

THE DRONES IN CONSTRUCTION GUIDEBOOK

A step-by-step guide by DJI and Propeller Aero that covers everything you need to know about using drones for construction



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INTRODUCTION

Drone technology has made impressive strides in the last few years and the construction sector has taken notice. Affordable survey-grade drones are making business digitization accessible to contractors of all sizes and getting the right information from the field is no more the most frustrating part of a construction worker's job.

Drones are providing construction companies with accurate site data in significantly less time and at a lower cost than traditional options. Innovative firms are leveraging drones to increase efficiency, inject transparency into operations, and reduce safety risks to workers. More recently, construction managers have started using drones to operate with fewer people onsite – a precaution deemed necessary to mitigate the spread of the novel coronavirus.

The COVID-19 pandemic has also compelled organizations to look for ways to become more adaptable to an uncertain future. Construction companies across the board have woken up to the need to in-

vest in remote technologies that would help stimulate operational workflows, enhance collaboration between distributed teams, and safeguard business viability in the long-term. It has become a top priority to:

- Boost efficiency and make up for the time lost during quarantine
- Create 3D models of assets and monitor them remotely
- Increase safety through contactless work

As such, adopting drone technology into construction workflows has become a matter of 'when', not 'if'. But for someone new to robotic solutions, there's a lot to consider before getting a drone program off the ground.

This guide offers an overview of the challenges drones can help construction companies to overcome, different types of results drones can deliver, leading solutions available in the market, the ROI realized by early adopters, and the steps your organization can take to harness the incredible potential of drone technology.



CHALLENGES IN THE CONSTRUCTION INDUSTRY



With its ecosystem accounting for 13 percent of the global GDP, construction is the biggest industry in the world. And yet, for the last two decades, productivity growth in construction has been notoriously slow. Most construction projects fail to come within 10 percent of budget or deadline, making [underperformance](#) a constant thorn in the sides of project owners. So, what is holding the industry back?

UNDER-DIGITIZATION OF DATA

There is a chronic problem of under-digitization in the construction industry.

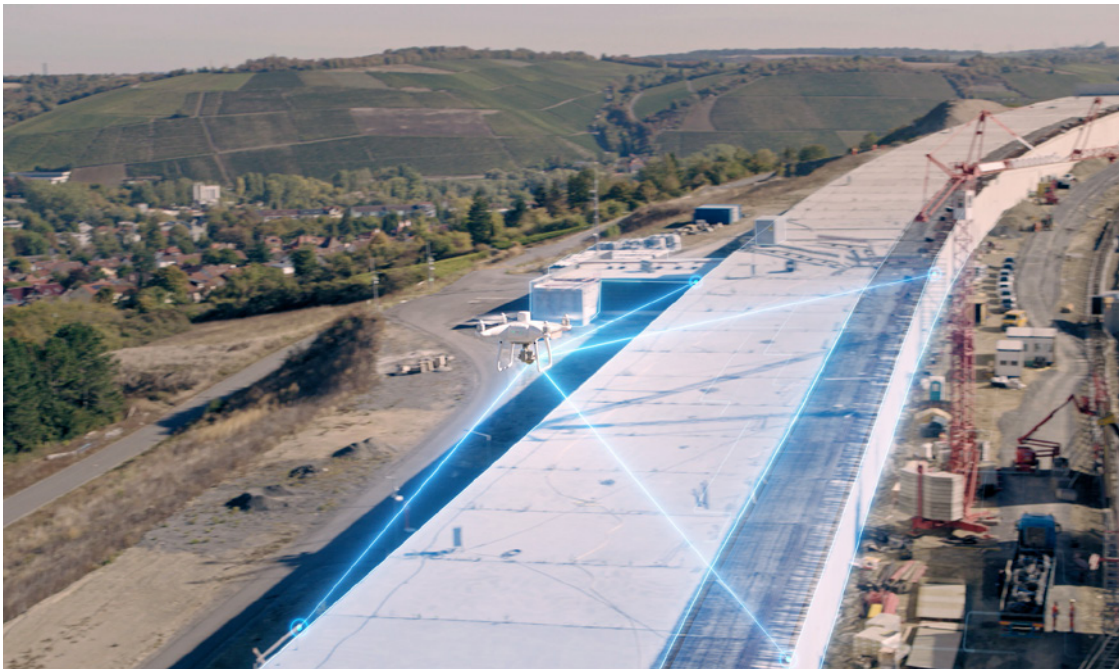
Construction site offices are still riddled with paper plans, administration and logistics are still carried out by hand, and non-digital habits cost businesses dearly.

In the United States alone, \$177 billion are [estimated](#) to be lost annually to the paucity of accurate project data. Globally, there is a \$1.6 trillion [opportunity](#) waiting to be tapped with higher productivity.

