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Lighter-Than-Air (LTA) "AirStation" Unmanned Aircraft System (UAS) Carrier Concept

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The advantages of utilizing an airship as an airborne carrier for support and deployment of Unmanned Aircraft Systems (UAS) are examined. Whether as a stand-alone platform or in concert with conventional aircraft, the airship UAS carrier provides a number of compelling benefits for both military and civilian missions. As a mobile base it can remain operational despite political fallout that may render ground or ocean based UAS sites unavailable. It offers the psychological impact of a power projection tool that has few geographical limits, and holds promise as a new method for cost-saving intelligence gathering. It is also adaptable for civilian variants for supporting: emergency response, security/surveillance, delivery of medical/food supplies, as well as commercial package delivery to metropolitan and remote communities. This paper presents the background on airship-aircraft operations, and explores the general airship carrier concept. Additionally, a catalog of contemporary technologies available to support the airship carrier concept are discussed, and essential elements for an Air-Station Development program proposed.

I. Introduction

Over the last two decades, the military missions proposed for modern airship technologies have been mostly focused on exploiting the airship's on-station persistence. The most popular application has been for direct surveillance missions over large geographic areas from altitudes between 20,000 ft. and 65,000 ft. mean sea level (MSL).[1] While this mission clearly has value, and the airship is well suited for it, the airship remains significantly constrained in three regards: (1) All of the surveillance sensors, communication systems, and other mission equipment are concentrated in the airship vehicle itself. (2) The airship is required to be physically in the vicinity of the areas to be directly observed. (3) To achieve a broad field of observation, and for its own safety from small arms fire and man portable air-defense systems (MANPADS) the airship must fly at altitudes above 20,000 ft. MSL. These three constraints create substantial developmental risks and operational limitations for the airship. To carry even a moderately sized sensor payload (1,000 kg) to the minimum acceptable mission altitude requires that the airship be large and constructed of the lightest possible materials to reduce the weight of structures and propulsion systems. While the high altitude airship provides the sensor suite with a broad range of view, the high altitude also demands more powerful optics and electronic sensors to provide the high resolution necessary to be effective. The sensor suite is also limited because it can only provide observation from a single viewing position, which can be obscured by time of day, local weather, or by buildings or terrain that create sensor viewing "shadows."

To provide a more distributed, multi-platform, and multi-sensor surveillance capability, military planners are dramatically increasing their use of small- and medium-sized unmanned aircraft systems (UAS). While most UAS platforms have until recently been operated as individual aircraft on single purpose missions, great advances have been made in launching and operating swarms of small, semi-autonomous UAS. Groups of UAS equipped with a distributed suite of various small sensors can be deployed for flight at low altitudes to form a netted, distributed surveillance system network that can meet a series of surveillance needs, from: electronic, thermal, synthetic aperture radar, to electro-optical. To further advance this idea, the Defense Advanced Research Projects Agency (DARPA) is currently developing the capability for groups of UAS to operate in unison, and have the entire UAS flight under the control of one person, instead of multiple individual controllers. The intention of the Collaborative Operations in

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Denied Environment (CODE) program is to develop the software necessary to enable this expanded use of UAS by leveraging the latest autonomous vehicle control programs (Figure 1).[2, 3]

