EVOLUTION OF THE CRUISE MISSILE DISCOURSE: A CONCEPTUAL CONSTRUCT

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By all reckoning, the cruise missile has arrived on the world stage. It no longer seems a mere supplement to the global inventory of weapons; rather, it has acquired a taxonomy of its own by gradually coming up to the demands of modern warfare. Many nations have already mastered it and many more are striving for it. Surprisingly, the missile has been used more frequently than any other weapon system. While the major powers have used the "Big Stick" conveniently in increasing numbers, the Third World countries find in them the "poor man's arsenal". In the process, the system has been enriched with more lethality and sophistication but its evolutionary trend vindicates that it may revolutionise the discourse of modern warfare in many ways. When the world is grappling with the issue of weapons of mass destruction (WMD) proliferation and no way out of this menace is on the horizon, would the cruise missile further complicate the WMD imbroglio?

There exist considerable ambiguity and assessment challenges in regard to the global inventory of cruise missiles. One estimate shows that as many as 130 types of cruise missiles exist today, with 75 countries possessing them.[1] A

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1. Andrew Feickert, "Cruise Missile Proliferation", http://www.fas.org/sgp/crs/nuke/RS21252.pdf#search=%22Feickert%20cruise%20missiles%2

Approximately 70,000 cruise missiles are operational worldwide. Seventy-five different types of systems are currently in service and over 40 additional cruise missiles are reportedly under development.

Congressional Research Service estimate reveals that 81 countries today appear to have cruise missiles of some kind. In 1992, 63 countries had cruise missiles. Approximately 70,000 cruise missiles are operational worldwide. Seventy-five different types of systems are currently in service and over 40 additional cruise missiles are reportedly under development.[2] Moreover, overall trends since the end of Cold War show a significant net decrease in worldwide ballistic missile arsenals. Even though the range of ballistic missiles has slowly increased, their horizontal spread has been largely kept under check. By the start of the 21st century, one can observe that while the spread and use of ballistic missiles had dominated the policy-maker's attention, during the last decade of the 20th century, the land attack cruise missiles (LACMs) had become more prominent instruments of warfare than ballistic missiles. Witness America's use of LACMs in seven different contingencies. Cruise missile use, beginning in 1944 to the present (19,645), greatly exceeds that of ballistic missiles (5,880) by over 3 to 1.[3] More than 2000 cruise missiles have been fired since Desert Storm, including 802 Tomahawks in Operation Iraqi Freedom alone. Does the trend suggest that cruise missiles have reached their mature stage or that the process of evolution is in full swing?

Available literature on cruise missiles mostly concentrates only on the extent of their spread and the threat they are assumed to pose. This is partly owing to the fact that the discourse has "evolved without a well-defined conception"[4], of *why and how they have evolved*. However, assessments have

2. Statement of Christopher Bolkcom, analyst in national defence, Congressional Research Service, before the Senate Governmental Affairs Committee Subcommittee on International Security, Proliferation, and Federal Services. Hearing on Cruise Missile Proliferation, June 11, 2002, p. 14.

3. Dennis M. Gormley, *Missile Contagion: Cruise Missile Proliferation and the Threat to International Security* (London: Praeger Security International, 2008), p. 47.

4. Richard K. Betts, ed., *Cruise Missiles: Technology, Strategy, Politics* (Washington D.C.: The Brookings Institution, 1981), p. 1.

been undertaken lately on why they are needed and their full implications. With the nuclear weapons and ballistic missile discourse all pervasive in the strategic domain, the emergence of the cruise missile as a viable weapon system seems to have been given meagre attention. However, its emergence to the stage that it has reached today is not haphazard. Rectification of the limitations at each stage of its evolution over the years has gradually endowed it with the intended capability, cleverly evading all non-proliferation norms. The cruise missile today is a reality; it is no longer a potential weapon that can still be shelved. But, is it merely another weapon in the familiar class of aerial munitions or does it represent a potentially revolutionary class of weapons in its own right? This necessitates an intensive survey into the history of the missile development, national policies and strategies, as well as the strategic environment in which it has been designated.

SURVEY OF LITERATURE

Though the history of use of modern cruise missiles can be traced back to World War II and their use in a rudimentary way during World War I, scholarly study on their development, spread and consequences has started to be undertaken only recently. This does not mean that development of cruise missile technology has been unnoticed, but a concerted effort to monitor and analyse the phenomenon started only in the late 1980s and more vigorously post-Gulf War.

The first study to notice the cruise phenomenon was perhaps the edited volume *Cruise Missiles: Technology, Strategy, Politics* by Richard K. Betts published in 1981, where he says that "cruise missiles have evolved without a well-defined conception of why they are needed and without an assessment of their full implications".[5] Though the study is focussed on the US, Soviet Union and the Cold War rivalry, it brings a perspective on the question of what transformed the neglected cruise missile into an important part of US defence programmes. The study says that the evolution of cruise missile was an "uncoordinated, integrative, and synthetic technological innovation,

5. Betts, Ibid.

Before World War I was over, the cruise missile, or the "aerial torpedo", as it was then called, was touted as "the gun of the future" and compared in importance with the invention of gunpowder. Former Assistant Chief of the US Air Service Billy Mitchell saw it as "a weapon of tremendous value and terrific force to air power."

rather than a deliberate effort or an epochal breakthrough." In the volume *Evolution of the Cruise Missile,* Kenneth P. Werrell describes that "the cruise missile, as an operational concept and system, has been around for some time; and very early on inspired rather far-reaching claims".[6] Before World War I was over, the cruise missile, or the "aerial torpedo", as it was then called, was touted as "the gun of the future"[7] and compared in importance with the invention of gunpowder[8]. Former Assistant Chief of the US Air Service Billy Mitchell saw it as "a weapon of tremendous value and terrific force to air power".[9]

Dennis M. Gormley, in an article entitled "The Neglected Dimension: Controlling Cruise Missile Proliferation" in *The Nonproliferation Review* (Summer 2002) observes that we have undergone an era where cruise missile and unmanned aerial vehicles (UAVs) were considered merely "lesser-included cases". However, Gormley hopes that this era is coming to a close.[10] Particularly, the events of September 11, 2001, appear to have changed such treatment of missile threats. In his view, there now emerging "complicating predictions about the evolution of the cruise missile threat" owing to "a

