BEST PRACTICES FOR DRONE INFRASTRUCTURE INSPECTIONS

How to use drones to improve monitoring and maintenance of infrastructure — today and in the near future

☐ Drone program managers
☐ Inspection supervisors
☐ Drone pilots
☐ Health and safety managers

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Skyward can help you take your drone program further, faster.

Drone Consulting

Skyward consultants help drones prove their value throughout your business as quickly as possible.

Proof of Concept
We'll show you how drones can deliver ROI across your business

Procurement
Our team can acquire the hardware and equipment for you and register aircraft with the FAA

Risk Mitigation & Compliance
Get the policies and procedures you need to run a safer operation and comply with regulatory and corporate requirements

Team Training
Get training for the FAA's Remote Pilot Certificate (Part 107) as well as beginner and intermediate flight training

Skyward Implementation
Setup and training for your team to help your team get the most out of Skyward

Efficient, Scalable Workflow
We'll help you refine your workflow, engage your stakeholders, and create customized flight and ops checklists

Technology Configuration
We'll configure your fleet to serve your business, including drones, sensors, and data-processing software

Ongoing Support
Call on our experts during regular check-ins and get early updates on Skyward's product roadmap as well as regulatory developments

Drone Management Platform

Skyward's software provides operational oversight and transparency, customizable workflows, and access to controlled airspace.

Know where you can fly

Collaborate with team members

Simple & powerful flight planning tools

Track and report details that matter to your business

Quickly gain permission to fly in controlled airspace

Meet regulatory and insurance requirements

Get in touch at contact@skyward.io & schedule a 15-minute consultation

Watch a 2-minute video of Skyward in action at
go.skyward.io/Skyward-Demo.html

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WELCOME

Over the past several years, it's been exciting to see how companies have used drones to help save time, increase revenue, and lower risks to workers in industries as diverse as energy, utilities, media, oil and gas, and commercial construction. And we're just getting started. Drone connectivity will — once again — revolutionize the way companies gather data and accomplish tasks.

As much as drones have added value, we have only just begun to scratch the surface in terms of what they can do. In 2018, 10% of major enterprises in the U.S. were using drones — and almost none of them were connected to a wireless network. At Skyward and Verizon, we're working to change that. When drones are widely connected to wireless networks, the transformative capabilities of drones can be unlocked in ways that will change many aspects of our society.

With all these changes coming so quickly, it can be confusing to set up a drone program ready to adapt to tomorrow's technology and regulatory advances, while still producing today's deliverables and ROI.

The American Society of Civil Engineers gives the nation's infrastructure a D+ grade, with many systems past their designed lifespans, including some transmission lines, pipelines, highways, levees, dams, and railroad tracks.[1]

Then there are buildings like schools, warehouses, and server farms that are also essential to public well-being and commerce.

Finding faster, better ways to survey and maintain infrastructure is a rising concern. This guide shows how drones are being used for infrastructure inspections with meaningful results: better data, safer workforces, reduced corporate risk, lower costs — and more reliable infrastructure systems.

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Advantages of Using Drones for Infrastructure Inspections

KEY ADVANTAGES OF USING DRONES FOR INFRASTRUCTURE INSPECTIONS

- ☐ Faster surveying at lower cost
- ☐ Improvements in worker safety
- ☐ Better data
- ☐ Reduced corporate risk
- ☐ Improved infrastructure reliability

Common types of infrastructure inspections being performed by drones

- ☐ Electric transmission and distribution (T&D) lines

- ☐ Oil and natural gas pipelines

- ☐ Water systems — dams, hydroelectric equipment, fish ladders, aqueducts, reservoirs

- ☐ Waterways — ports, levees, canals, locks

- ☐ Highways, freeways, bridges, light poles, signage, underpasses, overpasses, culverts

- ☐ Railroad tracks, bridges, poles, yards

- ☐ Utility-scale solar arrays

- ☐ Onshore and offshore wind turbines

- ☐ Site selection surveys, 3D models, and line-of-sight analysis for power lines, wind turbines, solar farms

- ☐ Construction progress

- ☐ Vertical structures — nuclear cooling towers, flare stacks, storage tanks, smokestacks, piers

- ☐ Security fencing

- ☐ Damage assessments — emergency, post-weather-event, post-disaster

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Faster Inspections at Lower Cost

Drones can lower the cost of infrastructure inspections — by a lot. Some of the savings comes from how fast the work can be done compared to traditional inspection methods. Eliminating operational disruptions and reducing the need for heavy equipment also contribute to cost savings.

Examples:

▸ Using drones to pull rope for power line repair after a storm can reduce the time required from a week to under a day.

▸ Drones can zoom in for close-ups of equipment like flare stacks while they are running, instead of shutting down the entire system while an inspector climbs the stack to examine it.

▸ Transportation departments can reduce investments in heavy equipment like under bridge inspection vehicles (UBIVs), which can run between $500K to $1M.[2] Highway lanes and shoulders don't have to be shut down during bridge surveying, saving an additional $500 to $2500 per day.[3]

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8 EXAMPLES OF COST SAVINGS FROM DRONE INFRASTRUCTURE INSPECTIONS

T&D Lines

After Hurricane Maria, Skyward customer Southern Company used drones to pull 72,000 feet of rope for conductor wire, completing work in eight weeks that used to take six to eight months
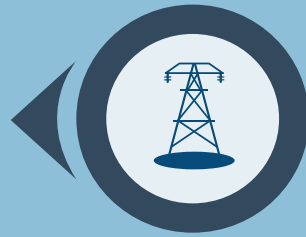
Bridges

One trial of drone-assisted inspections saved a state department of transportation an average of 40 percent over traditional methods — and produced superior data, like 3D modeling.[4]

O&G Pipelines

Aerial leak detection for oil and gas pipelines saved an Oklahoma pipeline owner an estimated 90 percent in produced-water remediation costs.[5]
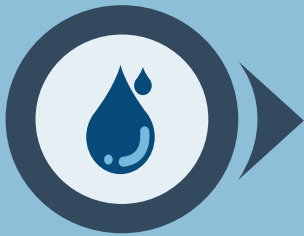
Other O&G Infrastructure

A full North Sea oil platform scope was performed by drone at 20 percent of the cost of a traditional rope-access inspection.[6]

Solar Plants

Drones have cut the cost of thermographic inspections of utility-scale solar farms between 30 and 40 percent, with the time required shaved from about a month to about a week.[7]
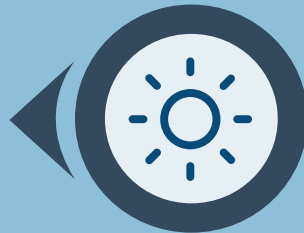
Wind Turbines

One company reports that using drones to examine wind turbines costs 30 to 50 percent less than sending a worker to climb towers to look.[8]
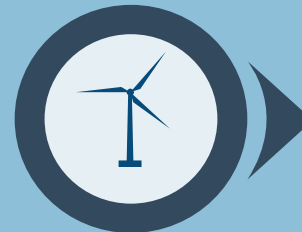
Dams

One Italian use case found inspection costs can be reduced by 40 to 60 percent, while allowing managers to keep eyes on the hardest-to-access places.[9]
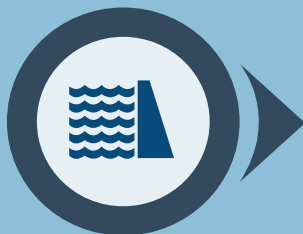
Railways

Drones eliminate the need for "possessions"[10] (traffic shutdowns during inspections) and reduce labor costs, two big areas of savings for rail companies.

