



# Expanding Oil & Gas Unmanned Aircraft (UA) Inspections

**Beyond Visual Line of Sight, One-to-Many advanced operations generate cost savings in the millions.**

**REGULATORY SERVICES WHITE PAPER**

# Introduction

Unmanned Aircraft (UA) aerial infrastructure inspection is transforming the oil and gas services industry, creating avenues for improved worker and public safety, increased productivity through enhanced data availability and more timely and broader-scope data analysis, as well as enhanced operations and reduced costs. In the oil and gas industry, UA inspections today are already utilized for monitoring pipelines, surveying facilities and equipment, detecting unauthorized personnel in protected areas, identifying damages and leaks, and more. As the UA commercial market continues to mature, the efficacy of the systems and regulated use continues to widen, barriers to advanced operations like Beyond Visual Line of Sight, One-to-Many, and At Night are lowering, enabling even greater efficiencies. Oil and gas companies with FAA approval to fly unmanned aircraft beyond sight lines, and/or fly multiple vehicles with just one operator, will reap cost savings in the millions. Add to those capabilities intelligent avionics that can detect and avoid obstructions, while delivering real-time data through edge processing, and UV inspection operations are transformed into a powerful industrial application that delivers more insights at a fraction of the cost.

AiRXOS, part of GE Aviation, has moved beyond the promise of UA advanced operations and is today enabling oil and gas customers to realize the efficiencies and cost savings offered through advanced operations and intelligent systems to their UA inspection operations.



# Background

Fossil fuels (petroleum, natural gas and coal) comprised 78% of the primary energy production in the United States in 2017, of which 28% was from petroleum alone<sup>1</sup>. In 2018, the U.S. produced an average of 10.2 million barrels of oil per day and 88.5 billion cubic feet of natural gas per day<sup>2</sup>, powering the U.S. economy, industries, and daily life. Over 46% of total U.S. oil production and 16% of gas production<sup>3</sup> is produced in the Permian Basin off the Texas coast in the Gulf of Mexico. The Permian Basin consists of mature, legacy, onshore oil and liquid-rich natural gas reservoirs that span approximately 86,000 square miles in West Texas and New Mexico. Given the daily demand for energy, the region is expected to swell by upwards of 110,000 new wells over the next several years<sup>4</sup> – fueling job creation and economic growth in the Permian Basin and the region. It was recently projected that crude oil production in the Permian Basin could reach 5.4 million barrels per day by 2023 up from 3.2 million barrels per day in 2018<sup>5</sup>, putting the Permian Basin on track to deliver more crude oil than Saudi Arabia and Russia. Natural gas in the area is expected to double by 2023<sup>5</sup>.

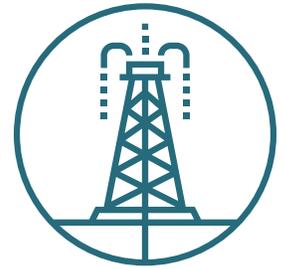


■ U.S. production of fossil fuels in 2018: **10.2 million** barrels oil per day; **88.5 billion cubic ft** natural gas per day

■ **Over 46%** of total U.S. oil production, and **16%** of gas production is in the Permian Basin, TX

> By 2023, Permian Basin crude oil production could reach **5.4 million barrels oil per day** alone; natural gas will double.

> **110K** new wells expected in the Permian Basin



## INFRASTRUCTURE BOTTLENECKS

As oil and gas utilization rates rise, the struggle to keep up with takeaway capacity has put a spotlight on infrastructure and pipeline bottlenecks caused by inefficient logistics – transportation by cumbersome truck, rail, and barge – and limits on natural gas flaring, which can reduce crude production when producers can't evacuate enough gas from the site. In the Permian Basin, pipeline companies are investing heavily in building new lines, while maintaining existing ones, but the ability to inspect those lines is still a manual and dangerous task, hampering productivity.

## HAZARDOUS OPERATIONS

The oil and gas industry occupational fatality rate is 2.5 times higher than the construction industry and 7 times higher than general industry<sup>6</sup> with 148.9 severe injuries per 100,000 workers a year due to exposure to dangerous chemicals, falls, fires, explosions, and other causes<sup>7</sup>. Transportation of materials is a leading cause of accidents and fatalities. In the Permian Basin, transportation of hazardous materials is done primarily over Texas Route 285, which slices through the Permian Basin and is known by locals as the 'Death Highway'<sup>8</sup>. In 2017, there were 93 highway fatalities recorded on the Texas side of the basin. With the rising price of crude, highway casualties grew from an average of 10 per month in 2016 to over 16 per month in 2017 in the Permian region<sup>9</sup>.