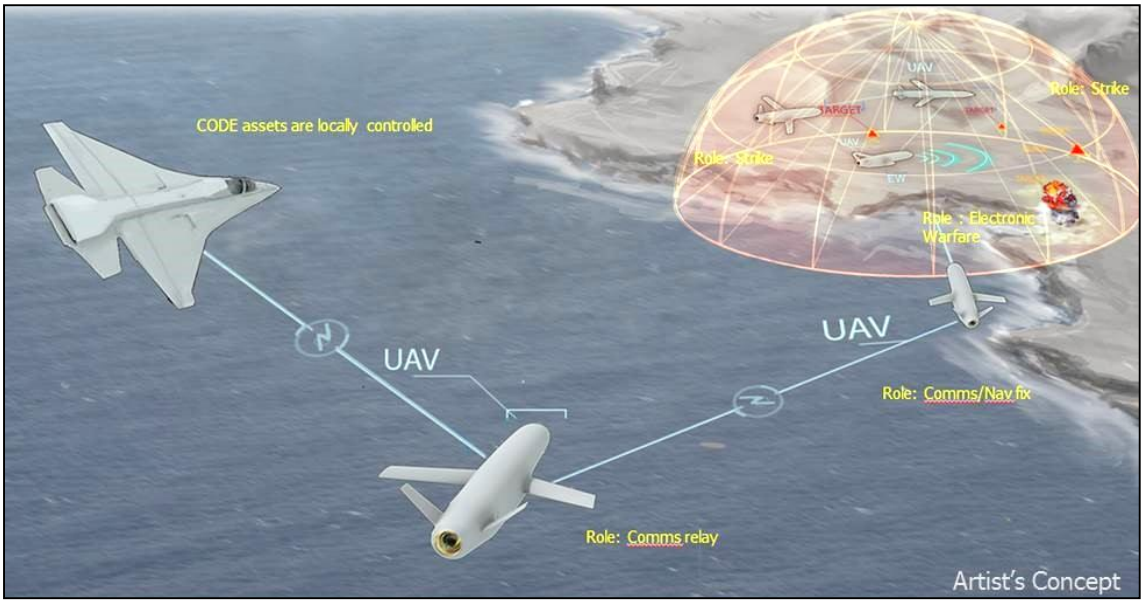

Figure 1. DARPA CODE Concept

However, just as the employment of UAS is expanding, these remarkably capable systems often experience mission limitations imposed by restrictions of their support infrastructures and concepts of operation (CONOPS). Their ground- and ship-based launch sites often can't be quickly relocated as needed, and are often unable to operate on land or ocean areas due to political sensitivities. As the cost of manned aircraft operations continues to increase, the potential cost savings from unmanned aircraft becomes better defined as operational experience with a wide range of UAS platforms advances. In 2013, the Association for Unmanned Vehicle Systems International (AUVSI) assessed the question of US Air Force (USAF) UAS operating costs vs. manned aircraft and produced a bar chart (Figure 2) showing their relative operating costs, with unmanned aircraft costs highlighted in red.[4]

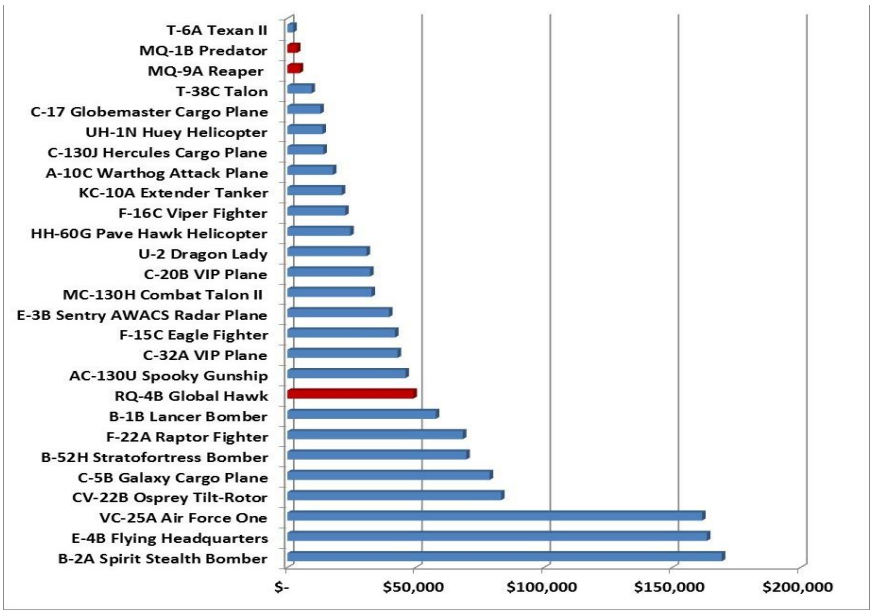

Figure 2. USAF Aircraft Cost per Flight Hour with UAS in Red

Even among the most popular UAS, such as the Global Hawk, Reaper, and Predator, the total cost per hour for flight operations are not fully captured because their support infrastructure costs are shared with extensive operational facilities that also support other missions (Figure 3).[5] Large UAS are typically dependent on runways or large launch rails and similar infrastructures that must be staffed to conduct launch and recovery of the UAS at their takeoff location.

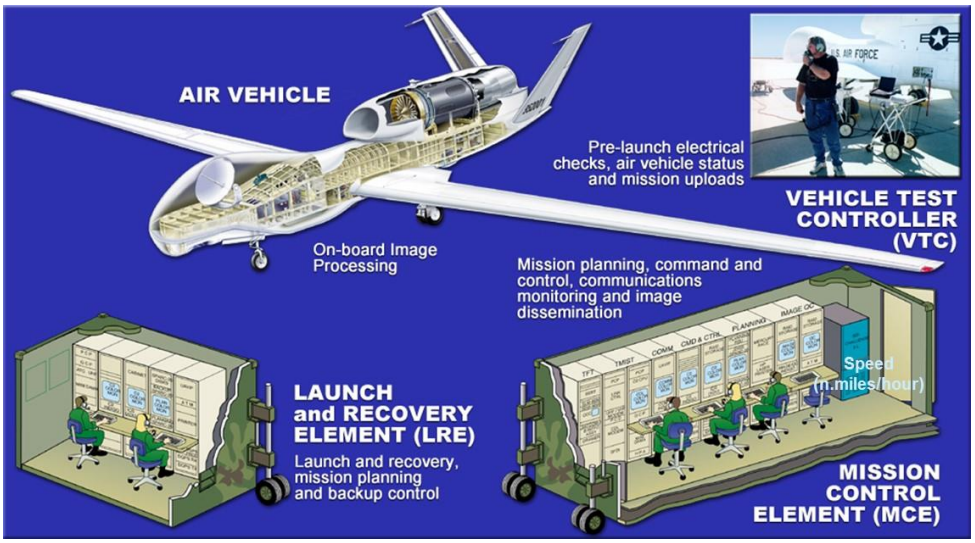

Figure 3. The Northrop Grumman Global Hawk is an Integrated System

UAS launching sites on the surface require some degree of committed resources, personnel, and protection. Full automation of the entire UAS support activities could provide a means to reduce these commitments and provide possible cost efficiencies.