Improvements in Worker Safety

Maintenance crews that work on infrastructure routinely encounter dangers on the job:

▸ **Climbing towers**

▸ **Driving remote roads**

▸ **Surveying high-voltage equipment**

▸ **Trimming trees from cranes or bucket trucks**

▸ **Working near high-speed traffic**

▸ **Being exposed to flames, toxic chemicals, or emissions**

▸ **Working near moving machinery**

▸ **Rappelling**

Risks multiply when the asset is in disrepair, or the field team is on the front lines after a disaster, working to restore services in flooded, destroyed, or difficult-to-access areas.

Using drones to survey infrastructure substantially reduces the chances of harm to field workers, letting them do their work at a safer distance.

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Here are five examples of how drones are making the work of infrastructure maintenance and repair safer.

1 Instead of using crewed helicopters around high-voltage transmission and distribution lines, utilities are employing drones to check conditions. Inspections are typically faster and can be done more frequently, potentially heading off failures that can cause catastrophic fires.

2 There are more than 341,000 wind turbines operating globally as of 2016.[11] This means roughly one million blades that are battered by the elements and need regular inspections for wear. Drones provide close-up images of equipment that is hundreds of feet off the ground while field workers remain safely below.
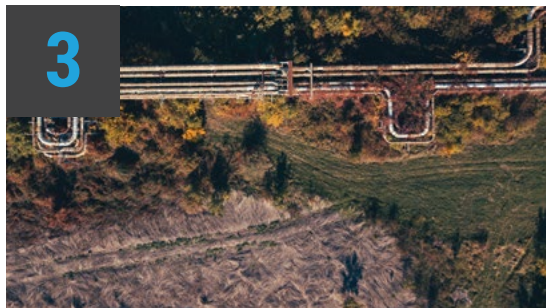
3 Beyond-visual-line-of-site (BVLOS) flights are allowing field inspectors to check railroad tracks, bridges, and pipelines for hundreds of miles, reducing the distances they have to drive on poorly maintained backroads.

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Five live flare tower inspections using drones saved an Egyptian petrochemicals firm $4 million in reduced shutdown costs, since the work was done with the towers in operation.[12]

Drones were an important tool during the 2017 Oroville Dam scare. Aerial views helped California Department of Water Resources officials see in real-time what was going on, guide emergency repairs, and determine evacuations, all at a safe distance.

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SAFER T&D LINE REPAIR

COMPANY:

Southern Company

CHALLENGE:

Working safely in mountainous terrain following a major hurricane

Some of the most dangerous work for utility field crews is restoring power following a disaster. Drones are especially valuable when damaged systems need immediate assessment and repair, but conditions are still hazardous.

This is a big reason why utilities are second in drone adoption in the U.S., behind only construction and engineering companies. The FAA projects there will be over 280,000 utility projects piloting drone technologies in 2021.[13]

Southern Company is one of the largest electric and gas utilities in the United States, serving about 9 million customers across 19 states. The company began using drones to get away from helicopter inspections of T&D lines after a tragic crash that killed the pilot and a company engineer.

Southern's drone program has expanded to include many more operations, with the company reporting meaningful gains in worker safety, grid reliability, cost savings, and operational efficiency.

One example was stringing new power lines blown down in Puerto Rico during Hurricane Maria. Line pulling had to be done in terrain too steep for truck access, in thick vegetation.

The traditional method for repairing downed wires — shooting a pilot rope over a tower — wasn't feasible. The Southern drone team pulled 72,000 feet of rope for wire using drones, saving the company an estimated $5.7 million. Work that used to take a week took minutes, restoring power to many areas much faster.

Better Data

Before drones, vertical infrastructure was often inspected by someone using binoculars hundreds of feet below or in a hovering helicopter. Drones provide high-resolution views of the components on structures that allow inspectors to detect faults they might have missed.

Drones mounted with LiDAR, thermal, hyperspectral, and other sensors are further revolutionizing infrastructure inspections by providing new, rapid, highly precise insights.

▸ Drones detect concrete cracks on bridges down to a size of 0.02 inches, even in low-light conditions.[14]

▸ Utilities can map service areas using LiDAR cloud points. Using change detection, they can quickly determine damaged assets after storms move through.

▸ Drones mounted with infrared cameras can produce thermal imagery of pipeline routes. Hotspots may point to potential defects in pipeline insulation or leaks invisible to the human eye.

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- Underground pipeline leaks can also be pinpointed by high-resolution vegetation maps, revealing abnormal plant kill-off zones.

- A survey of existing railroad tracks, part of design work for a new line near London, cut the project time from three to six months down to about two days, with photographs providing 1 to 2 mm accuracy levels.

- Solar utilities use drones to capture geographic information and create 3D models and maps. They use the data for site planning and energy harvest estimates, determining which plant layout will generate the most megawatts by factoring in the angles of the terrain and optimizing the positioning of panels.

- Drones mounted with thermal sensors can detect specific panels in solar arrays that have gone offline or are underperforming.

Such technological advances help infrastructure managers make more informed decisions on priorities for maintenance, repair, and replacement. They help identify potential problems before they become major issues, improving the reliability of the systems being managed.

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Lower Corporate Risk

By keeping field workers out of harm's way, drones can help to curtail injuries and the lost work hours that come with them. That's great not only for the workers but also for reducing risk for the public agencies, utilities, and companies that own or manage infrastructure systems.

When companies do experience fewer safety incidents by using drones, they may also mitigate the costs of workers compensation insurance, employee health plans, and liability insurance. The full digitization of inspection data, from collection to analysis to reporting, is another plus for risk abatement: better data reporting can mean improved compliance with environmental and other regulations.

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How Skyward Supports Low-Risk Flight Ops

The Skyward platform, including our InFlight mobile ground control station, comes equipped with customizable preflight and operational checklists. That means pilots in the field have easy access to on-site checklists, right alongside their operational plans, airspace information, and current weather conditions. Safety and compliance are part of every pilot's workflow, rather than an afterthought. Within the Checklist Editor, Admin users can create, edit, and publish checklists to the teams they manage within Skyward. Steps can be designated as "required" or "optional."

Drone regulations and corporate compliance requirements are changing quickly, so Admins can update checklists as often as they need to. Skyward retains past versions of checklists for safekeeping. Checklists work dynamically across cloud and mobile apps. You can pull up a checklist and begin it on your computer at work, leave, and continue where you left off on a mobile device out in the field.

