CONCEPTUAL CHANGES BY USE OF NEAR SPACE

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Abstract

There are different opinions about the boundary of the space, the concept of near space as a new term enters into literature. Advances on the near space platforms, to overcome limitations in existing data systems, have the potential to obtain cost-effective systems. As a result of the developments in space technology, because satellite systems have continuous data transfer failure to target regions and the high costs of satellite systems, there are cost-effective near space platforms designed to transmit data continuously to battle field. Unmanned platforms positioned at the near space by means of more operational space systems have been developed on a continuous data transfer, providing more cost-effective information. These systems can stay in the air more than best-known Unmanned Aircraft Systems. Because there is a trend that conventional wars leaving their place to irregular warfare, close to real-time data transfer is crucial in terms of intelligence, reconnaissance and surveillance operations. The effect of near space systems on the concept of operational space usage as literature research; a comparison between near space platforms satellite and UAVs has been done in this paper.

Key Words: *Near Space, Unmanned Air Vehicles, Surveillance and Reconnaissance*

Introduction

Today different opinions about the space limits are put forth, the buffer zone between the height that air pressure is too low planes can fly and the height that is unnecessary for orbital deployment of satellites is accepted as "near space". This area, by development of new platforms offers a more efficient usage of air and space power. Today, by the advances on air and space technologies and the intensions of using air power more effective, it is expect that more effective development of near space platforms will occur and the concept of near space in air force is considered to place more and more in the next future.

While studies continue rapidly on the effective use of space, space-dominance theories are discussed for the future. Field studies on space indicated especially on operations uninterrupted information gathering only from satellites is insufficient, there is a need of gradual reconnaissance and surveillance systems besides satellites.

Satellites have created huge advantages in the military arsenal throughout the past several decades providing environmental monitoring, precision navigation, communication, missile warning, and intelligence surveillance & reconnaissance (ISR) platforms. While great for strategic peacetime uses where freedom of over flight is required, satellites have several drawbacks when supporting tactical military operations. while the conventional generally is replacing with asymmetric war, there is a need for persistence surveillance and reconnaissance. In this context, low-cost and operational systems have been developed that can remain in the air for long time compared to unmanned air vehicles.

Parallel with the developments in the world based, on the continuity of the national security, of the property to be able to transmit continuous information systems are needed especially in irregular warfare. Near space systems recently, by the advances on space technologies, are being used on intelligence surveillance and reconnaissance throughout of the world. The success of the all kinds performed operations depends crucially on providing near real-time and accurate flow of information, processing information, delivering these information especially to the decision makers, policy makers and all units in the field of operation to increase situational awareness. [1]

Today satellites provide information for strategic-level activities. Unmanned Aircraft Vehicles (UAV) and reconnaissance aircraft are used in role of operative and tactical level activities. The activities carried out by UAVs and the aircrafts encounter challenges such as meteorological limitations and time constraints. The aerial platforms developed to be deployed in near space are eliminating these

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difficulties and provide information for a strategic, operative and tactical at the same time. To call these platforms that are deployable in near space as "tactical satellites" will not be wrong at all. [2]

Concept of the Near Space

Definition of Near Space

The near space, considered as the region between controlled commercial air space and Low Earth Orbit (LEO), has been a cultural blind spot for many years but is not a new phenomenon. It has been used for weather forecasting by hoisting free floating hydrogen balloons (up to 27 km), scientific balloons (up to 42 km), by the strategic reconnaissance platforms like the MiG-25, SR-71, U-2 and more recently the unmanned Predator and Global Hawk flying at the lower envelope of near space at 65,000-70,000 ft. However, of late, it is being seen as another medium which would offer new capabilities not accessible to orbiting satellites or maneuvering aircraft, capabilities that are critical to emerging national defense needs. [3]

General John Jumper, the USAF Chief of Staff; Peter Teets, the DOD(Department of Defense) space czar; and General Lance Lord, head of Air Force Space Command, recently defined near space as the altitudes between 20 and 300 km. The Fédération Aéronautique Internationale defines the air and space boundary at 100 km. The region of near-space starts where controlled airspace ends. Over the U.S., the Federal Aviation Administration controls the airspace up to and including 60,000 feet mean sea level (Class A airspace). [4] As a result, the near space boundaries are taken as the lower limit 65,000 feet, or 20 km and the upper ceiling as 325,000 feet or about 100 km. The systems deployed according to the altitude are shown on Figure 1.