SHORTAGE OF SKILLED LABOR

Most (83 percent) contractors surveyed by the US Chamber of Commerce for the latest Commercial Construction Index ([Q3 2020](#)) have reported moderate to high levels of difficulty in finding skilled workers. So much so, more than one in three (36 percent) were forced to turn down work due to a shortage of skilled workers.

The skilled labor shortage has become a steady feature for the construction industry. Industry experts contend that apart from a hiring problem, the issue also pertains to workload and can be mitigated by adopting the right technology tools.



INEFFECTIVE STAKEHOLDER COLLABORATION

Poor communication – arising from a lack of a common data-sharing platform and teams working in silos – leads to construction professionals spending 35 percent of their time on non-optimal activities. Almost 5 hours per person each week go into managing disagreements between project stakeholders, while 4 hours are spent assessing mistakes that require rework, a [survey has revealed](#).

Leaders point to setting up standards and checkpoints to keep the idea as well as data sharing constant and making transparency the norm for all worksite communication.

THE IMPACT OF COVID-19

Apart from the abovementioned historical challenges, the coronavirus pandemic has put the construction value chain under further pressure.

- **Old operating models no longer work:** With cash reserves becoming more vital than ever to prepare for the future, construction companies need to rethink processes and seek out innovative workflows that would help them to reach new levels of profitability and eliminate human error.
- **Need for heightened worker safety:** Safety has always been a priority for the construction sector. But the social distancing norms induced by the COVID-19 pandemic have resulted in organizations implementing further onsite safety protocols which could likely hinder productivity.

Clearly, the status quo needs to change. And it's not that the industry is not aware of the barriers that are keeping it from reaching its full potential. Only, the incentive, as well as the need to innovate, have never been as high or urgent as they are today.

To succeed in a post-COVID-19 world, companies must infuse new technology and advanced automation into their workflows now.



THE ROLE OF DRONES



Drone data is as multifaceted as the construction industry itself. Drone solutions prove useful throughout the construction lifecycle to monitor progress, cut costs, save time, reduce rework, and improve safety.

STREAMLINE PLANNING

Every construction project begins at ground zero – sometimes in areas where there is no road access. But to gain a competitive edge from as early as the bidding process, it is essential for architects and contractors to understand the project environment in as much detail as possible.

Before his company added drones to its workflows, Adam Green, a construction technology specialist at Texas' Big-D Construction, used to survey potential drilling pad locations as large as 300 acres on-foot. "We could only do one location a day. Maybe two to three per week, depending on the size," [says Green](#). "With drones, we can fly multiple locations per day."

Drone technology makes data collection faster, easier, and more cost-effective. Project teams can get detailed, precise topographic survey data needed to evaluate large worksites rapidly. Architects and engineers can reference this data throughout the design process to develop designs that are both practical and aesthetically pleasing.



OPTIMIZE PROJECT MANAGEMENT

Large-scale, complex construction projects involve multiple subcontractors, hundreds of workers, several years of hard toil, and millions of dollars of investment. Working in silos often leads to construction waste which ultimately increases the project budget.

Drone technology provides all stakeholders with regular, detailed maps of the entire site to ensure that teams stay fully informed on the site progress and resource allocation.

"Sometimes, you find yourself in a finger-pointing match. '[Hey, you're behind!](#)' '[No, you're behind!](#)'," [shrugs](#) Rory Hall, COO at a Utah-headquartered grading and excavating services company, Grade Tech.

"But drone data takes all of that away. We have a picture of the site from two days ago to prove we're not behind. So once that caught hold, we haven't been thrown under the bus in a long time."

