Strategic Technologies for the Military: Breaking New Frontiers

Near Space Technology: Relevance in the Evolving Security Environment

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Chapter 1: Near Space Technology: Relevance in the Evolving Security Environment

The earth's first artificial satellite, Sputnik, was launched by the erstwhile Soviet Union on 4 October 1957. More than five decades have passed thereafter and mankind has made a remarkable progress in the space arena and has even conquered the moon. The space quest that started by placing the satellite into the lower earth orbit, approximately at the height of 250 km during 1957, has now reached to a stage where states have started reaching out to the ‘deep space’ region.[1] Now, satellites of a few states have been positioned at a height of approximately 400,000 km which even enable observation of the moon from extremely close quarters.

Over all these years, states have launched more than 6,000 satellites into various orbits of the earth, either independently or with the help of other states. Satellites in the uppermost orbit, commonly known as geostationary orbit, are positioned at the height of 36,000 km. During the period 2007–08, states like Japan, China and India have successfully placed their satellites in the lunar orbit.

Space technologies have utility in regard to remote sensing, communication, navigation, meteorology, education, astronomy, and so on. Conversely, these technologies inherently being dual-use technologies have a military dimension too. Satellites play a prominent role towards **[p. 20 ↓]** military communication and navigation. Also, satellites are being used for many years for military purposes like intelligence gathering, surveillance and reconnaissance. The theoretical possibilities exist where satellites could be armed and used to fire weapons at targets on the earth.[2] On the other hand, there are chances that ‘Weaponisation of Space’[3] could become a reality where the states would adopt such techniques to destroy the satellites of rival countries. On

11 January 2007, China successfully conducted an anti-satellite (ASAT) test which destroyed its own dysfunctional satellite by firing a ballistic missile from the ground (this is known as kinetic kill vehicle or the KKV technology[4]). Also, it is likely that a few states have developed satellite jamming technologies which could be used for temporarily jamming the satellites of other states. This technology essentially involves the usage of ground-based lasers to jam the satellites.

1 Deep space is the region which is considered to be a region above 100,000 km from the earth's surface.

The satellite era, in regard to militaries, could be said to have started with the 1991 Gulf War. Earlier during the Cold War period the satellites were used by the then superpowers, namely, the US and the erstwhile USSR for the purposes of monitoring nuclear activities. The world is witnessing a marked increase in the usage of space technologies for military-aid in the post-Cold War era. These technologies have transformed the modern-day battlefield significantly. Apart from dual-use technologies, military specific projects like spy satellites are also being developed. Entire world has witnessed with awe, the usage of space technologies by the US and its allied forces during the 1991 Gulf War. Subsequently, these technologies have been used with some success during Kosovo conflict and during the US invasion of Afghanistan (2001) and Iraq (2003). All these campaigns saw intense use of space assets by the US and its allied forces.

2 The concepts like ‘rods from the god’ talk about putting tungsten rods in the satellites and fire them over the target on the earth from the space.

3 ‘Militarisation of Space’ means using space assets in aid of military for purposes like communication, navigation and intelligence gathering. Space-faring nations are using their assets for these purposes for many years and this usage does not violate any international norm. However, ‘Weaponisation of Space’ means usage of weapons either from ground or from space to damage the assets of other country. There is no support for this activity from any country; however, there is also no globally acceptable treaty mechanism to ban such weapons.

4 KKV technology involves fixing a metal piece on top of a missile and firing that piece of metal towards the target. Here the target gets fragmented into small parts because of shear impact and the kinetic energy generated during the process. No ammunition per se is required to do the job.

[p. 21 ↓] Space science and satellite technologies involve significant financial and technological investments. The launcher technology, a technology used for putting satellites into the space, is closely associated with ballistic missile technology. At global level, the technology transfer in this area has mostly remained a selective proposal. Hence, both financial and technological limitations in this field have kept many states away from this technology. Until early 2009, only nine states in the world have proven their capability towards indigenous manufacture and launch of satellites. Among this group, a few are recent entrants and have very limited capabilities. All these years, the US has made substantial investments towards the growth of this field (both civilian and military). Also, a few European states have made steady investments by forming a European Space Agency (ESA). Russian investments had depleted for some period due to economic compulsions but not any more.

However, all these states with strong economic and scientific bases along with sustained investments of four to five decades are finding it difficult to continue with ambitious space agendas. This could be mainly because of the skewed nature of cost-benefit curve in regard to space exploration. Hence, in the civilian arena of space exploration, a few states have come together to undertake experimentation in the outer space. International Space Station (ISS) is the best example of such cooperation where 16 states (US, Russia, Japan, Canada and a few European states) have come together towards establishing a space station, at approximately 450 km above the earth's surface to undertake various experiments. To a certain extent, India's first moon mission, Chandrayan-1, also could be an endeavour of international cooperation where various sensors from ESA, Bulgaria, formed part of the mission.

Unfortunately, international collaboration is not always a trouble-free situation. States are forced to undertake a few decisions due to geopolitical compulsions, and then there are competitions among the states. In the end military demands of the states get precedence over other requirements. The states are not ready to share ‘everything’ with each other because of the inherent characteristic (dual-use) of space technology.

At the backdrop of above, states are looking for alternative platform technologies which could offer them similar benefits as spacecrafts, but which are cheaper and technologically less challenging. They are looking for technologies which could be developed indigenously. Moreover, the biggest disadvantage with the satellites is that its life period is more than a decade. The rapid developments in the sensor technologies do not **[p. 22 ↓]** instantly find a place on board of satellite and the sensors which are on board of such platforms do not always remain in the bracket of ‘state-of-the-art’. Under such circumstances, there is a need to have economically viable space platforms with shorter life period.

A new frontier of technology is being discussed and researched for the last few years, which is cost-effective and could provide most of the benefits, the satellites offer. Near Space technology is gaining prominence in security thinking of a few states particularly with the US after the 2003 Iraq war. Like satellites, this technology also has its utility in the civilian field. The term ‘Near Space’ could be defined as a region between 20 and 300 km altitude. The seam between what had traditionally been regarded as high altitude (usually aircrafts over all international flying routes fly approximately at 12 km height, most of which happen in troposphere; higher altitudes are the ones which could be said to be lying above troposphere and form a part of stratosphere), and low Earth orbit (LEO, usually considered as the region till 400 km above the earth's surface), is of interest to the military for several reasons. The inflatable airships operating in this region are likely to fulfil many of the missions now assigned to satellites or to high-altitude aircraft, such as the U-2 or the Global Hawk UAV. These could be the key to the collection of affordable persistent intelligence, surveillance and reconnaissance (ISR) information[5]. This chapter explores the relevance of Near Space technologies from a security perspective.