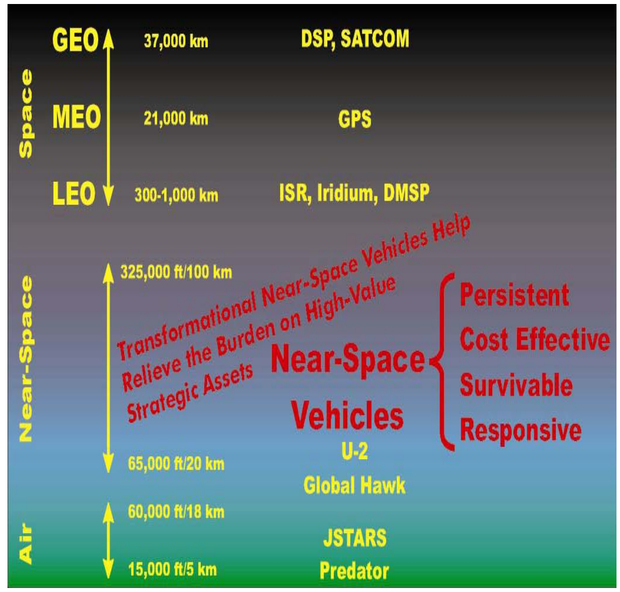

Figure 1. Graphical Depiction of the Gaps Filled by Near-Space [2]

Near Space Environment Characteristics

Near space differ from atmosphere and outer space with outside the influence of the ionosphere, temperature, wind, pressure and the effect of ozone.

Atmospheric air temperature decrease -2 ^{0}C per 1,000 feet. It reaches -59 ^{0}C at 36,000 feet and remains constant up to altitude of 65,000 feet. Subsequently, the temperature begins to rise, and rise up to -27^{0}C at 120,000 feet. [5] The temperature changes related to the altitude shown on Figure 2.

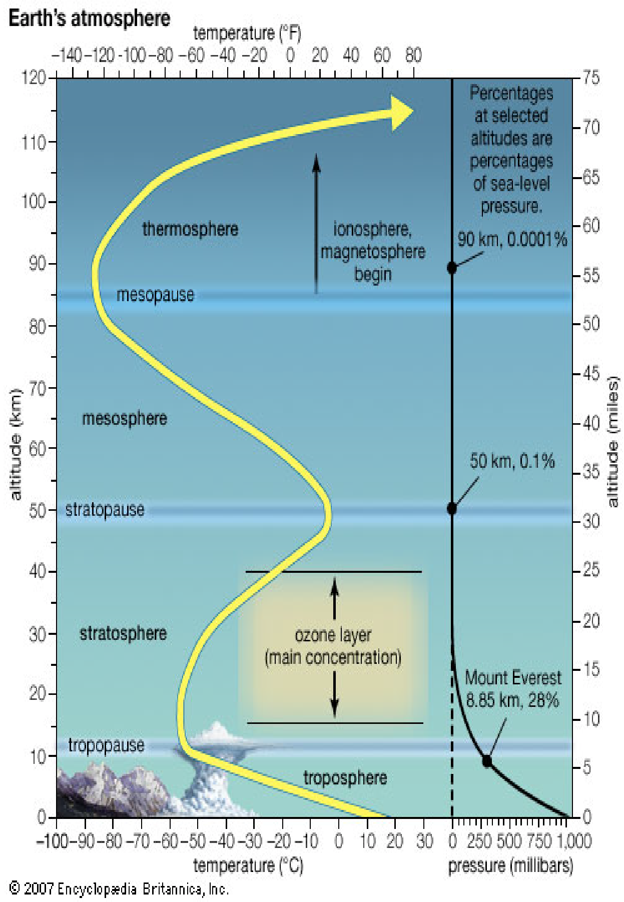

Figure 2. The Temperature Changes According to the Altitude [5]

Wind patterns are also different in near space as opposed to space (see Table 1). Compilations of surveys of the general wind condition in near space had shown that for equatorial regions such as India, wind speeds average at 15 knots, with speeds gusting up to 40 knots 95 percent of the time. However, as the density of the atmosphere in near space ranges between 7 percent of sea level down to 0.5 percent of sea level at 120,000 ft, gusts and transient changes in wind speed will have minimal effects as there are very few air molecules to transfer momentum. Only sustained winds will cause an object to slowly accelerate to the ambient wind velocity, so all-in-all, the environment can be characterized by 15 to 30 knots of ambient wind speed. [3]