For UAS operations to fully reach their maximum capability, they require the mobility and geographical independence of an airborne support platform dedicated to UAS launch and recovery operations. Current efforts by DARPA and others in the military community have centered on the adaptation of high speed, conventional military transport aircraft to provide an airborne UAS launch and recovery capability. In 2014, DARPA released a request for information (RFI) on a program called "Distributed Airborne Capabilities." The DARPA RFI stated, "We want to find ways to make smaller aircraft more effective, and one promising idea is to enable existing large aircraft, with minimal modification, to become aircraft carriers in the sky." … "We envision innovative launch and recovery concepts for new UAS designs that would couple with recent advances in small payload design and collaborative technologies." [6] In April 2016, DARPA announced the selection of four teams for the first phase of its "Gremlins" program which will demonstrate the launch and recovery in flight of multiple, limited-life UAS (Figure 4).[7]

In addition to the challenge of providing large numbers of UAS, ready for deployment and recovery, is the problem of replacing depleted weapons from fighters and bombers. The stealth qualities of modern fighters require their weapons be carried within internal bays where the small volume limits the numbers and variety of weapons that can be carried. In the 2017 Defense Department (DoD) budget request, Defense Secretary Ashton Carter announced that the USAF is developing what's called an "Arsenal Plane." The DoD Secretary describes it as "a flying launch pad for all sorts of different conventional payloads. In practice, the arsenal plane will function as a very large airborne magazine, networked to 5th-generation aircraft that act as forward sensor and targeting nodes." [8]

Figure 4. Depiction of DARPA Gremlins

Figure 5 depicts an eight-engine Boeing B-52 bomber wing with the body of a Lockheed Martin C-130 turboprop launching a barrage of networked Raytheon Small Diameter Bomb II glide bombs at mobile enemy radar warning and air defense targets.[9]

Although they provide available and well-proven platforms, these legacy aircraft are not optimized for the UAS support mission. For instance, these legacy platforms have unrefueled flight endurances measured in a few hours, juxtaposed to an airship, which measures endurance in days. Large aircraft also have their own ground logistics (maintenance) needs that limit their utilization rates and on-station mission availability. Lastly, the dramatic mismatch of airspeeds between the large turboprop powered carrier airplanes and a fleet of mid-to-small sized UAS presents a challenge. A purpose-built platform is needed that can easily accommodate the performance envelopes of large swarms of small- and medium-sized UAS. This special UAS carrier would provide high persistence in most airspace, and do so at acceptable operational sustainment costs. An optimum solution for this need would be to combine the low speed, long endurance performance of an airship with the capability to launch, operate, recover, refuel, and re-launch multiple sets of UAS carried by the airship. Although the UAS would be operated remotely from the airship, they would return to the airship as a base of support. A concept very similar to this was pioneered more than 80 years ago with two US Navy airships: the Akron and Macon.

Figure 5. Depiction of proposed Arsenal Plane

II. Flying Aircraft Carrier Background

The US Navy commissioned two airships -- the USS Akron (ZRS-4) and USS Macon (ZRS-5) -- as flying aircraft carriers during the early 1930s. Each had a useful lift of 80 tons, of which 55 tons were utilized to carry fuel. This allowed 25 tons available for mission equipment, crew, and provisions. Of these two airships, the Macon, with a length of 785 feet, a diameter of 133 feet, and a crew of 91, was the most advanced (Figure 6).[10] The USS Macon operated up to three days at sea, conducting long-range strategic reconnaissance missions with an onboard fleet of five Sparrow Hawk scout planes. Each Sparrow Hawk scout plane measured 25 feet by 23 feet, weighed 2,770 lb. when fully loaded, and had a top speed of 174 kt. with a stall speed of 55 kt. These scout aircraft were carried in the airship's internal aircraft hangar from which they could be launched and recovered using a deployable trapeze mechanism that moved the planes inside and onto an internal trolley system (Figures 7 and 8).[10] At its cruising speed of 60 kt., and using only two of its five scouting bi-planes the USS Macon could provide a surveillance sweep of 165,000 square miles of ocean in 12 hours (Figures 9 and 10).[10]

Figure 6. USS Macon airship (photo credit: US Navy)

The Akron and Macon were created to investigate and refine the scouting capabilities of the airship/airplane combination. Broad scouting (surveillance) approaches were possible by deployment of the scout aircraft to their maximum search ranges, and subsequent scheduled return to the airship for recovery, refueling, and re-launch. Though these combined airship and scout plane systems worked successfully for manned surveillance missions, their unfortunate destruction during severe storm events curtailed full investigation of the airship carrier experiment. A larger follow on airplane carrier airship (Figures 11 and 12) was planned (circa 1938) but subsequent advancements in long range manned surveillance airplanes provided more cost effective and versatile manned scouting solutions. It is the more recent advances in anti-aircraft targeting and weapons systems over the defensive countermeasures of surveillance aircraft that have greatly increased the vulnerability of manned platforms. This development provided the impetus for the now ubiquitous rise of UAS development as a lower cost and lower risk alternative to manned aircraft.[11, 12] The extensive legacy experience with flying aircraft carriers can now be refreshed to provide a new capability to support the expanding UAS development and support more ambitious UAS mission applications.

