Hybrid UAV propulsion systems: How internal combustion engines and generators are pushing the boundaries of electric flight systems

Greater range, higher payloads, and longer flight times for demanding UAV missions

Longer flight times, greater operational ranges, more powerful sensor systems, and higher payloads are among the most important development goals for many UAV manufacturers today. At the same time, despite their high efficiency and ease of control, purely electric propulsion systems are increasingly reaching their physical limits due to the limited energy density of today's battery systems.

Hybrid UAV propulsion systems offer a technically mature solution to this challenge. They combine the high energy density of liquid fuels with the advantages of electric propulsion systems. The result is flight platforms that enable significantly longer mission times, can carry larger payloads, and at the same time benefit from the precise control capabilities of electric propulsion systems.

Sky Power has developed integrated hybrid propulsion systems specifically for this application, combining an internal combustion engine, a generator, control electronics, and a cooling system into a single compact unit. This results in high-performance power supply systems for modern UAV platforms that demonstrate their strengths particularly in long-range missions, VTOL applications, and sensor-intensive operations.

The operating principle of a hybrid UAV propulsion system

In a serial hybrid propulsion system, the internal combustion engine does not directly drive the propeller. Instead, it generates electrical energy via a generator, which then powers the UAV's electric engines. At the same time, flight control, avionics, communication systems, and, if applicable, battery storage are supplied with power.

This concept enables a complete decoupling of power generation and propulsion. While the internal combustion engine operates continuously within its optimal operating range, power control is managed by the electric propulsion system. This improves the overall efficiency of the system while reducing fuel consumption and mechanical stress.

Unlike conventional aircraft engines, the internal combustion engine does not have to constantly respond to changing load conditions. Instead of directly responding to takeoff, climb, cruise, and descent, it operates largely at a constant speed within an optimal RPM range. This reduces load fluctuations, thermal stress, and vibrations, and contributes significantly to the service life of the entire system.

Sky Power's hybrid technology

Sky Power takes a fully integrated systems approach to its hybrid solutions. The systems consist not only of an engine and a generator, but also of a coordinated, comprehensive solution designed for UAV use.

Key components include electronic fuel injection (EFI), a brushless DC generator, the starter-generator control unit, the ignition system, and a specially developed cooling and airflow system. The generator is mounted directly on the engine's rear output shaft, resulting in a particularly compact design with high

power density. The integration of all components into a single aluminum frame reduces the installation effort for UAV manufacturers and enables easy integration into a wide variety of platform designs..
In addition to the SP-55 FI TS Hybrid for smaller UAV platforms, Sky Power also offers more powerful hybrid solutions based on Wankel engine technology, such as the SP-180 SRE Hybrid. In addition, generator-optimized variants of the proven Boxer engine families are available, including the SP-110 FI TS GEN, SP-170 FI TS GEN, and SP-210 FI TS GEN models.

Figure 1: Sky Power International offers the SP-55 FI TS Hybrid for small UAV platforms

Hybrid propulsion systems solve the key energy problem of modern UAVs

From a technical perspective, hybrid propulsion systems address the greatest challenge facing modern UAV systems: the amount of energy available per kilogram of system weight. While electric engines achieve very high efficiencies, the energy density of today's battery systems remains limited. Liquid fuels, on the other hand, store many times more energy per kilogram. Hybrid propulsion systems leverage this advantage by converting the fuel's high energy density into electrical energy and supplying it as needed to the propulsion system and onboard electronics.

For UAV engineers, this means significantly greater design flexibility in terms of range, flight time, and payload. The available energy is no longer limited solely by battery capacity but can be flexibly provided by the on-board fuel supply. Furthermore, as flight time increases, the UAV's total weight decreases because the amount of fuel in the tank decreases. Once a battery has discharged its energy, its weight remains the same and must continue to be carried by the UAV. This can be particularly important in terms of payload, as it allows for the use of smaller battery systems.

Special advantages for VTOL UAVs

The advantages of hybrid propulsion systems are particularly evident in VTOL platforms. A typical VTOL flight profile involves three completely different power requirements: the energy-intensive vertical takeoff, the transition phase to forward flight, and the comparatively efficient cruise flight.
In all-electric systems, the battery must be designed to handle the high peak loads during takeoff. As a result, a large portion of the battery capacity is carried on board for only a few minutes of flight time.