> The Oil and Gas industry experiences **7 times** as many fatalities than general industry



> **148.9 severe injuries per 100,000 workers** a year due to exposure to dangerous chemicals, falls, fires, explosions, and other causes



> In the Permian Basin, highway casualties grew from 10 per month in 2016 to **over 16 per month in 2017**



<sup>1</sup> U.S. Energy Information Administration, Oil: Crude and Petroleum Products Explained, Where Our Oil Comes From, 2017.

<sup>2</sup> U.S. Energy Information Administration, Short Term Energy Outlook, October 2018.

<sup>3</sup> U.S. Energy Information Administration, Drilling Productivity Report, November 13, 2018.

<sup>4</sup> Midland Reporter-Telegram, "Top Permian producers see opportunities for future growth," January 23, 2018.

<sup>5</sup> IHS Markit, Fixing the Permian mismatch: Upstream growth and mid-stream takeaway capacity, June 13, 2018.

<sup>6</sup> American Journal of Industrial Medicine, "Occupational exposures in the oil and gas extraction industry: State of the science and research recommendations," March 14, 2014.

<sup>7</sup> E&E News, "Oil and gas industry leads in severe injuries" May 2, 2017.

<sup>8</sup> Bloomberg, "'Death Highway' is where oil prices, truck fatalities intersect," July 30, 2018.

<sup>9</sup> Texas Department of Transportation, Fatal Crashes by County and Road Type, 2016 and 2017.

## INEFFICIENCY IN UA INSPECTIONS TODAY

Whether it's siting a drilling pad, assessing the right-of-way for a pipeline or checking for leaks, inspecting the integrity of production facilities, or routing and surveying construction, critical infrastructure inspections today are performed by foot, helicopter, and UA. Of the three, UA aerial inspections provide the greatest productivity and safety impact as they can acquire more accurate digital and thermal imagery quickly, be deployed to hazardous areas, and can identify safety issues not seen by the human eye.

However, current UA inspections are not performing at optimum efficiency. Today, oil-well and pipeline UA inspections occur under FAA regulations known as '14 CFR Subchapter F, Part 107' rules. Under these regulations, drone operations must be conducted using at least one drone per pilot. The drone can be flown manually by the pilot using a remote controller or automatically using some form of automatic flight control system flying a pre-planned flight plan. The UA remains within the line of sight of the pilot so that control of the vehicle can be maintained should issues arise with the vehicle.

Conventional remote aerial inspections – single operators and single UA flying in line of sight – are limiting the impact of UA inspections. Take a well-pad inspection, for example – at each well-pad, there may be up to 80 inspection points that include compliance, infrastructure, and maintenance inspection. As of November 2018, there were 492 oil rig drilling holes in the Permian Basin. Under the FAA's Part 107 rules, a UA operator is limited to inspecting only 6-10 wells per day.

While this current method of operation is functional in locations where a pilot can easily see the vehicle at all times, in locations like the Permian Basin, with vast infrastructure requirements, operating within the confines of 'Part 107' becomes more of a hindrance than an efficiency. To maximize the benefits of UA inspections, regulatory waivers for advanced operations can open up a world of new possibilities.

# Advanced UA operations – the next generation of UA inspections

The potential benefits of aerial infrastructure inspection are substantial. In the upstream or exploration phases, aerial sensors can detect naturally occurring methane seeps or serpentine sweeps. Midstream, inspection and monitoring of hard to reach assets by UA can replace rope-access and scaffolding and can easily be scheduled as frequently as needed. Downstream, UAs can detect corrosion in pipelines and early signs of leaks that may be unseen to the human eye.

More importantly, aerial inspections help reduce industry fatalities and injuries as they will move people from oft dangerous 'field' jobs into automation management, operations and data analysis. Furthermore, aerial solutions can help identify suspicious and un-authorized activity around critical infrastructure.

While UAs are already delivering these kinds of benefits, true optimization comes in the form of Advanced operations – Beyond Visual Line of Sight (BVLOS), One-to-Many, Flight over Non-Participants, and Night Operations. These Advanced Operations give UA inspection programs new functionality, capabilities and the freedom to expand inspections.

Adding advanced capabilities to UA inspection programs increases the number of inspections per day, saving a company money which can be used to increase production through more well development, thus scaling operations.