6. Kenneth P. Werrell, *The Evolution of the Cruise Missile*, Maxwell Air Force Base, Alabama (Air University (AU), Air University Press), September 1985.
7. Elmer Sperry to Admiral Earle, October 25, 1918, quoted in Delmar S. Faluney, "The History of Pilotless Aircraft and Guided Missiles," manuscript, Naval Historical Center, c. 1958, pp.112, 113.
8. George O. Squier to Chief of Staff, October 5, 1918, Subject: "An Automatic Carrier for the Signal Corps (Liberty Eagle)"; Bion J. Arnold to the Secretary of War, "Secret Report on Automatic Carriers, Flying Bombs (FB), Aerial Torpedoes (AT)" January 31, 1919, Exhibit F, Air University Library Film 623 .451 W253B.
9. William Mitchell, "Lawrence Sperry and the Aerial Torpedo," *US Air Services*, January 1926, p. 16.
10. Dennis M. Gormley, "The Neglected Dimension: Controlling Cruise Missile Proliferation", *The Nonproliferation Review*, Summer 2002, pp. 21-29.

diverse set of crosscutting motivations and constraints facing proliferating states".[11] Gormley, in an earlier writing, had suggested that "understanding the differences between cruise and ballistic missiles helps to explain why cruise missile proliferation could become at least as severe a threat".[12] Ron Huisken, the research consultant, United Nations Centre for Disarmament, is of the view that "the debate has centred on the weapon's military value and on its implications for strategic arms control but in consequence, the question of where and how the concept of a strategic cruise missile originated, insofar as it has been addressed at all, has been addressed in a peripheral way".[13] He traces the origin of the strategic cruise missile to the development of the US submarine-launched Regulus-I which became operational in 1955.[14] This was followed four years later by the ground-launched Snark, the first and so far the only cruise missile with intercontinental range. By 1960, military interest in strategic cruise missiles in the US had waned. A little more than a decade later, a period in which first the US and then the Soviet Union deployed huge forces of land and sea-based strategic ballistic missiles, the strategic cruise missile staged an abrupt and unheralded comeback.

Lt Col David J. Nicholls of the US Air Force (USAF) in an Occasional Paper of the Centre for Strategy and Technology, Air War College, says that by the late 20th century, significant technological advances that accrued over the past thirty years have transformed cruise missiles into reliable weapons, which have militarily significant ranges and sophisticated defences.[15] Further, he asserts that proliferation of technologies has remedied the historical shortcomings of cruise missiles to produce a weapon that has significant military capabilities and this will transform cruise missiles into important and perhaps decisive

11. Gormley, Ibid., p. 23.
12. Dennis M. Gormley, "Hedging Against the Cruise-Missile Threat", *Survival*, vol. 40, no. I, Spring 1998, p. 93.
13. Ron Huisken, "The Origins of Strategic Cruise Missile: Perceptions and the Strategic Balance", *Australian Journal of International Affairs*, vol. 34, Issue 1, April 1980, pp. 30-40.
14. Huisken, Ibid.
15. David J. Nicholls, "Cruise Missiles and Modern War: Strategic and Technological Implications", Occasional Paper No. 13, Centre for Strategy and Technology Air War College, Air University, Maxwell Air Force Base, May 2000.

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weapons in the 21st century. In future, this will also be the cost-effective weapon for developing states in comparison with manned aircraft and ballistic missiles. Published on December 1, 1987, the *Adelphi Papers 28: 226* opines that the cruise missile is increasingly become a competitor of the ballistic missile for strategic missions, such as hard-target kill that require great accuracy.[16] The *Jane's Intelligence Review* (April 2000) concludes that while considerable effort has been made in the development of weapon systems for ballistic missile defence at the tactical, theatre and national levels, cruise missile defence has remained of marginal concern. These efforts have been undermined by the ambiguity of the threat posed by cruise missiles.[17]

Also, the *Review* asserts that proliferation of cruise missiles will be driven primarily by the attraction of regional powers to the weapon. Other drivers include the increasing number of cruise missiles that are out in the market, the deflation in the military effectiveness of ballistic missiles as anti-missile systems are deployed, and the relaxation of acquisition rules. However, if at any point the spread of cruise missiles is expected to slow down, it may be so only owing to the lack of innovative tactics by regional armed forces. But recent trends show that all innovative technologies and equipment are easily available in the market and indigenous research and developments (R&D) in several countries is rampant.

Considering the pace and gravity of the spread of cruise missile technology and their use, several issues merit attention. Have these threats been exaggerated or has the threat been announced prematurely, with the prospect for cruise missile proliferation only now beginning to emerge? During Operation Iraqi Freedom, Iraq fired five modified HY-2 missiles at US forces and Hezbollah used them during the conflict with Israel in

16. "II. Modern Cruise Missile Programmes", http://www.informaworld.com/smpp/title~content=t713662270, December 01, 1987, p. 5.

17. "The Cruise Missile Threat: Exaggerated or Premature?" *Jane's Intelligence Review*, April 2000, pp. 47-51.

Lebanon. These events in the post-9/11 period have highlighted the potential threat to the international community. From the other angle, a major power like the US is using cruise missiles more frequently than any other weapon. In August 1998, the US Navy fired 79 Tomahawks against Afghanistan and Sudan, destroying a pharmaceutical plant in Sudan. During the "Global War on Terror" the Allied forces used this in greater numbers. Therefore, defence analyst Steven Zaloga rightly says that the Tomahawk "has proven the ideal weapon of the New World Disorder, a 'Big Stick' when diplomacy fails."[18]

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From the above comments, it seems that the passing of years has not dimmed enthusiasm for the device. A newspaperman in 1977 claimed that "except for gunpowder and atomic bomb, no weapon has threatened a greater effect on war and peace than the cruise missile".[19] In a recent study, Dennis M. Gormley finds that rapid and unexpected developments facilitate the proliferation of missiles capable of delivering WMD and highly accurate conventional payloads, and this trend is approaching a critical threshold.[20] In his view, cruise missiles are not destined to supplant ballistic missiles but when both are employed together, they could severely test even the best missile defences. He further sayss that several LACM development programmes probably commenced in the mid-1990s, but only now, roughly a decade later, has a series of seemingly small events nudged LACM growth toward a dangerous "tipping point" in missile proliferation. The question he repeatedly raises is: *what might be shaping the sudden outbreak of cruise missile proliferation?*

Therefore, an intensive review of the cruise missile's long historical record is warranted and can illuminate not only where it has been, but suggest where