Table 1. Wind Conditions in Lower Near Space [3]

		Wind Speeds		
Latitude	Altitude	Average	95% of the time	99% of the time
Equatorial	65,000 ft	<10 knots	<30 knots	<50 knots
(0-20 degrees)	80,000 ft	<15 knots	<40 knots	<60 knots
Mid	65,000 ft	<15 knots	<30 knots	<50 knots
(20-60 degrees)	80,000 ft	<20 knots	<45 knots	<60 knots
Polar	65,000 ft	<25 knots	<40 knots	<50 knots
(60-90 degrees)	80,000 ft	<30 knots	<60 knots	<70 knots

Atmospheric pressure is another difference between space and near space. In space, pressure is essentially negligible. In near-space, pressure is a significant factor, especially for structures based on gas-filled volumes. This relationship and the plot of pressure through lower near-space can give some rules of thumb for a volume- doubling altitude change. Between about 65,000 ft and 120,000 ft, the pressure halves with every change of approximately 15,000 ft, implying that such an ascent would approximately double the volume of a balloon. These large changes in volume can be a severe design constraint for near space platforms using helium lift. [2]

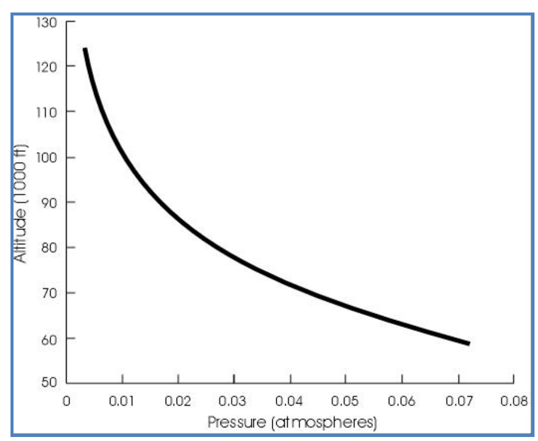

Figure 3. Pressure Profile Through the Lower Portion of Near-Space [2]

Metal corrosion is likely to occur due to exposure to the particularly high ultraviolet. While many atmospheric gases help shield the lower atmosphere from damaging ultraviolet (UV) radiation, ozone is the primary absorber. UV degradation can have a similar effect to corrosion on many materials, and designs must take UV damage into account. [2]

Military Space Missions Areas

In terms of national security and the armed forces, space environment being evaluated as an operation area as air, land and sea environment. According to the general World and NATO literature space missions have four functions. [6] The current primary space missions are:

- Space Force Support
- Force Enhancement
- Space Control
- Force Application

Space Force Support

Space force support function contains the creation force of space, orbit insertion and maintenance. The ability to launch a satellite, satellites and space control, commanding all kinds of forces logistical support are the main topics of this capability. Space force support, as a force task, is a superior and equally important task as force enhancement development function in the fields of space. [7]

Force Enhancement

Force enhancement includes the capabilities to support of ground based forces(air, land and sea). For effectiveness of land, air and naval operation force enhancement elements are as follows;.

- Communication
- Navigation
- Surveillance and reconnaissance satellites
- Warning Systems
- Environmental Control
- Mapping and Geodesy

Space Control

Space control is combat, combat support, and combat service support operations that ensure freedom of action in space; when directed deny an adversary freedom of action in space. The space control mission area includes: surveillance of space, protection of space systems, prevention of an adversary's ability to use space systems and services, negation of hostile space systems and services; and direct support to battle management, command, control, communications, and intelligence. [8] The function contains:

(1) To deny any damage or threat to friendly space systems,

(2) To prevent adversary forces the use of space in their favor.