Concept and Present Status of Technology

The Air Force's operating domain is frequently called the ‘vertical dimension’. Traditionally it has been defined as that area ranging from the surface of the earth to geosynchronous spacecraft orbits (36,000 km up in the space). However, this definition is more of a notional definition. In reality, Air Force aircrafts fly approximately at the

heights of 12–15 km and satellites are placed into various orbits[6] of the space, which also **[p. 23 ↓]** provide useful information for the purposes of national security. A large slice of space in this domain where neither aircrafts fly nor do satellites operate has been ignored until now. This place in question is the region sandwiched between an altitude close to the internationally accepted upper limit of controlled airspace and an altitude which is the lower limit of space.[7] At present, this region is a ‘no man's land’. Air is too thin to support flight by most operational military aircraft, and yet gravity is too strong for a satellite to sustain itself in orbit. As a result, neither any aircrafts fly nor any satellites are placed in this particular Near Space region. Many defence officials believe that this space could prove to be a key operating area in future.[8]

5 Taylor Dinerman, ‘Near Space: A New Area of Operations or a New Pentagon Buzzword?’ 20 September 2004, http://www.thespacereview.com/article/230/1 (accessed on 12 January 2007).

6 Low Earth Orbit (LEO) could be said to be the region from 100 to 400 km above the earth's surface. Medium Earth Orbit (MEO) is above that and geostationary orbit satellites are positioned at an approximate height of 36,000 km.

According to the International Aeronautical Federation (FAI), the realm of Near Space officially lies between 14.2 miles $_{(\sim 23}$ km) and 62.5 miles (100 km). However, many consider a wider range that extends up to 200 km or even more, particularly, till an envelop where it becomes safe for satellites to remain in orbit without being dragged down by friction with the residual atmosphere, as an outer edge of Near Space.

The vehicles that traverse this high altitude domain are called *near-craft.* These include sub-orbital rockets, which make quick jumps into and out of near space, and high-altitude balloons that can loiter there for extended periods. Weather balloons routinely go up to 27 km and scientific balloons go up to 42 km and remain at high altitudes for several days.[9]

Until very recently, the distinction of space as a set of effects instead of a medium was irrelevant because the only platforms that could deliver space effects were satellites. However, a convergence of several technologies has changed the landscape

of capabilities. This is an important distinction. Evolutionary advances in several disparate disciplines have led to a revolutionary advance in capability. Particularly, the advancements in microelectronics and material sciences are impacting various other fields of technologies. Some technologies contributing to this **[p. 24 ↓]** revolution in capability are: (*a*) power supplies, which includes thin and lightweight solar cells, small and efficient fuel cells and high energy-density batteries; (*b*) the tremendous miniaturisation of electronics and exponential increase in computing power, enabling extremely capable, semi-intelligent sensors in very small, lightweight packages and (*c*) very lightweight, strong, flexible materials that can resist degradation under strong ultraviolet illumination and are relatively resistant to low atomic-mass gases.[10]

7 An individual is qualified to become an astronaut if his/her craft reaches a height of 90 km or more. There is no globally accepted understanding in regard to what could be called as the lowermost boundary of space. Since the eligibility to become an astronaut is to fly above 90 km; it is generally perceived that the region above 90 or 100 km could be known as the beginning of space.

8 Hampton Stephens, ‘Near-Space’, *Air Force Magazine* 88, no. 7 (2005), http://www.afa.org/magazine/july2005/0705near.asp (accessed on 26 January 2007).

9 Paul Verhage, ‘Near Space: The Shore of our New Ocean’, http://www.hobbyspace.com/NearSpace/ (accessed on 16 February 2006).

Such technologies have made the development of Near Space platforms feasible. These small platforms which are powered by long-lasting and efficiently renewable power supplies are capable of performing almost all the tasks which other conventional satellites can perform. Such Near Space platforms need a further push in regard to research and development to make them military-compatible.[11]

Near Space platforms have already found a utility in the civilian arena. Some industrial houses in the US are using such commercially developed platforms for purposes like communication.[12] Amateurs are also designing and building various models of Near Space kits with considerable success. The heart of any such Near Space programme is its near spacecraft design. The simplest design even permits the use of a zippered,

soft-sided, reusable lunch bag normally available at the local departmental store. More complex designs, airframes are built from specific materials. A secure method for carrying the Near Space craft on its mission is to cover it inside a cloth jacket, which prevents the avionics and batteries from getting too cold during the mission. The avionics could be as simple as a Global Positioning System (GPS) tracker or as complex as a complete flight computer. A recovery parachute (approximately 6 feet in diametre) to get the craft back to the earth is a must.[13]

10 Lt Col Ed 'Mel' Tomme and Col Sigfred J. 'Ziggy' Dahl, 'Balloons in Today's Military?' *Air & Space Power Journal,* Winter 2005, http://www.airpower.maxwell.af.mil/airchronicles/apj/apj05/win05/tomme.html.

11 Edward B. Tomme, 'The Paradigm Shift to Effects-Based Space: Near-Space as a Combat Space Effects Enabler' (Research paper, Airpower Research Institute, Maxwell, 2005), 5.

12 Jennifer Thibault, 'Developing the Near Frontier', *Military Aerospace Technology* 4, no. 3 (2005) http://www.military-aerospace-technology.com/article.cfm?DocID=1210 (accessed on 26 December 2007).

13 L. Paul Verhage, 'The Poor Man's Space Program', 27 October 2003, http://www.thespacereview.com/article/55/1 (accessed on 26 December 2007).

[p. 25 ↓] Among the major global military powers, the US Air Force (USAF) has maximum (almost 50 years) experience with high altitude balloons. When used as research tools, they have played a useful role in development of escape systems for pilots and in developing the recovery capsule for spy satellites. Numerous space probes have been tested using the Air Force's balloon capability. According to the 1997 Air Force report, 'The Roswell Report: Case Closed', it was these balloons that set off the notorious UFO (Unidentified Flying Objects) incident.[14]

For the last few years, particularly post-1990, a number of aerospace corporations are devoting considerable time and effort towards exploring this realm. Also, the USAF has started looking at it more seriously for its military utility. This has brought in some

amount of secrecy into the recent developments in the field and hence, it is difficult to judge the exact status of technology.

