MEASURE

MEASURE WHITE PAPER

Your Guide to Managing an Effective Drone Program

Version 3.0

MEASURE.COM

Introduction

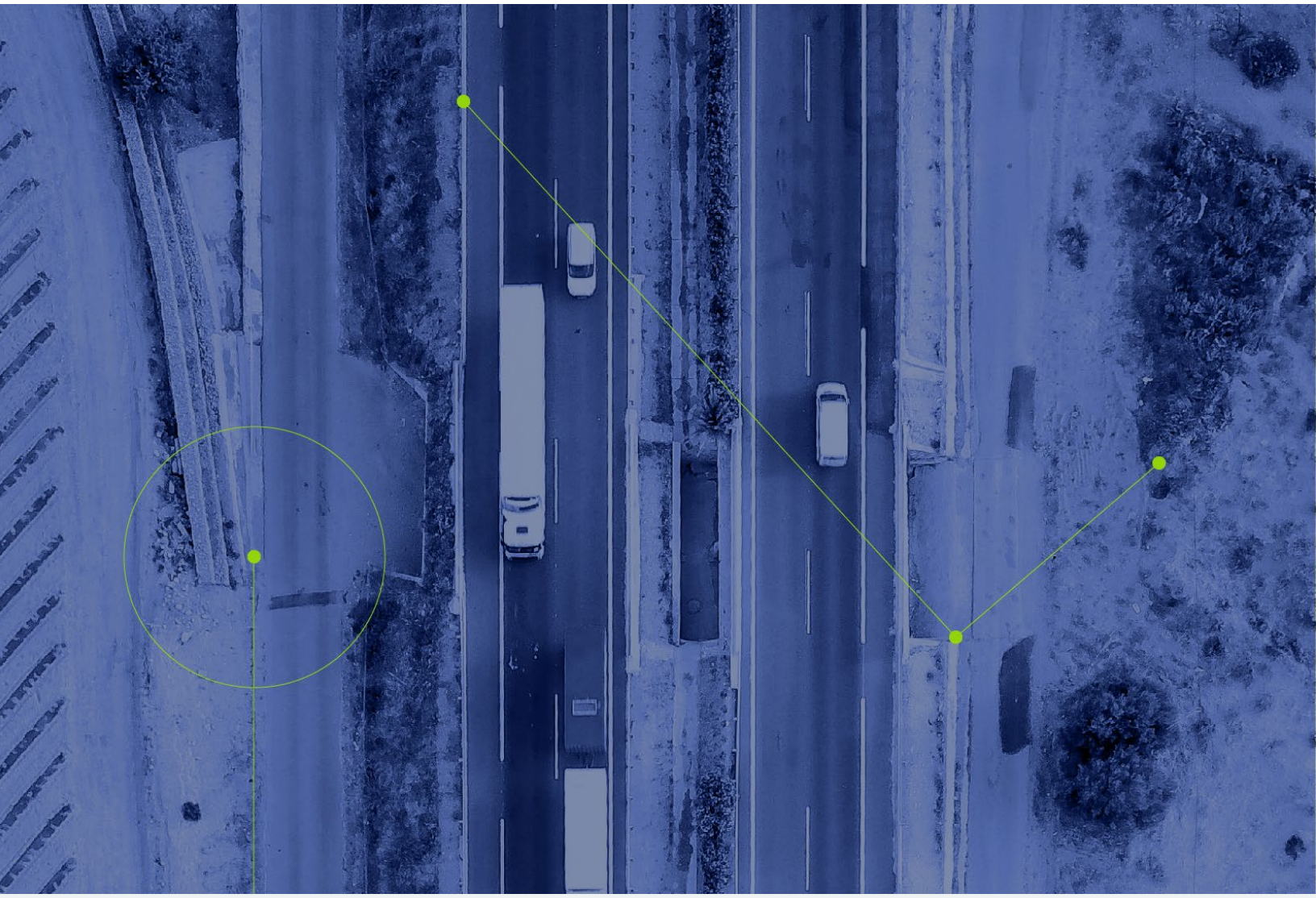
Measure was early to drone services and grew to serve some of the largest companies across the energy and construction industries. We completed tens of thousands of missions with zero reportable incidents and collected data on high-value assets like utility-scale solar and wind farms, energy transmission and distribution infrastructure, and mile-long construction sites for warehouses and data centers. Working for Fortune 500 clients and at high-value sites requires a safety-first culture, professional-grade processes, highly skilled teams, and a commitment to quality.

Today, Measure is refocusing its business on providing the tools that other companies need to be successful with their own corporate drone programs and their own drone services businesses.

In this whitepaper, we'll outline five major components to a successful drone program:

1. **Program Management**
2. **Pilots & Pilot Training**
3. **Drones and Sensors**
4. **Flight Planning & Data Collection**
5. **Data Processing, Mapping, and Analysis**

We will take a deeper dive into each of the elements, with the goal of guiding you in developing your very own drone program and giving you practical tips that you can utilize today.



1.0 PROGRAM MANAGEMENT

Component 1
Program Management

01 PROGRAM MANAGEMENT

Companies will implement their drone program in different ways, depending on size, program scope, and geography. However, proper execution of a drone program must include the functions summarized in Figure 1.1.

Simply put, without the Drone Operations Manager, you have no Drone Operations.

Drone Operations Manager

Most companies will designate someone to lead the charge and manage the many moving parts of the program. Depending on the size of your organization and how you are structured, this can be one person at a central location (like the business owner or program lead), or it might be several people managing flight operations in their region. Regardless of how you are structured, you will need a Grand Central Station, of sorts, to manage your company's drone operations. Typically, this would be the Drone Operations Manager.

The Drone Ops Manager (or whatever the title he or she is given) is responsible for ensuring all the functions of the program are running smoothly, whether accomplished in-house or outsourced. Simply put, without the Drone Operations *Manager*, you have no Drone *Operations*.

For this reason, the Drone Operations Manager must be an **excellent communicator and demonstrate a mastery of people skills.** Their job will require coordination between many different parties; the ability to influence each of these parties and reach common ground is an important part of the job.

Also, the ability to **respond to emergency situations and high-pressure events** is important. If anything goes wrong during a mission, the Drone Ops Manager is the first call from the pilot. They must be able to effectively problem-solve on the fly and be confident in their ability to make decisions.

Managing drone operations requires the coordination, oversight, and execution of a wide range of tasks and functions. The Drone Ops Manager will work with a team that might include full-time and/or contract pilots, engineers, and data analysts, among others. They may be managing multiple missions simultaneously and in various stages of completion. With so much to manage, it's important to streamline operations as much as possible. Measure developed a comprehensive program management tool, Measure Ground Control, to help run our complex drone program.