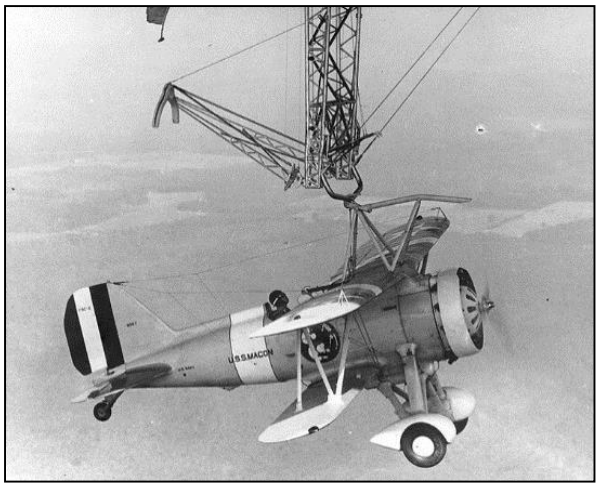

Figure 7. Sparrow Hawk engaging USS Macon trapeze

Figure 8. N2Y-1 plane hauled into USS Macon hangar

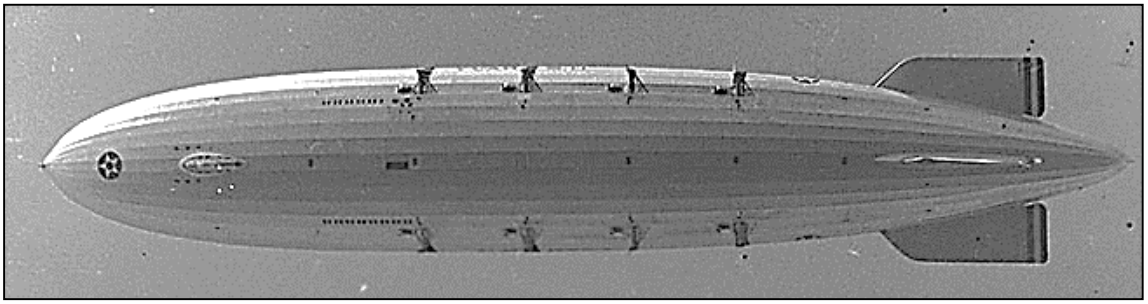

Figure 9. USS Macon viewed from directly below (US Navy)

Figure 10. USS Macon model showing airplane hangar and trapeze

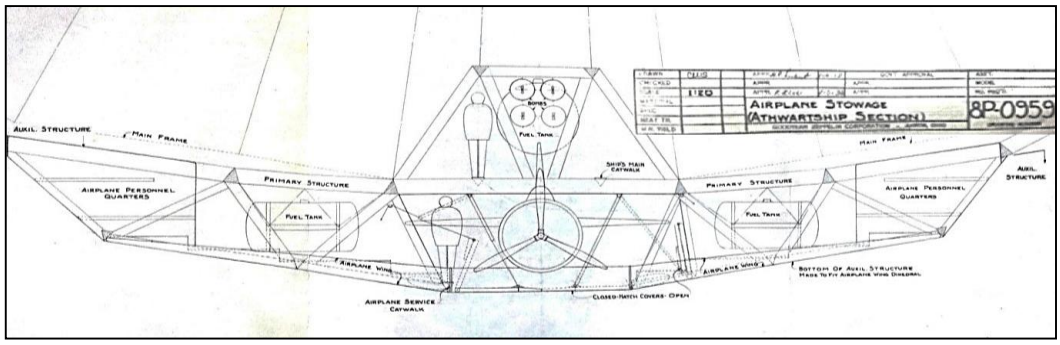

Figure 11. Front view drawings of airplane hangar for Goodyear proposed Macon follow on airship

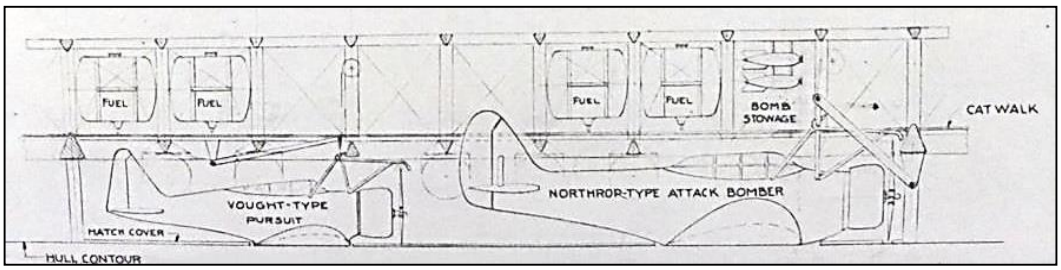

Figure 12. Side view drawings of airplane hangar for Goodyear proposed Macon follow on airship