The Johns Hopkins University's Applied Physics Laboratory (APL), has been working in this field for more than a decade. The APL Near Space concept calls for a balloon type vehicle and sensor package to be tightly packed into an aircraft and missile, which could fly the high-altitude reconnaissance vehicle (HARVe) to high altitude, then dispenses it. The airship would self-inflate and automatically activate its solar powered electric-propulsion system and sensors. Here solar-recharged batteries are expected to enable round the clock HARVe operation in a particular region, serving as an over-the-horizon communications node/relay or ISR platform.[15]

The physics behind putting the Near Space flight in higher latitudes is very unique. Near Space technology is still in nascent stage and yet to overcome many technical challenges to make this technology operational. For example, the carrying capacity of balloons depends partly on their size. The physics of volumetrics and diminishing return as one increases payload capability and altitude are pretty challenging. It is envisaged that increasing payload or time on station will demand innovation and induction of few additional technologies apart from increasing the size of the balloon. So far, demonstrations have explored how balloons floating above a battlefield could be used to improve tactical communications. By attaching radios to balloons, the range of line-of-sight radio **[p. 26 ↓]** communications can be significantly extended. Such a set-up could dramatically improve close-air-support operations.[16]

14 Taylor Dinerman, ‘Near Space: A New Area of Operations or a New Pentagon Buzzword?’ 20 September 2004, http://www.thespacereview.com/article/230/1 (accessed on 21 December 2007).

15 William B. Scott and Colorado Springs, ‘Near-Space Frontier’, *Aviation Week and Space Technology* (2005): 72.

Some commercial concerns are already using Near Space equipment like balloons for business purposes. This is possible because their technical requirements are not stringent as that of the military. As mentioned earlier, a few oil and gas producers in west Texas and Oklahoma receive data from wells transmitted through high-altitude

communication balloons. This system is found to be useful and much more cost-effective than trying to establish a cellular network in such sparsely populated regions.[17] Such balloons collect and transmit information, such as how much oil is being pumped from rigs in remote areas with the help of very little communications infrastructure.[18]

Understanding the commercial viability of such economical communication techniques, commercial houses have already started thinking on lines of developing a network that may challenge the existing cellular network. These houses are taking their wireless broadband network ideas to new heights. They are prototyping High-altitude Airship Platforms capable of transmitting various types of wireless communication services currently handled from cell towers and satellites. Such airships are 100 per cent reclaimable, utilising proprietary lifting gas technology.[19]

Apart from the US, countries like Japan are also making investments in this field. They are eyeing large stratospheric airships. An aeronautic research arm of the Japan Aerospace Exploration Agency (JAXA) is sponsoring the 'Stratosphere Platform Project'. They oversee a network of huge unpiloted airships that stay afloat, high in the stratosphere, outfitted with telecommunications gear and sensors. Japanese authorities expect to use them for the purposes of broadcasting, earth observation and disaster monitoring.[20]

16 Hampton Stephens, 'Near-Space', *Air Force Magazine* 88, no. 7 (2005), http://www.afa.org/magazine/july2005/0705near.asp (accessed on 26 December 2007).

17 'Air Force Revisiting Balloons for Missions', 5 July 2005, http://www.foxnews.com/story/0,2933,161534,00.html (accessed on 12 December 2007).

18 Jeremy Singer, 'U.S. Air Force Prepares to Buy Near Space Vehicles', *C4ISR Journal for Net-Centric Warfare,* 6 May 2005, http://www.isrjournal.com/story.php?F=831726 (accessed on 21 December 2007).

19 Leonard David, 'Sky Trek to the 'Near Space' Neighborhood', 9 November 2005, http://www.space.com/businesstechnology/051109_airships.html (accessed 24 February 2007).

20 Ibid.

[p. 27 ↓]

Cost-Benefit Analysis

Near Space assets are capable of providing similar services (to a significant extent), as compared to the satellites which are cost-effective and have greater flexibility. A basic cost-benefit analysis of space systems versus Near Space systems shows that putting a platform in Near Space is easier and much less expensive than launching a system into orbit. Near Space could be seen as a low-threat, high-payoff environment. In terms of payoff, the vehicles would be 20 times closer to the earth than LEO satellites, which offers large coverage areas.[21] Here, it could be said that a lesser cost Near Space platform could offer almost the same coverage as provided by an LEO satellite over the area of interest. In certain cases, more than one Near Space platform would be required to be launched for this purpose. However, still it would remain an economical option. In view of this, it is expected that the Near Space systems will probably provide the same responsive capabilities to war fighters that are currently provided by the orbital platforms. Also, the time taken for conceiving such systems, from drawing board to commissioning them in the Near Space environment, is expected to be far less compared to the existing or other space systems.

The nature of Near Space system will essentially decide the cost of the system. Many existing proposals for Near Space craft vary in complexity. Some free-floating balloons would cost only a few hundred dollars and would be afforded to be dispensed if lost to the winds. A glider with a payload and some capability to manoeuvre and also with the ability to stay longer over the target would naturally cost higher. More expensive proposals, such as a massive blimp[22] called the High Altitude Airship, move beyond the realm of expendable balloons. Such a design could also carry bombs or other weapons to drop on ground targets. These would cost much more. But, here the platforms are expected to stay aloft at least for a couple of years.[23]

Near Space platforms will defiantly be less durable than satellites that can stay in orbit even for 30 years or more. As per estimates, cost of **[p. 28 ↓]** micro satellite is 1 per cent of the cost of conventional satellite and its lifetime can be anything between two to 10 years. When compared at the backdrop of the micro satellite, Near Space technology is expected to be more cost-effective.

21 Hampton Stephens, 'Near-Space', *Air Force Magazine* 88, no. 7 (2005), http://www.afa.org/magazine/july2005/0705near.asp (accessed on 26 December 2007).

22 Blimp is an informal term applied to non-rigid airships. Such airships have no rigid structure that holds the airbag in shape. They are different form aerostats, which are tethered to the ground while blimps are free flying aircraft.