Customizable Checklists

▸ Support consistent flights
  (and consistently high-quality deliverables)

▸ Help drone program managers work with corporate compliance teams to develop low-risk workflows

▸ Help every team to operate safely while following company and regulatory rules
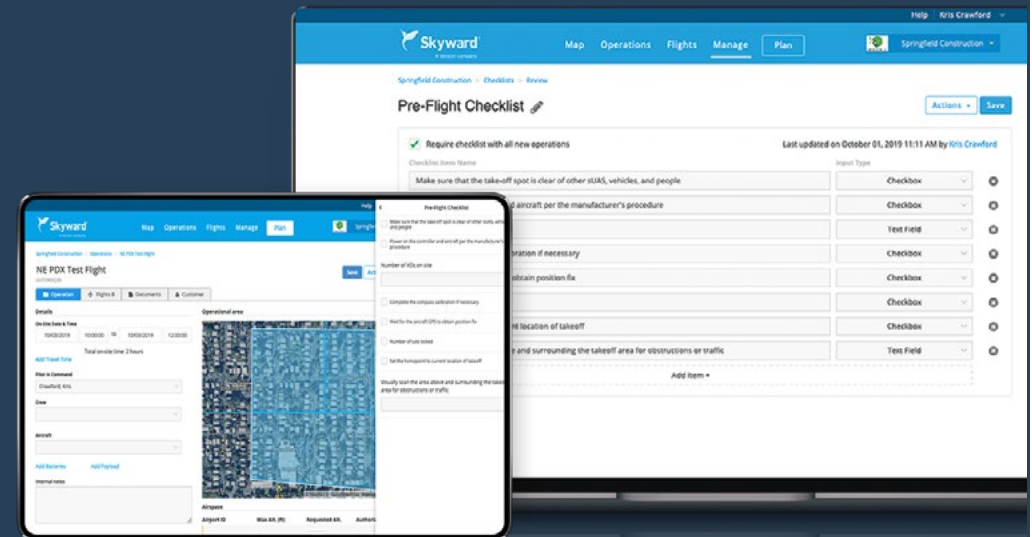
Take Flight General Operating Manual

[Take Flight Package](#) includes more than 200 pages of standard operating procedures and checklists to ensure efficiency and quality at every stage of a commercial drone operations, from equipment maintenance to pilot training and from customer engagement to emergency landings.

Because every company is different, we realized early on that checklists should be customizable. So far, dozens of enterprises have used Take Flight to establish low-risk, high-efficiency drone operations, with checklists customized to their various workflows and corporate requirements.
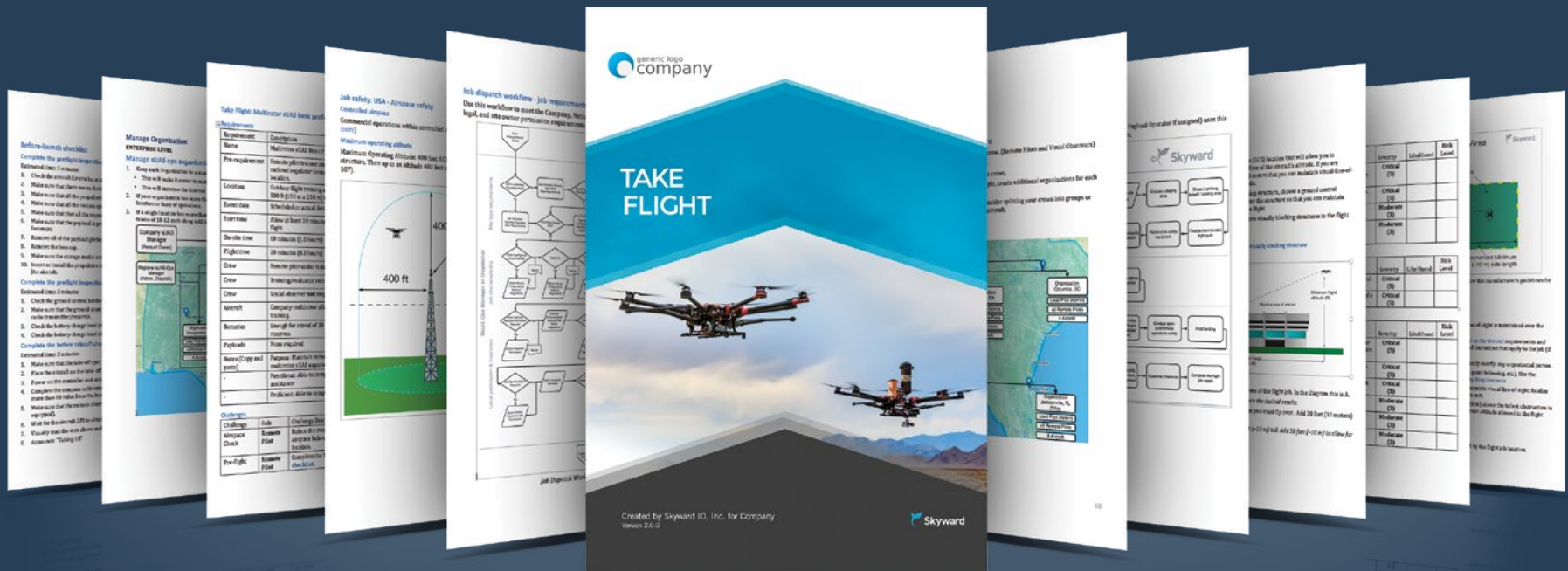
Improved Reliability and Resiliency

Drones already let infrastructure managers do better monitoring more often, improving the reliability of energy, water, transportation, and other systems. Coming advances will take this further.

Combined with artificial intelligence (AI), Internet of Things (IoT), and machine learning, drones are ushering in a new era when predictive maintenance will be the norm. Artificial intelligence software can analyze data from connected sensors on drones in order to alert managers that servicing is needed before something fails.

A benefit of the predictive maintenance model is improved infrastructure resiliency. Drones have made it possible to survey systems much faster and in new ways. This will become even more important as critical systems face hotter temperatures, bigger storms, and massive flooding.

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When there's a destructive event, drones provide eyes in places not safe for people. Imagery from drones, combined with change-detection software, allows responders to accurately assess damage early on, so the right resources are sent where they need to be. This means energy, telecom, and other infrastructure gets back up and running sooner.

PRO TIP:

Drone pilots using Skyward can launch in controlled airspace in a matter of minutes using the automated LAANC approval process. They can see temporary flight restrictions and coordinate safe flights with colleagues who may also be flying in disaster recovery zones.

Learn more at
skyward.io/enterprise-solutions

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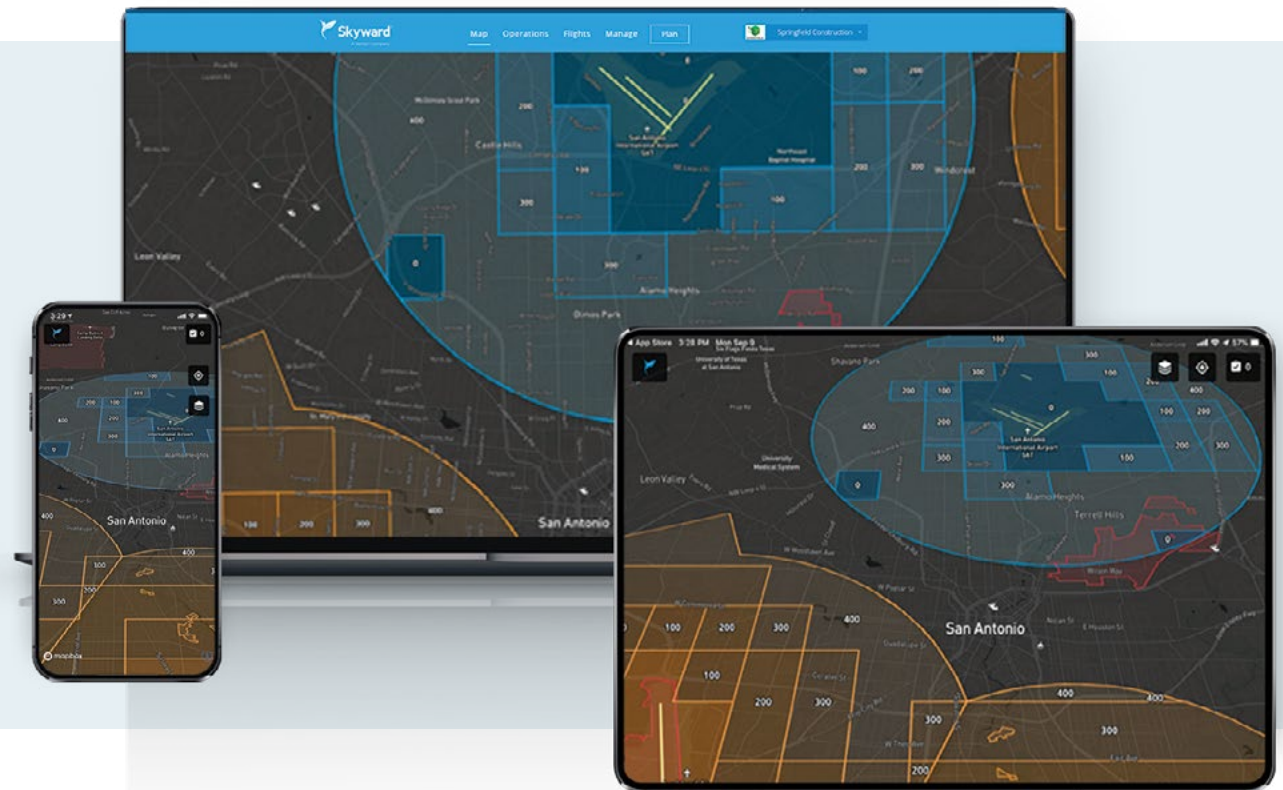
Best Practices for Drone Infrastructure Inspections