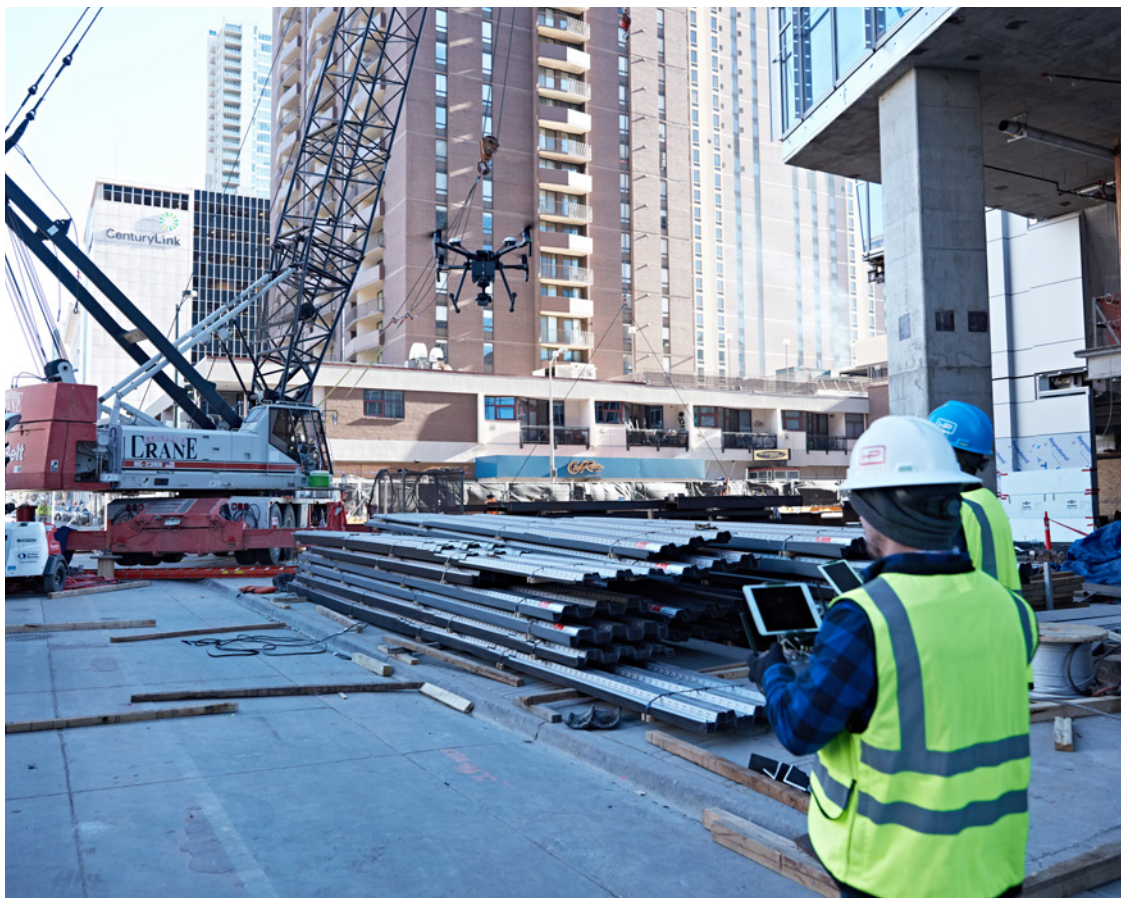
Further, documenting onsite data throughout the project lifecycle allows contractors to track changes easily and maintain regular as-built vs. as-design reports. This, in turn, allows site managers to catch a mistake before it takes shape, avoiding costly rework. Projects remain on-schedule and within budget.

MINIMIZE RISKS

Being able to survey and inspect hard-to-reach places without putting feet on the ground results in safer, more efficient construction workflows. Structural inspections, that often require teams to implement manual, rope-access techniques, can instead be conducted by a drone in a single flight. With high-quality aerial imaging and real-time video transmission, inspectors can evaluate buildings from the ground without putting themselves in harm's way. Thermal sensors and intelligence inspection features can detect physical, water, or electrical damage even mid-flight.

There are safety benefits to be realized at landfill sites as well. Kansas-based highway construction and waste services firm, Hamm Companies, has been flying drones since 2013. Hamm uses drones to survey stockpiles at more than a dozen quarries and multiple construction sites.

"One big reason we went with a drone was the safety factor," [says](#) Paul Johnson, Survey and Construction Technology Manager at Hamm. "It's a much safer alternative to walking up and down steep, tall, or jagged piles. Not having to physically scale them was a huge win."



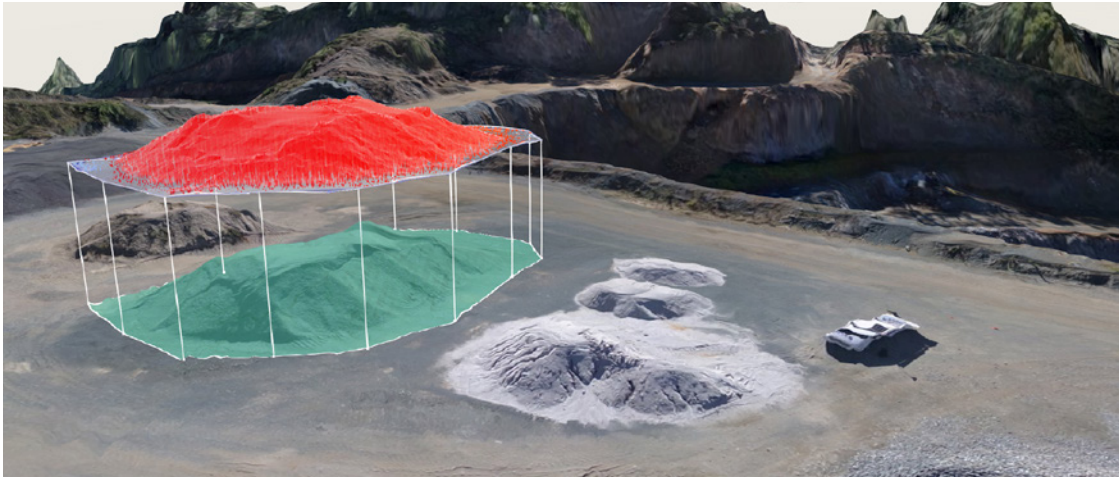
KEY APPLICATIONS IN CONSTRUCTION



VOLUMETRIC CALCULATIONS

Volumetrics is one of the most popular use cases for drones on any construction site. Since the entire site can be captured in a couple of hours or less, drone data serves as an affordable source of timely and accurate information on volumes for companies that operate their own quarries.