23 'Air Force Revisiting Balloons for Missions', 5 July 2005, http://www.foxnews.com/story/0,2933,161534,00.html (accessed on 12 December 2007).

Military Utility

From the foregoing paragraphs, it is apparent that the Near Space technology is evolving and offers many benefits over the conventional satellite technologies. Major aerospace manufacturing houses are yet to make significant investments in this field and in a few cases, this technology is just reaching a stage next to the drawing board. Also, 'space dependence for security' is yet to evolve fully in regard to many militaries. Naturally, many states are yet to factor-in this technology in their current and futuristic military planning. In view of this, it is essential to understand the efficacy of this technology for the militaries from various angles. Otherwise, like it happens with other technologies, Near Space technologies also will be accessible only by a limited few. More importantly, it becomes imperative to remain involved in this technology because there exists a danger that a few interested states may come together and formulate some sort of internationally binding legal mechanism which may restrict the assess of others to this technology when it gets fully developed and become commercially and militarily viable. During informal discussions, a few western experts have indicated that they would not like to call this technology as Near Space technology because it could then bind the states to follow international rules and regulations applicable to space

technologies. Such approach clearly indicates that because of the strong significance of space technologies, military states may not like to expose the developments in this field to others. There is a need to understand various facets of this technology from a military perspective.

Background

Much before the Wright brothers discovered flying aircrafts, the first man-made objects to fly were balloons (in the 17th century). By then, Science had already discovered that certain gases like hydrogen are lighter than air and also that air becomes lighter when heated. In the 17th century, France pioneered the civilian and military uses of balloons. Balloons were used for the first time for military purposes during **[p. 29 ↓]** French Revolution and Napoleonic wars (1792–1815). France created a balloon corps called Aerostiers in 1794 and had even used balloons for aerial bombardment.[24] Balloons tethered to ground (they drifted uncontrollably in winds) and carrying observers in a suspended basket were used for tracking enemy troop movements. This conferred a priceless advantage on the French Army and contributed to many of its victories. Later this technique was also used during the American Civil War (1861–65).[25]

State of development of aviation and related fields, like electronics and explosives largely affected the evolution of warfare during the 19th and 20th centuries. During the same time period, rocket technology—the decisive weapon carrier technology—came into being (in the Napoleonic wars, in 1807, the city of Copenhagen was set on fire by thousands of rockets fired from British naval ships), which may not be exactly in the same form as we see it today, but definitively gave indications about the future of that technology.[26] During the last few decades, this technology has developed very rapidly from short-range rockets to long-range Inter Continental Ballistic Missiles. Further large, liquid fuelled rockets brought-in revolution in communication by launching satellites in outer space. Over the years, this satellite technology has been used increasingly for various military purposes, such as communication, meteorology, navigation and intelligence gathering.

In short, it could be argued that the technology like balloon technology (which could also be called as the 17th century 'Near Space' technology), showed tremendous utility for the armed forces during early period of the 17th century but the promise died down soon and almost became extraneous subsequently.

Technology Relevance

Particularly, post-World War II, the militaries all over the world became overly obsessed with rocket technologies and satellite technologies, hardly realising that they were overlooking a cheaper and more effective substitute particularly in regard to the collection of information from **[p. 30 ↓]** the space and developing mechanisms for long-distance communication. Now, it appears that the militaries are taking Near Space technology a bit more seriously after the 2003 Iraq War.

24 'Balloons: The Beginnings of Aerial Transportation', http://www.aeragon.com/air/bal/index.html (accessed on 26 December 2007).

25 K.V. Gopalakrishnan, *Impact of Science and Technology on Warfare* (New Delhi: National Book Trust, India, 2003), 72–73.

26 Ibid.

Enhanced communications systems, network relays and intelligence-surveillance-reconnaissance capabilities could use the Near Space realm to quickly meet battlefield demands. Lighter-than-air vehicles operating in Near Space could quickly and inexpensively provide the capabilities that troops and commanders demand. Near Space platforms carrying critical systems into the far reaches of the atmosphere could include balloons, airships or anything else that is persistent, cost-effective, survivable and responsive.

There is a potential for Near Space platforms to provide some of the same capabilities as space-based platforms. Air-breathing intelligence-surveillance-reconnaissance aircraft is perpetually overtaxed and could be denied access over hostile territory. Here, Near Space concept opens up an entirely new realm of possibilities for the armed

forces. Near Space is expected to provide many of those effects more responsively and more persistently than space itself.[27]

It is perceived that high-altitude balloon relays can play a major role in the close air-support missions. Ground forces often do not have satellite access, and thus require communicating directly with aircraft operating in their line-of-sight to call-in air strikes. This means aircrafts need to loiter near the battlefield, which increases their vulnerability. High altitude balloons could be used to reduce this vulnerability. Near Space crafts could also perform radar and multi-spectral imaging missions as communication nodes (mini-Milstar, a military strategic and tactical relay satellite and a satellite system by the same name also exist, which provide secure, jam-resistant, worldwide communications to meet wartime requirements for the US military), and in future, it could even relay laser beams from a ground-based source against a wide assortment of targets.

Military Investments

In the US, work on a new generation of lighter-than-air vehicles has been going on for many years under many guises. Since the US Navy got out of the blimp business in the late 1950s, the military use of these **[p. 31 ↓]** craft has been limited to things like aerostats.[28] In the Iraq war (2003), such systems were used to provide the limited area surveillance for the US bases. They are also commonly used in border protection and for costal radars.[29]

27 Edward H. Allen, ‘The Case for Near-Space’, *Aerospace World* (2005): 15.

Since the beginning of the 21st century, there has been a lot of excitement particularly in the US military and air force about Near Space and its potential. The USAF is actively exploring ways to use helium-filled free-floating balloons and remotely controlled glider-like aircraft to protect the US convoys, track friendly forces, assess battle damage and boost communications among the groups of troops in military hot spots like Afghanistan and Iraq.