Program Management Software

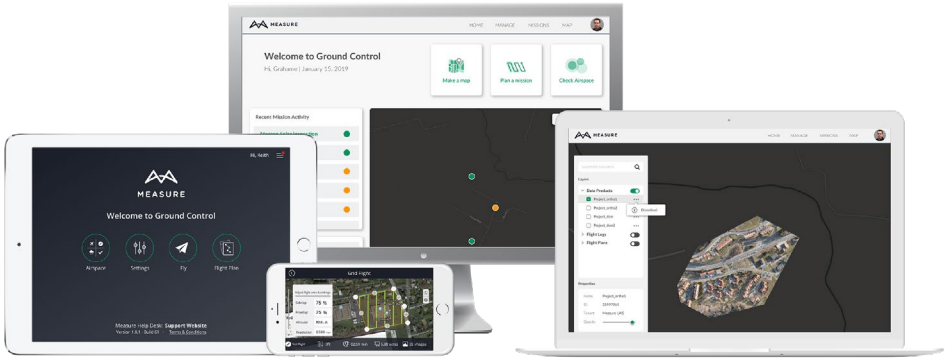
Managing a drone program is a complex operation, covering many functions. Looking across the drone software market, you will find a plethora of products targeted at one or a few of these functions. For example, there are popular software products focused only on flight logging, or only on equipment management, or only on data management.

However, using a single software solution for as many functions as possible - work ordering, resource management, flight planning and tracking, program reporting, compliance, and data

01 PROGRAM MANAGEMENT

Get a free trial of Measure Ground Control >>

management - will help you streamline your operations and manage your program more efficiently. You'll also have the program oversight that most companies need to ensure consistently safe and compliant execution of all aspects of their drone program.



Here are a few ways in which proper program management software can help solve management challenges:

- Avoid the cost and complexity of multiple software tools
- Ensure that flight logs, completed checklists, and other compliance data are captured
- Track equipment status, assignments, and usage efficiently
- Reduce miscommunications regarding logistics and data collection plans
- Simplify pre-flight checks, flight setup, and data collection for your pilots
- Enable data quality checks while pilot team is on-site
- Keep data organized and associated with missions without requiring extra steps
- Process raw drone data into actionable data products
- Easily generate reports for leadership and compliance purposes

Measure was searching for a comprehensive software platform to manage its own extensive drone operations. **Unable to find a platform that met all of its needs, Measure built one, based on the experience of managing thousands of flights across myriad applications.** That product is Measure Ground Control™. Measure Ground Control (MGC) is an end-to-end software product that combines a user-friendly flight application with a comprehensive program management portal and data tools powered by Pix4D. With MGC, drone program operators can manage and scale their operations through one cost-effective solution. A basic overview of Ground Control's features is provided in Appendix C.

01 PROGRAM MANAGEMENT

Figure 1.1 - Functions of Drone Program Management

Function	Description
Work Ordering	Placing a work request for drone data.
Fleet Management	Scheduling of aircraft and sensor payload for each job, managing shipping and storage logistics, following equipment maintenance schedules, and completing repairs or upgrades as needed.
Pilot Management	Tracking certifications, licenses, training, and proficiency of each pilot; assigning pilots to each job; overseeing travel schedules; ensuring rest requirements are met; and measuring on-the-job performance.
Compliance	Checking airspace, flight, and pilot rules and regulations for each job; ensuring that any necessary permits, licenses, trainings, or waivers are in place; and confirming that all applicable rules, regulations, and policies are adhered to.
Flight Planning	Determining flight schedule, pattern, altitude, and image capture specifications, as well as any weather-related requirements (e.g. temperature, light, or irradiance limitations), to meet the data goals of the job.
Data Collection	Flying the drone and appropriate sensor payload, according to the flight plan and safety procedures, to collect the data from the job site.
Flight Logging	Collecting all flight data such as flight path, altitude, speed, battery usage, and screen captures to effectively document and track the flight.
Data Engineering	Automated and/or manual processing and analysis of the raw drone data to create a usable data product or report.
Data Management	Storing, tracking, organizing, and delivering the reams of drone data collected, processed, and analyzed.
Performance Tracking	Continuously ensuring company policies are followed, tracking program metrics, and measuring program benefits (e.g. costs and hazardous man-hours saved).

FUNCTIONS OF DRONE PROGRAM MANAGEMENT

Air Operations Manual

An Air Operations Manual is the foundational document of a professional drone program and should be distributed to every in-house or contract pilot, operations personnel, drone engineer, and any other member of the drone program. Each company's Air Operations Manual will be unique depending on the attributes of your organization, but should always address the following subjects (summarized in Figure 1.2):

1. Authority and Control of Flights

While often overlooked, it is imperative to establish who has the authority to approve flight operations and under what circumstances.

Establishing clear lines of authority holds individuals accountable and improves safety outcomes.

- **First**, determine who is capable of putting in a request for drone operations.
- **Second**, establish a mechanism for internal review by a person or group given the authority to approve or deny flights.
- **Third**, delineate the overarching authority of the person approving missions and the authority of the pilot in command leading the mission in the field.

For example, Measure often encounters situations where the viability of a mission is called into question due to factors such as inclement weather or an operating environment with too many distractions (such as an unexpected gathering of persons nearby). The Pilot in Command (PIC) must determine whether that mission can be flown based on conditions in the field, but certain situations detailed in our Air Operations Manual dictate when a pilot in command should make a call to the Drone Operations Manager for approval to continue or discontinue the operation. One example is if an aircraft sustains damage but it appears to not affect the airworthiness of the drone. After explaining the situation to the Drone Ops Manager, the PIC will receive a "go/no go" order.

Establishing clear lines of authority and scopes of responsibility not only makes individuals more accountable to each other—improving safety outcomes—it also can help determine responsibility in the case of an accident.

2. Regulatory Compliance and Training Requirements

State clearly in the Air Operations Manual that all pilots must abide by federal, state, and local regulations concerning the operations of drones as well as other applicable rules like FCC guidelines concerning the use of certain types of spectrum for command and control of an unmanned aircraft system. These rules should be written so as to apply not only to internal pilots but to any third party operating on behalf of the organization.

Your Air Operations Manual must also make clear that pilots maintain required licenses and certifications in good standing. It should outline your company's training requirements and procedures for meeting these requirements (we'll discuss more in the next section).

