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WHITE PAPER

Extending UAV Flight Time and Distance Through Optimized Motor Selection

Unmanned aerial vehicles (UAV) play an increasingly important role in military, security, policing, humanitarian and commercial operations.

In a growing range of applications, UAVs enable rapid, flexible traverse of large areas while minimizing human burdens and risks. For example:

- In military missions, UAVs can be used as decoys, signal jammers, counter-unmanned aircraft systems, strategic bombers, loitering munitions, and as intelligence, surveillance and reconnaissance platforms that allow soldiers to see beyond the line of sight without putting them in harm's way.
- In border security and surveillance operations, UAVs serve as eyes in the sky, helping border agents monitor crossings and promote border safety.
- In policing, UAVs can be used to monitor crowds, assess disaster areas, monitor traffic patterns and provide situational awareness in advance of tactical operations or first-responder deployments.
- In search and rescue missions, UAVs can quickly cover large areas of terrain that would otherwise be slow, difficult and dangerous for ground-based searchers to navigate, and can use thermal/infrared visualization to see victims who would otherwise be undetectable.
- In humanitarian aid missions, UAVs can be used to quickly deliver food, water, medicine, blood products and other supplies to remote areas.
- In commerce, UAVs are already playing a revolutionary role in increasing supply chain efficiency and delivering commercial goods, and these uses are projected to increase exponentially in the coming years.

Minimizing Size and Weight While Maximizing Power

These applications and others benefit from any technology that can allow the aircraft to remain airborne longer and travel farther. For example, when searching for a lost hiker or escaped criminal, the faster a UAV can travel to the destination and the longer it remains on station, navigating the designated search area "racetrack," the greater the likelihood of success.

In these types of applications, UAVs typically fly at relatively low altitudes; but in other applications, such as border surveillance and drug interdiction, unmanned aircraft fly at much higher altitudes to escape the notice of people under watch on the ground. Because reaching these higher altitudes consumes a significant amount of energy, achieving the greatest possible time at altitude and on station requires subsystem designs that maximize power and efficiency while minimizing weight and size.

To achieve these goals, it's essential to use the lightest-weight, most power-dense components available. One of the greatest opportunities for weight savings and power gains is in the main consumer of electric power — the motors that control aircraft flight, sensors and visualization systems, dispensable and active payloads, and other motion-dependent subsystems.

The motors that power these subsystems have highly specialized jobs to do, and it's common for them to be oversized, undersized, or otherwise poorly suited to the task. In an automobile, excess loads placed on an inefficient alternator can significantly decrease performance and mileage. In the same way, incorrectly specified aircraft motors can adversely affect handling qualities and reduce maximum flight time.

Problems when specifying motors include:

- Oversizing, resulting in a motor that continuously draws more power than necessary for the application.
- Undersizing, resulting in a motor that operates inefficiently and is prone to overheating and early failure.
- Specifying motors with suboptimal torque and power density, adding unnecessary weight to the aircraft and requiring a larger installation footprint that can compromise the overall aerodynamic design.
- Specifying motors that are not suited to the rigorous and continually varying environments encountered in flight.

Understanding Motor Requirements

All else being equal, a UAV will achieve the longest flight time without refueling when all motors are designed and built specifically for their application. While the application requirements on a single aircraft may vary widely, all motors should be:

- Correctly sized, delivering the highest torque while operating within the optimum speed range for the application.
- As compact as possible while meeting the application's performance requirements.
- Cool in operation and with a sufficient maximum winding temperature to deliver full performance in the hottest ambient temperatures that will be encountered.
- Built rugged and reliable to withstand all conditions the UAV may experience.
- Delivered reliably and supported anywhere in the world, for the life of the UAV program.

Few motion suppliers can meet all these requirements. All motors operate most efficiently at a specific load, torque and speed point, but most suppliers design their motors to meet a wide range of applications rather than meeting the specific needs of UAVs in particular classes, with highly specialized designs.

For these applications, UAV engineers want to meet their own very specific performance points to suit the requirements of each subsystem. When there is a mismatch between available motors and the engineering specifications, compromises are inevitable. The limited motor selections and options offered by most motion suppliers force these compromises.