It has been reported that the US Air Force (USAF) is evaluating about 10 different concepts for aircraft that could be used for surveillance, intelligence and reconnaissance and perhaps to augment a fleet of global positioning satellites orbiting the earth.[30]

The US administration's Defence Advanced Research Projects Agency (DARPA) is investing in a heavier-than-air vehicle that produces lift through advanced breakthrough technologies in aerodynamics, thrust vectoring and gas buoyancy generation and management. They also plan to develop and evaluate a very large airlifter which aims to move loads up to 1,000 tons across international distances. This could carry a complete army brigade right from the fort to the fight.[31] In Afghanistan conflict, the NATO forces faced difficulties to get their logistical supplies delivered by ground route. Pakistani Taliban had destroyed much of their logistical supply. Under such circumstances, Near Space logistical supply units could have become very useful. The situations like this demonstrate the urgent necessity for the states to invest more in research and development in regard to this technology.

28 An aerostat is a tethered or moored balloon often shaped like an airship and usually filled with helium. Aerostats differ from airships and balloons in that, airships and balloons are both free flying whereas aerostats are tied to the ground.

29 Taylor Dinerman, ‘Near Space: A New Area of Operations or a New Pentagon Buzzword?’ 20 September 2004, http://www.thespacereview.com/article/230/1 (accessed on 12 January 2007).

30 Andrea Shalal-Esa, ‘U.S. Air Force Excited about Near-Space Prospects’, January 2005, http://www.publicbroadcasting.net/wmub/news.newsmain?action=article&ARTICLE_ID=729021 (accessed on 10 March 2007).

31 Leonard David, ‘Sky Trek to the “Near Space” Neighborhood’, November 9, 2005, http://www.space.com/businesstechnology/051109_airships.html (accessed 24 February 2007).

[p. 32 ↓] Apart form developing a heavy lift platform, the DARPA is also working towards building a stealthy Near Space craft without metal that could be equipped with

special sensors and remain in the air for months. Such craft when fully developed would help meet the demand for persistent surveillance, which is difficult with current satellites that revolve at altitudes above 300 km.[32]

The US administration is also involving private defence industry to invest in various Near Space ventures. After spending two years on the drawing board, an experimental, unmanned blimp which is designed to float in 'Near Space' to help the US military test missile warning systems is getting prototyped. The United States Missile Defence Agency has awarded defence contractor Lockheed Martin USD 150 million contract to build a prototype of a high-altitude airship—a 400-feet long, solar-powered and sensor-laden blimp. The aircraft is expected to float in the outer fringes of the atmosphere, high above rough weather and the jet stream.[33]

The maiden flight of this craft is projected to take place at the end of the first decade of the 21st century. This airship is part of the US military plan to test how well airships can perform as geostationary platforms for short- and long-range missile warning systems. Hovering at 65,000 feet below satellites, but much higher than most aircraft, a reusable high-altitude aircraft could also help with communications and weather surveillance.[34] The military establishments are looking at this platform not only as a sensor platform but also for moving cargo probably because the blimps are cheaper, more responsive, and avoid many of the hassles and waiting involved with more traditional platforms like spacecraft and aircraft.

The USAF has plans to establish a full-fledged programme office for buying high-altitude atmospheric vehicles that provide satellite-type services. Space Command is also eyeing for significant commitment of Near Space funding in the budgets.[35] For the USAF a private company **[p. 33 ↓]** with already proven credentials in flying data-relay balloons for oil and gas companies has demonstrated a prototype 'Near Space craft' called Combat Sky Sat modified for military utility during 14–17 March 2005. This untethered demonstration vehicle basically was a hydrogen-filled balloon carrying a military radio. The balloon was purposefully filled with hydrogen because the gas can be easily generated from water in the field, and thus does not impose the same logistical burdens as other lighter-than-air gases like helium. The entire platform was weighing less than 2.3 kilograms. The cost of the demonstration vehicle was about USD 20,000,

but it is believed that the produced versions could carry a price tag of about USD 2,000. The demonstration focused on the utility of high-altitude balloon relays for close air-support missions.[36]

32 ‘US Plans Spy Craft in Near Space Zone’, 15 December 2004, http://english.al-jazeera.net/NR/exeres/CCE21042-9632-4D8B-9A15-5CD8B5468C4F.html (accessed on 22 December 2006).

33 It is a strong wind current of the order of 120 kmph or more covering a wide area of few thousands of kilometres, almost 10–20 km above the ground level.

34 Alex Gronke, ‘Blimps in Near Space’, 8 December 2005, http://www.redherring.com/Article.aspx?a=14829&hed=Blimps+in+Near+Space+# (accessed on 12 December 2007).

35 Hampton Stephens, ‘Near-Space’, *Air Force Magazine* 88, no. 7 (2005), http://www.afa.org/magazine/july2005/0705near.asp (accessed on 24 July 2007).

Advantages and Limitations of Technology

The benefits of Near Space technology are numerous and they offer a very inexpensive solution to communications over specific regions on the globe. Military near-space vehicles would operate above the weather, be inherently stealthy, and fly above the range of nearly all threats.

Most importantly, this technology gives a cheaper and quicker access to space-like conditions when compared to a launch to orbit. The cameras at that high altitude can see for several hundred miles farther than with aerial photography and also access to a given area is more flexible than with the infrequent fly-over by remote sensing satellite.[37]

Near Space platforms have utility for militaries both during wartime and peacetime. Such platforms could be used for secure communications, border control/ border

surveillance, security duties, earth remote sensing and surveillance, battlefield control, as well as to address non-military threats like global warming.

Military technologists are of the opinion that, armed forces can build a Near Space vehicle capable of hovering over one point, at an altitude of about 23 miles. It could remain on station for months, far longer than an unmanned aerial vehicle and a period approximately equal to the mission duration of certain satellites. This would be an inexpensive substitute **[p. 34 ↓]** for a low-orbiting satellite constellation that would probably have 40 or 50 satellites.[38]

36 Jeremy Singer, 'U.S. Air Force Prepares to Buy Near Space Vehicles', *C4ISR Journal for Net-Centric Warfare* (2005), http://www.isrjournal.com/story.php?F=831726 (accessed on 16 January 2007).

37 Paul Verhage, 'Near Space: The Shore of Our New Ocean', http://www.hobbyspace.com/NearSpace/ (accessed on 16 February 2007).