All DJI drones are equipped with a powerful digital camera to capture high-resolution photos that can be processed in Terra software to derive accurate cut/fill volumes and other key analytics necessary for planning and tracking job progress.

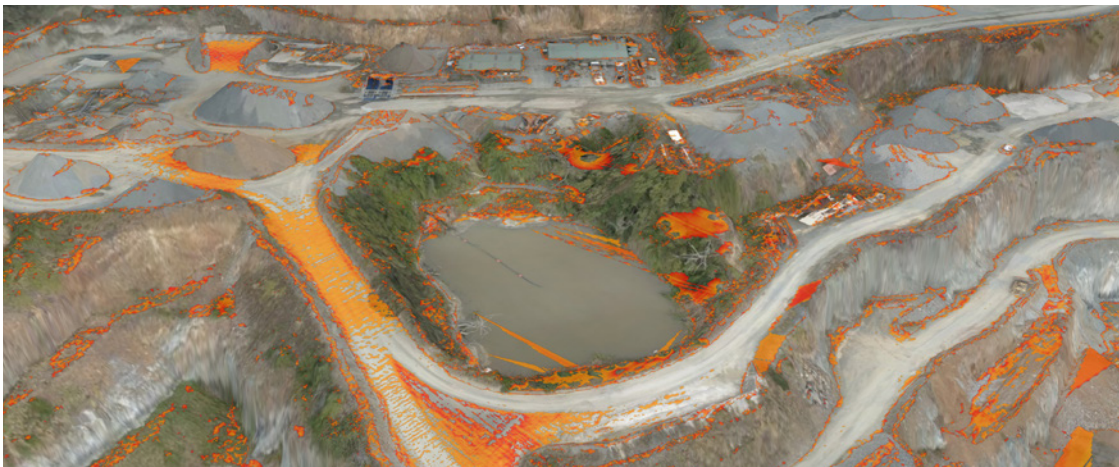


Source: [Propeller Platform](#)

ASSET MONITORING

Construction projects typically see hundreds of tools and assets distributed throughout the worksite. Tracking and monitoring them is essential for the safety of both the workers and the asset itself. DJI drones can quickly capture high-res photos

to keep a record of the site condition on any given day. These photos can then be annotated using Terra software, downloaded as a report, and shared with project stakeholders.



Source: [Propeller Platform](#)

3D MODELING

3D models – a mosaic of thousands of individual photos – make construction sites more accessible and provide the ability to measure site attributes accurately. 3D models can also be used to pinpoint safety hazards, compare completed work against design documents, and measure stockpiles from a fresh vantage point.

DJI's 3D modeling solutions use real-time kinematic (RTK) technology, which enables drones to record

GPS information and geotags images as they're captured during flight. As such, DJI's solutions can gather real-time, centimeter-level positioning data for improved absolute accuracy on image metadata. And in areas that lack mobile network coverage, DJI drones allow surveyors to use PPK for subsequent evaluation while keeping the same accuracy provided by RTK.



Source: [Propeller Platform](#)

DIGITAL TWINS

A digital twin is a continually-updated virtual representation of a real-world object or environment. Construction professionals can use a digital twin model to visualize the project site, maintain up-to-date records, validate adherence to municipal codes, and run analysis to predict potential failures in the system. Digital twins prove invaluable for future planning and decision-making.

Accurate drone data is a key ingredient in the creation of a digital twin. DJI offers a variety of solutions to capture georeferenced 3D data, mapping,



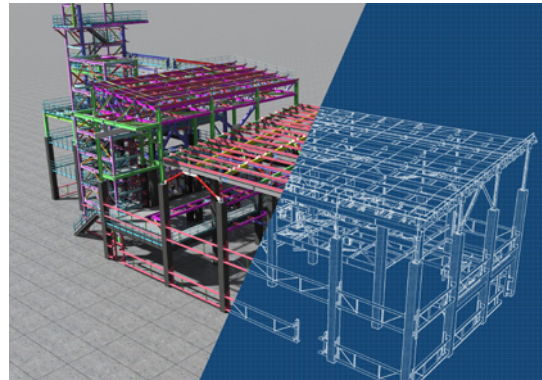
LiDAR survey data, and volumetric measurements to create a realistic model of a construction project from each angle.

BUILDING INFORMATION MODELING (BIM)

BIM is a process for creating and managing information about construction projects right from their inception to completion and beyond. In reality, the BIM designs can be quite different from the as-built model, making it difficult to visualize and verify the design. DJI drones, capable of capturing highly-accurate georeferenced data, can play a crucial role in such scenarios. Drone data can be used to create 3D models with accurate positioning information that can be readily fitted into the BIM models to visualize designs.