## BEYOND VISUAL LINE OF SIGHT

One of the key challenges to deploying and scaling infrastructure inspection has been attainment of the required FAA authorization to enter the National Airspace System (NAS). For the United States to properly capitalize on the full safety and efficiency benefits of drones, a workable regulatory framework that allows safe operations BVLOS of the pilot is necessary. Whether drones are being used to inspect oil and gas and other critical infrastructure in remote locations, respond to natural disasters like hurricanes, or deliver packages, companies need to be able to fly drones beyond the range of human sight. However, under the current regulatory framework for commercial drone operations in the U.S. (Part 107 or Section 333/347/2210), drone flights BVLOS of the pilot are prohibited without an approval from the FAA, a waiver specific to the operator and site for every given operation.

As of November 2018, the FAA had issued 2,223 Part 107 waivers – yet only 1.17% were BVLOS waivers (with a few additional BVLOS exemptions that have been approved)<sup>11</sup>. While the FAA and the industry have referred to these previously-granted approvals as "BVLOS," in fact all of these approvals required the use of a visual observer or a second pilot to visually scan the airspace with their eyes to identify other aircraft that could create a collision hazard with the drone. This 'visual observer' version of BVLOS is limited in its utility.

<sup>10</sup> <http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-rigcountsoverview>

<sup>11</sup> Federal Aviation Administration, Part 107 Waiver Granted, November 13, 2018.

## ONE-TO-MANY

An alternative to BVLOS inspections is performing inspections with a 107.35 waiver enabling one (1) pilot to operate multiple UAs. A waiver to operate One-to-Many Advanced Operations expands UA operations by giving one inspection pilot the ability to fly multiple operations simultaneously. This is significant on two fronts: 1) It allows a single pilot to conduct multiple inspections at the same time inspections on a single site: increasing productivity; enhancing safety; and reducing program costs. 2) Multi-operator, multi-UA operations contribute to increased efficiency and system effectiveness, thus optimizing assets. Depending on the site and the costs of ownership of the UA, labor and infrastructure, there may be considerable labor savings in operating with a 107.35 waiver.

By example, if an inspection pilot could perform 2X as many inspections per day flying multi-drone operations, the cost savings are substantial. Expanding the geographic footprint of pipeline monitoring, chimney and flare stack inspection or refinery and storage tank inspection by allowing a single pilot to conduct multiple operations simultaneously allows a company to expand and scale UA inspection programs.

> Current U.S. commercial drones operate under Part 107 rules, which restrict operations to within line of sight. **BVLOS requires a waiver.**



> As of November 2018, **2,223 Part 107 Waivers have been issued**, of which, only **26** were granted for BVLOS, but still required use of a visual observer.

> **October 2018, AiRXOS'** obtains **precedent setting** FAA-approved civil use of BVLOS with radar in Loving County, Texas, a **22.5 sq. mile area**.

## PRECEDENT SETTING BVLOS WITH RADAR APPROVAL FOR PERMIAN BASIN

In October 2018, AiRXOS' Approval Services helped Avitas Systems, a GE venture, to develop the processes, procedures and training enabling Avitas Systems to obtain Federal Aviation Administration (FAA) approval to fly an unmanned aerial system (UAS) Beyond Visual Line of Sight (BVLOS) in Loving County, Texas, a 22.5 square mile area owned by the Shell Oil Company. The permission authorizes Avitas Systems to fly a UAS over 55 pounds at low altitudes without a visual observer for industrial inspection; it is the first FAA-approved civil use of BVLOS with radar. This is true BVLOS capability at its best; by understanding the specific needs for these operations, AiRXOS was able to craft the applications that were needed to optimize Avitas Systems' operational capabilities.

Unlike a Part 107 waiver which restricts the visual field, the 2210 waiver allows for vehicles to fly out of the pilots' sight line. The extended range of true BVLOS operations allows for safer, and more efficient monitoring of critical industrial infrastructure, including well pads separated by rough terrain in the Permian Basin in West Texas. Better turnaround of inspection data leads to cost efficiency and faster facility repairs, compared to traditional methods such as driving to each individual inspection site.

True BVLOS operations are also a boon to transportation safety in the Permian Basin. According to 2018 statistics published by the Texas Department of Transportation, a vehicular fatality occurred every 37 hours across 16 counties in the Permian Basin for the first four months of 2018<sup>12</sup>. BVLOS capability can help address these numbers by reducing the number of hours that inspectors travel on a regular basis to perform surveillance activities in remote areas.