18. Zaloga, Ibid.

19. Howard Silber, *Omaha World-Herald*, April 17, 1977, p. 11.

20. Dennis M. Gormley, *Missile Contagion: Cruise Missile Proliferation and the Threat to International Security* (London: Praeger Security International, 2008), p. 5.

it may be going. For instance, what has changed and what has remained constant between the earlier and current versions of cruise missiles? What are the advantages of, and disadvantages inherent in, cruise missiles as a class of weapon? Why were cruise missiles not introduced on a large scale into military inventories earlier? What obstacles, if any, has the weapon system encountered? Overall, what lessons can be gleaned from the historical record of the cruise missile? Is there any useful parallel? Moreover, how important is the cruise missile? Is it just another weapon like so many others, or does it represent a revolutionary class of weapon? The answers to these questions may well have far-reaching implications, for the current version of the cruise missile represents not just an evolutionary development but a quantum leap forward in weaponry. However, before attempting to answer these intriguing questions, it is pertinent to first understand the cruise phenomenon – the concept of cruise missile – and its operational principles. The basic aspects in this regard that need careful introspection are: how did the idea come about? Where did it take place? What were the chief motives that encouraged its emergence? Surprisingly, existing literature provides hardly any perspective on the cruise missile as a concept.

THE CONCEPT OF THE CRUISE MISSILE

Weapons come and go. Sometimes, some classes of weapons cast both dramatic and lasting impact upon the conduct of warfare. This is because they are not only revolutionary but also clearly superior to equipment already inducted. In the course of their use, loopholes in the system get exposed. At the same time, new challenges of warfare demand more efficiency in the system. In the process of meeting these challenges, the system acquires sophistication and lethality. Such a case is the cruise missile. It has come a long way and seems set to dominate the strategic thinking for many decades to come. In this study, an endeavour is made to find out conceptually what cruise missiles are all about and the causes of their spread.

According to the Intermediate Range Nuclear Forces (INF) Treaty, a cruise missile is an "unmanned, self-propelled vehicle that sustains flight through

the use of aerodynamic lift over most of its flight." The treaty considers the missile a "weapon-delivery vehicle". In contrast to a ballistic missile which is powered during launch and flies to a high altitude, a cruise missile relies on aerodynamic lift to keep it in the air, is powered during most or all of its flight, and has flight controls that allow it to manoeuvre.[21] Starting from the pre-World War I till the recent days, there have been many variants of cruise missiles and, therefore, defining them too strictly can be problematic. For example, there is no consensus on categorising a missile by its range. Cruise missiles can be built with ranges as short as 20 km and as long as 3,000 km. The INF Treaty covers missiles with a range of 500 km or more, irrespective of size or character of the payload. Similarly, the Missile Technology Control Regime (MTCR) is concerned only with missiles capable of a range of 300 km or more while carrying at least a 500 kg warhead. Weapons with a range of 40 km or less can be strategic in many parts of the Third World, given the small size and their proximity.

A cruise missile is an "unmanned, self-propelled vehicle that sustains flight through the use of aerodynamic lift over most of its flight."

In the first instance, a missile is a piece of war technology, basically air power. It is the *culmination of the principles of war strategy and tactics* imbibing an efficient *coordination of distance, time and force*. Originally, strategy was understood to govern the prelude to a battle, while tactics controlled its execution. It is often said that the art of strategy defines the goal to be achieved in a military campaign, while tactics define the methods to achieve these goals. But during the conduct of warfare, there always exists "'time-induced tension' between political and military imperatives". And it is the application of air power that resolves the time-induced tension as air power works through a time-based strategy. A time-based strategy is defined as one in which time is a paramount or extremely significant consideration. Such a strategy seeks to overcome time-induced tensions and achieve political-military congruence by employing forces and forms of military power. A time-based strategy also

21. W. S. Carus, *Cruise Missile Proliferation in the 1990s* (Washington: CSIS and Praeger, 1992), p. 8.

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weighs operational risks and benefits with the goal of balancing them to achieve the greatest time benefit at the lowest risk. The missile, as an instrument of air power which uses aerodynamic techniques, addresses the time-induced tension effectively by minimising chances of risk as it inflicts sufficient damage on the adversary from a larger distance, with speed and precision.

A corollary to the distance-time-force coordination is the *surface-to-air-space continuum*.[22] It denotes coordination among the triad of land, air and sea, instead of a classic separation among them. A classic separation among them is inimical to proper interaction between air and surface arms. This is why it has encouraged the historians of land campaigns to treat "the air" as another background topic along with the weather, logistics, etc.

Second, at the basic, a cruise missile is a projectile with a certain degree of *independence in its operation* or automatic action. Beside other things, war-fighting very often requires automated action to reduce or eliminate time-induced tension. The certainty of the weapon reaching the target depends upon the weapon system's capability to sustain manoeuvrability. To manoeuvre, the system needs to be equipped with a self-propellant and guidance mechanism.

Third, the key to success in a war is the *temporal dominance* of the adversary. Robert Leonhard's *Fighting by Minutes* identifies four temporal characteristics of warfare[23]. They are: duration – length of conflict; frequency – tempo or length of events; sequence – order of events; opportunity – time sensitive decision points, and synchronisation of all means at disposal. A cruise missile imbibes all the qualities to meet the difficulties that arise at each level of the four temporal characteristics. It is endowed with the capabilities to

22. Neville Brown, *The Future of Air Power* (London: Routledge, 1986).

23. Robert Leonhard, *Fighting by Minutes: Time and the Art of War* (Westport, CT: Praeger, 1994).

meet the temporal imperatives by achieving significant results quickly, ensuring freedom of action quickly, and inflicting a profoundly upsetting psychological blow quickly. Since the last two centuries at least, the nature of the land battle has drastically changed which Sir Basil Liddell Hart identified in 1960 as "the defence has been gaining a growing material ascendancy over the offence" – the thesis is popularly known as the "Liddell Hart Fallacy"[24]. In his opinion, this is a consequence of a steady fall in the number of troops needed to hold a mile of front in pitched battle, that in its turn was due largely to improvements in firepower though also to those in mobility and communications.