III. Modern UAS Airship Carrier Technical Description

The three basic types of airships are: non-rigid, semi-rigid, and rigid. Non-rigid airships use the pressure of the lighter-than-air (LTA) gas inside the flexible bag or 'envelope,' to carry the aerodynamic loads and maintain the airship's shape. Rigid airships enclose gas cells inside a rigid, streamlined framework to which external structural components are attached. The semi-rigid airship combines elements of both types. All airships principally operate by displacing a weight of air greater than the weight of the overall airship. It is the static lift of the LTA gas inside the airship that keeps it afloat. Airships can be further delineated into two classes: near-buoyant and semi-buoyant ("hybrid") vehicles. Near-buoyant airships are able to operate over a small range of heaviness or lightness divergent from their buoyant or "equilibrium" point. The hybrids always operate slightly heavier than air by generating an extra margin of lift aerodynamically through forward flight or by use of helicopter-like rotors. The practical speed limit for airships is around 87 kt. to 95 kt., but most concepts currently under development are expected to have top speeds in the 72 kt. to 78 kt. range. Cruise speeds for an airship are typically around 40 kt. to 50 kt. and fuel consumption can be a quarter or less than that of a jet transport having the same payload capability. For near-buoyant airships operating near their equilibrium point, the minimum airspeed can be as low as zero. In practical terms, this means the UAS hook-on speed should be 50 kt. or less. These airship features may provide a better overlap of operable airspeeds, when compared to conventional heavier-than-air craft, between the carrier airship and the UAS to be carried (Figures 13 and 14).

A. Launch and Recovery

The singularly unique capability of the UAS carrier airship would be the launch, recovery, refueling, and re-launch of the UAS. Modern robotic systems can be leveraged to provide the functionality necessary for completely automated capture and release of a wide variety of UAS. For example, an articulated robotic arm with a purpose designed computer controlled vision and capture mechanism would enable the stowage of the UAS in an internal hangar deck located at a strategic location on the airship (Figure 14). The use of automated systems should also be extended to the airship's flight deck. For maximum flexibility of operation, the airship should be designed for pilot-optional operations. This would enable a small flight crew (2 – 4 members) to conduct flights and provide an onboard maintenance and repair capability to deal with any damage to the returning UAS, or to the airship itself.

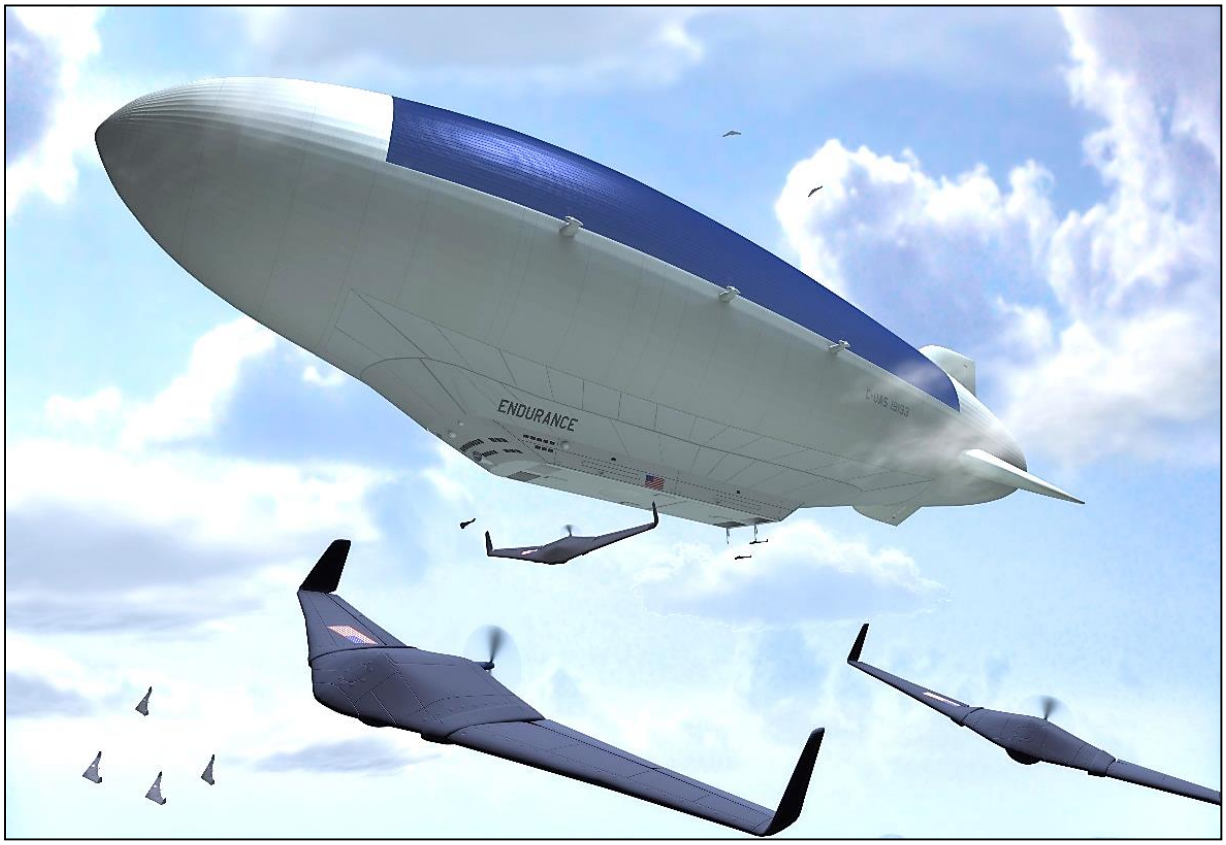

Figure 13. Notional concept of a UAS Carrier airship with deployed squadron of UAS

Figure 14. Notional UAS carrier airship demonstrating simultaneous launch and recovery of UAS

B. Signal Relay

In addition to extended endurance, a transformational feature of the UAS carrier would be in providing over-the-horizon (OTH) UAS control and data relay between operators and the UAS. The benefit of OTH signal relay is that it extends the operating range of existing UAS, especially where there are terrain or urban obstacles that preclude line-of-sight (LOS) control links. This could also be accomplished by equipping the UAS refueling aircraft to provide the OTH data link between the deployed UAS fleet and the carrier airship station-keeping at its distant location (Figure 15).