For example, when prefabricated embeds need to be installed inside concrete, forming the core of a

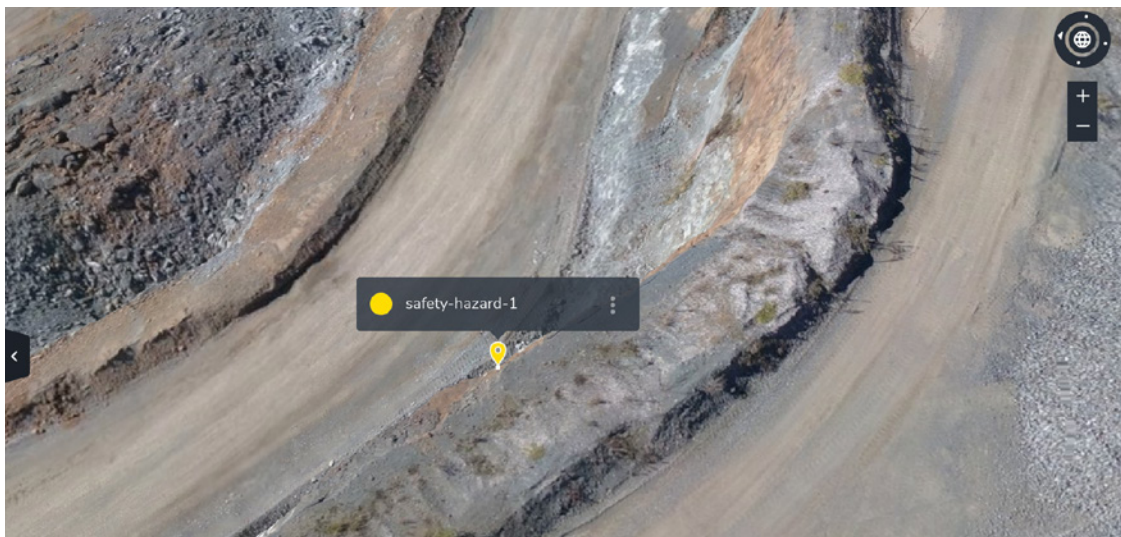
building's structural system, pinpoint accuracy is required. LiDAR inspections through DJI drones can ensure that the embeds are installed correctly by identifying the location of the embeds that interface with the concrete.



INSPECTIONS

The conventional methods of building inspections require teams to walk across potentially dangerous rooftops and scaffolding. DJI drone solutions, on the other hand, provide inspectors with high-definition site images that can be used for visual inspection.

That's not all. DJI's leading drone solutions come with an 'AI Spot Check' inspection feature, which has been designed to eliminate human error from project inspections. Users can mark objects of interest after a demo flight, and then, the aircraft will leverage onboard artificial intelligence algorithms to automatically replicate the position, angle, and framing of the camera for future missions.



Source: [Propeller Platform](#)

DJI SOLUTIONS: FIND THE BEST FIT





PHANTOM 4 PRO

The perfect educational training tool to make your team familiar with flying machines, the P4 Pro is an entry-level solution that can be lever-

aged to capture high-resolution site images and videos.

- [20 MP camera sensor / 4K videos](#)
- [Powerful obstacle avoidance](#)
- [Most affordable](#)



PHANTOM 4 RTK

An intuitive surveying solution that captures centimeter-level accurate data to create georeferenced 2D maps and 3D models of project sites, the P4 RTK

has been a trusted workhorse of the construction industry for years.

- [1/10ft accuracy](#)
- [Real-time geotagging](#)
- [Less expensive than alternates](#)



MATRICE 300 RTK + ZENMUSE P1

A complete aerial photogrammetry solution, the M300 RTK + P1 can generate orthomosaics that meet the 1:500 and 1:1000 accuracy requirements without GCPs. Perfect for capturing highly-detailed

2D and 3D information in medium to large-area operations.

- [Centimeter-level precision](#)
- [45 MP full-frame sensor](#)
- [Automated inspections](#)