01 PROGRAM MANAGEMENT

3. Flight and Mission Planning Procedures

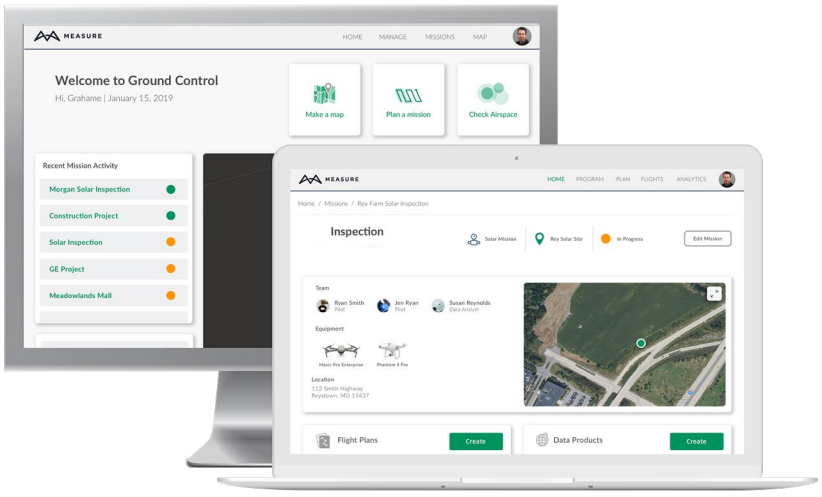
Flight and mission planning should make up the most in-depth sections of a quality Air Operations Manual, as flight and mission planning done right will ensure consistently successful aerial data collection and safe flight outcomes in the field.

Let's take a high-level look at some of the planning stages to get an idea for this process.

Pre-flight planning includes the gathering of information such as mission location, timing, type of operation, client data needs, and any unique site requirements. With this information, a flight planner can determine and schedule the exact aircraft, sensor, and other equipment needed for a job; assign pilots; obtain any regulatory approvals that might be required (airspace, night waivers, etc.). They may also provide precise flight settings or a pre-determined flight path to the pilots.

Field flight planning procedures involve the assignment of duties within a flight crew, a pre-flight equipment inspection, adjustments to the pre-flight mission plan based on the realities on the ground, and more. The Pilot in Command will also complete a final check of weather and airspace, conduct an overall safety assessment, and complete a pre-flight checklist.

Post-mission procedures begin upon completion of the mission for the day. These procedures ensure that the data collected met the mission goals and that the crew safely leaves the area with all its gear organized and stowed properly. They often include instructions for completing a post-flight checklist and ensuring that the collected data is uploaded for processing and analysis.

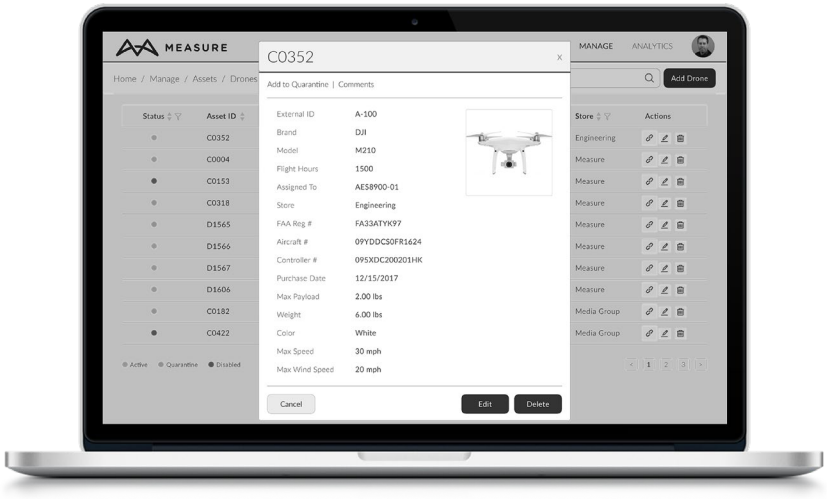


Mission Management in Measure Ground Control

4. Maintenance & Repair Program

Having a structured drone maintenance and repair program will eliminate many potential safety hazards in the field, reduce unproductive downtime due to malfunctioning equipment, and lessen instances of poor quality data acquisition.

Maintenance schedules cover procedures ranging from preflight inspection to internal aircraft inspection to bench testing to complete overhauls, dictating the frequency with which these should occur. Measure Ground Control's program management tools track the usage of drones, batteries, and sensors over time via automatic telemetry data upload so that maintenance activity can be based on actual equipment usage.



Equipment Management in Measure Ground Control

5. Mishap Reporting

Mishaps will occur from time to time in the field, and a professional drone program must have policies in place for what to do when accidents happen. The Air Operations Manual should answer the following questions:

- What severity of accident warrants a report?
- Who needs to be informed when an accident happens?
- What information needs to be collected at the scene and by whom?
- Who will be responsible for filing a mishap report?

Collecting flight telemetry data is a useful way of tracking the information required for mishap reporting. Program management tools that automatically collect and analyze telemetry data, such as Ground Control, can make mishap reporting more streamlined and accurate.

Figure 1.2 gives an easy-to-reference summary of the sections of an Air Operations Manual.

Figure 1.2 - Components of an Air Operations Manual

Subject	Purpose	Considerations
Authority & Control of Flights	Establish who has authority to approve flight operations under what circumstances	Who can put in a request for drone operations? How are operations reviewed and approved? What authorities do the approver and the pilot-in-command have?
Regulatory Compliance Guidelines	Unequivocally state that all applicable rules and regulations must be followed	What federal, state, and local regulations affect your operations? What is the process for requesting regulatory waivers? What other regulatory guidelines (e.g. FCC) may apply?
Training Standards	Stipulate pilot training requirements by mission type and ensure only qualified pilots are flying	What training is required for each of your mission types? How often must training be renewed? Do training requirements differ between employee and contract pilots?
Flight & Mission Planning Procedures	Ensure consistently successful aerial data collection and safe flight outcomes	What are your data collection requirements? What is the type, location, and timing of the mission? How are you managing your equipment and pilots?

AIR OPERATIONS MANUAL

Figure 1.2, continued - Components of an Air Operations Manual

Subject	Purpose	Considerations
Crew Resource Management	Reduce and mitigate errors related to human factors in in-field flight operations	What are your crew rest requirements? How do factors like weather or stress impact pilot scheduling? How are crew errors or infractions addressed?
Equipment Maintenance and Repair	Reduce safety hazards, downtime, and data quality issues due to malfunctioning equipment	Who will be responsible for drone maintenance and repair? What are your pre-and post- flight maintenance procedures? How will you track equipment usage over time?
Mishap Reporting	Determine policies and procedures for when accidents happen	What severity of accident warrants a report? Who needs to be informed when an accident happens? What information needs to be collected at the scene and by whom? Who will be responsible for filing a mishap report?

AIR OPERATIONS MANUAL

2.0 PILOTS AND PILOT TRAINING

Component 2
Pilots and Pilot Training

02 PILOTS AND PILOT TRAINING

An obvious requirement of any drone program is pilots. The FAA requires any sUAV operator to have a Part 107 certification before flying for any commercial purpose. So who will be your pilots? Where will they be located?

The answers to these questions will vary depending on industry, company size, and corporate structure. Rather than try to apply a blanket approach to all drone operations, we've listed a few examples of how some organizations in various industries are structuring their internal pilot programs:

Utility T&D

Select utility workers obtain their pilot license for regular line patrols, spot checks, issue investigations, and disaster response.