High-altitude balloon relays can play a major role in close air-support (CAS) missions. Such missions involve the use of combat aircraft (fighter aircrafts like F-16, Mirage, Su-30) to assist and support ground units in the successful completion of their tasks. Ground units engaged over tactical battle area often do not have satellite access, and thus must communicate directly with aircraft operating in their line-of-sight to call-in air strikes. This means aircraft needs to loiter near the battlefield, which increases their vulnerability. The use of high-altitude balloons could reduce this vulnerability. The results of technical experimentation in this arena are encouraging. The tests indicate that ground-based forces can increase their communications range with aircraft from 13 km to approximately 320 km.[39]

Vulnerability of Near Space vehicles to enemy fire is not a big concern. The balloons are difficult to detect using infrared or radar sensors, and operate at altitudes that are above the range of fighter aircraft. It is possible for the ground-based missiles to take out high-altitude relay balloons but this cannot be a cost-effective solution.[40]

The technical challenges posed by this technology are not completely known as it is still being evolved. Many ideas are only theoretical possibilities and are still at the

conceptual level. The major hindrance for these systems appears to be the weather and prevailing atmospheric conditions at that point of time. Even though these systems are likely to remain in a no-weather area, they will have to withstand significant ultraviolet radiations and other tough environmental conditions, such as handling the corrosive effects of ozone. One other factor that might limit the effectiveness of untethered, high-altitude balloon relays is wind.[41] The issues of particular concern would be the jet streams. Such streams **[p. 35 ↓]** are strong, narrow, continuous currents of air with speeds exceeding 120 kmph. However, such currents are present only at specific latitudes and have seasonal variations.

38 Hampton Stephens, 'Near-Space', *Air Force Magazine* 88, no. 7 (2005), http://www.afa.org/magazine/july2005/0705near.asp (accessed on 24 July 2007).

39 Jeremy Singer, 'U.S. Air Force Prepares to Buy Near Space Vehicles', *C4ISR Journal for Net-Centric Warfare,* 6 May 2005, http://www.isrjournal.com/story.php?F=831726 (accessed on 16 January 2007).

40 Ibid.

41 Winds are relatively low between 65,000 feet and 80,000 feet, usually less than 20 miles per hour but mostly during the ascent of the balloon and sometimes even in the Near-Space atmosphere, they are high.

The basic drawback of the Near Space craft is the lack of ability to recharge the air vehicle's power source. Passive regeneration of batteries does not handle the required electrical load. The problem becomes acute because fuel cell technology is not yet fully developed and lithium-iron batteries add weight to the blimp. Incidentally, the technology to regenerate the air vehicle power through a laser source is still under development and is showing a great promise.[42]

There are several other problems which need to be resolved—such as, the weight to be placed high above the *terra firma,* durability of the air vehicle, power regeneration and several others.[43] Also, there are a few gray areas about the efficacy of the system in general, especially for the purposes of military usage. This could be because of less publicity and support it has received so far, and that may be the reason why very few

major research and development are being done in this field. There is also a need to discuss the issues like what could be the likely countermeasures adopted against this technology. On the other hand, technology developers also need to think of some form of hardening technology for these platforms to avoid the ill effects of any likely mid Near Space collisions of two or more platforms. Also, a few counter measures could be thought of, to be put onboard of this platform, in order to deceive or duck enemy fire.

There is a likelihood of breach of international norms from the usage of this technology. Normally, Air Forces regard Near Space altitudes as a part of their country's sovereign air space, unlike orbital space that is open to all. So the military would be violating internationally accepted practices and law if it sent an intelligence-gathering balloon over another country without permission.[44] Also, there exists a possibility of a Near Space craft making an uncontrolled landing in a hostile or neutral country **[p. 36 ↓]** adjacent to a war zone. The induction of technology is likely raise a debate on space laws in general and outer space treaty[45] in particular.

42 Alex Gronke, ‘Blimps in Near Space’, 8 December 2005, http://www.redherring.com/Article.aspx?a=14829&hed=Blimps+in+Near+Space+# (accessed on 12 December 2007).

43 Leonard David, ‘Sky Trek to the “Near Space” Neighborhood’;, 9 November 2005, http://www.space.com/businesstechnology/051109_airships.html (accessed 24 February 2007).

44 ‘Air Force Revisiting Balloons for Missions’, 5 July 2005, http://www.foxnews.com/story/0,2933,161534,00.html (accessed on 12 December 2007).

Near Space: An Asset to Developing States

Apart from the US, Russia and ESA, a few states like China, India and Brazil are investing intelligently in various space programmes which are essentially civilian in nature. But, the technology being dual-use in nature, naturally, would have military ramifications for these states. Such developing states have financial as well as infrastructural limitations in regard to investments in space field. On the other hand,

they do not have global military interests like the US. Hence, their military expectations from the space technologies are limited to a particular geographic area. There investments in military space technology would mainly remain restricted towards gaining communication and ISR capabilities. To undertake a macro analysis of what utility the Near Space technologies could serve to developing nations which are investing in space technologies, a typical case study of India is undertaken.

Case Study: India

Indian Space Programme, with a history of almost four decades is globally appreciated for its professionalism. As per a Chinese scholar: 'Indian space programme shows stamina of a long-distance runner in space technology and in recent years have made great achievements and continually rewrote its own records on annual basis.'[46]

India's space programme is civilian in nature. Surprisingly, in spite of having a high quality civilian space programme, India as a state has not invested into a full-fledged military space programme. Over the years, **[p. 37 ↓]** Indian Armed Forces are getting limited benefits out of India's space developments, particularly in the field of communication, meteorology, and so on. The reasons for India not investing into this fourth dimension of warfare could be many, but knowing the increasing relevance of space technologies into armed forces, because of revolution in technology as well as changed nature of warfare, it would be unwise on part of India to neglect this space dimension.

45 The Outer Space Treaty provides the basic framework on international space law and it came into being in 1966. Incidentally outer space, also called just *space,* refers to the relatively empty regions of the universe outside the atmospheres of celestial bodies. *Outer* space is used to distinguish it from airspace (and terrestrial locations). The Federation Aeronautique International has established the Karman Line at an altitude of 100 km (62 miles) as a working definition for the boundary between atmosphere and space. The US designates people who travel above an altitude of 50 miles (80 km) as astronauts. Airspace means the portion of the atmosphere controlled by a particular

country on top of its territory and territorial waters or, more generally, any specific portion of the atmosphere. John J. Kelin, *Space Warfare* (London: Routledge, 2006), 6.