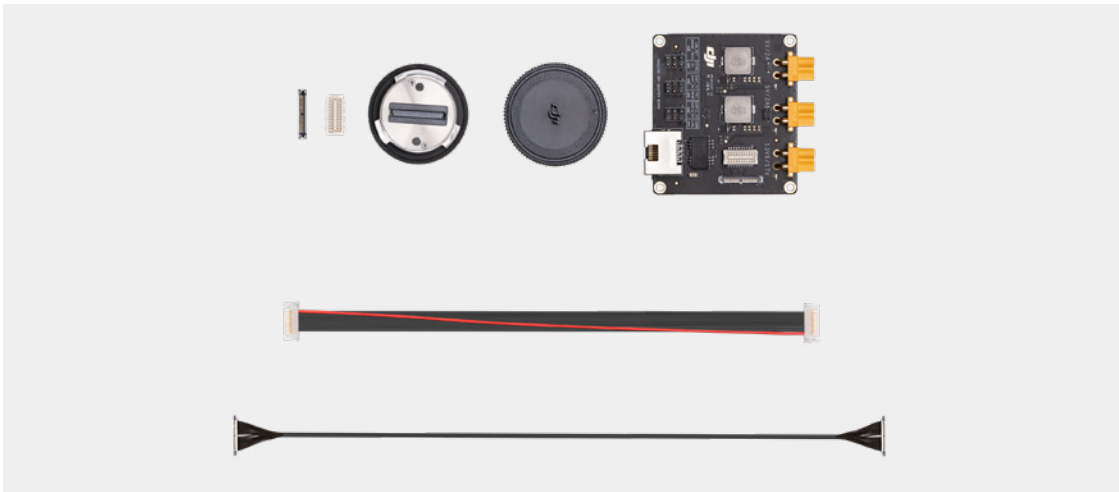


MATRICE 300 RTK + ZENMUSE L1

DJI's first LiDAR solution for aerial surveying, the M300 RTK + L1 can render centimeter-accurate reconstructions, thanks to its high-accuracy IMU, a

vision sensor for positioning accuracy, and the incorporation of GNSS data.

- [Real-time true color point clouds](#)
- [All-weather, nighttime operations](#)
- [Automated inspections](#)



PAYLOAD SDK

This is the developer kit you need to integrate any third-party payload – sensors, robotic components, and more – with DJI drones. Supports the Matrice

300 RTK via a standard adapter and a ready-to-build standard gimbal.

- [Mobile SDK communication](#)
- [Custom widget integration](#)
- [Aircraft state data](#)

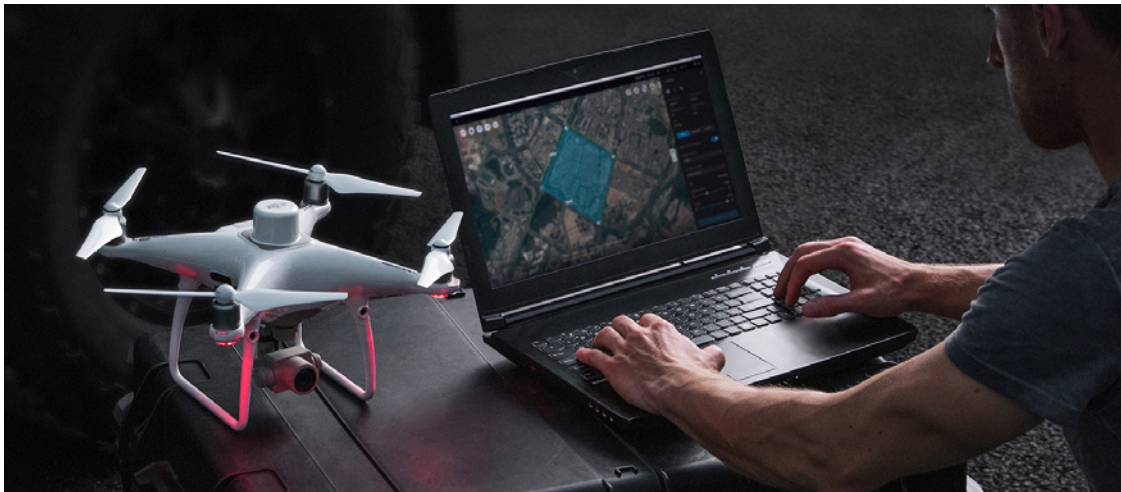


MATRICE 600 PRO

With a maximum payload of 6kg, the M600 Pro is the go-to heavy lifter for specialty and third-party payloads, such as multispectral cameras, hyper-

spectral cameras, oblique systems, high-res cameras, and LiDAR.

- [HD live streaming](#)
- [Dual-RTK GNSS system](#)
- [Intelligent battery management system](#)



DJI TERRA

A complete drone mapping solution designed to harness the full potential of P4, P4 RTK, and M300 RTK drones, Terra enables everything from mission

planning and data acquisition to area mapping and data analysis.

- [Real-time 2D mapping](#)
- [Real-time 3D point clouds](#)
- [2D and 3D point clouds](#)

When selecting a drone solution, it is important to recognize your needs and the tradeoff between speed and accuracy. Click [here](#) for more information on DJI's solutions for the construction industry.

PROPELLER AERO SOLUTION: THE PPK POWERPLAY



The release of DJI's Phantom 4 RTK (P4R) inspired Propeller Aero, a global leader in 3D mapping and drone analytics solutions, to harmonize hardware and software for the first time.

After working closely to test and validate the accuracy of a full-integrated drone surveying workflow, DJI and Propeller brought easy, affordable, and highly accurate maps to the wider commercial drone industry with a solution called Propeller PPK.