Kollmorgen is different. With more than 70 years of experience developing motors specifically for aerospace and defense applications, and with a team of engineers who understand the industry's unique requirements, Kollmorgen works directly with UAV engineers to understand and meet their exacting needs.

Instead of forcing a limited choice of torque-speed curves, Kollmorgen has the unmatched ability to fine-tune the winding characteristics of frameless motors so that they deliver the highest efficiency at the optimum load-torque-speed point in the most compact form factor for each subsystem.

For example, a competing supplier might offer its highest-efficiency motor that can fit the application, but require the motor to run at 2,500 rpm to produce the necessary torque at optimum efficiency. If the application requires the same torque to be delivered at 400 rpm, the motor will necessarily run at well below its peak efficiency. Or another motor may be required that compromises on other design specifications such as size and weight.

In contrast, Kollmorgen has the engineering expertise, prototyping processes and manufacturing capability to create frameless motors that deliver the exact performance requirements at the highest level of energy efficiency, in the most compact and lightweight form factor. And Kollmorgen can deliver these highly specialized motors reliably in the quantities needed to support any UAV program.

Meeting Environmental Requirements

UAV control surfaces must operate with reliable precision even in the most adverse flight conditions. Actuator motors must have the ability to deliver smooth, precise motion despite unpredictable exposure to sand, water, corrosives, high and low ambient temperatures, and more. They must also withstand the vibration and shocks routinely encountered in flight.

A new generation of supersonic and hypersonic drones will be placing even more severe demands on these motors. In hypersonic flight, the torque required to move control surfaces increases exponentially even as extreme ambient temperatures limit a conventional motor's maximum thermal rise. An insufficient maximum operating temperature can severely compromise the performance of motors that actuate control surfaces, even as violent aerodynamic forces threaten to overwhelm the aircraft's stability.

Few motion suppliers have the expertise to understand the dynamics of proper motor design and sizing to meet these wide-ranging adverse conditions while ensuring maximum performance under all conditions.

Kollmorgen is the exception. Kollmorgen's deep aerospace and defense expertise and advanced collaborative engineering proficiency ensure that frameless motors are fit to perform flawlessly in the environment they're intended for — from the depths of the ocean to the far reaches of space. For subsonic, supersonic and hypersonic UAVs, that means creating motors with:

- Specialized electromagnetic designs that dramatically increase maximum operating temperature, ensuring full torque even in hypersonic flight where ambient temperatures can exceed 150°C.
- Specialized magnets, encapsulation, insulation and other materials that ensure reliable performance in the harshest environments.
- Specialized performance characteristics to deliver the optimum torque and speed required for each application in the most compact and lightweight form factor.

Offering an extremely wide range of standard motors, standard modifications and fully custom capabilities, Kollmorgen can supply virtually any UAV application with an ideal-fit, ideal-performance motor.

Kollmorgen also understands the dynamics of proper motor selection and sizing for any application, in any operating environment, and provides engineer-to-engineer guidance to help ensure the success of UAV motion designs.

Collaborate with a Motion Expert

The partner you choose is as important as the motion technology. Kollmorgen works with you in the initial design phase to understand your exact requirements, then provides the engineering support you need to simplify product selection, sizing, configuration and optimization. Rapid prototyping, delivery and iteration of your solution can potentially save months in your development process.

When the final design is ready, Kollmorgen's AS9100 certified manufacturing facility applies lean manufacturing, repeatable processes and quality controls to enable a quick transition from prototype to full-rate production, so you can expect motion solutions delivered on time, every time. And Kollmorgen's proven aerospace heritage and global footprint are your assurance of long-term support, in-region/for-region, to sustain product delivery throughout the lifecycle of your UAV and help you manage costs while scaling production as needed.

Want to Fly Farther?

Contact Us to discuss your needs and goals with a Kollmorgen expert for UAVs and other aerospace and defense applications.

About Kollmorgen

Kollmorgen, a Regal Rexnord Brand, has more than 100 years of motion experience, proven in the industry's highest-performing, most reliable motors, drives, linear actuators, AGV control solutions and automation platforms. We deliver breakthrough solutions that are unmatched in performance, reliability and ease of use, giving machine builders an irrefutable marketplace advantage.

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