46 Tang Yun, 'India Dreams of Being a Space Giant', *Beijing Review* (2003): 16.

However, this does not mean that the Indian administration is totally neglecting the importance of space. Under Integrated Defence Staff (IDS) a 'space cell' has been formed by the Ministry of Defence (MoD) to look after the space needs of Indian Armed Forces. In regard to Indian Air Force (IAF), it is envisaged that the IAF could utilise development in space technologies in the following manner:[47]

- 1. To build real-time situational awareness through space communication and space sensors.
- 2. To link radar and other communication networks over the entire span of the country.
- 3. To assist in Ballistic Missile Defence.
- 4. To gather real-time intelligence about enemy aircraft, missiles and space-borne threat.
- 5. To prevent the enemy from using their own space assets, by jamming.

The strategic vision of the IAF also puts 'space' as a very important element. It is foreseen that future wars are going to be lethal, fast-paced and will demand faster decision-making and implementation. This brings in the concept of net centric warfare (NCW) to the fore. IAF understands that apart from communication and reconnaissance role, the space assets can bring in significant improvement in speed of action, accuracy of weapon delivery and flexibility of operations.[48] Apart form the Air Force, Indian Army and Indian Navy have their own understanding in regard to utility of space assets for their individual requirements and also for the overall military requirements.

Under the backdrop of these realities, it could be argued that Indian Armed Forces are likely to have more dependence on space technologies **[p. 38 ↓]** in years to come. Indian Armed Forces are likely to have enhanced utility of space technologies for the purposes of communication, surveillance, reconnaissance, meteorology and navigation. Military is also expected to invest more towards the usage of the space-based geographic information systems (GIS) tools.

47 K.K. Nair, *Space the Frontiers of Modern Defence* (New Delhi: Knowledge World, 2006), 179.

48 Air Chief Marshal S.P. Tyagi, 'Indian Air Force in the Evolving Security Environment', *Defence Digest* (March-April 2006): 6–7.

The Indian Space Research Organisation (ISRO) has launched a few remote sensing satellites which also have military utility. A cartographic satellite CARTOSAT-1 was launched during 2005. This was followed by CARTOSAT-2 in 2007 and CARTOSAT-2A in 2008. During 2006 the IAF retired its aging strategic reconnaissance aircrafts (MIG-25) because they were neither cost-effective nor had a strategic use for India. Now, India proposes to use INSAT 2B, multi-purpose satellites to assume the role carried out by these aircrafts.[49] All these developments indicate that the phenomenon of usage of space assets for security purposes has just began in India and there is a further need to invest in emerging technologies to gain maximum advantage for India's overall security apparatus.

Probably, till date, India has deliberately not invested much in military space programme, may be as a matter of choice. At the same time, financial reasons and technological limitations also could have played a significant role towards not perusing a military space agenda. But, now when India has already established itself as a key player in the global civilian space arena and, on military front, is facing difficult challenges from changed nature of warfare, it becomes imperative to invest more in space technologies for security reasons. Near Space technologies could offer India the most viable and economical option.

At present, global thinking on space issue is essentially dictated by the the US philosophy because of it being the world's leader in the use of space. However, even for the US, the Cold War attributes of their existing space programmes, limit their ability to maintain space superiority required in today's rapidly changing strategic environment. Specifically, the mission criticality that grew out of the Cold War, and the very high cost of their sophisticated, highly capable space systems, lead to a high consequence of failure. The required corresponding riskmitigation strategy places a premium on expensive, long-lasting, heavy, multi-mission payloads. Such heavy payloads require high cost launch vehicles. Also at times operational and tactical capabilities are decided

[p. 39 ↓] merely as an afterthought.[50] The Indian state is yet to make substantial investments in military space arena. Essentially, the state's remote sensing assets appear to be employed into an additional role, as for the defence purposes. In the absence of any dedicated satellite military communication network, it appears that the existing networks could have been tasked for military purposes. In view of this, India could plan to invest in Near Space technologies, which can have direct military utility for tactical communication and earth observation purposes.

49 ‘India to Replace Ageing Spy Planes with Satellites’, 1 May 2006, http://www.forbes.com/finance/feeds/afx/2006/05/01/afx2709565.html (accessed on 12 November 2006).

Also, it needs to be emphasised that aerospace power has limits. First, flying aircraft for military purposes is very expensive. Second, the combination of complexity and cost, results in smaller aircraft inventories. Third, prudence dictates that expensive and relatively scarce airframes and crews should be put at risk, and expensive weapons should be expended only against lucrative targets. Last, the most significant vulnerability of aerospace power occurs whenever the aircraft leaves its operating environment which means when they are on ground near-heroic measures are required to protect them like hardened shelters.[51] Similarly, over the years, it has been observed that space technologies also have various limitations. Launch operations are complex, time-consuming, manpower intensive and costly. Many satellites do not provide continuous coverage.[52]

Under this backdrop, for developing states like India, if Near Space technologies are found capable of taking even 10 per cent load of reconnaissance missions and are also able to ensure information dominance for the military commanders and provide environmental data to support military operations, then it could still be considered as an intelligent investment. Also, vulnerability of close air-support missions could be reduced over Tactical Battle Area because of improved communication networks.

Micro- and nano-class satellites are perceived as the most viable and economic options by many. Besides, since India still does not have the ‘launch on demand’ technology; the other option could be a Near Space technology. However, in this field

also India needs to do some **[p. 40 ↓]** investments initially in the arena of research and development. The biggest drawback of this technology could be that it is not a time-tested technology.

50 A.K. Cebrowski and J.W. Raymond, ‘Operationally Responsive Space: A New Defence Business Model’, *Parameters* (2005): 71.

51 Dennis M. Drew, ‘The Essence of Aerospace Power: What Leaders Need to Know’, *Air Power Journal* 1, no. 1 (2004): 48–49.

52 ‘Space support to Army Operations’, Document No. FM 110–18, 20 July 1995, United States Army, http://www.fas.org/spp/military/docops/army/fm100-18/59 (accessed on 24 March 2006).

Naturally, there could be many challenges involved in developing such a technology. Fortunately, the recent advances in microelectronics and micromechanical engineering do allow catering for requisite paraphernalia that weigh only a few hundred grams for microsatellites.[53] Similar technology could be developed to suit the requirements of Near Space technologies. One of the reasons for Near Space technologies for not becoming a reality till date, in spite of having capabilities to send the balloons to upper stratospheric layers, could be the absence of lightweight sensors and battery technologies.