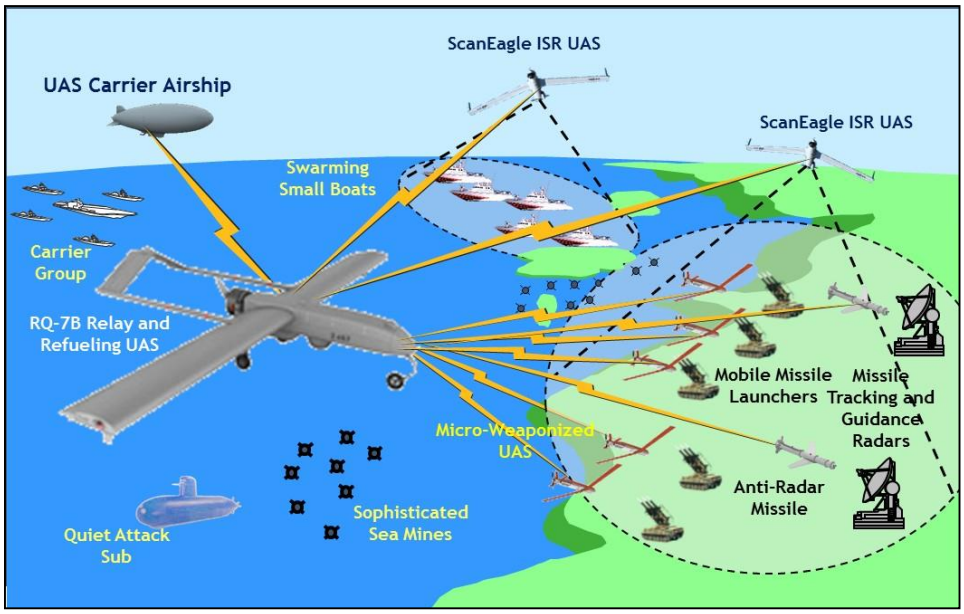

Figure 15. CONOPS for OTH control and support for various UAS from relay/refueling UAS

Signal relay also enables the use of smaller (low power) UAS that could more easily maintain data-links with the refueling/relay UAS overhead than directly with the airship hovering some distance away. The UAS carrier could also reduce the ground control station (GCS) "footprint" required to support conventionally based UAS missions. One GCS location could support several UAS carrier airships operating in unmanned mode. The UAS carrier's data-link capacity, power, and range, could enable direct management of local UAS via satellite links from the airship to the continental US (CONUS), thus further reducing the theater command and control (C&C) commitment and costs. UAS maintenance support could be removed from the GCS location and placed in a near theater area. UAS carriers could stay in a rear area until needed for dispatch to operation areas hundreds of miles distant. Transits with a quantity of UAS onboard could be made at night or at altitudes above MANPADS height.

C. Fueling

Although any number of means could be developed, two methods of in-flight refueling of UAS are described as follows. A modified conventional trailing refueling drogue and probe system can be used or the UAS can be recovered onboard the carrier, refueled and re-launched. The first approach allows the fastest possible refueling and subsequent return to mission, but inherently can only refuel one UAS per drogue line. The ability to recover multiple UAS concurrently, refuel, and re-launch them allows faster turnaround of larger numbers of UAS. A further multiplication of UAS carrier capabilities is possible if the airship itself can be re-fueled in flight. To be practical, the UAS carrier airship would require an unrefueled flight endurance of at least 24 hours, and preferably 36 hours or more. This capability was developed for the US Navy airships in the 1950's whereby a floating fuel bladder was put into the ocean, trailing a short lanyard. The airship would fly over the bladder and winch down a cable containing a snagging mechanism that would trail through the water and catch the floating lanyard. The fuel bladder was then hoisted up to the hovering airship.[13] This technique was re-demonstrated in the early 1990's with a Skyship S-1000 manned airship operating under the Navy Airship Program. For the unmanned UAS carrier this proven technique could be modified to facilitate the automated connection of the hoisted fuel bladder to the onboard pump that would empty the contents of the fuel bladder into the airship's fuel tank, and then drop the empty fuel bladder back to the sea surface for subsequent retrieval.

A more challenging, and advantageous alternative might be to modify an existing mid-sized UAS, or convert a light manned aircraft to unmanned operation, to serve as a "flying fuel tank" having the ability to hook on to the UAS carrier in flight. This aircraft would have a large fuel tank installed in the fuselage and a special adaptor to permit automated and rapid transfer of fuel into the UAS carrier's onboard fuel tanks. Once the carrier is refueled the re-fueling UAS would detach from the airship and fly back to its operations site either on the ground or on a conventional aircraft carrier. The airship's internal fuel load could be designed such that refueling of the UAS carrier would typically be needed approximately every 24 to 36 hours. With this technology the UAS carrier could stay airborne for weeks at a time.