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Fourth, the endurance of any war technology lies in its wide application, in other words, *application across the spectrum* of military engagement: intercontinental, strategic, theatre, nuclear and conventional. Also armaments are always considered in the context of the quality-quantity trade-off. Military establishments usually prefer quantity to quality in weapons.[25] After World War II, the military Services became accustomed to the rapid pace of innovation, thus, concentrated on maximising the sophistication of weapons systems. But in recent years, the pendulum has swung toward concern about quantity. Unit costs of high-performance weapons have risen geometrically, and the technological sensitivity of complex systems has outstripped maintenance capacity. The cruise missile system is a potential combination of high quality and quantity, with emphasis on the latter. The simplicity and commonality that make the cruise missile versatile permit economies from very large purchases.

Fifth, *versatility* is another important feature of an enduring war technology. It fits the system for apparent wide application. To be versatile, a system

24. John Mearsheimer, *Liddell Hart and the Weight of History* (Ithaca: Cornell University Press, 1988)

25. I.B. Holley, Jr., *Ideas and Weapons: Exploitation of the Aerial Weapon by the United States During World War I* (Yale University Press, 1953), pp. 175-176.

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needs to be open to innovation in the changing defensive threat environment. In this matter, a cruise missile can be modified more quickly than a manned aircraft and performance parameters can be attained which are not economically feasible for manned aircraft.[26]

Sixth, the most important conceptual issue is whether the system provides new *tactical options*. And a salient question is *cost-effectiveness*. Does the system offer more "bang for the buck" than other systems? In this respect, the cruise seems to have fulfilled the expectations in successive stages of its evolution.

Seventh, *stand-off-ness* is one of the important features of modern generation warfare where combat operations are conducted without direct participation by ground forces. The indirect method and form is used to inflict damage on the enemy, thereby reducing the chances of retaliation. The new generation wars are known as stand-off wars where there is absence of classic armed confrontation between states. This requires the use of stand-off precision offensive and defensive conventional weapons, weapons based on new physical principles, information and electronic warfare (EW) assets. Perhaps stand-off-ness is one of the major concepts upon which the missile system, especially the cruise missile, is based.

Eighth, *selective engagement* is the concept upon which the application of cruise missiles is also based. Analysis of development trends in high-precision weapons and their combat employment in recent conflicts shows that the required effectiveness of engagement of targets can be reached through selective strikes, and it is not necessary to engage the entire specified areas. Selectivity consists of the destruction of a strictly specified individual target or a combination of such targets (target selectivity), in determining the time of the strike (time selectivity), in the selection of a damage-producing element, and selective-action weapons. Depending on the prevailing conditions (available

26. John J. Kohout III, "Cruise Missile Carrier or Manned Penetrating Bomber: Must It Be Either Or?", *Air University Review*, cited in Betts, n.4, p. 6.

assets, specified destruction extent, resistance to the high-precision weapon systems), by automated identification of the target, it is possible to single out for destruction the elements vital to the enemy's functioning.

The concept of an artificial intelligence-based framework for planning missions is the core of cruise missile functioning.

Ninth, efficient and advanced *manoeuvrability* is an important attribute of *aerodynamic stability*. Aerodynamic stability connotes the property of a body in the air to maintain its altitude, or to resist displacement, and if displaced, to develop aerodynamic forces and movements tending to restore the original condition. The degree of manoeuvrability depends on the magnitude of aerodynamics the body is equipped with. The cruise missile is evolved around this concept. Advanced aerodynamism generates efficient manoeuvrability for the missile to determine its flight path to locate, and guide it towards, the target.

Tenth, precise guidance is the hallmark of targeting. The cruise missile, imbibing the attribute of *precision targeting*, manoeuvres effectively. While targeting, the explosive must arrive quite close to the target as the power of an explosive decreases radically with the distance from the detonation. Cruise missiles with the global positioning system (GPS) can be guided to their target with constant position updates.

Eleventh, *artificial intelligence* is a critical component of the missile that provides the input guidance to the aerodynamism for effective manoeuvring. The concept of an artificial intelligence-based framework for planning missions is one of the core aspects of cruise missile functioning.

Last, the core concept of *unmanned-ness* is probably the progenitor of the idea of a missile. Distance matters greatly in warfare. The main objective of a nation in a war situation is to inflict sufficient damage on the adversary while minimising the chances of getting damaged. Therefore, it is needed to be stationed at a distance while fighting a war until the situation of temporal dominance over the adversary emerges. When distance is involved between adversaries, air power comes into play. But

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till the 20th century, the traditional way of overcoming distance in a war scenario was the use of manned aircraft. In such operations, the risk of losing the man and the aircraft is high. Therefore, to inflict sufficient damage from a distance without losing much is the core idea. Employment of technology in such places is the only way to minus the human factor from such tasks. But the technology that intends to replace the human being is not that simple. Such *technology is a package* combining many supporting structures. For example, consider the task of delivery of a warhead. Here, to deliver it exactly at the target, the delivery system leading towards the target must be equipped with an efficient guidance system. It must also be equipped with reconnaissance technology. Therefore, the endeavour to upgrade the system for one specific capability necessitates adding new technology to the system. Perhaps this is how the evolution of the cruise missile emerged: with every attempt, shortcomings in the process have been identified and overcome in the process, but in the long run, it has generated a new set of problems to address which vindicates a cyclical process of evolution.

By reviewing the success story of the cruise missile, one can easily figure out the series of failed attempts through its long history. The practical effort, on record, for an unmanned flying bomb was first attempted in April 1915 when Peter C. Hewitt, the inventor of the mercury vapour lamp, approached Elmer A. Sperry of Sperry Gyroscope Company with the idea of an automatically controlled "flying bomb" or "aerial torpedo". But the device was expensive, required complicated launching facilities and its "use in long range attacks against forts and cities is of doubtful military value on account of the difficulty of striking at any desired point rather than at random within the limits of the city or fortress." Among the Europeans, the British were the first to launch such a programme under the leadership

of H.P. Folland but the Folland missile proved unsuccessful, failing to get airborne on three attempted launchings in July 1917 and, finally, that led to end the project. In April 1917, America's Naval Consulting Board recommended, and allotted funds for a "flying bomb" project. After the success of the manned N-9 tests, failure dominated the new phase with the unmanned vehicle. On the first attempt at an unmanned "flying bomb" on August 18, 1920, the machine crashed after 150 yards. The third "flying bomb" launched on April 25, 1921, flew for less than two minutes. The missile's lack of progress, coupled with declining funds, led the navy to cancel the effort in 1922. Meanwhile, the army had developed a somewhat more successful flying bomb with the interest of Glenn Curtiss and Maj Gen George O. Squier and under the leadership of Charles F. Kettering. But the Kettering missile experiments faced difficulties. Launch problems caused a number of crashes. Limited knowledge of aerodynamics, lack of testing, and haste in building the machine guaranteed problems. In particular, neither guidance systems nor engines performed as designed. Only one of the 12 Sperry-Navy tests functioned properly. By 1927, the British were developing three types of missiles: a mechanically-controlled "flying bomb", a radio-controlled missile, and an air defence missile to break up enemy aircraft formations. However, the Royal Air Force really did nothing with the flying bomb until its final cancellation. In September 1936, the Air Staff reviewed both the air defence and Larynx missiles and decided that neither merited further development. The British, however, did have a successful inter-War missile development programme. The Queen Bee first flew under radio control in 1934.