If you're making the move from traditional inspections to drones, begin by asking the right questions. Here are some core topics to kick-start the discussion with your internal stakeholders:

- ☐ What area of operations presents the biggest potential gains for cutting costs?

- ☐ What area of operations presents the biggest potential gains for improving workforce safety?

- ☐ Are there infrastructure assets at higher risk of failure that need quick attention?

- ☐ How will we compare baseline data on traditional infrastructure inspection costs and safety with what we achieve using drones?

- ☐ Should we build the program in house or outsource?

PRO TIP:

Skyward has a rich library of getting-started assets — case studies, budgeting tools, fact sheets, and more — that can help refine what you need. See how we support budding and scaling programs: https://skyward.io/resources/.

Five best practices for drone infrastructure inspections

Once you've set your business goals, you can build your drone program strategically. We've identified five best practices that underpin every well-run drone infrastructure inspection program as a starting point:

1. **Be strategic about data collection.**

2. **Protect your data.**

3. **Keep up with emerging technology.**

4. **Have a plan for regulatory compliance.**

5. **Mitigate your risks.**

PRO TIP:

Skyward provides a Quick-Start Package for Enterprises that supplies the software, hardware, training, and tech support you need to get off the ground fast. Best practices included. https://skyward.io/quick-start/

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Be strategic about data collection

Drones allow organizations to collect data that hasn't been easily accessible until now. Be sure you understand the full possibilities and select what's going to provide your organization useful, actionable data.

Understand the full range of use cases for your industry or sector

Case studies showing the types of data collected by drones for infrastructure are easy to find online. Here are some of the most common use cases from our clients.

▸ High-res images collected from the air reveal wear on power lines (like corrosion on transmission line conductors) from a safe distance and at high speed.

▸ Geological data gathered by drones is used to generate models that help identify promising oil and gas drill sites.

▸ Topographical data from drone flyovers is used to optimize layouts for solar utility arrays, so they produce the most energy.

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- Drones mounted with infrared sensors produce heat maps that pinpoint potential leaks in water, oil, and gas pipelines.

- Live aerial video can examine structures after disasters when conditions on the ground are too risky for people.

- Infrastructure managers can compare before and after imagery with change detection software to pinpoint the extent of damage to equipment following a weather event.

Think about the drone infrastructure inspection data you really need
Drone sensors are rapidly advancing, and new applications will continue to emerge as AI, computer vision, machine learning, and IoT technologies progress.

Below are some of the most common types of infrastructure data we see clients collecting now. Select those that offer the best prospects for meeting your goals, then add on as your program matures and more data collection makes strategic sense.

- High-resolution photos

- High-definition videos

- Thermal imagery

- Terrain maps

- 3D models

- Point clouds generated through LiDAR

- Volumetric assessments

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Protect your data

The infrastructure data collected by drones can be highly sensitive. It can be a target for bad actors with designs on infiltrating critical infrastructure systems like dams, electrical grids, airports, and pipelines. It's important to have a data security plan. Here are a few considerations.

▸ The storage capacity you need may be high to accommodate high-resolution photos, high-definition videos, 3D terrain models, point clouds, thermal imagery, etc. Figure out a secure archiving strategy, like a mix of on-premises and cloud storage.

▸ Data often has to be fed into organization-wide information systems. Do you know how the inflowing data will be securely integrated with existing IT systems?

▸ Drone data has to be protected during multiple phases. Include in your plan measures for data security during gathering, transmission, reporting, storage, and archiving.

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Keep up with emerging technology

The pace of drone innovation is fast! Connected drones powered by 5G cellular networks are arriving soon, opening up new capabilities like autonomous, remote-guided, nighttime, and BVLOS flights.

What's next for drone infrastructure inspections

▸ Drones operating on Verizon's proprietary 5G Ultra Wideband wireless technology will allow an organization to stage hundreds or even thousands of drones far from the office, at the ready to inspect railroad tracks, highways, oil and gas pipelines, transmission and distribution power lines, levees, bridges, and dams, whenever needed.

▸ Small communication nodes placed directly onto structures in the field will communicate with sensors on drones that are connected to an energy-efficient, 5G wireless network, for real-time visibility into equipment status.

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- Computer vision, deconfliction technology, a universal traffic management system, and digital license plates will allow drones to avoid collisions with other aircraft and be tracked by authorities.

- AI software will guide flights, with drones programmed to detect infrastructure damage and AI telling the drone when to look more closely.

- The data collected — terabytes of high-definition video, 3D point clouds, or infrared sensor data — will be crunched faster, with 4x more data processed every second.

PRO TIP:

Skyward's professional services team can help your drone program stay current so you get the most from it. Learn how we can help: https://skyward.io/enterprise-solutions/corporate-drone-consulting/

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Next-gen infrastructure inspection examples

▸ Mobile command centers leveraging 5G could be stationed in very remote locations, with connected drones delivering live aerial audio and video in places not safe for people.

▸ A drone operating on a 5G wireless network could be flown to distant locations at speeds as high as 310 mph. Massive stretches of highways, flood zones, power lines, fire zones, or pipelines could be examined in minutes.

▸ Granular analytics, down to individual power poles, will become possible, with up to one million devices per square kilometer one day wirelessly monitoring equipment and conditions.

▸ Drone data will be processed right where collected and transferred to decision makers in near-real time. In a heat wave, a utility could use connected drones to quickly assess how each transformer on an aging power line is performing, getting information that could head off equipment failure — and the next mega-fire.

Drones have already transformed many business operations. That evolution is ongoing, and organizations that want to tap drones' full potential know that what is a best practice today could be behind the times next year. Get help from experts if it feels overwhelming to figure out the right choices for your organization.

