for oil and gas pipelines has a strong rationale. Countries such as India have already introduced enabling regulations and policy initiatives to encourage the manufacture and use of drones and their components.⁵⁷ Industry, academia and government must collaborate to formulate sector-specific operating procedures, firm up technical requirements and address concerns pertaining to demand creation.

The overall length of oil and gas trunk pipelines globally is expected to reach 2.03 million kilometres in 2024.⁵⁸ For its part, the drone industry must recognize the enormous business opportunities in the pipeline segment. No single entity can offer integrated aerial intelligence for the energy sector, and a multistakeholder approach that ensures frequent deliberations and consultations is imperative to ensure deployment of drone technology, associated visual intelligence solutions and their seamless integration. Participation from all relevant stakeholders will further ensure the creation of cost-effective delivery models. In summary, **drone manufacturers and service providers must collaborate with pipeline operators and government authorities to deliver superior solutions and to accelerate the creation of enabling regulatory frameworks that could fast-track deployment.**



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