Space Force Application

Force application mission is simply combat operations in, through, and from space, including ballistic missile defense and force projection operations. [9] Force application in space, to support military operations, means the use of force against the ground targets. This capability is part of the most active space programs for military maneuvers. [7]

The Conceptual Effects by Use of Near Space

The Current Force Enhancement

Communication, navigation, surveillance and reconnaissance satellites; warning systems, environmental and control mapping , and geodesy are the information needed for force enhancement. Because the main purpose of the space platforms is force enhancement, evaluating near space as the effects of force enhancement will be appropriate. Nowadays, in terms of force enhancement: satellites are being used at strategic level, reconnaissance aircrafts and UAVs are being used at operative and tactical level. The most important needs for recent operations are two main cases an organic intelligence platform for uninterrupted information and communication beyond the horizon for continuous communication. Number of satellites used in order to obtain the desired information from the satellites due to the high cost of tactical sense is not enough to be used. To manufacture, launch, deploy to the orbit and maintain a GEO (Geostationary Orbit Eath) satellite brings extremely high costs. [10] Figure 4 shows the variation needs of satellites for years.

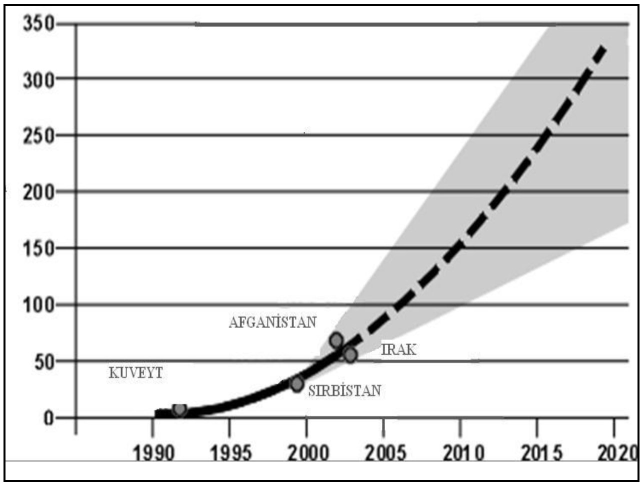

Figure 4. The Variation Needs of Satellites for Years [11]

The Near Space Conceptual Effects

Wide Area Coverage

By virtue of being placed high up in the air, near space vehicles provide large area coverage for either communications or surveillance functions (see Figure 5). The lack of obstacles between earth and near space enables the maximum range communication, assuming that the power output of the radio is high enough to propagate through this distance or that the lens used is wide enough to capture the full area of operations for surveillance type functions. At 30 km, the minimum expected LOS range would be 720 km as calculated by the LOS equation, while a radio atop the tethered aerostat balloon hoisted at a height of 5 km provides an LOS range of 300 km. Tests carried out by the US Air Force (USAF) Space Battle Lab under the Combat Sky Sat balloon programme revealed that the range of the PRC-148 radio increased from 16 km on the ground to 650 km when used from an altitude of 20 km. [3]

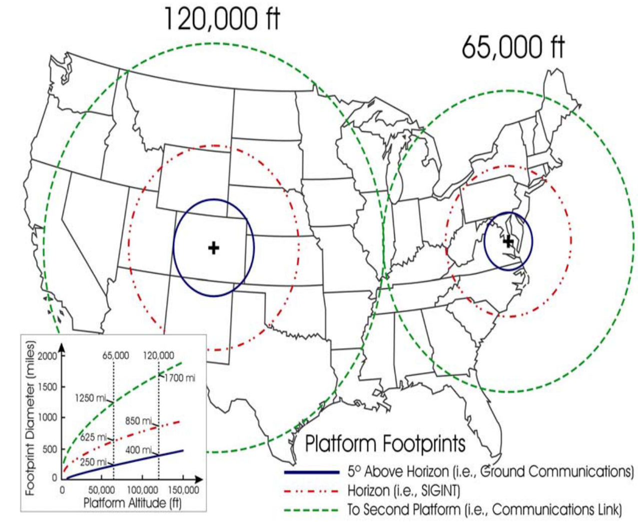

Figure 5. Footprint Sizes for Platforms at 65,000 and 120,000 Feet for Three Look-Angle Restrictions [2]

High Resolution, Better Sensitivity

Near space platforms operating at 30 km are at least 15 to 20 times closer to earth than their orbital counterparts (see Table 2). Considering that similar optical infrared (IR), Multi-Spectral Imaging (MSI), or Synthetic Aperture Radar (SAR) sensors onboard the satellites are employed as payloads on near space vehicles, they would be expected to provide 10-20 times better resolution. Distance is critical to resolving features in images and receiving low power signals. The power received by a passive antenna decreases as the square of the free space distance to the transmitter, while that of an active transmitter/antenna system decreases as the fourth power of the transmitter/target distance. A passive antenna on a satellite that receive one watt of power from a transmitter in its footprint would receive between 100 and 400 watts on a near space platform, implying that it could detect much weaker signals (10 to 13 dB weaker). The signal strength improvement for active systems such as Radio Detection and Ranging (RADAR) or Light Detection and Ranging (LIDAR) would be factors of 10,000 to 160,000 (40 to 52 dB) for near space platforms. [2]