Construction

Pilots serve a geographical region; 1099 pilots or local contractors are on call.

Renewable Energy (Wind, Solar)

Corporate pilots serve several regional sites. Particularly large farms with on-site personnel may have a dedicated pilot. Geographically dispersed sites may be best served by third-party vendors.

Public Safety

First responders obtain their pilot licenses and go through rigorous training.

takeaway

Create incentives and provide resources for existing employees to become Part 107 certified.

Motivating Existing Employees to Get their License

If you'd like to have existing employees get licensed, you should consider developing an incentive program to motivate employees. Becoming a drone pilot requires a good amount of dedication and training and adds a big responsibility to an existing job description.

Many companies have found the best way to motivate employees to become certified is through company-provided training, paid time to study for Part 107 exam, and incentives – some offer a bonus after successfully acquiring Part 107 certification and completing training. Human Resources and Talent Management remind employees that sUAV skills are a great way to beef up their resume. Still others make it a requirement to achieve promotion or next-level advancement within the company.

Whatever approach you take, making sure employees are rewarded and recognized for their expertise will go a long way to creating a successful drone program.

Assessing Internal Resources

With the vast growth of the consumer drone market in recent years, many employees already involved in facility operations and maintenance may have some existing familiarity with drones.

Furthermore, people with manned aviation experience - those holding sports pilot licenses for example - will have an important leg up in understanding the complexities of the National Airspace System. At Indianapolis Power & Light, Contract Coordinator Stephen "Stix" Dorsett became a resident expert on drone inspections of transmission and distribution lines and served as a leading pilot.

> "Find the person flying in his/her free time."
>
> -Stephen "Stix" Dorsett, IP&L

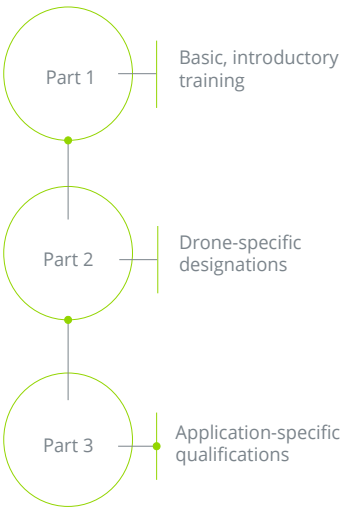
Stix advises companies to identify the drone hobbyists first: "Find the person who's been flying in their free time." He goes on to explain, "A lot of companies are looking at commercial pilots to do these jobs, but your own internal hobbyists are excellent for this because they are teachable and also possess job knowledge."

Hiring Externally

In many cases, managers will need to bring on additional resources to fill drone pilot roles. Regardless of whether you will be hiring a contractor or a direct employee, characteristics to look for include an aviation background, organizational skills, superb attention to detail, professionalism, high regard for safety, willingness to travel, and familiarity around advanced technology. Use clear job requirements to set expectations. Here are some examples:

1. Hold and maintain a FAA Part 107 certification as a commercial drone pilot.
2. Complete training on specific sUAS and missions that are required for the pilot to perform his/her function.
3. Possess a thorough understanding of the capabilities and limitations of sUAS airframe and sensor payload equipment.
4. Develop flight plans, check NOTAMS, TFRs, and weather; coordinate airspace integration with any affected controlling agencies or privately-owned properties.
5. Facilitate pre-mission briefs, complete safety risk assessments prior to flight and after-action reviews upon post-flight.
6. Solve problems on the ground in real-time and perform limited UAS and ground support equipment troubleshooting in the field.
7. Maintain knowledge of civilian airspace and aeronautical charts.
8. Be on call to travel on short notice.

Pilot Training Types



Facilitating Pilot Training

Whether hiring new drone pilots or designating current employees as pilots, comprehensive, ongoing training should be a non-negotiable requirement. There are a number of different ways to structure an effective training program, but Measure recommends three types of training: basic introductory training, drone-specific designations, and application-specific qualifications. Of course, **all trainees must pass the Part 107 exam prior to the following training.**

Basic Introductory Training

The introductory training should cover many of the core principles of your organization's program architecture, as outlined in the Air Operations Manual (which is covered in the next section). This includes items like maintenance guidelines, crew rest requirements, drug and alcohol policy, regulatory compliance, and more.

Drone-Specific Designations

Drone pilots should be trained on a specific drone platform, for example the DJI Inspire 2 or the senseFly eBee. Measure denotes training of this sort as a "designation." Designations are important in setting a baseline for safe operation of aircraft and ensuring that pilots can adequately take manual control of the aircraft at any time to avoid hazardous situations.

Application-Specific Qualifications

Pilots should be trained to perform one or several specific industry applications - also known as a qualification. Qualifications might include such things as flying around high-voltage transmission lines, conducting a wind turbine inspection, or flying a grid pattern over a construction site. Certain qualifications, for example solar plant inspections that require thermal imagery, can only be performed with certain aircraft or sensor. Therefore, a pilot must often become designated on a particular aircraft type before "unlocking" an associated qualification course.

3.0 DRONES AND SENSORS

Component 3
Drones and Sensors

Aviation is proof that given the will, we have the capacity to achieve the impossible.

-Eddie Rickenbacker

03 DRONES AND SENSORS

The next obvious part of any drone program is, well, the drones. In order to get started, you'll need to answer some very basic questions to help understand your needs:

- How will we be using drones and what kind of data do we need to collect?
- What is the skill level of our pilots, analysts, and drone engineers?
- Where will drones be used and where will equipment be stored when not in use?
- Do we need compatibility with existing equipment, software, or procedures?
- How will we maintain our equipment?
- What is our equipment budget?

Drone Hardware and Sensors Recommendations

Drone aircraft come in two major physical configurations: multirotor and fixed-wing. Simply put, for operations that require greater maneuverability within a more confined space or for mapping of relatively small areas, a multirotor drone is almost universally the right option.

takeaway

Multirotor drones are best for agility; fixed-wing drones are better for endurance.

Operations that require long-distance flight or wide-scale mapping are typically better served by fixed-wing aircraft. These include such use cases as long-distance transmission and distribution line inspection and large-scale solar plant inspections. Fixed-wing platforms lack the maneuverability and ease-of-use associated with multirotors, but offer superior endurance.

In the multirotor drone marketplace, **DJI dominates with over 70% market share.** DJI products offer high quality and reliability at an affordable price and cover a wide range of applications and levels of sophistication. Standardizing on one drone manufacturer, or, if possible, one drone airframe, will simplify aircraft maintenance and repair. DJI's market dominance and expansive equipment selection makes it an attractive choice. Concerns over data handling practices can be mitigated by using a feature called "Local Data Mode" available in select flight control applications, such as Measure Ground Control.

