

The Case for Persistent Flight: Enhancing Small Unmanned Aerial Systems for ISR Applications

Introduction

Use of small Unmanned Aerial Systems (sUAS or drones) has revolutionized numerous fields, including defense, national security, and public safety by providing unparalleled cost-effective capabilities in intelligence, surveillance, and reconnaissance (ISR).

Their agility, ease of deployment, and ability to hover make these drones indispensable for missions requiring detailed situational awareness. However, the state-of-the-art in drone technology faces a critical limitation: flight time. Current quadcopter drones rely predominantly on lithium-ion or lithium-polymer batteries, which offer limited energy density, capping operational endurance to 30 to 60 minutes on average. This constraint significantly hampers their utility in prolonged ISR missions, where persistent monitoring is essential for actionable intelligence.

GuRu Wireless Inc. has pioneered a cutting-edge proprietary technology that enables wireless charging of quadcopter drones in mid flight, heralding a transformative era of persistent flight for small UASs. This technology was used to demonstrate a continuous uninterrupted drone flight for over 96 hours. This groundbreaking innovation has been showcased as a proof-of-concept to personnel from the U.S. Marine Corps and U.S. Army, receiving exceptional positive feedback for its potential to redefine operational capabilities.

State of the Art: Today's sUAS Used in ISR Applications

Today's sUAS are predominantly based on quadcopter drones. These drones have seen advancements in sensor integration, data transmission, and autonomous navigation. Compact high-resolution cameras, thermal imaging systems, and lightweight synthetic aperture radar (SAR) systems are now commonly mounted on these platforms, expanding their use cases in both military and civilian domains. Despite these advancements, battery technology remains the bottleneck. Lithium-based batteries, while efficient, are fundamentally constrained by energy density, weight, and charge cycle limitations. There is a diminishing return to include larger batteries in sUAS due to the added weight of the larger batteries. As such, most systems today have flight time of 30 to 60 minutes before the drone is required to land.

For ISR missions, particularly in defense and national security, the short flight duration necessitates frequent battery replacements or recharging, leading to operational inefficiencies and increased logistical demands. In dynamic environments, such as border surveillance or battlefield reconnaissance, interruptions caused by limited flight time can result in missed opportunities to gather critical intelligence, thereby compromising mission success. Other applications such as base security and convoy protection, continuous surveillance is crucial for effective monitoring of threats and interdiction of unauthorized activities. The limited endurance of today's small UAVs means they cannot provide persistent ISR coverage, leading to potential lapses in surveillance.



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The Drive Towards Persistent Flight for ISR Applications

Persistent flight—the ability of a drone to remain airborne for extended periods without significant interruptions—is a transformative capability for ISR applications in several national security domains. In general, persistent ISR ensures seamless tracking of targets and activities over extended periods, reducing the risk of information gaps. In addition, longer flight capability improves overall operational efficiency by eliminating frequent takeoffs and landings which in turn minimizes logistical challenges and human intervention. Lastly, persistent ISR provides enhanced decision making by allowing real-time, uninterrupted data feeds which are crucial for time-sensitive missions. These capabilities are crucial in applications such as border security, convoy and troop protection, forward-operating base security and maritime surveillance.

A family of drone systems called “tethered drones” can hover longer than conventional battery powered drones. These systems utilize a physical tether (i.e., an electrical cable) that provides continuous power to the drone from a source on the ground, effectively charging the battery in mid-air and enabling longer flight durations. However, tethered systems come with significant limitations stemming from their physical connection to the power source including reduced maneuverability and potential tangling issues in complex environments. The tether inherently confines the drone's operational range to the vicinity of the ground station, resulting in a limited coverage area and making them less effective for tracking mobile targets or responding to dynamic mission requirements.



Computer-generated image of a tethered drone. Created using OpenAI's ChatGPT

GuRu Wireless, Inc. 24GHz Wireless Power Beaming Technology

GuRu Wireless, Inc. (Pasadena, California) has developed a technology for wireless power beaming using radio-frequency. The company has used its proprietary 24GHz Wireless Power Beaming Technology (WPBT) to demonstrate the capability to wirelessly power drones while in flight. By harnessing RF power beaming, drones can receive energy wirelessly from a ground base phased array, ensuring uninterrupted performance while maintaining agility and operational efficiency. In 2024, using this technology, GuRu Wireless successfully demonstrated continuous drone flight of over 96 hours. This Technology Readiness Level (TRL) 4 milestone showcases the potential of wireless power beaming to revolutionize drone operations, enabling persistent ISR for defense and national security applications. Currently, the company is developing a TRL 7/8 Persistent ISR sUAS solution as a complete end-to-end system for defense applications. This ideal solution for “mid-air” recharging without the need to physically tether the drone opens the possibility of enhance mission effectiveness for ISR, troop and base protection and other critical missions. GuRu Wireless intends to be a supplier of complete end-to-end systems for persistent ISR applications. The company is seeking R & D funding to accelerate its development and make available persistent ISR capability for national security applications.



Computer-generated image of a wireless powered drone. Created using OpenAI's

