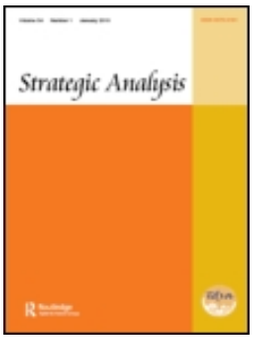

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Application of Unmanned Combat Aerial Vehicles in Future Battles of the Subcontinent

C.N. Ghosh

The experiences of the Gulf and Kosovo Wars brought several strategies to the forefront, and the supremacy of air power was clearly established. While strategic air power cannot win the battle all by itself, as was also clearly established in the Gulf War, air power made it easy for the ground forces to complete the annihilation of the Iraqi Army. That is why the war strategists do not have any doubt that some form of air power will decide the course of future battles. Such deliberations naturally bring the factor of the unmanned combat aerial vehicle (UCAV) to the forefront. The UCAV has not only the attraction of keeping combat casualties low but overcomes many human limitations. The unmanned aerial vehicles (UAVs) will be smaller, faster and more agile than manned fighters. Such unmanned vehicles could be used in preference to manned flights in a dense air defence battle space optimised by low looking radars and QRMs (quick reaction missiles). They will be very useful in keeping long vigil on enemy activities and passing on information to the command posts. The UCAV concept is technically feasible. UCAVs can meet the operational needs and fit into a sound plan of operations. Historical biases for manned aircraft should not be a stumbling block for embracing this technology in the futuristic technology driven wars. These forces need to be understood and their application made accordingly. No doubt, the Indian Air Force has taken a step in the right direction by inducting them in its force structure.

It is likely that future wars will be decided by some form of air power being the principal driving force before the surface forces are able to make contact with the enemy in major battles. And it is more or less definite that the unmanned combat aerial vehicles (UCAVs) will play a definitive role towards augmentation of air power. The UCAVs will be smaller, faster and more versatile than their manned counterparts. They will be used to penetrate airspace that may be considered dangerous for manned aircraft can carry out reconnaissance and surveillance, or be used for jamming the enemy air defence system. This has become a necessity in the face of

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the quick reaction, low looking missiles that have been developed by almost every warring nation. UCAVs or unmanned aerial vehicles (UAVs) made their presence felt in the Gulf War and more recently in the Kosovo War. The Israeli UAVs in the Bekka Valley War,[1] caused havoc for the Syrian Air Force. In his keynote address in the Aero India show in Bangalore in February 2001, the Chief of Air Staff Air Chief Marshal Tipnis laid great stress on UCAVs and mentioned that the "UCAV has not only the attraction of keeping combat casualties low, but overcomes human limiting stipulations on G crunching manoeuvres, and sitngent cockpit environment for protection and survival of the pilot".[2] No doubt, this shows the keen interest evinced by the Indian Air Force to induct this futuristic technology to recast its force structure.

There is a volume in the *Jane's* series titled *World Unmanned Aircraft* by Kenneth Munson,[3] which describes the programme from 1998 till date. This may be the most comprehensive and contemporary source data about the world's UCAVs. Despite worldwide efforts for the UCAV programme, only a few such attempts may be termed success stories for many have withered due to lack of interest and resources, and a few have been spectacular failures. UAVs fly more complex missions than cruise missiles and are more autonomous than remotely piloted vehicles. The distinguishing characteristics comprise the automation of complex functions. The main requirement of these unmanned vehicles is to perform tasks as part of the main systems and return unharmed, as in the case of a manned aircraft. The operator or the remote pilot guides the vehicle through its mission and brings it back, sitting at a location according to the mission's demand. But it must be understood that UAVs are not a panacea. Some missions can benefit by the use of UAVs but some others have to be left to manned flights. It is for the air force to determine the correct mix of manned and unmanned aircraft in future battle scenarios.

The decision regarding manned versus unmanned aircraft application requires careful consideration of the following factors:

(a) The scenarios to be encountered.

(b) The missions and tasks to be performed.

(c) The alternatives.

(d) The relative risks.

(e) The relative costs of the task.

(d) Availability of the technology.

For a number of reasons, the time for acceptance of UAVs appears to be ripe for many reasons. Declining force structure and equipment necessitates innovative thinking about more cost effective solutions for air forces. The air forces of the developing nations always find themselves at a disadvantage when it comes to bridging the gap between technology and force levels. The critical condition of the Indian Air Force (IAF) is well known. It will be facing obsolescence in a few years

time and there are no feasible cost effective solutions. Replacement of the ageing MiG-21s is not possible by off-the-shelf procurement of state-of-the art aircraft. Even if they are available, the cost of procurement would be prohibitive. The present defence expenditure cannot support such replacements of manned fighters. On the other hand, the training of pilots is getting increasingly costly and there are not many from the younger generation who would like to join the fighter force in preference to a highly paid managerial job. The factor of increasing rate of accidents is also causing serious concern in the air force hierarchy. All these are reasons for UAVs to replace some of the manned missions. These could provide lower operational costs, and increase sortie rates. In addition, their long endurance and potential for strategic and tactical applications could bring a new dimension to air force operations.

Therefore, we need to assess the concept as well as the technologies of platforms, weapons, and also the human factor, as they all contribute directly to the accomplishment of the tasks of the air force. But it must be noted that UAVs are not a complete solution to the problems of the air force. They will never be able to replace manned missions completely—some missions are better left to manned aircraft. The mix of force between manned and unmanned aircraft should be left to careful planners of the air force. The force mix decision process is especially complex for the unmanned vehicle because the introduction of a radically new weapon system entails a great deal of uncertainty. The methodology of the operational procedures has also not been demonstrated by any air force clearly so far.