PRO TIP:
Skyward provides a quick-start package with all the support, hardware, software, and training needed to shorten the runway for your drone inspection program.
Learn more at https://skyward.io/quick-start

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Have a regulatory compliance plan

Drone program managers also need a way to manage internal corporate and regulatory compliance. In the US, critical infrastructure is defined on a state-by-state basis, and the airspace above it is designated as a no-fly zone. The Golden Gate Bridge prohibits drone flyovers. Tennessee's critical infrastructure includes electric power plants, petroleum refineries, and petroleum or chemical storage facilities.

Plus, temporary flight restrictions can go into effect in airspace you routinely fly without a problem. Events like parades, visits from dignitaries, sports contests, and protests may ground air traffic. The same is true in disaster areas or places where first responders have an active situation.

On top of this, regulations around drones are evolving as the technology matures. This means both new possibilities and potential constraints.

> ▸ Rulemaking is underway for beyond-visual-line-of-sight (BVLOS) flights.

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▶ New rules are coming to make night flights routine — to date these have required special FAA waivers.

▶ The rules for flights over people or moving vehicles are also evolving. One proposed policy would prohibit drone flights over moving vehicles, which would have significant ramifications for state highway departments using drones for bridge and road bed inspections.

While the actual risks presented by commercial or public drone operations are low, the potential consequences to the organization are real. Airspace regulations have the force of law. National aviation regulators have the authority to impose civil penalties including fines or loss of privileges on any entity that violates aviation regulations or endangers the safety of the airspace system. That's just one more reason why corporate drone programs need consistent methods of ensuring external compliance. Knowing the airspace for each and every flight is the first step. No matter how experienced your pilots are, they must check a validated drone airspace map to see if an operation is located in controlled airspace or faces obstructions such as transmission lines or tall buildings — before each and every flight.
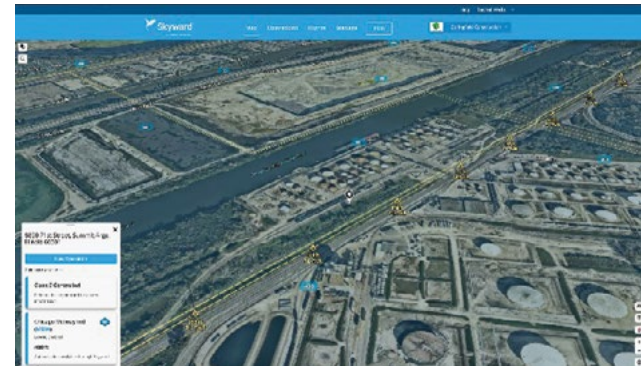
PRO TIP:

As a member of the FAA's Drone Advisory Committee, we keep a close eye on emerging rule changes. Subscribe to Skyward's news and insights list to keep up: https://skyward.io/news-press/.
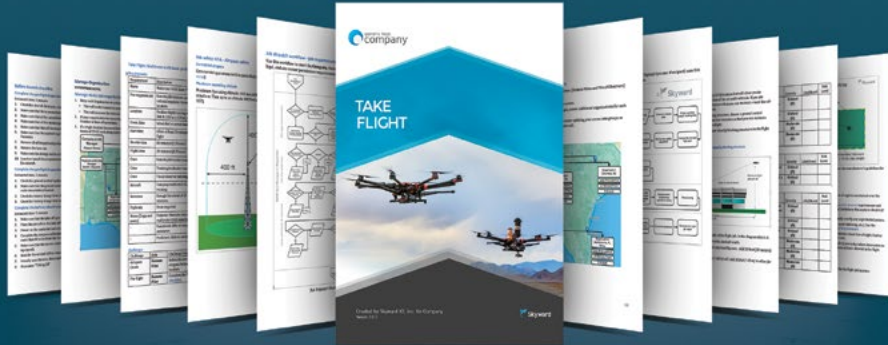
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Mitigate risks

Many companies have well-established internal regulations designed to protect the organization from operational losses and liability. Similarly, your drone program must have consistent methods of ensuring internal compliance. Your company's risk-mitigation plan should include the following

STEP 1

Develop a comprehensive general operating manual

A general operating manual decreases risk. By ensuring that every team and pilot follows the standard operating procedures for every flight, you decrease the variables that lead to human error and establish a strong bedrock of accountability.

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A general operating manual should contain checklists and procedures concerning pilot training, equipment handling, maintenance, setup of the flight area, flight planning, regulatory information, data management, and anything else germane to your drone operations.

STEP 2
Get insurance

If you work at a big company, this comes as no surprise. But if you're looking to provide contracted drone services to a major corporation, know that a general liability policy will be a precondition of any work that you do.

There are policies available already, and more providers are expected to offer coverage as regulators provide greater clarity to the regulations. As it stands, the question around insurance is: can we get a good rate? After all, paying a high premium for drone insurance could cut into the efficiency gains they offer.

A drone presents similar insurance risks as a traditional aircraft, albeit on a much smaller scale. You need to be able to show that your operations are as safe and responsible as possible. In other words, insurers want to see that you have a loss control program, which reduces the odds of an incident and limits severity. Having a strong general operating manual is one way of demonstrating this. Another is keeping detailed records of your flights and operations, which goes a long way to prove your professionalism — and brings with it other advantages.

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STEP 3

Make risk mitigation easy by integrating it into the workflow

The most efficient flight operations are also the ones that integrate regulatory and corporate guidelines into the day-to-day workflow. When both are managed via a single system, such as Skyward, your corporate risk managers and legal team will feel confident that you're taking compliance seriously and that all your flight crews can understand and abide by rules every time. And with a complete system of record that includes the totality of operations and workflow, you'll avoid last-minute scrambling to prepare for audits.

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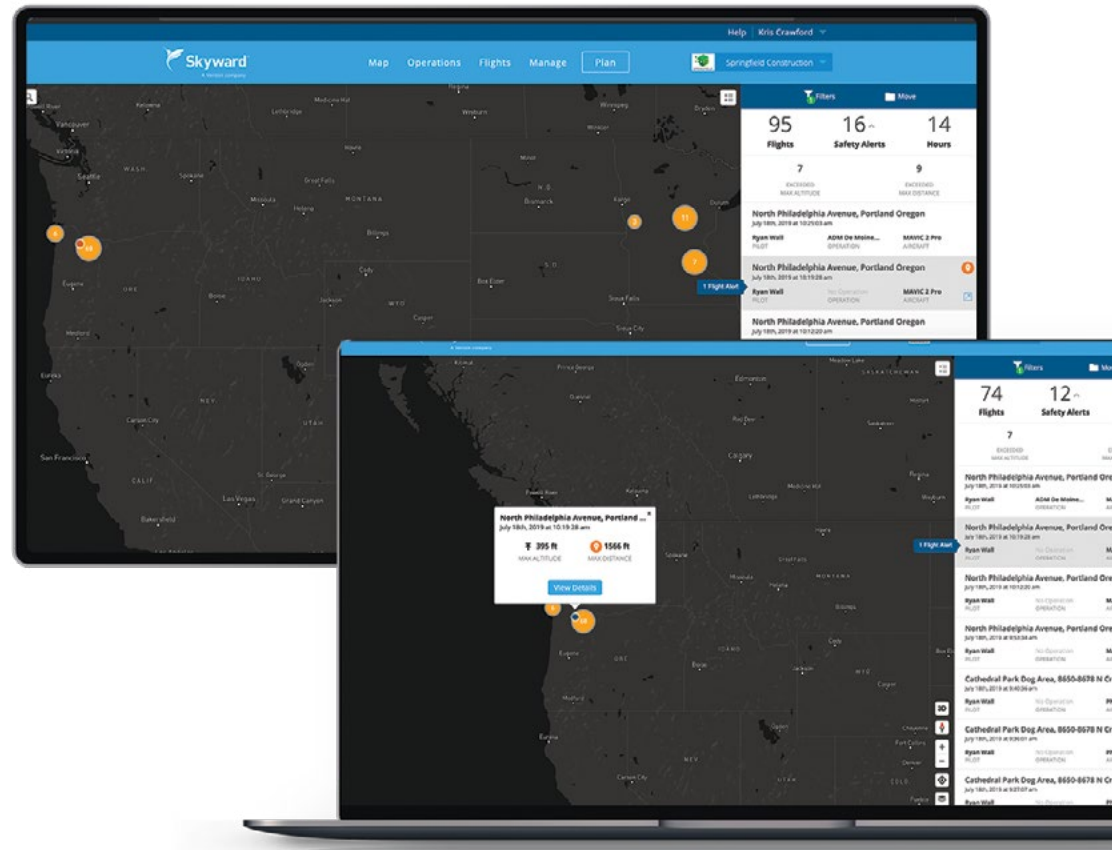
STEP 4