Recovery periods of the UAS carrier would be determined by its operational mission(s), however its endurance would be limited principally by the reliability of its systems and scheduled maintenance. In fact, this extreme flight endurance may present a problem for the UAS carried onboard if the system reliability of those UAS do not equal that of the airship's systems reliability. This issue could become a factor that could dictate the overall endurance of the UAS carrier concept.

D. UAS Types

The UAS carrier could support a wide range of UAS designed for military or civilian missions. Many existing military UAS could be operated from a carrier airship with some examples being: the L3 Cutlass (Figure 16), Boeing Dominator[14] (Figure 17), Boeing RQ-21A Blackjack (Figure 18), and Textron Systems Shadow RQ-7B. These small UAS are optimal for operations that can take advantage of high numbers of deployed aircraft capable of carrying small payloads. The RQ-21A Blackjack is an example of a larger UAS that can fly for 16 hours with its heavy fuel (diesel) engine.[15] The RQ-7B is even larger weighing 467 lb. (includes an 80 lb. payload), and has a nine hour flight endurance.[16]

Figure 16. L3 Cutlass Tube-Launched Small UAS

Figure 17. Boeing Dominator

Figure 18. Insitu RQ-21A Blackjack

Figure 19. Textron Systems Shadow 2 (RQ-7B V2)

A number of commercial UAS are also being developed to serve the growing number of industrial, agricultural, and retail applications for unmanned vehicles.[17] Early studies of UAS delivery concepts and technologies suggest this could become a highly profitable delivery service, especially for small packages.[18] Perhaps the most significant interest is directed at commercial package delivery services (Figures 20 and 21). To succeed in this mission the UAS must be able to access the air space between the package warehouse and the final delivery locations. Current FAA regulations however, do not allow UAS to be remotely operated beyond the pilot's line of sight (LOS). A possible mitigation of this restriction could be the operation of commercial UAS package delivery UAS from a commercial UAS carrier airship. The UAS carrier airship could be launched with a large quantity of packages stored onboard. Dozens of UAS could also be carried on the airship and used to ferry the packages from the airship to their delivery point, and return to the airship for more deliveries. UAS pilots stationed on the airship would have direct view of the UAS throughout their flight. The UAS carrier operating for example over a city at 10,000 ft. MSL would have a far larger area affording a direct LOS for UAS flight control than would be possible from a ground based UAS flight operations site. By locating the hovering airship above the majority of the population center it may be more acceptable to aviation authorities to permit vertical UAS delivery operations while horizontal UAS delivery safeguards are being developed with the FAA and the UAS industry. In time it may be practical to utilize an intermediate UAS (as depicted in Figure

15) to provide flight control and visual signal relay for operation of commercial UAS flying well beyond direct LOS from the airship.

Figure 20. A six rotor package delivery UAS

Figure 21. An Amazon Prime package delivery UAS

A purpose-built UAS, designed specifically for airship carrier operation, will not require the same type of hardware used in conventional ship carrier operations; thereby removing the need for heavy aircraft landing gear, or cumbersome catapult rail-launch systems. UAS designed to operate exclusively from an airship could have simple, removable landing gear for transitions to UAS airfields or surface ships. Operating without landing gear increases UAS payload, or flight endurance. The Scan Eagle and RQ-21A UAS are recovered by flying them into a SkyHook™ Retrieval System (a vertically suspended rope) and snagging it with wingtip hooks.[19] However, by modifying these and other UAS for easy retrieval and launch by the UAS carrier's robotic arm, a wide range of UAS could be accommodated by a common launch and recovery system. Many UAS are being redesigned for compact stowage (folding wings and empennage) and carriage in rugged containers that allows underwater launch from submarines, as well as self-contained launch from airlifters, helicopters, bombers and tactical aircraft. These enhancements support a high stowage density aboard a UAS carrier airship.

Some of the more novel payloads proposed for small UAS include lightweight (2 lb.) synthetic aperture radars, like the NanoSAR C, and small imaging laser radars (LADARs).[20] For these and many other payloads, deploying them from a carrier airship may present the optimum means for new microsensors and microweapons to be supported, given the short range and slow speed of the UAS, and their need for on-station persistent iterative deployment. The operational potency of mass-producible, and more critically, mass-deployable payloads allows UAS to substitute for manned aircraft for a fraction of overall cost, meanwhile mitigating reliance on large land and sea bases.

E. UAS Carrier Airship Survivability

There are a number of threats, such as mines or torpedoes, which pose no risk to a UAS carrier airship. For other threats, such as fighters, and anti-air missiles, the airship hull, structures, and propulsion units can be treated to provide visual, RF, and EO/IR stealth characteristics. There are also several proven systems that can be installed in an airship to provide effective electronic and kinetic self-defense. To deal with the airship's principal threat from the weather, a constantly updated, weather-optimized flight route planning capability can be utilized to enable airship operations to the fullest extent while avoiding exceeding weather limits.

IV. UAS Carrier Airship Concept of Operations (CONOPS)

The preeminent value of the UAS carrier airship is to enable long duration access to an area sufficient to allow UAS to be inserted into an air space to conduct missions for as long as required. The UAS carrier can station-keep in a relatively safe standoff location from airspace that is contested or congested, but still be close enough to control, refuel, or replace the UAS engaged in their tasks. Like the arsenal aircraft concept being investigated by the USAF, the UAS carrier provides a more "organic" UAS resource for field command units and ships operating in Littoral waters, or commercial package deliveries operating above a city. The UAS carrier can be on-station in the airspace ready when called upon to deploy and support the UAS to meet the immediate needs of local commanders.