Propeller PPK combines:

- AeroPoints: High-precision, wifi-connected ground control points that operate on any coordinate system (including locals).
- Phantom 4 RTK: The first affordable RTK drone built for survey mapping.
- And the Propeller Platform: A cloud-based data analytics and processing platform that heavy civil and resource operations use to measure material movement, track progress, and visualize their survey data.

This combination of ground control, PPK/RTK-enabled hardware, and data processing delivers centimeter-grade accuracies to users in a tenth of the time (and nearly tenth of the cost) of traditional methods.

Today, civil contractors around the world use Propeller's PPK workflow to survey faster, more frequently, and more accurately. And the benefits do not stop at collection—and in fact, transcend the world of surveying altogether. Armed with up-to-date data, worksites are able to reduce instances of rework, resolve conflicts, and remove the communication silos that debilitate collaboration.

Keep reading to learn how worksites are turning drone data into hard dollar figures.



Source: [Propeller Platform](#)

UNLOCKING THE ROI



Companies looking to make a new investment in technology today are not interested in the drone industry's unofficial motto: 'Drones save time and money'. They want to know 'how much'.

But until a few years ago, it was hard for businesses to quantify the Return on Investment (ROI) from a drone program. Digitization being a fairly new concept, companies would not prioritize tracking drone data or extracting new information from it.

Most would treat it like an apples (traditional surveying cost) – to – apples (drone survey cost) comparison. When in reality, it's an apples-to-oranges comparison because drone data adds a tremendous amount of value across the entire lifecycle of a project.

The savings that construction firms can expect from drone technologies can be grouped into two major categories:

- Increasing profit margins
- Reducing opportunity costs

Here are some examples from forward-thinking organizations that have adopted DJI drones and Propeller Aero's cloud-based visualization and analytics solutions into their construction workflows.

REALIZING ~\$1.7 MILLION IN ROI IN ONE YEAR: GRADE TECH

Civil contractor Grade Tech has regularly flown the Phantom 4 RTK, using Propeller's PPK workflow, once a week for every active project over the last



Source: [Propeller Platform](#)

year. The Utah-based company estimates that in one year alone, it has:

- Saved \$250,000 in operational costs
- Made \$1.5 million in additional revenue

“Whether it was saving in trucking costs from accurate volumetric calculations, or saved crew days because a drone survey would reveal that the construction site wasn’t ready for us, or enhanced productivity from better scheduling... this [drone program] has definitely been a gamechanger,”

Grade Tech COO Rory Hall tells. “We have also been able to avoid conflict and maintain better relations with our clients because drone data gives you the power to win all arguments. We have evidence of how the site was before and after we were there.”

If you registered to attend DJI AirWorks 2020, you can watch Hall explain in detail exactly how the ROI of a drone surveying program manifests in the wild. [Click here.](#)

ELIMINATING THE NEED FOR \$20,000 AERIAL SURVEYS: SUKUT CONSTRUCTION

California-headquartered Sukut Construction decided to use drones after traditional aerial surveying proved too costly and too slow for their fast-moving project needs.

“Not only does an aerial survey cost upwards of \$20,000, but it’s also a minimum of three weeks to a month before you get a contour map back,” says GPS Program Manager Matt Eklund. “If something’s going wrong, you don’t want to know a month later. You want to know the next day, if possible. It allows red flags to go up earlier and you can make changes earlier. So, with respect to that, it’s saving money.”



Source: [Propeller Platform](#)

ACHIEVING 8X MORE EFFICIENCY DURING INSPECTIONS: HENSEL PHELPS

Established in 1937, Hensel Phelps is one of the largest general contractors and construction managers in the US. As an early adopter of drones in construction, Hensel Phelps' Virtual Design and Construction Manager, Richard Lopez, openly acknowledges that utilizing DJI drones has taken his organization to a new level.

"For an exterior inspection of a 15-story building, we would traditionally have spent a lot of money in hiring workers to set up scaffolding, and then the inspection crew would do their job; it would have taken weeks. But, once we were armed with drones, it took us only 4 hours to complete the flying, 8 hours to process the data, and another 4 hours to analyze it. It was uncanny how fast we could finish that inspection!"



Source: [Propeller Platform](#)

KEEPING EVERYONE ON THE SAME PAGE: ELDER CORPORATION

Elder Corporation, one of the largest contractors operating out of Illinois, leverages DJI Phantom 4 drone and Propeller's AeroPoints GCP solution to stay ahead of the curve. By capturing survey data frequently, the contractor allows project managers and other stakeholders to check site progress themselves and plan operations more easily.

GPS Manager Shawn Swygman explains, "We can do it the old school way, or I can fly a site once a week, share the data with the project manager, and then he can go in there and look at his cut/fill areas and see how much dirt he has that needs to go from section A to section B. Even the foremen and superintendents, I can invite them into the [Propeller] platform and they can just log on and see everything themselves. And customers that come into my office, I can show them this fantastic 3D model and they're blown away."