Subsequently, technical problems proved too great. The American flying bomb development shifted from pre-set guidance to radio-control from an accompanying aircraft. While radio-control efforts worked in theory and in tests, they did not work well in combat. Mechanical problems with the missile, explosive, and guidance systems precluded adequate testing of both the equipment and the concept. A realistic appraisal of these piston-powered flying bombs during World War II led to the conclusion that although they

were comparable in cost to manned aircraft, they proved less reliable, less accurate and more vulnerable than conventional aircraft. The Germans, however, came up with a breakthrough to make the flying bomb a marginal, if not truly practical, weapon. Therefore, the path of cruise missile development was marked with failures but every attempt was made to overcome the difficulties with some innovation.

All the above concepts were not assimilated simultaneously when the cruise system was initially experimented with. In subsequent stages of its evolution, the imperatives of war experience and changing pattern of warfare necessitated sophisticated features to be added to the system through consequent R&D. Primarily, these are some of the important concepts upon which the evolution of the cruise missile system is based. Many more concepts and features would also be added to the cruise missile technology according to the demands of the time. So to define a cruise missile in definite terms is a difficult task as new features have been assimilated in subsequent stages and its evolution is still not complete. Therefore, there is no single definition for the cruise missile. According to one widely accepted definition, a cruise missile is an "unmanned, expandable, armed, aerodynamic, air-breathing autonomous vehicle".[27] "Expandable" signifies its wide application; "autonomous" means it carries out a "programmed mission" or guides itself after it is launched. This definition describes it as an offensive military weapon which is different from rocket powered and remotely controlled vehicles. Though many vehicles which have been experimented with, and used, since World War I can be termed as missiles, discussions of cruise missiles usually offer the German Buzz bomb (V-1) of World War II as the progenitor of the cruise missile.[28] Also, rocket powered anti-ship missiles were usually regarded as cruise missiles.

THE CRUISE TECHNIQUE IN ANTIQUITY

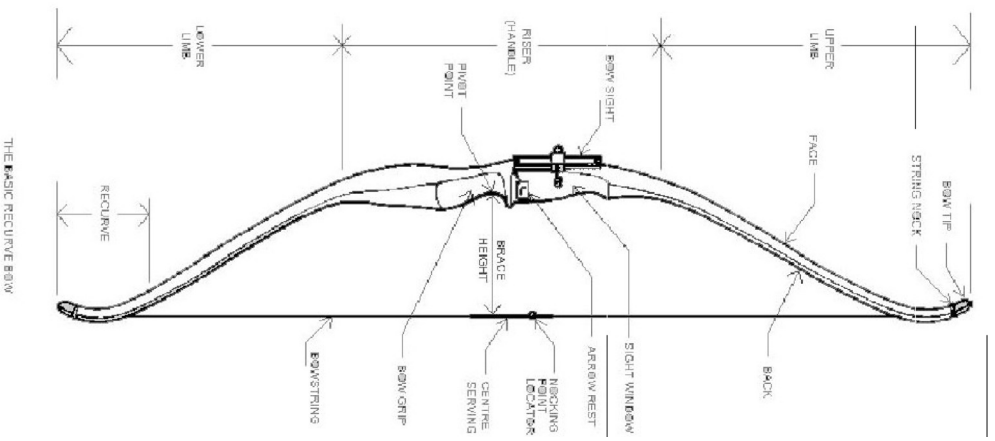
At the basic, the cruise, both as a concept and technology, is as old as human

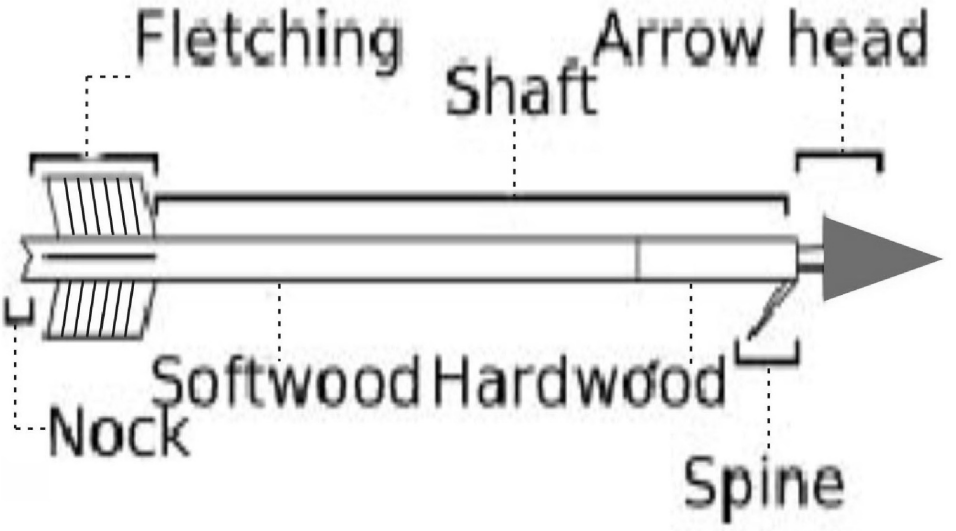
27. John C. Toomay, "Technical Characteristics", in Betts, n.4, p. 31.

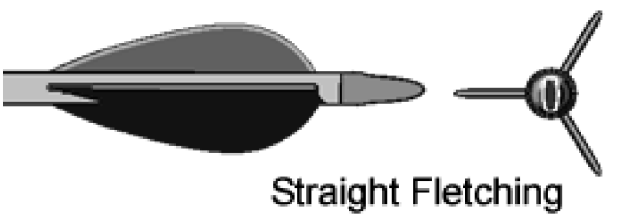
28. Ralph Kenney Bennett, "The Missile the Russians Fear Most", *Reader's Digest*, February 1977, pp. 129-32; Juan Cameron, "The Cruise Missile Can Do It All—Almost", *Fortune*, May 8, 1978, pp. 174-184.