## AiRXOS is already helping UA programs that require advanced operations.

### > **BEYOND LINE OF SIGHT**

Precedent setting, true BVLOS with Radar for Shell in Permian Basin

### > **ONE-TO-MANY**

UAS, over agriculture, up to 3 locations

### > **AT NIGHT**

Nationwide Night demonstrations and testing

### > **ON AIRPORT**

Approved USS provider of LAANC Authorizations with Further Coordination

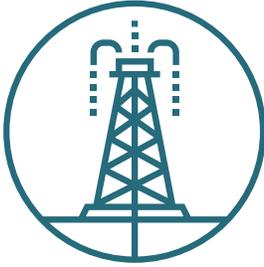
On Airport inspections performed for FedEx

### > **DETECT & AVOID (DAA)**

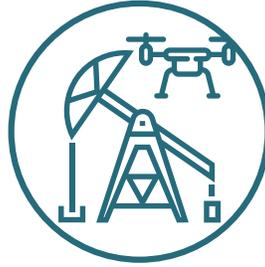
Integration firsts - flight collision threat detection and autonomous avoidance for both manned and unmanned aircraft

<sup>12</sup> From Hogan Lovells, Avitas Press Release, October 17, 2018.

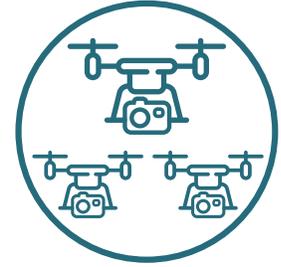
> It takes **10 FTE inspectors** to inspect **5 wells/day** by traditional methods. May inspect up to 80 items at a given location.



> Under Part 107 rules, a single UA operator/inspector can inspect **10 wells/day** – **shortened inspection time, reduced risks.**



> BVLOS or 1:Many can **increase** the number of inspections **2-3 times**, reducing inspection costs and time.



## AiRXOS ACCELERATES EXEMPTION APPROVALS

AiRXOS has streamlined and accelerated the process for obtaining FAA civil use approval. Today, in addition to BVLOS, AiRXOS is already demonstrating One-to-Many capabilities and has obtained waivers to fly these missions. AiRXOS has generalized the operational approval process helping reduce the barriers to gaining permission. Utilizing decades of aircraft and airspace safety expertise, analyzing the operating environment and key flight hazards, AiRXOS has worked effectively with customers, ground based radar and vehicle providers and operators to develop a BVLOS safety-case, prepare a successful waiver application and gain operational approval from the FAA.

Additionally, AiRXOS provides workflow automation and aviation expert consulting services to attain Federal Aviation Administration (FAA) approval for any number of high-value, 14 CFR Subchapter F, Part 107 waiver-able operations, not just Beyond Visual Line of Sight, but also One-to-Many, Flight over Non-Participants, Night Operations, and more. AiRXOS develops concept of operations, specifies the UAS and support equipment, including performance requirements necessary to meet the safety requirements for operations, as well as developing the robust safety case, operations manual and pilot training, and the waiver/exemption package and application for the FAA. AiRXOS then performs testing necessary to validate the UA can meet performance requirements and provides periodic re-certifications and auditing of operations performed under a given waiver or exemption.

## Extend & Scale UA critical infrastructure inspections

> **TODAY**  
Must fly within line of sight.



1 inspector/visual contact/1 site/X days

**IMPACT:**

- Each deployment and landing—and ground travel time in between—increases inspection time and response.

> **TODAY + BVLOS**  
Fly BVLOS.



1 inspector/BVLOS /1 site/1 day

**IMPACT:**

- BVLOS allows drone to collect more data in fewer deployments
- Replaces long range aerial data collections
- Reduce multi-day inspections to 1 day inspections.

> **TODAY + BVLOS + ONE:MANY**  
Fly multiple UAs.



