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Near-Space Airships: The Solution to Persistent ISR

by

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Disclaimer

Abstract

Long duration conflicts have become the staple for 21st century engagements. Whether for counter-insurgency operations, humanitarian assistance, border patrol, or homeland security, the need for years or even decades of persistent intelligence, surveillance, and reconnaissance (ISR) has place tremendous strain on collection platforms. The Department of Defense (DOD) has strove to field improved capabilities but has consistently overlooked a major region of operations: near-space.

Near-space provides a tremendous opportunity to provide persistent ISR. Operating at altitudes above 65,000 feet, near-space vehicles enjoy wide fields of view than can encompass an entire theater of operations such as Iraq or Afghanistan. Unlike low-earth orbit (LEO) satellites, which only briefly pass through the area of operations, near-space vehicles have the ability to loiter over the area of responsibility and provide the persistence necessary for current operations.

Near-space airships, with the ability to host large payloads and loiter in near-space for months at a time, provide the solution to the DOD's problem of persistent ISR. Technology demonstrations have drastically reduced the technical risk of fielding near-space airships. With a unit cost similar to that of a Global Hawk Remotely Piloted Aircraft (RPA), near-space airships improve support to the warfighter while substantially reducing long-term operational costs. The DOD needs to invest significant effort into developing near-space airships now to ensure it can meet the ISR needs of the future.

Never before has the need for persistent intelligence, surveillance, and reconnaissance (ISR) been as apparent as it has been over the last five years in Afghanistan and Iraq. The need for persistence has proven more taxing on ISR assets in the post-war counterinsurgency environment than in major combat operations. The Department of Defense (DOD), straining to meet the insatiable needs of the joint warfighters, has strove to field improved capabilities within its comfort zone. Throughout these initiatives, a major region of operations is consistently overlooked. Near-space is the optimal medium from which to execute theater ISR operations, yet this atmospheric region remains woefully undeveloped. The DOD needs to invest significant effort into developing near-space capable vehicles, specifically near-space airships, to maximize warfighter support in the most economically efficient manner.

Near-space provides opportunities to support a wide range of militarily useful missions. With altitudes between 65,000 and 325,000 feet, this is the realm above where most winged aircraft can fly and below where satellites can operate without significant atmospheric drag.[1] In general, this region is above the jet stream and the ozone layer but below the majority of the ionosphere. The rarified air of near-space minimizes the effects of wind gusts resulting in relatively low steady winds.[2] For example, the annual winds between 65,000 and 85,000 feet over Baghdad average less than 25 knots with maximum wind speeds of less than 35 knots.[3] Any mission requiring persistent access to a large ground footprint is ideally suited to a near-space platform. Examples include ISR, beyond-line-of-site (BLOS) communications relays, blue force tracking, missile defense, and theater missile warning. [4] Since ISR tends to be the driving requirement for current operations, this paper will focus on near-space applications for the ISR mission.

Several vehicle design options exist to take advantage of near-space altitudes for persistent ISR. Platform options include balloons, airships, and specially designed RPAs to operate at these extreme altitudes.[5] Balloons require launching zones upwind of the area of responsibility (AOR) and drift freely in the wind currents at high altitudes. They also require a continuous launch cycle to generate the persistence desired by the warfighter since wind speed limits their time over the target.[6] Near-space RPAs and airships both provide the capability to loiter over the target area for extended durations. Developers project near-space RPAs to remain on station for several days with payloads of a few hundred pounds. Objective near-space airships are high-tech maneuvering blimps that will carry payloads of several thousand pounds and hover over the theater of operations for months at a time.[7] With increased capacity for sensitive payloads and their superior staying power, near-space airships provide the most potential utility for extended duration ISR operations.

The significant capabilities of near-space airships make them optimal platforms for persistent ISR applications. The increased operating altitudes provide them with a wider field of view than RPAs. At 65,000 feet, the footprint of a near-space platform would extend over 625 miles, large enough to cover the entire country of Iraq.[8,9] Higher altitudes further increase the effective viewing area (850-mile footprint at 120,000 feet altitude) and reduce the negative impacts of mountainous terrain by increasing the grazing angle of the sensor to the target.[10] Since near-space vehicles are not bound by orbital dynamics like spacecraft, these airships can loiter over the target for their entire mission duration of months or years, providing large-area persistence unavailable from other platforms.[11] Research at the Naval Postgraduate School of the most effective platform for ISR and communications missions confirmed the usefulness of near-space airships. Their analysis considered traditional RPAs, near-space vehicles, and tactical satellites and concluded (using weighted measures of effectiveness across an array of potential missions) that near-space airships provide the maximum benefit to the warfighter. [12]