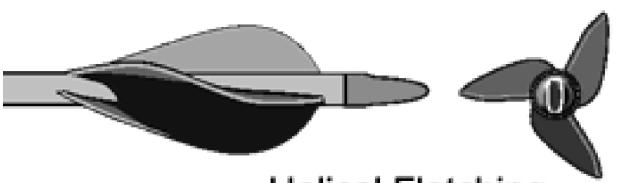
civilisation itself. If we analyse the objectives of a cruise missile, it is clear that even primitive man utilised this technology while hunting, though in a completely different fashion. For example, since time immemorial, the bow and arrow comprised one of the first ranged weapons which used mechanical principles.

The bow seems to have been invented in the late Paleolithic or early Mesolithic age. There are numerous instances in the epics regarding the uses and techniques of archery. It was a complete war-fighting system with considerable innovation. The bow functions by converting elastic potential energy stored in the limbs of the bow into kinetic energy of the arrow. In this process, some energy is dissipated through elastic hysteresis, reducing the overall amount released when the bow is shot. Of the energy remaining, some is damped both by the limbs of the bow and the bowstring. Depending on the elasticity of the arrow, some of the energy is also absorbed by compressing the arrow, causing it to bow out to one side. This results in an in-flight oscillation of the arrow in which its centre protrudes out to one side and then the other repeatedly. The flight of the arrow is dependent on its fletching which is a fundamental in an aerodynamic technique.






Straight Fletching


Helical Fletching


Flu-flu Fletching

Perhaps the technique of fletching is the ancient art of aerodynamicity to stabilise the arrow through air resistance in flight. Fletches are the fins or vanes attached to an arrow, each of which is known as a fletch. Traditionally, fletching consists of three matched half-feathers attached near the back of the arrow or dart's shaft that are equally spaced around its circumference. Some fletches act to impart a spin on the projectile, but all are there to impart a drag on the tail of the projectile to ensure that it does not tumble during flight. They are usually angled to make the arrow spin as it flies, to give a more stable, straighter flight. The fletching can be arranged to cause the arrow to rotate along its axis if desired. This improves accuracy by evening out pressure build-ups that would otherwise cause the arrow to slowly tilt in a random direction after shooting. If the fletching is not arranged to induce rotation, it will still improve accuracy by causing a restoring torque any time the arrow tilts away from its vector of travel. Arrows themselves may be designed to spread or concentrate force, depending on their applications. Practice arrows, for instance, use a blunt tip that spreads the force over a wider area to reduce the risk of injury. Arrows designed to pierce armour would use a very narrow and sharp tip to concentrate the force. Arrows used for hunting would use a narrow tip that broadens further down the shaft to facilitate both penetration and a large wound.

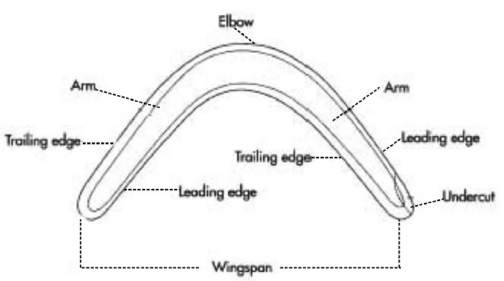
Various techniques of bows and arrows were practised in Egyptian culture since its predynastic origins. Classical civilisations, notably the Indians, Persians, Parthians, Koreans, Chinese, and Japanese fielded large numbers of archers in their armies. Archery was highly developed in Asia and in the Islamic world. In East Asia, the ancient Korean civilisations were well-known for their archery skills. Central Asian and American Plains tribesmen were extremely adept at archery on horseback. The Sanskrit term *Dhanurveda* (from *Dhanus* "bow" and *Veda* "knowledge" which came to refer to martial arts in general) is the term for the "science of archery" in Puranic literature.

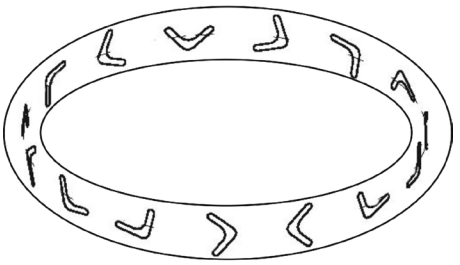
There are numerous references in the Hindu epics of the *Mahabharat* and *Ramayan* to the unprecedented techniques mastered by characters like King

Dasaratha of Ayodhya and Ekalavya, the young prince of the Nishadha tribe. King Dasaratha was capable of shooting arrows at distant objects only by listening to the sounds they produced. While Sravana Kumara was collecting water in his pitcher for his blind parents, Dasaratha, who was on a hunting expedition, mistook the sound for a deer drinking water, and shot an arrow in his direction, instantly pinning him to the ground. The same was the case of Ekalvya. While practising archery, Ekalavya heard a dog barking. Before the dog could shut up or get out of the way, Ekalavya fired seven arrows in rapid succession to stuff the dog's mouth, without injuring it. The technique of shooting arrows to kill only by listening to the sound from the target, without seeing it, is called *Shabdavedi Vidya* (the art of shooting by listening) in Sanskrit. If such skill and concept really existed, then ancient man was much advanced in matters of defence and warfare.

Beside archery, instruments like the boomerang are based on the aerodynamic principles and microgravity dynamics of flight. The boomerang is primarily associated with Australian Aborigines, but has been found amongst the peoples of Northeast Africa, Sardinia, Arizona, southern California, Native Americans, and in India. A boomerang is an airfoil. When it is thrown with high spin, the wings produce lift. Because of its rapid spinning, a boomerang flies in a curve rather than a straight line. When thrown correctly, a boomerang returns to its starting point.

Returning boomerangs consist of two or more arms or wings, connected at an angle. Each wing is shaped as an airfoil, so air travels faster over one side of the wing than the other. This difference in air speed creates suction or lift along what is roughly a plane which intersects the airfoil at a near right angle along the long axis of the wing. These wings are set so that the lift created by each wing opposes the lift of the other, but at an angle such that the flight pattern is constantly shifted as the forces of lift, drag, speed, rotational inertia etc. 'attempt' to reach equilibrium. Gyroscopic precession is what makes the boomerang return to the thrower when thrown correctly. Some boomerangs have turbulator bumps or pits on the top surface that act to make the flight more reliable.