1 inspector +1:M/ X multiple sites/1 day

**IMPACT:**

- Multiple automated inspections performed simultaneously
- Rapid response for post-event and storm response

# Amplifying inspections through Intelligent Avionics

Constructing an approval system for proven safe and reliable data gathering is the first step on the path to fully-automated aerial inspection. Further improvements in safety, productivity and revenue creation will be enabled by elevated levels of flight autonomy and inspection automation. Once the drone is in position to legally record the inspection data, it needs to possess the intelligence to attain insight from and act in response to the data gathered. Drones will need to evolve from capturing data along a prescribed path and employing off-line reporting to fully autonomous

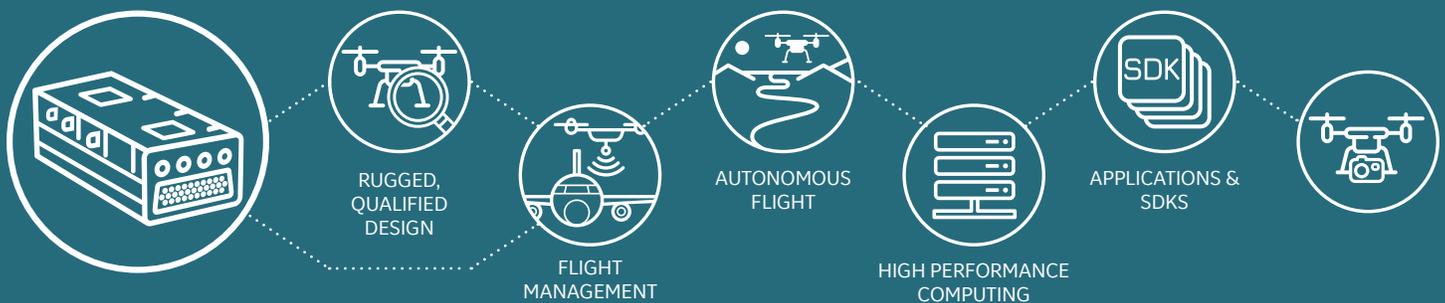
inspection driven by the real-time situation at the inspection site and the adjacent sensing and decision making employed on the vehicle. Most commercially available avionics for UAs have not been designed or tested to aviation-specific safety standards, contain potential security vulnerabilities due to the inclusion of open source software, and have limited contingency mode operations, hampering the scalability of operations.

On-board data fusion, analysis, flight automation and deployment of 3<sup>rd</sup> party applications and sensors are made possible by availability of ample edge-compute and an accessible mission environment deployed around widely used robotics frameworks. Of these, the most complex and time-consuming analysis is in the vehicle command and control hardware and software.

## AiRXOS INTELLIGENT AVIONICS – INSPECTIONS ON THE EDGE

AiRXOS' Intelligent Avionics is a drone-safety and autonomy-enabling solution comprised of navigation sensors, radios, flight critical software and industry leading edge-compute combined in an ultra-low Size, Weight and Power (SWaP), rugged and secure flight solution. Intelligent Avionics is a fully customizable platform in which inspection operations can literally build the 'intelligence' of any autonomous to build the 'brain' of any autonomous UAS and includes numerous software, hardware and validation artifacts that enable construction of safety cases for any advanced UAS operation. Better technology enables operators to increase their operational footprint, improving productivity and increasing occupational safety by removing people from dangerous environments.

Optimize UAS operations with customizable, integrated, automated behavior.



## Conclusion – The freedom to expand operations

Autonomous aerial inspection is already having a significant impact on oil & gas inspection work. The Permian Basin, TX, is an example of the challenges and benefits of a UA program. However, the capabilities have yet to reach their full potential. Advanced operations like Beyond Visual Line of Sight and One-to-Many will dramatically help expand and accelerate UA programs in the industry and will provide even greater opportunities for enhanced productivity, reduced costs, and optimized assets.

What's clear is that the future of UA inspections is taking flight today. The ability to receive approval to fly beyond Part 107 restrictions for operations, beyond the visual line of sight, and that include one-to-many, are no longer 'impossible to get', they are being obtained by industry-leading AiRXOS on a consistent basis. Adding Intelligent Avionics further amplifies inspections in providing customizable intelligence specific to the operation.

UA technology and regulatory parameters are changing rapidly, and organizations will want a tested partner dedicated to the highest levels of manned and unmanned safety, backed by regulatory industry aviation expertise and technology and engineering experts in order to meet the rigor, specifications, and level of safety required by the FAA in getting the next generation of inspection waivers.



**AiRXOS**  
Part of GE Aviation

## About AiRXOS

AiRXOS, part of GE Aviation, is solving the big problems of unmanned flight – opening a new era in aviation that will change the way businesses operate and grow. With innovative technology, hardware, and services, AiRXOS unlocks the value of unmanned solutions – helping organizations improve productivity, reduce costs, and increase safety, while scaling operations.

For more information, visit <http://www.airxos.io>, or follow on Twitter (@airxos\_) and LinkedIn.