Many inspection applications suited for fixed-wing aircraft remain limited by FAA regulations prohibiting beyond visual line of sight (BVLOS) flight without a special permit, but one of the most versatile platforms currently available is the **senseFly eBee**. The eBee is a fixed-wing drone that packs a lot of power in a small platform. The eBee accepts a variety of payloads, including visual, thermal, and multispectral sensors.

The proper combination of drone and sensor is key to quality data collection. Figure 3.1 and 3.2 outline popular equipment that Measure has used successfully in the past. But always remember that equipment has to be well-matched to your specific business and operational needs, so you'll always want to thoroughly understand your requirements before making what can be an expensive investment.

Figure 3.1 - Drone Hardware Recommendations

Drone Make & Model	Style	Specs	Best For	Notes
DJI Mavic Pro 2	Multirotor	Max Flight Time: 31 min Wind Speed Resistance: 10 m/s	All purpose	*Good for tactical situational awareness for emergency response and basic small-scale mapping for most construction sites as well as distribution line inspections due to its portability, low price point, and ease of use.*
DJI Inspire 2	Multirotor	Max Flight Time: 27 min Wind Speed Resistance: 10 m/s	All purpose	*The workhorse in the industry; rugged and field-tested. Carries a high-resolution camera. Excellent all-purpose drone.*
DJI M210	Multirotor	Max Flight Time: 38 min Wind Resistance: 12 m/s	All purpose	*Dual gimbal payload allows for simultaneous thermal and RGB data collection. Preferred platform for police and fire use, and for industrial applications requiring both RGB and thermal imagery.*
senseFly eBee	Fixed-wing	Max Flight Time: 50 min Wind Resistance: 12 m/s	Utility-scale solar plant inspections	*Lacks maneuverability of multirotors, but has superior endurance. Best choice for large-scale mapping missions in mining, solar, agriculture, and large construction sites.*

Figure 3.2 - Sensor Recommendations

Sensor	Type	Compatibility	Functions
Zenmuse X45	RGB	Inspire 2, M200 series	RGB mapping
Zenmuse X5S	RGB	Inspire 2, M200 series	Primary fleet RGB payload, High-res inspection, RGB mapping
Zenmuse X7	RGB	Inspire 2, M200 series	Cinematography
Zenmuse XT-R	Infrared	Inspire 1, M600, M200 series	IR Mapping, Surveillance
Zenmuse Z30	RGB	M600, M200 series	Live inspection, Surveillance
SenseFly S.O.D.A.	RGB	eBee, eBee+	Mapping
SenseFly Thermomap	Infrared	eBee, eBee+	IR mapping
SenseFly Sequoia	Multi-spectral	eBee, eBee+	NDVI mapping (primarily agriculture)

DRONE EQUIPMENT

4.0 FLIGHT PLANNING & DATA COLLECTION

Component 4
Flight Planning & Data Collection

The most valuable thing you can have as a leader is clear data.

-Ruth Porat

04 FLIGHT PLANNING & DATA COLLECTION

Data quality assurance begins with flight planning. Good data in equals good data out, and bad data in equals bad data out. If the raw imagery that is collected at the job site is bad, there is absolutely no genie or magic wand that can make that bad data into a good data product.

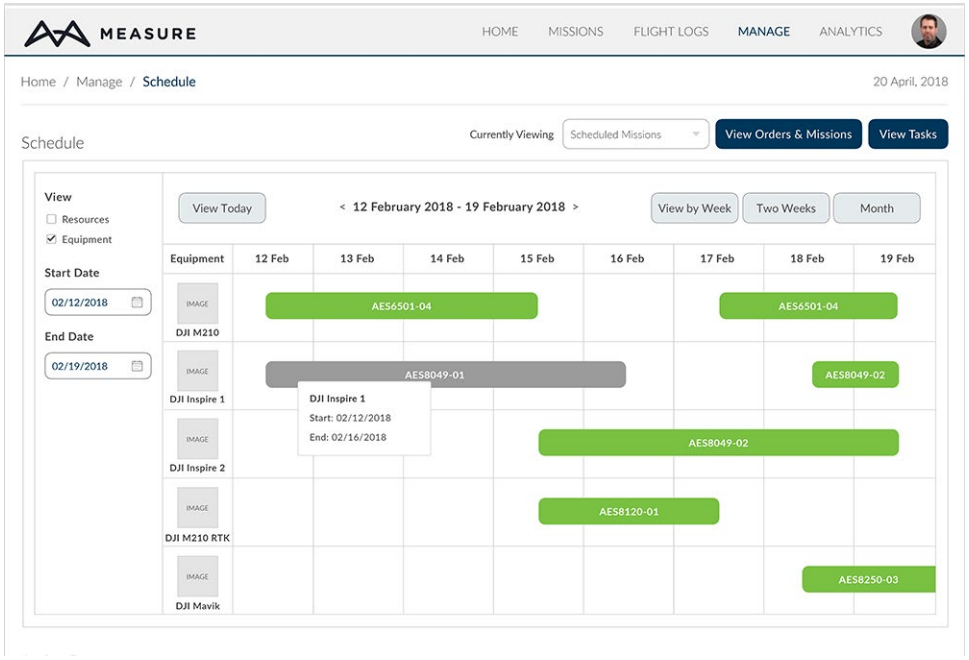
This is why flight planning is such an important part of the drone operation. To begin, it is imperative that you **understand the job location and what kind of data you need** to collect. That information will drive decisions on pilots, equipment, and flight settings, just to name a few. To help with the planning process, you should invest in streamlined software that can manage the end-to-end drone workflow. We will walk through an example process using Measure Ground Control (MGC) to schedule a mission, create a flight plan, and collect data.

Get a free trial of Measure Ground Control >>

STEP 1. CREATE MISSION AND ASSIGN PILOTS & EQUIPMENT

Create a new mission, which might also be called a job or project in your organization, with the location, type, date/time, assigned pilot, and equipment. During this process, managers should always check the airspace at the mission location to confirm that it is legal to fly and request any needed waivers or permissions in advance. The planner must match schedules for pilots to ensure those with the right skillsets are available for the job and, likewise, assign the right equipment to match the job type, pilot skills, and data required.

Measure Ground Control can automatically email pilots their mission information and will notify them of a new mission assigned when they login to the flight app. Depending on how you communicate with your team, you may also want to copy site or project managers for effective coordination.