Hybrid UAVs take a different approach. The battery briefly provides the necessary power for takeoff, landing, and transition. During the subsequent cruise phase, the hybrid system takes over the continuous power supply and can simultaneously recharge the battery. This significantly increases flight times and ranges without having to sacrifice the advantages of an electric VTOL propulsion system. Especially for surveying drones, inspection platforms, or military VTOL systems, this can represent the difference between an operational duration of less than two hours and missions lasting several hours.

More power for modern sensor systems

Another key advantage of hybrid UAV propulsion systems lies in their ability to power energy-intensive payloads. Modern UAV platforms today often carry high-resolution EO/IR cameras, LiDAR systems, Synthetic Aperture Radar (SAR), satellite communication systems, or powerful AI-based data processing units on board. These systems often require several hundred watts of electrical power.
In battery-powered UAVs, every additional payload directly reduces the available flight time. Hybrid propulsion systems provide a significantly larger energy reserve in this regard. The generator continuously supplies electrical power, thereby reducing the load on the battery systems. For UAV

manufacturers, this means greater freedom in integrating high-performance sensor and communication systems.
Particularly for ISR missions, mapping tasks, or complex inspection applications, the hybrid propulsion system thus becomes a mobile power source for the entire platform.

Long-range missions and persistent surveillance

The greatest advantages of hybrid propulsion systems are evident during missions with long operational durations. With conventional reconnaissance drones, limited battery capacity often leads to mission interruptions due to battery changes or the use of multiple UAVs in a rotational operation.

Hybrid UAVs, on the other hand, enable hours of uninterrupted surveillance and observation missions. This not only improves data collection but also reduces operational effort and the number of flight platforms required.

Typical applications include:

- Border surveillance
- ISR missions
- Coastal protection
- Pipeline monitoring
- Power line inspection
- Early detection of wildfires
- Infrastructure monitoring
- Maritime reconnaissance

Figure 2: Hybrid engine designs are particularly well-suited for use in the monitoring of critical infrastructure

Especially for BVLOS (Beyond Visual Line of Sight) missions, the system's endurance is increasingly becoming a key competitive factor.

Heavy-lift drones and logistics applications

Hybrid propulsion systems also offer significant advantages in the field of heavy UAV platforms.
As payload increases, the energy demand in purely electric systems rises dramatically, often resulting in a drastic reduction in flight time. Hybrid propulsion systems counteract this effect by continuously generating new energy.

This opens up potential applications for:

- Logistics drones
- Medical care in remote regions
- Offshore supply
- Disaster relief
- Industrial transport tasks
- Military resupply missions

Hybrid concepts often offer the more economical and technically capable solution, particularly for missions involving long flight distances and heavy payloads.

Redundancy and greater mission reliability

In addition to range and flight time, reliability also plays a crucial role. Hybrid UAVs generally have two power sources: the fuel system and the battery system. This architecture can provide additional redundancy and increase operational reliability, depending on how the battery system is designed.

If the generator fails, the battery can enable a controlled return or emergency landing. Vice versa, the generator can maintain the power supply when high loads occur temporarily or battery capacity is reduced. This additional redundancy represents a significant safety advantage, particularly for BVLOS flights, offshore operations, defense applications, or critical infrastructure missions.

The link between electric and conventional UAV propulsion systems

Hybrid UAV propulsion systems are much more than just a combination of an internal combustion engine and a battery. They represent new energy architecture specifically designed for demanding long-range missions, sensor-intensive applications, and high payload requirements.

Sky Power's hybrid solutions combine the high energy density of liquid fuels with the advantages of electric propulsion systems. This results in UAV platforms that enable longer flight times, greater ranges, higher payloads, and a continuous power supply for modern sensor systems.

Hybrid propulsion systems will play a central role in the future, particularly in the fields of VTOL, ISR, BVLOS inspection, maritime surveillance, logistics, and defense. They bridge the gap between traditional internal-combustion-engine UAVs and all-electric flight platforms, opening up new possibilities for the next generation of professional unmanned aerial systems.

About Sky Power

Sky Power International is a leading manufacturer of 2-stroke combustion- and Wankel engines for UAS (Unmanned Aerial Systems) and hybrid applications. Besides in-house development and manufacturing, Sky Power International produces all engines in Germany. Custom adaptations, new developments and continuous performance improvements of the combustion engines are ongoing company objectives.
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