Table 2. Reconnaissance Platforms [4]

Platform	Data Type	Coverage	Dwell Time	Comments
Eros[51]	Optical/ Infrared (IR)	1 satellite at 480 km sun-synchronous 7 launches planned	1 pass twice a week constellation allows twice a day	1.8 m
Ikonos[52]	Optical/IR	1 satellite at 680 km sun-synchronous	10:30 am local pass once every 3 days	1 m color or 4 m multispectral
SPOT[53]	Optical/IR	3 sats at 832 km sun-synchronous	At least 1 picture a day	2.5 -20 m multispectral
E-8C[54]	SAR	140 nm 50,000 sq nm/hr	3000 9	
U-2S[55]	SAR	100 nm 100,000 sq nm/hr	6000 9	
RQ-1[56]	Optical / IR / Synthetic Aperture Radar (SAR)	5.8 nm[57]	400 24[58]	1 ft resolution @15K ft altitude
RQ-4[59]	Optical / IR / SAR	110 nm 2300 sq nm/hr	12,000 35	

Being lower than satellites also brings another advantage to near-space platforms: they fly below the ionosphere that prevents image signal reflections and the prevention of fractures. Ionospheric distortion of electromagnetic signals and geolocation errors is shown on Figure 6.

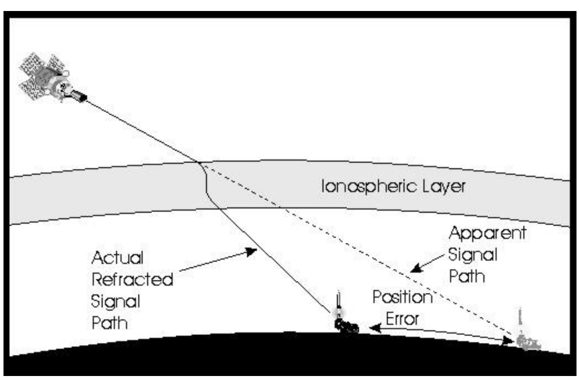

Figure 6. Ionospheric Distortion of Electromagnetic Signals Can Cause Geolocation Errors [2]

Survivability

Near-space platforms are inherently survivable. They have extremely small radar and thermal cross sections, making them relatively invulnerable to most traditional tracking and targeting methods. They also tend to move very slowly compared to traditional airborne targets, almost drifting on the wind similar to the chaff that modern Doppler radars are designed to ignore. Documented examples exist of sophisticated military airborne radar platforms being unable to find high-altitude balloons. At these altitudes, they are very small optical targets as well, only showing up well when the background is much darker than they are—dawn and dusk. Thus, the acquisition and tracking problem is very difficult even without considering what sort of weapon could possibly reach them at their operating altitudes. Manned aircraft and surface-to-air missiles (SAMs) could be a threat at the lower end of near-space, but even if they were able to acquire, track, and guide on a near-space platform, their probability of kill would likely be low, as will be discussed below. As platform altitudes get higher, the difficulty in delivering a weapon to the target only increases. Very few SAMs are designed to reach above about 80,000 ft, and those that do are most likely not designed to engage a very low cross section, slow, non-maneuvering target at those altitudes. Economics also discourages such an exchange, as the trade between an inexpensive, quickly replaceable near-space platform and even a relatively cheap SAM would rapidly become cost-prohibitive. [2]

Responsive Persistence

Although the near-space advantages in footprint size, resolution, received and radiated power, cost, and survivability are significant, perhaps the most useful and unique aspect of near-space platforms is their ability to provide responsive persistence, the ability to deliver their space effects to battlefield commander-specified locations around the clock with no gaps in coverage. The greatest persistence that a commander can currently expect from an air-breathing asset is about a day or so for a Global Hawk. Air-breathing assets provide responsive, close-up, staring persistence for the duration of their limited loiter times. In contrast, one near-space platform currently receiving technology demonstration funding will be able to stay on station for *six months*, and planned followons are projected to stay aloft for *years*. [12]