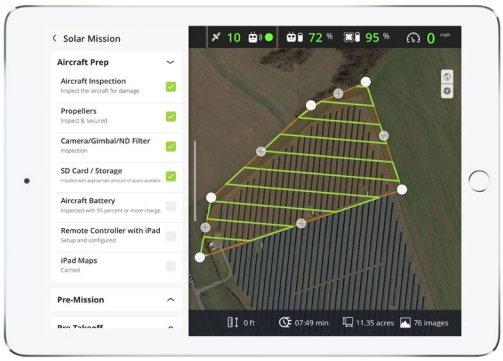
04 FLIGHT PLANNING & DATA COLLECTION

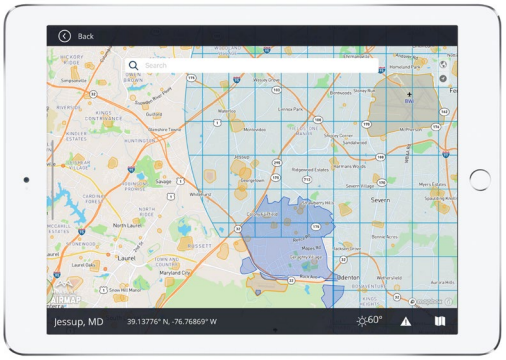
STEP 2. SETUP FLIGHT PATHS AND PARAMETERS

Since you have a good understanding of the mission and data requirements, you can, pre-load flight guidelines, paths, and parameters into the Measure Ground Control web portal. You can upload a flight plan to a mission, and automated grid flight paths can be created in either the web portal or the flight app (when using the web portal, flight plans will automatically sync to the MGC flight app for the pilot in the field). Advanced waypoint flights can be setup in the flight app, where pilots will find additional flight control features. See Figure 4.1 for more details on the flight planning tools in Measure Ground Control.

STEP 3. CONDUCT IN-FIELD CHECKS

When the pilot opens the MGC flight app on their iPad or iPhone, they can access their missions with any pre-set flight plans and follow a pre-flight checklist. Checklists help keep pilots organized in the field and help to ensure that proper protocol is followed on each and every flight. In addition to going through the checklists, the pilot will check weather and airspace and, if needed, get real-time approval through LAANC. Often, the pilot will also conduct a pre-flight safety assessment with everyone on the mission.





04 FLIGHT PLANNING & DATA COLLECTION

Figure 4.1 Automated Flight Path Features in Measure Ground Control

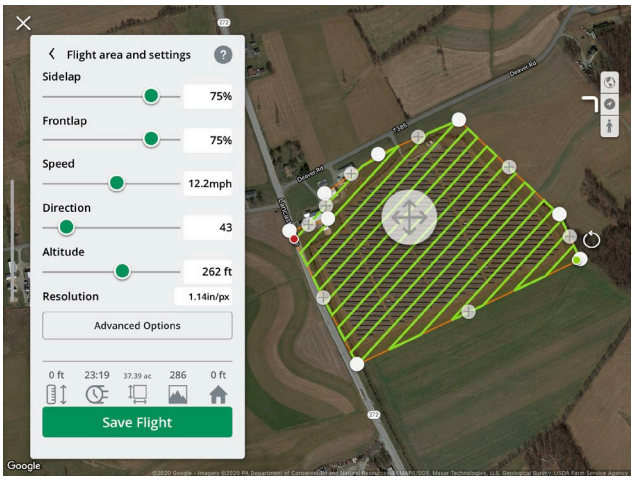
Measure Ground Control allows you to create automated grid flight paths in either the web-based portal or the flight application. Web-based flight planning allows flight paths to be set in advance and enables data analysts to review or own this part of the workflow, which can improve data quality and optimize time spent in the field.

With MGC's advanced grid flight settings, you can improve data capture by automating the flight path and camera settings. Set a custom gimbal angle, drone and camera direction, and starting waypoints; and add cross-hatch. In the field, you can also re-fly a portion of your grid in case you need to re-capture data.

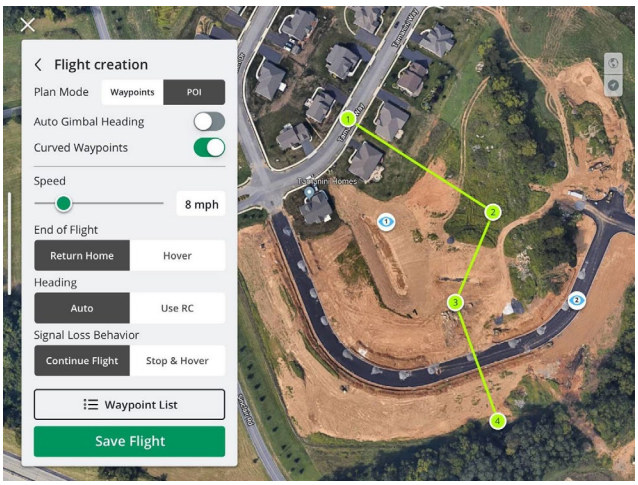
Automated waypoint flights can be created in the MGC flight app. You can set multiple waypoints, points of interest, and actions such as taking standard or 360 pano images, changing altitudes, or turning around. Start the flight and watch the aircraft and sensors perform your choreographed path and data capture. There is also a record option for turning a manually flown flight into repeatable Waypoint flight.

These features can significantly enhance the efficiency of your flight planning process and the quality of your data capture.

Grid Flight Setting in MGC Flight App



Waypoint Flight Settings in MGC Flight App



04 FLIGHT PLANNING & DATA COLLECTION

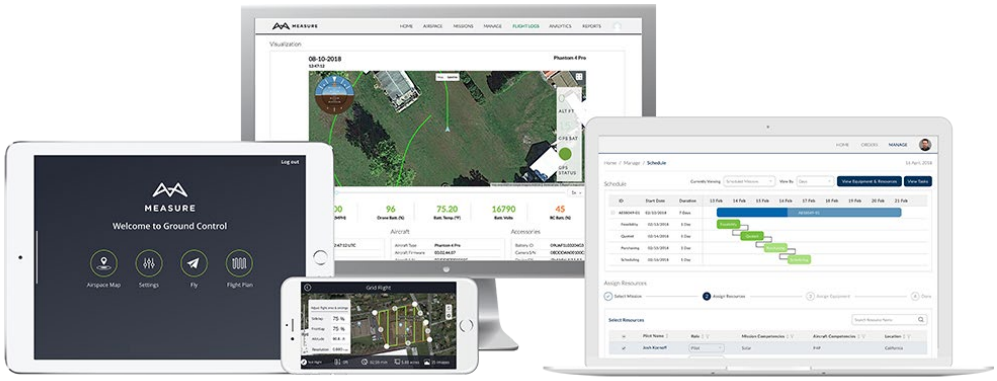
STEP 4. FLY AND COLLECT DATA

Using the MGC flight app, pilots can control the flight of the drone with a streamlined, user-friendly interface that puts features and controls relevant to commercial pilots right at their fingertips. They can conduct an automated grid or waypoint flight, use GPS-aided manual controls, and access active track modes including spotlight, POI, trace, orbit and profile. The type of flight conducted, along with the image capture settings, depends on the data needs of the project and would have been determined during the planning stage.