In an unprecedented experiment, on March 18, 2008, Japanese astronaut Takao Doi "threw a boomerang and saw it come back" at the International Space Station (ISS).[29] In the pressurised environment of the ISS, microgravity has very little effect on the boomerang flight.[30] It was proved that the boomerang is versatile, with gyroscopic precession and angular momentum compensating for the lack of gravity.

From the above description, it is clear that missiles, in general, and cruise missiles, in particular, have their ancestors, though of completely different variety and quality. The stage that missile technology has reached today simply symbolises a *graduated process of evolution* through various ups and downs. According to Kranzberg's third law of technology, "Technology comes in packages, big and small"[31]. One innovation leads to another and very much according to the need of the time. Kranzberg's sixth law of technology also asserts that "technology is a very human activity and so is the history of technology". In that sense, the spread and sophistication of cruise missiles in the course of time is not surprising. But no human activity takes place in a vacuum. And again, while studying the evolution of technology, that too war technology, one needs to explore in detail the "period of ideological and social preparation".[32] Lewis Mumford argues that "mechanisation (of war)

29. "Boomerang Works in Space, Says Astronaut", http://www.news.com.au/couriermail/story/0,23739,23411383-952,00.html, March 21, 2008.
30. "Does a Boomerang Work in Space?", http://www.universetoday.com/2008/03/24/does-a-boomerang-work-in-space/
31. Melvin Kranzberg, "Technology and History: Kranzberg's Laws", *Technology and Culture*, vol. 27, no. 3, pp. 544-560.
32. Lewis Mumford, *Technics and Civilization* (London: Routledge & Kegan Paul Ltd., 1967), p. 4.

Conceptually, the phenomenon of the spread of cruise missiles can be looked at in two ways: (1) the cruise missile as a piece of technology; and (2) the cruise missile as a piece of the war machine.

and regimentation are not new phenomena in history; what is new is the fact that these functions have been projected and embodied in organised forms". Further, "Techniques and civilisation as a whole are the result of human choices and aptitudes and strivings, deliberate as well as unconscious, often irrational when apparently they are most objective and scientific"[33].

With this perspective in mind, we need to examine the evolution and spread of cruise missiles in the world: why they have spread; is there any discernible pattern in their spread; is their evolution purely the story of innovation of technology; what necessitated the cruise missiles to come up to this stage after a sustained and unrelenting endeavour? Is it only the sheer curiosity for technological innovation that motivated the innovators for their sustained effort? Or is it the non-technical factors that have taken precedence in such technology policy decisions? Kranzeberg's fourth law of technology amplifies the point that "although technology might be a prime element in many public issues, non-technical factors take precedence in technology-policy decisions". Therefore, the evolution of cruise missiles and the extent of their spread, need to be looked at both from the point of view of laws of technology and the politico-ideological context. The subsequent section investigates such aspects but at a very conceptual level.

SPREAD OF CRUISE MISSILES

Conceptually, the phenomenon of the spread of cruise missile can be looked at in two ways: (1) the cruise missile as a piece of technology; and (2) the cruise missile as a piece of the war machine. Though both perspectives are complementary and mutually reinforcing, such categorisation would serve the purpose of judging the trend and nature of their spread. Also, a term like 'proliferation' is deliberately avoided since the focus of this paper is purely on

33. Mumford, Ibid., p. 6.

the evolution of the cruise missile as a piece of technology. In both respects, various theories are applied to examine the path of its evolution.

(1) Spread of the Cruise Missile as a Piece of Technology: In the first instance, we need to consider the evolution of the cruise as an artifact and its spread thereof. According to Melvin Kranzberg's first law, "Technology is neither good nor bad; nor is it neutral".[34] It evolves "in a socio-cultural milieu and its interactions with both the social and cultural factors sometimes lead to developments that are far removed from the original goals of the technical elements themselves".[35] In other words, for Kranzberg, technology acquires value and meaning in a socio-cultural context and gets shaped in a never ending process, leading to further addition of value and modification of its structure and function. For that matter, if we apply his principle to the evolution of the cruise missile as a piece of technology, it is evident that the aerodynamic principle and rocket technology have been utilised in different societies for different purposes. Countries used them for launching satellite and space missions; and many countries have used them for military purposes. In the same line of argument, the *instrumental theory* of technology views technology as subservient to values like politics or culture. But it views technology as "neutral," without a valuative content of its own.

In the instrumentalist understanding of technology, *neutrality* means: (1) technology is indifferent to the variety of ends it can be employed to achieve; (2) it appears to be indifferent with respect to politics – it appears to be quite different from traditional legal or religious institutions which cannot be readily transferred to new social contexts. The transfer of technology, on the contrary, seems to be inhibited only by its cost; (3) the socio-political neutrality of technology is usually attributed to its rational character and the universality of the truth it embodies; (4) the universality of technology also means that the same standards of measurement can be applied in different settings. Then, if we apply the instrumentality approach to examine the phenomenon of

34. Melvin Kranzberg, "The Information Age: Evolution or Revolution?", *Information Technologies and Social Transformation*, National Academy of Engineering (NAE), 1985.

35. Kranzberg, Ibid.

At every stage of its evolution, only a technical solution was applied to any technical problem that occurred, as there was no alternative to it. And this kept it evolving.

the spread of cruise missile technology, it amplifies the fact that this technology tends to spread, firstly, as a tool standing ready to serve the purposes of the users. How its leaders use this technology depends on the national culture, whether for war-fighting or civilian application.

But the *substantive theory of technology* attributes an autonomous cultural force to technology, overriding all traditional or competing values like politics. Ellul and Martin Heidegger argue that technology constitutes a new type of cultural system that restructures the entire social world as an object of control. Ellul makes it clear that the technical phenomenon has become the defining characteristic of all modern societies, regardless of political ideology. *Technique* has become autonomous. It is not simply a means but has become an environment and a way of life. That is its "substantive" impact. Among many other human activities, *technology is progressive as it is rational*. [36] If this argument is applied to the spread of cruise missiles, it may emphasise the fact that the evolution of the cruise missile from its rudimentary stage in the past to today's sophistication stage is marked by the *technological fix* principle. At any stage of its evolution, only a technological solution was applied to any technical problem that occurred, as there was no alternative to it. And this kept it evolving.