Refine future processes by analyzing past data

The idea of recordkeeping doesn't fill most of us with excitement, but there are many excellent reasons to make it an integral part of your drone operations.

As with any new field, there is plenty of room for adjustment as businesses learn the most efficient ways to run their drone operations. Analyzing past operations, including any unplanned incidents, is a prime opportunity to improve your program and maintain the competitive advantage of early adoption. By keeping meticulous records, you'll have a data set that reflects the true state of your drone program.

For example, did the majority of a company's incidents happen with one model of aircraft? Do pilots with fewer flight hours tend to collect subpar data? Do operations in the months of January and February take longer? This knowledge can help you identify trouble spots and inefficiencies and continue to improve.
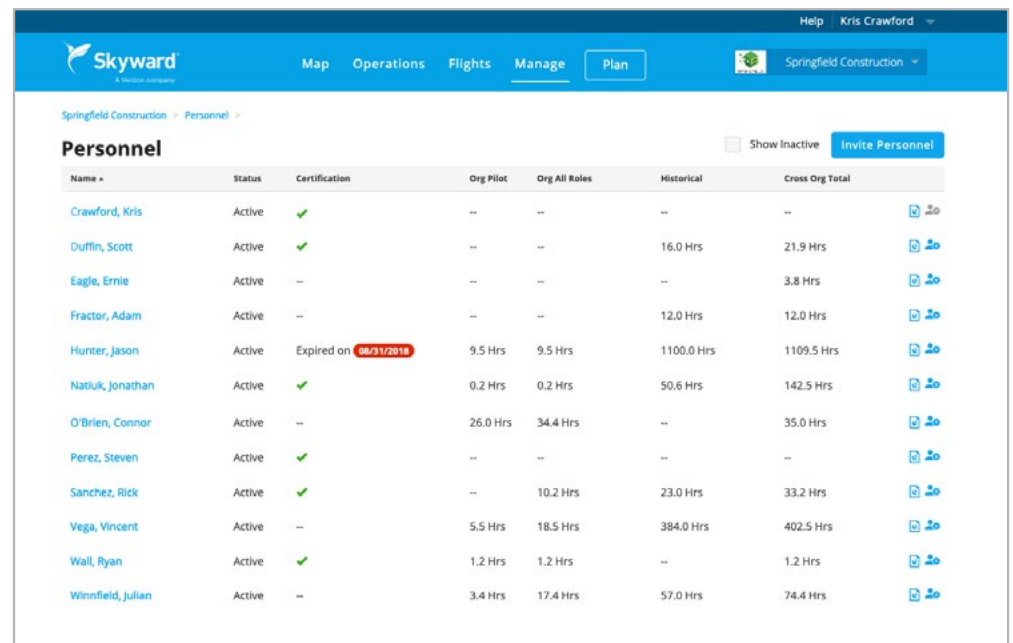
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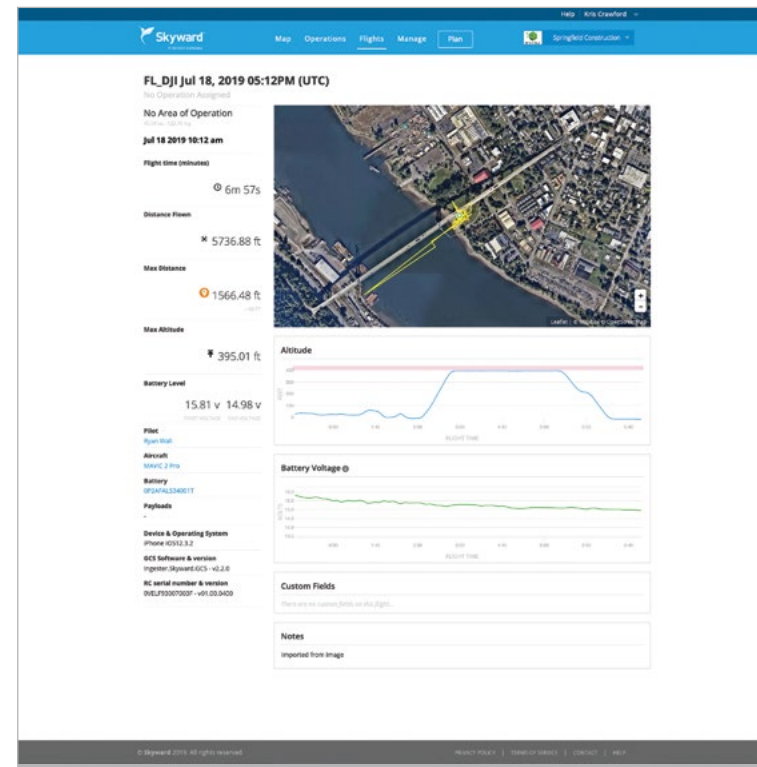
STEP 5

Maintain an audit trail to provide transparency and save time

Recordkeeping in the form of flight logs is central to the standard operating procedures used throughout aviation.

When your executives, a corporate legal team, or outside auditors request records of your drone operations, you don't want to be in the position of having to scrape together inconsistently recorded data from a variety of sources with differing levels of precision and detail. You want centralized, up-to-date data about the entire scope of your unmanned aviation program.

Many companies use Skyward to store records of each flight and operation, including date, time, personnel, equipment, and classes of airspace where the operation took place. To provide full transparency, give executives, lawyers, and risk managers access to your Skyward account so they can check in whenever they'd like.

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STEP 6

Track pilot credentials, maintenance, and inventory

Making sure your fleet is properly maintained and your equipment is thoroughly tracked is essential. From the batteries to the propellers, every inch of your aircraft needs to be inspected and documented. Documentation is key, because it's not enough to simply replace a part. Knowing when, how, and why a part was replaced is vital to understanding your equipment and forecasting your maintenance needs in the future, increasing safety and reducing the cost of upkeep over time.

There are multiple points of failure in any complex machine, and there are identifiable signs of wear that can be tracked. Certain parts are best replaced on a planned cycle, and

Having this information in the same place as your other drone documentation is not only convenient, it also allows you to maintain detailed records as a natural byproduct of planning your flights in Skyward. In this way, a firm can be sure its operations are in compliance and know that they have the information to prove it.

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batteries should be rotated to distribute wear and tear across your entire set of equipment, not concentrated among a few overstressed items. With in-depth documentation of your inventory, this is much easier to accomplish.