As a flight is completed, the telemetry data sent from the drone to the iPad or iPhone ground control station is automatically uploaded to a secure cloud storage system run off US-based servers. Once in the cloud, this telemetry data is parsed, analyzed, and made available in the MGC web platform. Pilots can review each flight they have flown with second-by-second reconstructions that provide information on altitude, roll, pitch, yaw, speed and more.

takeaway

Measure Ground Control is a one-stop-shop for program management and data collection.



STEP 5. PREPARE DATA FOR PROCESSING

The imagery (RGB and/or thermal data) collected by the drone should be properly organized and uploaded for processing. Depending on the type of inspection, data may be organized by location, mission, flight number, and/or an asset identifier system (for example, solar fields may use row numbers, wind farms may use turbine and blade numbers, etc.). Data is uploaded and associated with a mission in the MGC web portal, or, if using an outsourced company for your data processing, it may be saved to a cloud storage system shared with your provider.

5.0 DATA PROCESSING AND ANALYSIS

Component 5
Data Processing and Analysis

Chaos was the law of nature; order was the dream of man.

-Henry Adams

05 DATA PROCESSING AND ANALYSIS

There are many different ways to use drone data. Sometimes, simply capturing a few pictures and reviewing them on-site is all you need. But, to get the most value out of your drones, you will likely want to capture many images and have them process and analyzed. In other words, you'll want to create a data product.

There are many different data products; we've outlined some of them in Appendix A. As part of your planning process, you will already know what type of data product is required and how you will create it. In some cases, you will use your industry-specific software platform and an internal data team to process and analyze your data. In other cases, you will send your data out to a third party. And, hopefully, in many cases you will use an automated processing system that will help you easily create your data products yourself.

We cannot cover the process to create every type of data product, so we will focus on a few basic products that should be attainable for most people, with no GIS or specific software expertise required.

Mapping

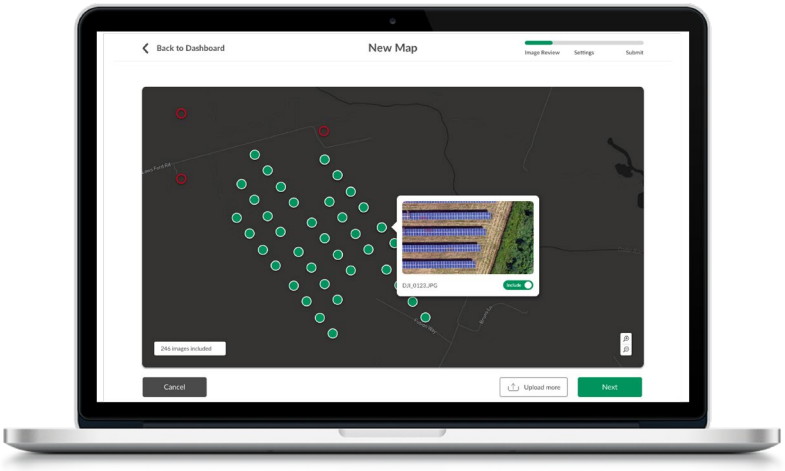
Mapping is a general term that can refer to several different data products. In Measure Ground Control, mapping includes orthomosaics, digital surface models, and contours. MGC integrates Pix4D software to produce high-quality maps through a user-friendly interface.

When you plan to create a map, pilots will typically collect data using an automated grid flight pattern with **at least 60% overlap**. Higher overlap settings help ensure data product quality, while also increasing flight times and the number of images captured.

05 DATA PROCESSING AND ANALYSIS

Watch a video of how to make a map in MGC >>

After data collection, images are uploaded to the mission page in the MGC web portal, where, you will have the opportunity to review each image, along with its capture location, to confirm data quality prior to processing. As mentioned previously in this paper, bad data in equals bad data out, so it's important that you create your map using a complete set of quality imagery.



Once you are happy with your raw data set, you will simply choose to process your images. Images are processed and data products are created through a seamless integration with Pix4D, the industry leader in photogrammetry. Processing time varies anywhere from an hour for small maps to more than 24 hours for very large maps in excess of 1500 images. Once processing is complete, you'll have the following data products to view or download:

- **ORTHOMOSAIC**
- **DIGITAL SURFACE MODEL (DSM)**
- **CONTOUR MAP**

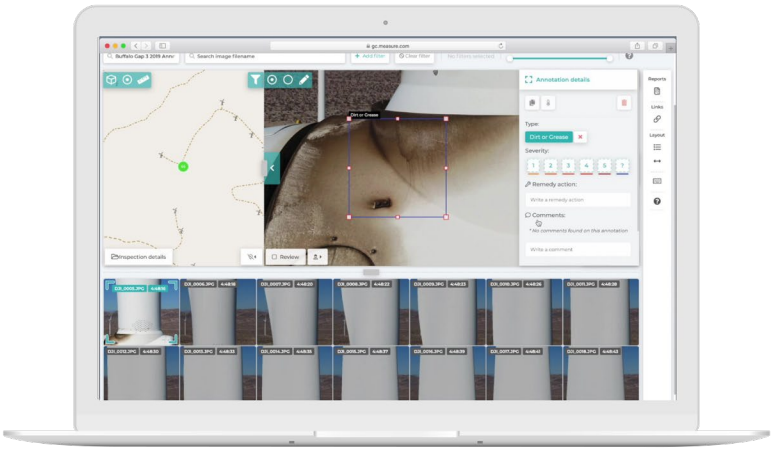
Ground Control's built-in map viewer is an advanced platform for viewing your data products in 2D. You can turn layers on and off, import your own 2D layer, and add information like the flight path. Because we use one, continuous base map, you can also move easily among all of your projects by zooming in and out and moving around the map.

You can also export your data products and other data layers for use in common GIS software platforms. Orthos and DSMs can be exported as GeoTIFF files while contours and flight paths can be exported as GeoJSON files.

05 DATA PROCESSING AND ANALYSIS

Inspections / Defect Identification

For Enterprise customers, Measure Ground Control offers an integration with Scopito, which provides tools to view, analyze, and report visual inspection data right within the MGC platform. Scopito, as well as other software useful for visual inspections is also available separately; you would simply purchase the software and upload your data directly.



Capturing high-resolution imagery in an organized way is essential for asset inspections. Depending on your use case, you might use standard manual or automated flight modes. MGC Enterprise offers an application-specific flight tool for wind turbines to help pilots capture high-quality inspection data using a standardized methodology.

After data is captured, it will need to be sorted and uploaded to your analysis platform. Proper sorting of your data is important. Likely, you will organize your data manually using systematic data collection, file naming, and organization techniques. In the case of wind turbine inspections, Measure offers proprietary sorting tools.

Once raw data is ready for analysis, use your analysis software, such as MGC or Scopito, to view inspected assets on a map, zoom-in on high-resolution imagery, classify defects, add comments, and sort the inspection data. When you're done, you can create and download an PDF report customized to show the inspection results important to your business.