However, the *critical theory of technology*, though it agrees with the instrumentalism, it rejects the neutrality aspect and argues instead that "technological rationality has become political rationality".[37] Meaning thereby that the values and interests of the ruling classes and elites are installed in the very design of rational procedures and machines even before these are assigned a goal. It further asserts that the dominant form

36. "The Technological Fix", http://www.clemson.edu/caah/history/FacultyPages/PamMack/lec122/techfix.htm

37. Andrew Feenberg, "Critical Theory of Technology", http://www.sfu.ca/~andrewf/CRITSAM2.HTM

The dominant form of technological rationality is neither an ideology nor is it a neutral requirement determined by the nature of technique.

of technological rationality is neither an ideology nor is it a neutral requirement determined by the nature of technique. Rather, it stands at the intersection between ideology and technique where the two come together to control human beings and resources in conformity with what Andrew Finberg calls "technical codes". Critical theory argues that technology is not a thing in the ordinary sense of the term, but an "ambivalent" process of development suspended between different possibilities. This "ambivalence" of technology is distinguished from neutrality by the role it *attributes to social values in the design, and not merely the use*, of technical systems. In this view, technology is not a destiny but a scene of struggle. If the evolution of the cruise missile is looked at from this perspective, national decision-making has a bearing on its march to the stage at which it stands now. The strategic culture, the ideological inclination of the decision-maker, the threat perception of the national leaders, and the security environment sufficiently impinge upon national security planning and, thereby, the defence planning and preparedness. Therefore, the plan to develop or acquire cruise missiles can be viewed as an offshoot of the national politico-security environment and, therefore, technology is not neutral, as argued by the critical theory. However, this leads to the other aspect of the discussion – the cruise missile as a piece of the war machine.

(2) Spread of the Cruise Missile as a Piece of the War Machine: The spread of cruise missile as a piece of technology, at the outset, needs to be viewed in the overall perspective of *diffusion of military technology*.[38] And the revolution of frequent change in military technology needs to be seen not as a thing apart but as an integrated element of a broader revolution in science, technology and the human condition as a whole. The advanced military technology has spread throughout the international system by transfer of weapons from the manufacturing countries to the non-manufacturing countries.

38. Barry Buzan, "The Diffusion of Military Technology: Looking Backward, Looking Forward", www.cia.gov/nic/pubs/research_supported_by_nic/conference_paper/chenghu.htm

States perpetually strive to address their perception of national security deficit by arming themselves with the latest military equipment. One adversary acquiring certain weapons tilts the balance that instigates the other side to enhance its capability, and this leads to an unending arms race.

And the well established arms trade, with a powerful constellation of vested interests has always supported the trend. But what is the motive that instigates a nation to acquire such weapons? Very often, a deteriorating national security situation is advanced by the concerned countries as the reason. Instead of achieving security by the help extended by other nations, countries always try to achieve an independent ability to defend, and wage war. One country in a given region acquiring any weapon leads to a chain reaction of an arms race among the adversaries of a given region, which Barry Buzan calls the *security complex*. It implies that the process of diffusion of military technology cannot be considered in isolation from the geo-politics of a given region.

Barry Buzan has formulated his security-complex thesis keeping only Asia in mind. If we look at any other part of the world, similar complexes can be identified, where states perpetually strive to address their perception of national security deficit by arming themselves with latest military equipment. One adversary acquiring certain weapons tilts the balance that instigates the other side to enhance its capability, and this lead to an unending arms race. All these security complexes are bipolar and suffer from a *security dilemma* which is the source of all conflict formation and armament race. And this regional bipolarity is characterised by an intense security dilemma: "A situation in which no community can provide for its own security without threatening the security of others".[39] None of the states involved want relations among them to deteriorate, but as each state acts militarily or diplomatically to make itself more secure, the other states interpret its actions as threatening. This

39. John H. Herz, "Idealist Internationalism and Security Dilemma", *World Politics*, Vol. 2, 1950, pp.157-180.

initiates the conflict formation process which channels external interventions along the line of internal rivalries. Also different regions are so interlinked that the issues of one region have sufficient implications on the other regions. Therefore, an arms race in one region instigates the same in the other regions as well. Such security complexes can be found mainly in Asia and Africa which constitute the Third Word. And most of the Third World countries either have their own missile programmes or have received them from their patrons.

The kind and variety of cruise missiles a country requires in one security complex may be completely different from the requirement of another country in another complex.

However, this regional complexity has actually helped the evolution process of cruise missiles in one way or the other. For example, the kind and variety of cruise missiles a country requires in one security complex may be completely different from the requirements of another country in another complex. So the nature of the regional security situation and geo-politics determine the features of the missiles of a nation. Therefore, if states start their own programmes, they design them according to their specific requirements, like the range, payload, speed, etc. If they receive the missiles from any other country, they redesign or modify them according to their strategic requirements, thereby the missiles go through a different phase of evolution.

Also the popularity and spread of a weapon depend upon the status it bestows upon the state, the objective it can accomplish, and how cost-effective it is. In this context, the nuclear weapon is viewed to bestow higher status and is considered so far the ultimate weapon. Though many countries have shown interest in it, only a few have achieved success only because it is not affordable for all and involves extremely difficult technology. Next to nuclear weapons, probably the missile is an instrument where status or prestige is involved. It is also comparatively affordable in both qualitative and quantitative terms, for a large number of countries. Therefore, many Third World countries have already acquired missiles.

Requirement generates new challenges which drive nations to work on

the leading edge of technology[40]. If we consider the cruise missile purely as a piece of the war machine and part of the military industry, the principle of "requirement push and technology pull" has also significantly contributed to its evolution. This push-pull factor has definitely worked in the evolution of cruise missiles.

Overall, the cruise is a sober success. But to address why the cruise missile has got relatively less attention in strategic studies, even though the missile discourse is much older than the nuclear discourse, one needs to resort to a comparative study on the psycho-dynamic aspects of weapon systems. In pursuit of this, at the basic, one needs to identify the nuances in the politics and psyche involving 'atom-power' while comparing them with the nuances involving the lesser known, lesser publicised concept of 'air-power' and aerodynamism.

40. James R. Hansen, "Technology and the History of Aeronautics: An Essay", http://www.centennialofflight.gov/essay/Evolution_of_Technology/Tech-OV1.htm.