In India's neighbourhood, China is emerging as a major space power and was correctly predicted to have covert investments in ASAT weapons.[54] Pakistan is a peripheral power but is likely to get into the Chinese space wagon in the near future.[55] For China, there is a strategic logic towards developing ASAT capabilities. China's decision to conduct ASAT is an indication of its long-term strategic goal of weakening the American monopoly on military space capabilities. China may focus on asymmetrical weapons such as ASATs to counter this dominance.[56] The Chinese January 2007 ASAT test has demonstrated that, even though satellites are not very easy targets, they still can be attacked. Chinese preparation may not be India-centric but is definitely a concern for India. ASAT capability could be said to be an extension of ballistic missile capabilities and India's neighbour, Pakistan possesses ballistic missile capabilities. Near Space

investments are not a deterrence to ASAT but provide an alternative to low earth orbit satellites. As per the existing status of technology, only LEO satellites can be targeted. Hence, near space assets could reduce instances of the enemy states targeting the LEO. This does not mean that Near Space platforms themselves are not going to be lucrative targets. However, the cost factor and launch **[p. 41 ↓]** on demand capability with such platforms allows the state to undertake additional launches in case of any loss of earlier platforms.

53 W. Gouveia Jr, ‘An Assessment of Anti-satellite Capabilities and Their Strategic Implications’, *Astropolitics* (2 July 2005): 175.

54 *The Military Power of the People's Republic of China 2005,* Annual Report to Congress (Washington: Office of the Secretary of Defense, 2005), 36 and Cheng Ho, ‘China Eyes Anti-Satellite System’, *Space Daily,* 8 January 2001.

55 Ajey Lele, ‘Pakistan's Space Capabilities’, *Airpower Journal* 2, no. 1 (2005): 143, 148.

56 W. Gouveia Jr, ‘An Assessment of Anti-satellite Capabilities and Their Strategic Implications’, *Astropolitics* (2 July 2005): 176.

Space capabilities are of utmost importance for any missile defence system. In general the fate of missile defence would eventually be decided by politics, availability of technology and in many cases by the cost factor. In the case of India, despite its obvious merits, pursuing missile defence could be unrealistic for various reasons. However, it is incumbent upon the government to take atleast some steps to protect its people against the small risk of deterrence failure by error, accident or twisted design. A limited missile defence to protect major targets (cities, nuclear facilities) is desirable for this purpose.[57] From an Indian point of view, since satellite programmes are expensive and generally have a long lead-time before capabilities are realised, it could be prudent to invest in Near Space technologies as a part of any missile defence architecture which could prove to be far more beneficial.

In the end it could be argued that a state like India which is surrounded by nuclear neighbours, cursed by terrorism, lacks monitoring of energy lines travelling through a

vast area of Indian Ocean, prone to frequent natural disasters and marred by internal security problems, needs help form space assets to safeguard its security. Near Space tools show a potential to provide cost-effective, technologically viable and opportune solutions in this regard.

Conclusion

Today, there is a pronounced trend in the growing role of space technologies in modern day warfare and without doubt, the dual-use space technologies are transforming the global security architecture radically. The Gulf wars (1991 and 2003), the conflicts in Afghanistan and Kosovo have clearly proved the efficacy of space systems in modern day warfare.

However, it has to be noted that the growth of space technologies is limited to a few countries for the want of knowledge and financial sources. The financial costs of sustaining space dominance are enormously high so much so that even the space superpower like the US finds it difficult to sustain its existing and proposed space missions both **[p. 42 ↓]** in military and civilian domains. Given its economical viability, Near Space platforms have the capacity to fill in the void and can be regarded as a ‘suitable’ replacement for investment-intensive space technologies. In such scenario, relatively inexpensive vehicles flying in Near Space environment could complement satellites and unmanned aerial vehicles.

57 Rajesh M. Basrur, ‘Missile Defence and South Asia: An Indian Perspective’, in *The Impact of US Ballistic Missile Defenses on Southern Asia,* eds, Michael Krepon and Chris Gagne (Washington: Henry L. Stimson Center, Report No. 46, 2002): 19.

Although the Near Space technology is in an incipient stage and not fully exploited, its potential cannot be wished away. Currently, a few analysts suggest that there is an urgent need to develop science and technology strategy that represents operational issues defined by combat commanders. The changing nature of warfare is also demanding quick real-time inflow of information to the soldier on the ground, which may not be always possible from existing space assets. Hence, Near Space platforms could be critical.

Over the years, no major investments in Near Space platforms have taken place. There could be various rationales for it. First, balloons are neither appealing nor exciting when compared to airplanes and spacecrafts; this could be one of the reasons for Near Space getting neglected. This demands a shift in the mind-set from political leaders to military managers. Second, industry may have vested interests in stopping the growth of this technology because of the low cost factor, less market volume and profit margins. Third, Near Space is an uncomplicated and affordable technology. This would remove the monopoly of few states in the space filed. Naturally, such states could feel vulnerable and this could force them to stall any further progress in this field (imagine availability of this technology with states like Iran). Fourth, there could even be a possibility that a few are trying to oversell this technology and actually it may not have the utility as it claims. But, in spite of all these rationales, the commercial success of this technology has shown an upward trend during the last few years. This clearly indicates that Near Space technology has great potential for its military utility.

Like satellites, Near Space platforms have certain duel-use utility. As such they are already in use for the purposes of communication with a few private enterprises, and it is predicted that it may open various avenues for business like Near Space tourism and hotel industry. It is likely that this technology may give a run for money to the mobile telephone operators. Direct to home (DTH) television technology depends entirely on satellite technology; however, there could be a possibility that this technology could offer a viable alternative at least over a limited area. Also, various amateur groups and non-government organisations could use this technology for popularising science. Ham radio operators who **[p. 43 ↓]** mostly play a significant role during disasters could also get benefited from this technology.

Finally, it is a considered view that for states like India, facing multidimensional security challenges, there is an incisive need to evolve a space strategy for its armed forces. Cost could be one of the prime hindrances for India not investing in military space technologies. Near Space platforms could, if carefully considered, become a cost-effective solution capable of enhancing the already existing space infrastructure. In view of the dividends that can accrue from Near Space technology, there is a need for a well-researched, well-planned and gradual induction of this technology in the armed forces. The need of the hour is to do out of the ‘atmosphere’ thinking.

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