The ability to recover UAS in-flight opens up many operational opportunities. It would be possible to load the UAS carrier with a compliment of UAS while the carrier is moored on the ground, pending subsequent flight to an operating location where they can be launched en masse or in sequence. This makes transiting the UAS to the operations site much easier, because numerous UAS are transported via the airship that will deploy them, eliminating

the need for any coordination of vehicle transit flights, or logistics surrounding conventional cargo carriage. In addition, multiple UAS transiting through an airspace present signal bandwidth challenges. In-flight recovery of UAS also allows UAS to be launched from subsurface vessels, surface vessels, ground locations, or airborne aircraft, and then recovered by the UAS carrier to be returned for refurbishment, maintenance, and reuse. This allows more sophisticated and expensive UAS to be employed and not always expended. In this way, the possibilities for potential UAS missions are greatly expanded.

V. Hypothetical UAS Carrier Airship Mission

A number of notional military missions could be enabled by a UAS carrier airship that would serve as the focal point for developing, producing, and fielding UAS and their payloads. Examination of one such mission provides an insight into the broader applications for ASW.

A. Anti-Submarine Warfare (ASW)

For ASW, a UAS carrier with its small fleet of embarked UAS could operate at 10,000 to 15,000 ft. MSL and at standoff ranges from 50 to 100 nm. The UAS carrier airship sends out UAS to conduct bathymetry measurements in sea regions of interest to determine the spacing, depth, and CONOP for a small UAS-deployed multi-static array of mini sonar buoys. Alternatively, the UAS carrier dispatches a small group of dual-mode UAS autonomous underwater vehicles (AUV) as dormant submersibles, fitted with mini sonar buoys to listen passively and relay their findings via low-earth orbit (LEO) satellite communications (SATCOM) to land sites and to the UAS carrier. Another option would be for the UAS carrier to dispatch a group of Insitu RQ-21A Blackjacks, or similar high-payload UAS, to strategically place, or "sow," multiple arrays of small vector-sensor sonar buoys across ocean areas to maximize the probability of detection.

The operation would begin with the UAS carrier airship dispatching its sonar buoy carrying UAS and dual-mode UAS to areas where a potential adversary has been confirmed. The UAS carrier airship can maintain a frequently refreshed group of UAS continuously flying above the scene of the submarine search. A UAS carrier airship sowing and servicing multiple sonar arrays, while retaining a dispatchable anti-submarine weapon, could provide tactical advantages. This integrated capability is difficult to do with manned aircraft whose on-station endurances are measured in several hours (when the fly-out/fly-back time is counted).

VI. A UAS Airship Carrier Development Program

A staged development program is needed to enable development of the critical systems required for the UAS carrier concept to reach its full potential. Initial design and development of an airship based UAS launch and recovery mechanism could be accomplished through high fidelity modeling and simulation investigations, followed by development of systems for operating small UAS from an available existing manned (or unmanned) commercial airship. Airship system design and mission CONOPS development could be initiated through additional modeling and simulation. The simulations could be validated with a series of flight trials and key technology investigations with the commercial airship equipped with UAS capture and re-launch equipment (Figure 22).

The current LTA industry and capacity for building UAS carrier airships is limited, but there is a community of engineers who have the essential airship design and construction expertise to build modern manned and unmanned airships. Modern aerospace materials and design concepts are available to produce UAS carrier airships as described in this paper. Currently a handful of companies are developing large manned airships (near-buoyant and hybrid) for commercial cargo operations. Any one of these designs could be adapted to produce a UAS carrier airship with payload capacities in the 10 to 40 ton range. By equipping a viable large commercial airship with tested UAS launch and recovery systems, a UAS carrier variant could be developed and made ready for flight trials for a range of UAS for civilian/commercial and military applications.

VII. Conclusion

The UAS carrier airship represents the next logical step in the deployment of unmanned aircraft for civilian and military applications. The ever expanding capabilities of the multitudes of new UAS designs can be further enhanced by operating them from the most mobile of UAS bases: the UAS carrier airship. The airship provides a long endurance and stable platform independent of land or ocean constraints or access approvals. The airship provides a means for conducting LOS operations of UAS over large areas or dense population centers. Missions can be further extended beyond LOS by the use of signal relay UAS providing an effective and secure intermediate link between remote UAS and the airship. The flexibility of the UAS carrier's launch and recovery systems can accommodate wide varieties of medium and small UAS. Thus, coalescing in one highly mobile and self-contained platform, this UAS operations center is easily adaptable to military, commercial, and emergency response missions over land and sea. The UAS carrier airship also offers promise as a more cost effective means for operating larger groups of UAS in coordinated tasks. Development of the UAS carrier airship is within the capabilities of the current aerospace industry and extant support infrastructures. For the UAS carrier concept to reach its full potential, a staged development program is needed to enable and test critical systems required for various civilian and military missions.

Figure 22. Concept of UAS airship with two Insitu Scan Eagles attached to recovery platforms

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