Cost

Near space vehicles offer tremendous cost advantages over satellites or aircraft. When compared to the cost of acquiring one Heron UAV, at a cost of US$4 million from Israel, a SU-30 MKI at a cost of US $ 47 million from Russia or an Airborne Warning and Control System (AWACS) at a cost of US $350 million from Israel/Russia, the cost of a free floating balloon would be less than US $ 1,000. Even at the high end of the spectrum, the US $ 50 million cost of a strategic high altitude airship with payload would be less than that of an AWACS, even if more than a UAV, and comparable to that of the SU-30 MKI. Comparing the cost of an NSV to that of a satellite, we find that satellites are much more costly. The surveillance cost per hour would also be the cheapest in the case of NSVs when compared to other assets due to the saving in expenses in terms of refueling, maintenance, major upgrades, payload reconfiguration, launch infrastructure and manpower for operation as it will be designed to stay on station for months at a time. Thus, we can say that when it comes to cost taken over the life cycle of an NSV, it has no peer. [13]

The cost of a near space airship for launching is so low when compared satellite systems launch. when compared to the other systems UAVs and satellite systems ground support units, maintenance personnel and operating costs appears to be more cost-effective. [13]

According to researches, the studies and the searches about near space and near space airships will not cost more than the other space crafts and UAVs. [13] The research and development costs of balloons are considered to be less because they have been used for long time and having experiences about the system. Due to the length of time near can operate and the size of the area they cover space platforms can operate the tasks of a large number of UAVs and satellites . Thus reducing the number of expensive satellite systems and UAVs will lead to lower costs.

Payloads

As regards payload (sensor/communications), there is a limitation of the amount one can place on a satellite considering the cost/kg of launch and the fact that the payload can neither be retrieved nor upgraded. Similarly, in the case of aircraft and UAVs, the sensor payload is one of the many factors that need to be factored in during the design stage.

Unlike the case of satellites, payload onboard aircraft and UAVs can be upgraded but at a considerable cost which involves reengineering of the platform to fit the payload. Even if the payload is a kind of plug and play and carried outside the platform, it would affect the range and endurance of the platform. The more advanced Global Hawk UAV of the US is capable of carrying a total payload of 850 kg to 65,000 ft and provides persistence of about 42 hours. When compared with these assets, NSVs are being designed to carry more than 1,000 kg to above 100,000 ft and provide persistence for months together without any major maintenance. The payload can be changed by retrieval of the NSV or a new NSV can be launched. In essence, the type of payload is independent of the platform, and volume is not a major design constraint. Further, not being exposed to the high levels of radiation common to the space environment, payloads flown in near space do not require the costly space hardening required for orbital assets. Near space payloads also are not exposed to high gravitational forces during launch, as are satellites. Operating in near space obviously eliminates a great deal of expense involved in space sensor construction. [2]

Weakness of Near Space

There are two most prominent weaknesses:

First, large helium-filled balloons present large cross sections subject to the effects of wind and turbulence during inflation, launch, ascent and descent through the troposphere, recovery, and deflation. Inflation times on the order of hours will probably require the construction of hangars to protect against the wind. [2]

Second, freedom of over flight is another weak area for near-space. ICAO treaties cover the airspace up to 60,000 ft. Satellites enjoy free over flight via other treaties and US national policy. However, the legal status of the near-space regime is a grey area that to our knowledge is not directly addressed by treaty or policy. Near-space is not a new legal regime; the question is only whether it falls under air law, where nations claim sovereignty over their airspace, or space law, where over flight rights exist. Due to lack of clear legal precedent governing the near-space regime, there is considerable disagreement among legal analysts over whether over flight rights exist. [4] See Table 3 for a list of Relative Strengths of Satellites, NSVs and Air Breathing Assets

Table 3. Relative Strengths of Satellites, NSVs and Air Breathing Assets [2]

S. No.	Attribute	Satellites	NSVs	Aerial Platforms
1	Cost		✓	
2	Sensor Payload		✓	
3	Persistence		✓	
4	Coverage	✓	✓	
5	Responsiveness		✓	✓
6	Resolution		✓	✓
7	Overflight	✓		
8	Survivability		✓	

Advances on Near Space Platforms

Lockheed Martin's High Altitude Airship (HAA)