While a near-space vehicle's altitude provides a theater-wide field of view, its location in the upper atmosphere provides considerably improved sensitivity over equivalent payloads on any space-based platform. The attenuation and refraction of electronic signals by the ionosphere will not be a factor for near-space platforms making them much more sensitive and increasing their signal geolocation accuracy. Similarly, the difference in altitude would give an equivalent optical sensor 10-20 times more resolution on a near-space vehicle than on an imagery satellite.[13]

Another major advantage of near-space airships is their flexibility and responsiveness. Near-space airships operate independently of the payload, as long as the payload falls within the power and weight constraints of the vehicle. Off-the-shelf payloads from Global Hawk RPAs, U-2s, or even low earth orbit (LEO) satellites would likely be suitable for near-space airship applications. This flexibility also allows for the rapid fielding of new or improved sensors to adapt to changes in the operational environment. Additionally, launching near-space airships from dedicated CONUS bases requires no forward deployment. "A near-space vehicle requires only two hours to arrive at an altitude of 120,000 feet and can then reach Korea or Afghanistan from the continental United States within a week."[14] This rapid response provides theater commanders with an immediate capability to augment existing assets or to mitigate the loss of a satellite due to hostile actions or a spacecraft anomaly.

Near-space airships are also surprisingly survivable. Operating at extreme near-space altitudes places the airship out reach of all but the most sophisticated surface-to-air missiles (SAMs).[15] Air-to-air intercept is also possible but the extremely small radar and thermal cross-sections will make them difficult to detect. The slow movement will also confuse Doppler radars which may ignore any radar return that is detected.[16] Even if they are engaged, near-space airships are extremely hard to shoot down. The internal overpressure of a near-space airship is between zero and one pound per square inch. Even if punctured full of holes from a munitions detonation, the internal gases would leak out so slowly as to have little effect on the near-term mission performance. A Canadian weather balloon demonstrated this survivability when it remained aloft for six days after being pierced by approximately 1000 20-mm cannon shells.[17]

The employment of near-space airships for ISR functions can also act as a force multiplier. Airships can provide instantaneous access to any location in a theater of operations at any time of day for extended periods. As such, fewer platforms will be required to satisfy theater intelligence requirements. These fewer vehicles operating above controlled airspace frees up airspace at lower altitudes currently occupied by ISR assets for other RPA or manned flight operations. Additionally, near-space airships require very little operator interface to maintain position so they require significantly less communications bandwidth to operate than traditional RPAs. Airships could also downlink collected data directly into theater if necessary to further reduce the required satellite relay bandwidth.

Not only do near-space vehicles provide substantial capabilities to the warfighter, they do so at an extremely reasonable price. The estimated recurring cost of a near-space airship is $50M, which is substantially cheaper than any satellite system and roughly equivalent to the unit cost of $55-$81M for a Global Hawk RQ-4B.[18,19] Launch costs for a near-space airship are extremely low, especially when compared to satellite launch costs, and the CONUS based facilities require minimal infrastructure.[20] CONUS basing also facilitates an optimal mix of military and contractor staffing to minimize personnel costs. Additionally, near-space airships have low operating costs because they can operate for extended periods with minimal human intervention. With remote command and control (C2), near-space airships will have little or no forward deployed footprint, eliminating any expensive logistics trail. The small number of airships required to provide adequate theater ISR coverage coupled with the low acquisition and operating costs make near-space airships very cost effective for long-term operations.

Near-space airship employment can also allay payload costs. The lack of g-forces experienced during launch and recovery can reduce payload ruggedness requirements compared to RPA or satellite applications. Flying below the ionosphere, near-space payloads would also not require the extensive radiation hardening necessary for orbital assets.[21] In addition, since payload volume tends not to be a constraint for near-space airships, expenses related to integrating a payload into a RPA hull or a spacecraft bus can be avoided.[22] The ability to recover near-space airships to repair or replace damaged or obsolete payloads also provides a long-term cost savings not available to satellite operations.

Despite their significant capabilities, the DOD investment in developing near-space airships has been extremely modest considering the potential long-term payoff of fielding this novel technology. The primary concern voiced against the development of near-space airships is the technology challenge associated with the construction of a vehicle that must operate in the extreme environment of near-space. The Air Force Scientific Advisory Board (AFSAB) study conducted in 2005 stated "the jury is still out on long-loitering high-altitude airships. Although promising, there remains the need for technological advances to make them viable."[23] A RAND study from the same year identified the primary technical concerns with fielding this capability. The study identified structural concerns such as hull strength, ultraviolet (UV) degradation of the airship skin, helium leakage, power generation, and thermal control. It also cited operational concerns with controllability during ascent and descent operations, weather, and airspace access.[24] Flight rules can mitigate the operational concerns because the longevity of flight provides some leeway in the launch and recovery schedules. Significant technology improvements in the areas of solar cells, hydrogen fuel cells, and material coatings have significantly reduced the risk of the structural issues.