When your executives, a corporate legal team, or outside auditors request records of your drone operations, you don't want to be in the position of having to scrape together inconsistently recorded data from a variety of sources with differing levels of precision and detail. You want centralized, up-to-date data about the entire scope of your unmanned aviation program.

Many companies use Skyward to store records of each flight and operation, including date, time, personnel, equipment, and classes of airspace where the operation took place.

To provide full transparency, give executives, lawyers, and risk managers access to your Skyward account so they can check in whenever they'd like.

STEP 7
Plan for New Capabilities

At Skyward, we want to make sure that our customers achieve drone ROI right away with the technology that's available today. We also want to make sure that we all innovate with the future in mind. In the case of infrastructure inspections, many new drone capabilities will require cellular connectivity.

When we think about planning for the future of connected drones, we're really talking about preparing for the tasks we'll be able to accomplish.

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We believe that infrastructure inspections stand to gain from connected drones in three main ways:

▸ Beyond-visual-line-of-sight flights

▸ Artificial intelligence

▸ Autonomy

Use of cellular networks is a key enabler to rolling out BVLOS operations at scale while keeping operating costs low — because you don't have to build new infrastructure.

If you're involved in your company's drone program, there's a good chance that you're focused on efficiency, lowering costs, and making the most of your resources. If your drone program

TODAY VLOS
UNLICENSED SPECTRUM WITH LIMITED RANGE
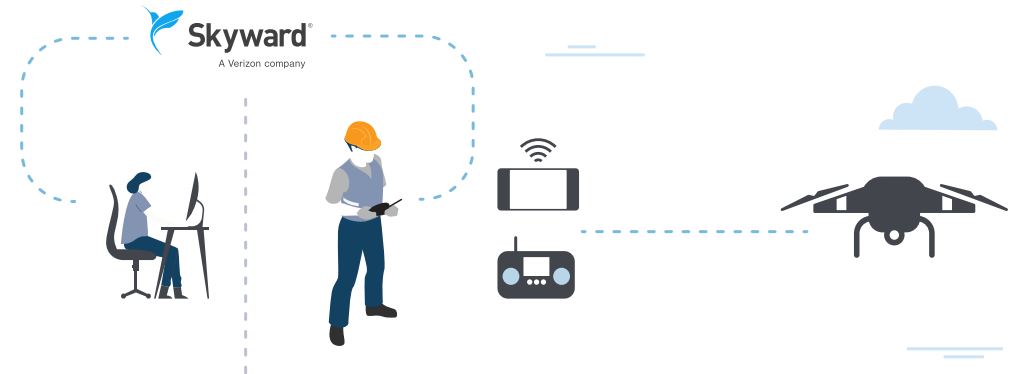
NEAR FUTURE BVLOS,
1 PILOT TO MANY DRONES
MANAGED SPECTRUM WITH UNLIMITED RANGE

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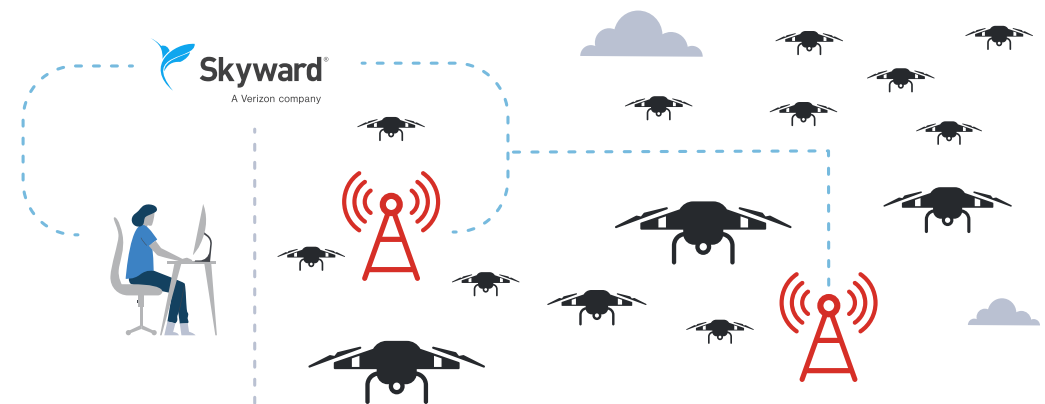
is relatively young, you're probably still exploring use cases and working to achieve standardized practices throughout your organization. If your drone program is a bit more sophisticated, you may have identified use cases for drones that aren't feasible just yet — either because of technological or regulatory limitations. These can include tasks such as package delivery, horizontal infrastructure inspections well beyond the operator's line of sight, and simultaneous remote deployments for ongoing surveillance or inspection.

These use cases would benefit many companies, but they aren't currently in widespread use. That's because each of these requires the ability to fly beyond visual line of sight. The biggest benefit to cellular connectivity on aircraft is in enabling BVLOS flight on a wide scale. Networks that companies like Verizon have already invested billions of dollars in can be used to connect a pilot over the network to a drone in many parts of the world.

Why companies care about BVLOS

BVLOS use cases range from infrastructure inspection to delivery. Other use cases that need near real-time transmission of video from the drone to an off-site location are good candidates for connectivity as well. We also see the best traffic management and deconfliction happening when vehicles have connection to a network of Universal Traffic Management services. All of these benefits are realized on current LTE networks today and should be supercharged with 5G.

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How to prepare

First, identify specific and essential use cases that require BVLOS capabilities. Then, partner with a company like Skyward to apply for a BVLOS waiver from the FAA so you can begin to test out your use cases while complying with current regulations. Skyward can also help to connect drones to the existing network, or set up a private wireless network for your company.

Artificial Intelligence

Why companies care about AI

Until fairly recently, the utility of a drone was limited to the sensors attached to it. But now artificial intelligence software enables drones to map, track, and analyze data in near real time. AI-powered drones assist in addressing emergency situations, assessing storm damage, finding people in the wilderness, and identifying structural defects in infrastructure. Companies are using AI to streamline inventory management and to map and identify all the objects in a vast warehouse or on a corporate campus.

REMEMBER :
Not every business problem has an AI answer, just like not every problem has a drone answer.

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How to prepare

Getting ready for artificial intelligence means taking the time to understand the business case and value of implementing the tech. AI can do amazing things, but it's important to ask yourself if it's really the right tool, or if you already have a way of gathering the data you need. Find subject matter experts internally or within your community that can guide you in this discovery process.

PRO TIP:

Imagine that AI has allowed your company to gain an important insight. Ask yourself, "Would we be able to act on this information immediately?" If you can't actually use AI insights for your business, then the technological investment may not be worthwhile.

It can be easy to spend too much time collecting data and allocating computing resources in a way that doesn't lead to business efficiencies, customer satisfaction, or sales. Focus on the questions you're trying to answer.

Other considerations

Data management

Determine storage, retention, and regulatory requirements for your data. How quickly do you need the data? How far back do you need the data? Are there special regulatory or data management rules your company is required to follow?

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Quality assurance

Artificial intelligence is a broad term that includes a variety of disciplines. Many of the approaches share common characteristics and need a way for the system to know if the AI processes are producing accurate information. Talk to software vendors about common errors, how they create and validate their models (called training), and whether you will have the ability to provide feedback to the AI software (called supervision). Determine how the AI will be updated and how you will ensure that the system is performing correctly. Learn the basics about common errors such as false positives and false negatives. If you are working on a system that involves reasoners, inferences, or rules engines, make sure your technology provider explains how these systems work.