Figure 7. Locheed Martin HALE-D [14]

Under contract to develop a HAA platform for the US Missile Defense Agency (MDA) since 2003 as part of an advanced concept technology demonstrator, Lockheed Martin was to execute the programme's third phase to build, flight test, and demonstrate the prototype HAA vehicle. The prototype under development is planned to have a mission life of one month, operating above 60,000 ft (18.3 km), while providing 10 KW of power for 227 kg/500 lb (operational version would carry 1,813 kg/4,000 lb) payload. The HAA vehicle would be 152 m (500 ft) long and 46 m (150 ft) wide. Photovoltaic cells and fuel cells would power the HAA. Electric-powered propeller technology would be used to propel the HAA and help it to maintain geostationary location. The HAA would be retaskable in flight and can be recovered and reconfigured as required for specific mission requirements. The operational vehicle is expected to provide mission times in excess of one year for a wide variety of applications like ballistic and cruise missile defense, theatre surveillance, environmental/weather monitoring and post-national disaster support, maritime domain awareness and broadband communications connectivity. [3] The HALE- D is under structured and being tested in 2009. The D model is planned to use solar energy and charge lithium ion batteries D model successfully deployed to the near space on 27 July 2011 and sent information from different angle of view. [14]

Japanese Sky Net High Altitude Airship (HAA)

Sky Net is a major HAA project funded by the Japanese government, and aims to provide TV and communication services with an inter-connected network of about 10 airships covering Japan. [15] Tests successfully accomplished in 2003 and 2004. The specific end applications are disaster relief/ event servicing, both 3G and broadband, broadcast HDTV, broadband fixed access to users and broadband mobile access to long distance trains and other vehicles.[3]

The South Korean National Project

Close on the heels of Japan, in 2000, South Korea launched a 10-year program, which consists of three phases, to develop an unmanned stratospheric airship. [3] The project aims 10 KW powered with 1000 kg payload carried altitude of 20 km for information transfer. The first phase accomplished in 2004, a 60 m airship carried 100 kg payload to the altitude of 3 km. [3]

Also, USA Sanswire Networks HAA (High Altitude Airship), NASA Stratosat, Helios; DARPA UAS (Unmanned Airship), Odysseus, Zephyr; Italian Polytechnic University HALE, Germany HALE are the conceptual studies for using capabilities of the near space.

Conclusion

Near space, with the support of civil and military fields have been used for time to time many years but the use of near space has been suspended in accordance with technological developments. It is a promising air block for national security while considering the effects of military use of space force, especially in the discovery and development of communication conceptual changes.

Near space, due to the specifications it contains, differs from outer space and the atmosphere. Near space platforms, in terms of communication remain outside the influence of the ionosphere, so the transfer of data as reflections and images is protected against erroneous impressions of ionosphere. The temperature, wind, pressure and atmosphere, and ozone that near space contains are more static space and atmosphere. Total temperature difference between 65,000 feet and 120,000 feet is about 32 °C. Also there is not so much changes in pressure and winds. The amount of ozone decrease at higher altitudes, thus decreasing the effect of ozone at high altitude increases ultraviolet rays and the amount of radiation. For these reasons, near space has a stable weather conditions, is not affected by meteorological events.

Today, the uninterrupted intelligence, reconnaissance and surveillance information in real-time acquisition is one of the most important factors that affect military operation. Tactical level commanders in operation need immediately and continuously capable of transmitting real-time information, and having superior features in many ways to transfer information rather than systems platforms that is not having time delay as UAVs. Near space platforms is superior from other platforms as cost-effectiveness, payload handling, maximum endurance, mobility, high resolution, flight over the target, survivability and coverage matters and able to respond to these needs mentioned above. However, they are large in size, affected by meteorological events and the legal uncertainty on the use of space are considered as disadvantages of the near space platforms. Space environment in terms of national security and the armed forces is divided into four tasks: space force support, force enhancement, space control, the force application. Near space is generally considered to improve force support function.

Conceptual designs for reconnaissance and surveillance intensified recently, the conceptual design models for the information transfer is usually support the space activities. Near space platforms are planned to support disaster monitoring, 3G, local publications, planned to be used in areas such as broadcast TV besides their military purposes. By providing near real-time data in operation, having many superior features and superior capabilities, near space platforms is expected to enhance military operations as a force multiplier.

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