There are many more solutions available for inspections and other types of data analysis. We have only scratched the surface. One example worth mentioning is automated analysis using Machine Learning algorithms such as the one built by Measure in partnership with Fortune 500 energy company AES and Google. Drone data analysis is sure to advance quickly so always research the best solution for your business.

00 WRAP-UP

Getting the fundamental elements right is crucial to creating an effective drone program that improves safety, produces valuable information, and drives a measurable impact for your business.

With a solid foundation of the key elements for your program in place, you will need the right tools to bring it all together. As you have seen throughout this paper, Measure Ground Control can manage the full scope of your drone operations. Because it is a single, end-to-end solution; it can streamline your operations and save costs.

To see for yourself how Ground Control can help your drone program succeed, sign up for a free trial: https://www.measure.com/freetrial.

Safe flying.

A APPENDIX A: DATA PRODUCTS GLOSSARY

3D Point Cloud – A 3D, rotatable set of data points representing an object (such as a building). Geolocated, measurable, and compatible with common design software.

As-Built Overlay – Creating 3D models or 2D orthomosaics that are then overlaid with site plans or CAD drawings to identify any discrepancies between plan and actual.

Construction Progress Tracking - Collecting aerial imagery at regular intervals to track changes over time and document milestone completions.

Contours - 2D lines that are placed on a map to show changes in the ground elevation at a defined interval.

Defect Identification - Identification, classification, and geolocation of defects for a wide array of applications including wind turbine blades, solar panels, utility poles, boilers, stacks, and expansion joints.

DSM / DTM – A digital surface model or 2D representation of a terrain's surface. Can be used for volumetric analysis and is convertible to CAD formats.

Erosion Assessment - Creation and analysis of topographic models to identify slope degrees and areas prone to premature erosion.

Fencing Infrastructure Review - Analysis of perimeter structures to identify compromised areas such as missing beams, corrosion, vegetation, and miscellaneous damage.

Orthomosaic – A detailed, accurate photo representation of an area, created out of many photos that have been stitched together and geometrically corrected ("orthorectified") so that it is as accurate as a map.

Pipeline Mapping - Aerial images stitched together to create visual and GIS data of pipelines and other transport systems.

Thermal Analysis – Using images of the heat given off by an object to identify anomalies such as malfunctioning solar modules, damaged electrical insulators, cracked expansion joints, and faulty substation components.

Topographic Map – A map of a ground area that is true to the shape and features of the surface of the earth to highlight variations in site grading.

Site Shading Assessment – Using the site's geographical location, nearby obstructions, and seasonal sun positioning to graph potential shading impacts over the course of the year.

Vegetation Growth Sampling – Aerial images are used to identify vegetation conditions, typically on a solar farm or along utility lines.

Volumetric Analysis - Using 2D and 3D data to estimate the volume of earthwork, cut and fill, or stockpiles. Repeated volumetric analysis of stockpiles can track inventory usage over time.

B APPENDIX B: MEASURE GROUND CONTROL FEATURES LIST

• Included ◦ Available

	Pro (1 user)	Teams (2+ users)	Enterprise (25+ users)
Flight Control & Data Collection. *Fly safely and collect quality data with a user-friendly app, airspace tools, and autonomous flight paths.*			
Mobile App. Fly and capture data with a user-friendly mobile app built for commercial use. Available for iOS, Android, and Crystal Sky. Connects to DJI drones.	•	•	•
Airspace Tools. Check weather and airspace, request LAANC authorization, retrieve and apply DJI Geo-Unlock.	•	•	•
Autonomous Flight. Setup automated grid flight paths or use advanced waypoint tools.	•	•	•
Advanced Planning Options. Upload a KML file or import your existing map tile layers.	•	•	•
Active Track Modes. Use active track modes including spotlight, POI, trace, orbit, and profile.	•	•	•
Flight Checklists. Help ensure safe operations with pre-flight checklists.	•	•	•
Live Streaming. Stream live to any RTMP service.	•	•	•
Automatic Uploads. Automatically upload detailed flight logs and mission screen captures.	•	•	•
DroneInsurance.com. Access on-demand flight coverage, 24/7 ground coverage and physical damage protection for drones, sensors, and ground equipment.*	•	•	•
Intelligent Inspection Modes. Collect data for inspections of structures such as wind turbines or utility poles.			◦
Data Processing and Analysis. *Produce high quality data products with an easy-to-use web portal and industry-leading data tools such as Pix4D.*			
Data Storage. Upload and store high resolution image files for each mission.	•	•	◦
Mapping. Process images into high-resolution orthomosaics, digital surface models, and contour maps with the industry leader in photogrammetry, Pix4D.	2000 images/mo	6000 images/mo	Custom
RTK Processing. Increase image processing accuracy with RTK drone data.	•	•	◦
Map Viewer. View your orthos and other 2D data files on an interactive, account-wide map.	•	•	◦
Measurements and Overlays. Measure linear distance and area or add a 2D image layer to your map.	•	•	◦
Exportable Files. Export 2D and 3D data products (ortho, DSM, contour map) as GeoTIFF or GeoJSON files.	•	•	◦
Inspection Viewer. Sort and upload your asset inspection images to an interactive map powered by Scopito.			◦
Inspection Annotation. Zoom-in, classify defects, add comments, and sort inspection data.			◦
Downloadable Inspection Reports. Create and download a PDF report customized to show the inspection results important to your business.			◦
Program Management and Integrations. *Plan missions, track program activity, and easily manage your operations.*			
Scheduling. Schedule missions, assign resources, and manage your program calendar.	•	•	•
Centralized Mission Management. Access everything about your mission - logs, pilots, aircraft, flight plans, files, and data products - all in one place.	•	•	•
Web-based Flight Planning. Check airspace and build grid flight paths to push to the integrated flight app.	•	•	•
Automatic Flight Log Uploads. View automatically uploaded flight logs, including detailed parameters, flight playback, and screen captures.	•	•	•
DJI Log Sync. Input your DJI user ID to easily import flight logs from DJI Go or DJI Pilot.	•	•	•
Manual Flight Logging. Log flights from non-DJI aircraft using auto-fill forms.	•	•	•
Activity Audits and Alerts. Check automatically flagged incidents for activity outside of safety best practices.	•	•	•
Program Reporting. Track your program metrics on dashboards and exportable reports.	•	•	•
Equipment Management. Create equipment kits, make annotations, and automatically track usage.	•	•	•
User Profiles and Permissions. Add users, setup user profiles, and limit access with pre-defined roles.		•	•
Image Allocation Sharing. Combine the monthly image processing allocation from all your users into a single, shared account so you can optimize your team's usage.		•	•
Single Sign On. Enable users to access multiple company applications or resources with one login.			◦
Premium Integrations. Integrate drone operations and data into Enterprise Asset Management systems.			◦
Geospatial API Access. Build custom apps and integrations for your organization to connect with MGC.			◦


MEASURE