Autonomy

Each company needs an organization-wide point-of-view and policy regarding autonomous drone operations. How will you integrate these rules and policies into your general operating manual, standard operating procedures, and operational checklists?

Why companies care about autonomy

There are different types of autonomous drone operations. For example, for repetitive tasks that must be done regularly — site surveillance, warehouse scanning, bridge inspections — automation can save a lot of time and money. Drones that can be programmed to perform these tasks on their own will help streamline business operations and cut down on recurring costs.

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How to prepare

Understand what kinds of decisions your drone will make and what sort of situations you want it to deal with. This is something that your drone manufacturer should be able to help you with. Some drones have very basic levels of autonomy, such as flying along a preset route, while others might be able to execute complex obstacle avoidance maneuvers while continuing to carry out their missions. In any of these cases, it is important that your team understand the terrain, sensing, and other operational capabilities and needs of the autonomy system, how much input is needed from human operators, and how the system alerts operators to a need for human interaction or to alert of a failure in an autonomy system.

It's also important to have a solid plan for how the system is checked for failures and how much human supervision is needed. Not only will technical conditions have an impact on the level of supervision needed, but operational risk may also require closer supervision for those operations that could involve higher risk.

As with all these technologies, understand and rehearse failure recovery, and in the event of a real failure, ensure that a good retrospective process exists for fault analysis, mitigation, training, and future planning.

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Near-Future Use Cases

So far we've discussed drone connectivity and how it will enable BVLOS flights, artificial intelligence and autonomy. So what might that look like in practice? Here are a few examples of what may be possible.

Better visibility during and after disasters

Mobile command centers leveraging 5G could be stationed near disaster-prone locations, with connected drones helping to deliver faster, better visibility to first responders, media companies, and line workers sent in to assess threats and damage. Connected drones could deliver live aerial audio and video in places not safe for people to access. With 5G, a drone could eventually be flown to distant locations at speeds as high as 310 mph while staying connected to the mobile network. Massive stretches of highways, flood zones, power lines, or fire zones could be examined in minutes, with insights on conditions fed in near real time to responders.

Improved analytics, down to individual power poles

New 5G networks should eventually allow up to one million devices per square kilometer to be connected wirelessly. And coupled with AI, devices operating on 5G wireless could produce actionable information out of raw data faster. Drone-generated videos, LiDAR readings, photos, and point clouds could be processed right where collected and transferred to decision makers in near real time. Utility companies could get better analytics on supply and demand or system

waste. Or, in a heat wave, connected drones could assess how each transformer on an aged power line is performing in near real time. This type of granular information could head off equipment failure — or the next mega-fire.

Entirely new capabilities via the Internet of Things (IoT)

Gartner predicts big innovations are coming in sensors: Information will be collected on a wider range of situations and events; sensors will be packaged in new ways to support new applications; new algorithms will crunch all the data. These will enable use cases for drones that we haven't thought of yet.

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Infrastructure inspections: the need for speed

Many of the systems that Americans rely on for work, commerce, and daily life were built in the 1960s, when the U.S. population was about half what it is today. They've reached or exceeded their design lifespans, and they're overtaxed. Some examples:

▸ Over $800 billion is needed to shore up the nation's roads and bridges.

▸ Nearly one-fifth of all passenger rail lines are in poor condition.

▸ The U.S. electrical grid dates to 1882, when Thomas Edison unveiled the first power plant, and its basic structure has remained much the same since.

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Drones are a proven approach to improving the pace, quality, and frequency of inspections of these creaky systems. Autonomous, connected drones operating on a 5G network should open up even more possibilities, with intelligent video, remote diagnostics, and near real-time analytics that should help infrastructure managers more quickly see what may be on the brink of failing. Managers should be better able to assess damage, prioritize repairs, and predict maintenance. And the systems we rely on for energy, transportation, water, and more should become more efficient and reliable.

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Technical Requirements

Connecting a drone beyond visual line of sight over cellular includes more than just the wireless segment most people think of. Various network segments are involved including the cellular on drone, the towers and radio network, the cellular core network, the backhaul telecommunications network, and the connected devices and services. Safe deployment of drones over a network requires you to understand the basics of the whole communications chain. Work with experts like those at Verizon to plan your connected drone network to make sure the whole system is ready for BVLOS operations.

Key Considerations

Radio environment. There are a lot of advantages in reliability when using managed spectrum, but that doesn't mean you don't have to be concerned with signal quality for the duration of your flight.

Data use. Understand how much data your drone use case needs. Data rates, latency needs, and frequency of communications are all helpful for network planners. We have best practices for cellular communication requirements of various drone use cases to help guide you.

Failure planning. Understand what your drones will do in case of a communications failure and what your drone operators and those relying on the drone will do, not just in case of a communications failure, but for all types of BVLOS data failures.

Other requirements. Have security, compliance, quality of service, and monitoring, likely guided by your IT department or network operations center.

Infrastructure Inspections: Today, 4G, & 5G

Let's take a look at long-distance infrastructure inspections — for example, transmission lines, roads, and railways. This is a great way to understand the varying capabilities of connected drones and how they will give enterprises the opportunity to innovate.

Today

Today, companies use airplanes, helicopters, and drones for aerial inspections of horizontal infrastructure. For U.S. companies operating under Part 107 rules, a pilot must be within visual line of sight of a drone at all times. Depending on terrain and distance involved, this sometimes means that it's more cost effective to use a plane or helicopter. If a drone does make sense, pilots may drive hundreds of miles per day collecting raw data, which they store on laptops or external hard drives and upload to company servers at the end of the day. If they don't have the time or expertise to process the data in the field, colleagues back at the office will analyze the data and determine whether any further action is needed. In this case, the drone is simply another tool in the field crew's truck. Its primary value is that, in many cases, it's cheaper and safer than using a traditional aircraft.

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With connected drones

When drones are connected to a wireless network, they can safely be deployed beyond a pilot's visual line of sight (BVLOS). If a U.S. company receives a BVLOS waiver from the FAA, they can remotely deploy drones from thousands of miles away to monitor a hundred miles of pipeline. Drones can capture a certain number of geotagged photos over a prescribed distance. Because they're connected to the network, they can send the photos back to the office in near real time for further analysis. The company's inspectors use software to compare images from the last inspection and spot defects. Then a field crew can be sent out to make repairs. This is clearly more efficient than the standard line-of-sight operations of today. But it can get even better.

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With 5G-connected drones

Let's take it a step further. Imagine hundreds or even thousands of 5G-connected drones stationed at regular intervals and ready to inspect railroad tracks, highways, transmission and distribution power lines, levees, bridges, and dams. They're equipped with remote ID, deconfliction technology, and AI-powered sensors, allowing them to avoid collisions with other aircraft and to be tracked by regulators. They're launched by a pilot at the home office and fly autonomously in airspace governed by a Universal Traffic Management system (UTM) that ensures the safe sharing of the airspace by all aircraft.

The drones are connected to an ultra-wideband, energy-efficient, 5G wireless network via small communication nodes placed on structures in the field. Artificial intelligence software guides the drone, detecting potential infrastructure damage and zooming in more closely at problem spots. It may even identify the nature of the problem or recommend the needed repair. The data collected — terabytes of high-definition video, 3D point clouds, or infrared sensor data — is streamed back to the office in near real time.

No longer just another "tool in the truck," these connected drones can become a transformative, cost-lowering, irreplaceable aspect of company operations.

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APPENDIX

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