WHERE TO GET STARTED



Before committing to a drone program, several questions must be answered:

- How will the organization use drones? What will be the key applications?
- What is the desired survey accuracy?
- What hardware and software will be required?
- How to get certified to fly a drone commercially?
- What is the expected volume of work? How frequently should flights be planned?
- How difficult will the missions be? How much training will in-house pilots require?
- How will the data be stored and processed?

There can be a lot of unknowns about how to get a drone program up and running on your construction site, beginning with getting the required certifications and determining what airspace your site is in. If your site is in controlled airspace, such as near an airport or a military base or in an urban environment, you may require additional permissions from the aviation authorities to fly.

Once you've gotten certified and cleared your flight in the airspace surrounding your site, you need to

pick the right drone and the data analytics software. Also, you must remember that when you're out on the field, even small mistakes can have big implications on the final survey, no matter what hardware or software you are using. Some of the key elements that can affect data quality include:

- Drone altitude and speed
- Camera settings, image overlap, weather conditions
- Ground control setup and calculation of ground sample distance

It is also essential to understand the surveying workflow that can be expected when you actually put boots on the ground — right from preplanning and ground control placement to launching the drone, monitoring the flight, landing the bird, and wrapping up the mission.

For a better understanding of drone operations and how to start one on your construction site, we recommend you dive into Propeller's [How to Start a Drone Program on Your Site eBook](#).



BUILDING YOUR DRONE PROGRAM: INTERNAL VS. EXTERNAL

Many industries prefer to outsource drone operations to third-party service providers because they can avail of the benefits of low upfront costs, flexibility to trial drone applications before committing capital, and limited exposure to operational risk.

But outsourcing drone missions also means less control over operations. And scouting a reliable vendor may prove to be a challenge in certain geographies. This is why most organizations in the construction sector prefer to build an in-house drone program.

Since construction sites are inherently dangerous places, safety is the most dominant focal point for any competent contractor. A vendor, who is not familiar with the construction environment, may not appreciate the importance of adhering to the safety protocols laid down by the organization.

Hensel Phelps, for example, has modeled its in-house drone program after its 'Zero Accident Safety Culture'. "We created checklists, procedures, and maintenance programs for each piece of the equipment. We developed drone zone maps and identified emergency landing sites. We roped in auditors and attorneys to ascertain we were following all the rules and regulations laid out by the Federal Aviation Administration (FAA) and doing everything in a safe manner," VDC Manager Lopez explains.

Another factor behind construction firms preferring in-house drone programs is that modern drones have become much easier and safer to operate. And companies are also grabbing the opportunity to up-skill existing staff.

For Arizona-based Blount Contracting, a heavy civil construction services contractor, the ease of use that the Phantom 4 RTK offers is above everything else. "I can basically have whoever has a Part 107 fly and upload. Notoriously, I'd be the one doing it all.



Source: [Propeller Platform](#)

But the Phantom 4 RTK is very user-friendly, so with a three-hour training, they're up to par and can run the actual drone," [says](#) Nick Blount, GPS Manager at Blount.

Justin Russell, Head Surveyor at Colorado-based heavy civil contractor Fiore & Sons agrees. "I've tried different drone hardware and nothing is as streamlined or simple as the DJI RTK drone with Propeller's PPK workflow. I compared base and rover shots with the drone survey and got the same accuracy consistently," Russell [explains](#). "Plus, I can complete a drone survey in 15 percent of the time it takes with traditional surveying which gives me the



opportunity to survey more often and have more accurate surfaces."

Many firms, meanwhile, have discovered a sweet spot in the middle ground, i.e., running a hybrid model. Third-party service providers are roped in as and when necessary, with an assurance that they will operate within the organization's existing frameworks. Hensel Phelps follows this model as part of scaling up its drone program.

For a complete overview of navigating the early steps of a drone program, the processes involved, things to consider before you start, and insights into ways to overcome challenges, download our *Building a Drone Program Playbook*.

The International Data Corporation (IDC) expects construction industry drone spending to reach \$1.4 billion by the end of 2020. While drones were a more safe and efficient construction site tool even before social distancing became a mandate, the fallout from the COVID-19 pandemic has made it necessary for construction professionals to aggressively disrupt their operational models.

Any firm looking to drive project performance and productivity in this economic landscape will need to accelerate the evaluation, adaption, and integration of drone technology into its workflows. We hope this guidebook helped steer you in the right direction.

Building a Drone Program Playbook

DJI's step-by-step guide on everything you need to know to start a drone program at your organization

[Download Playbook](#)

The image shows the cover of the 'Building a Drone Program Playbook' guidebook. It features a blue background with a white geometric pattern. On the right side, there is a photograph of a construction site with a large, curved structure under construction, possibly a bridge or a large building. The title 'Building a Drone Program Playbook' is written in white text on the left side.

<https://enterprise-insights.dji.com/learning-center/building-a-drone-program-playbook>



enterprise.dji.com