The US Army Space and Missile Defense Command/Army Forces Strategic Command (USASMDC/ ARSTRAT) is pursuing two near-space airship efforts. The HiSentinel vehicle is designed to carry a 200-pound/1000 Watt payload at 67,000 feet for greater than 30 days.[25] Two test flights have been conducted, the most recent of which carried 50 pounds to 65,700 feet in June 2008.[26] The next test will demonstrate the ability to carry 100 pounds to 65,000 feet and provide 200 Watts of payload power.[27] The second near-space airship development is the High Altitude Airship (HAA), which has the objective of hosting a 2,000-pound/15 kilowatt payload at 65,000 feet for more than 30 days.[28] The current spiral of the HAA development program is the High Altitude Long Endurance Demonstrator (HALE-D). The HALE-D will carry an 80 pound/150 Watt payload for two weeks at 60,000 feet.[29] The HALE-D specifically draws on technology developments in hull materials, thin-film solar arrays, lithium ion batteries, and flight computers to address the technical challenges previously discussed.[30] The significant progress achieved by these technology demonstrations greatly reduces the technical risks associated with fielding near-space airships and warrants further DOD investment in the technology.

Another major concern with fielding near-space airships is the legal issue surrounding freedom of overflight. Near-space falls at the boundary of two well-defined areas of operation. International Civil Aviation Organization (ICAO) treaties dictate airspace control and overflight regulations for altitudes up to 60,000 feet. Satellites in orbit enjoy freedom of overflight based on international treaties and US national policy.[31] Near-space lies in the undefined gray area between these two regimes. The USAF General Counsel issued a memorandum in 2004 stating "any activities conducted at near space altitudes must be analyzed using the applicable legal regime for air space or outer space."[32] This conclusion is based on the premise that only two regimes can exist, airspace and outer space. The reality is that an entirely new regime, a new set of laws, could be established to govern near-space activity. Much as a new outer space policy grew out of the airspace regime following the launch of the first satellites, a new regime can be established when near-space operations become a reality. This paper intentionally held on to the term near-space vice the more ambiguous term of high-altitude operations adopted by the USAF in 2007.[33] The intent was to leave the necessity of a near-space regime open to debate. In either case, this legal ambiguity should not be considered a roadblock to fielding near-space airships. In fact, it should actually encourage their development. By fielding the first operational vehicles in the medium, the United States would be in the position to set a precedent for near-space operations and could mold any treaties to suit its interests.

The final question concerning the development of near-space airships is who should be the lead agency. To date, the majority of experimental research has been accomplished by SMDC/ARSTRAT. However, the payloads flown on near-space airships would augment capabilities currently provided by Global Hawk and satellite assets, all within the purview of the USAF. In 2005, the Air Force Space Command (AFSPC) commander recommended that the USAF "be appointed lead agency for DoD Near Space activities."[34] AFSPC's involvement was short-lived, however, when direction to initiate an acquisition effort at the Space and Missile Systems Center (SMC) prompted a response that "this work is outside the core competencies of SMC."[35] Air Combat Command (ACC) has shown similar disinterest, opting instead to field larger numbers of the remotely piloted Global Hawks to address warfighter ISR requirements. It seems that near-space airships are so counter to the culture of the Air Force that they cannot find a welcome home within the service. Despite these cultural barriers, the USAF needs to step forward and take responsibility for the executive agent role they requested in 2005. Within the service, AFSPC is the most appropriate command to acquire and operate near-space airships. The technologies required, such as solar cells, power management, and thermal controls, are derived primarily from satellite applications. The strong, lightweight, and UV resistant hulls of the airships are likely to be closely related to the materials used for exotic space applications such as solar sails. Operationally, near-space airships have much more in common with satellite command and control than they do with piloted aircraft or RPAs and the services they provide are akin to those resident on spacecraft today.

Near-space airships offer long-duration persistent ISR capabilities that will maximize combat effects to the warfighter. Whether for counter-insurgency operations, humanitarian assistance, border patrol, or homeland security, the need for years or even decades of persistent ISR has become the standard for 21st century operations. Near-space airships provide improved ISR coverage to the warfighter at reduced costs and free up satellites, RPAs, and other ISR platforms to support missions requiring denied area access or a more tactically responsive sensor. As former Chief of Staff General Jumper said, "We need to push the envelope to determine what effect we can produce from near-space. More importantly, we need to fine the right synergistic mix of air, space, and near-space capabilities to produce the battlefield effects our combatant commanders need."[36] Regardless of which service leads the effort, the DOD needs to invest significant resources in developing near-space airship capabilities. The technologies have demonstrated sufficient promise to warrant an increased investment in their development. Modest investments today can guarantee persistent observation for tomorrow's warfighters.

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