Qualitative Requirements of UAVs

UAVs, no doubt, will give a different dimension to the concept of air power and its applications. The concept of weaponising the UAV may seem a radical one, but if this is examined closely, the apparent reasons come out very clearly. The Israelis in Bekka Valley for the first time, showed the devastation that UAVs can cause. As a result, a number of nations have become interested in weaponising UAVs in preference to manned fighters. The reasons are very clear: the UAV platform, sensor and weapons technologies have matured sufficiently to permit low risk, and quick development to weaponise the UAV. The operational risks may be seen from different angles. The utility of this unknown weapon system may create control and coordination problems, depending upon the role for which it is employed. But the greatest advantage that will accrue to air power proponents is that the UAV could be pressed into service with no risk of loss of life. Suppression of enemy defence would not be an easy task in the future air war scenario but the UAV could play a decisive role in situations where manned flights may face unacceptable losses. Therefore, the air power protagonists will seek certain qualities in this new kind of weapon system.[4] These are:

(a) *Endurance.* UAVs should have much greater endurance than manned flights, because there is no question of crew fatigue. This will allow persistent surveillance and continuous deterrence, and since fewer aircraft will be

needed to carry out the same job, it will reduce the cost of coverage of areas.

(b) *Operating Ability.* UAVs should be able to carry weapons and perform high attrition combat tasks. They should be able to operate in contaminated areas, because the future wars may see the use of chemical and biological weapons. UAVs can be used in a provocative role if the need arises. If necessary, these machines can be sacrificed in the interest of a mission. But it needs to be remembered that operational deployment would be disadvantaged by not having human reasoning power, and, hence, command and control problems have to be resolved before the operational deployment of the UAV.

(c) *Automated.* UAVs are simpler and easier to operate and that is why the cost of training is much less than for its manned counterpart. And since manned intervention in the air is not necessary, no crew safety training or systems are to be integrated. Control surfaces can be made simpler which will bring down the cost further and reduce design complication. The crew will be operating the UAVs from a remotely based control room in a controlled environment; as such, there will be little crew fatigue. In case long hours of watch are required, the crew will be able to hand over controls easily. This is not possible in the case of manned fighters.

(d) *Quick Response.* UAVs should have the capability of quick response within the zone of operation. They should be able to operate behind the enemy lines; combined attack with multiple weapons should be possible, with broad area coverage with multiple sensors, persistent surveillance, and reduced system vulnerability.

(e) They should have capabilities for high altitude operations, survivability, performance enhancements, broad area coverage and better viewing angle.

(f) UAVs have low altitude operation, survivability, short range of operations in the role of jammer, and smaller weapons.

The technological aspects expected in future UAVs[5] are:

(a) Low life cycle cost.

(b) Engines should be fuel efficient for better range.

(c) Simulation based design for systems relevant to humans.

(d) Lower signatures will assure lower observability.

(e) Mission planning should be automated, flexible, fast, utilising parallel computers.

(f) On-board processors should have excellent performance, and cost should be low.

(g) Sensors must be modular, lightweight, UAV-tailored.

(h) System design to be based on robust system with very low rate of failure.

(i) Integrated design/simulation, manufacturing automation.

(j) Crew selection and trained using modern methods.

(k) Vehicle management system to be optimised for UAVs in relation to performance, weight, cost and automation.

(l) The structure of the UAV should be a tailored, composite one, with very low part count and high fuel fraction.

(m) Weapons must be small, modular and be an integrated system.

Operational Missions for UAVs[6]

Attacking Fixed Targets. UCAVs could be employed to attack high value heavily defended fixed targets. Use of manned aircraft would cause unacceptable losses to men and machines. Also these could carry out supporting operations in the missions of strategic attack, interdiction and close air support. Given the location and type of target and the desired weapons effects, a target attack mission would determine tactics for target acquisition, weapons effects, collateral damage and terminal system based on the Global Positioning System (GPS), electro-optical, IR (infra-red) or millimetre wave based system.

Attacking Moving Targets. Typical missions covered by moving target attacks are interdiction, strategic attack and close air support. These could be made simpler because UAVs would be capable of loitering for a long time at high or low altitude, carrying sensors to detect and cue loitering weapon platforms to attack identified targets. The weapon platforms in this case would mostly be manned fighters in the near term and attack UAVs in the future.

Jamming. Application of a UAV in the role of a jammer could be most effective. These platforms could operate at high altitude, with long endurance/low observable electronic support measures/electronic counter-measures platform supporting multiple strike/bomber attack operations in standoff or close orbits. Long endurance would permit the UAV to support multiple strikes or bomber attacks on a heavily defended target. The vehicle would have the ability for preplanned orbit navigation or ground and airborne dynamic retasking in support of revised targetting. The concept of jammers preceding a strike force is being implemented by many air forces to deliver weapon load on targets defended by quick reaction missiles. UAVs, if matched well with the strike force, could be used to neutralise enemy fire control and tracking radar. A decoy UAV can be deployed before the actual strike force approaches the target. These could replicate the radar or IR signatures.

Suppression of Enemy Air Defence (SEAD). UAVs could be deployed to detect enemy air defence systems and pass the detection and precision location data to elements of the SEAD network that would deploy attack weapons. The best way to deploy UAVs in the present scenario would be to provide safe loiter time so as to

pick up emitter data and pass it on to the command post and, in turn, the manned fighter could be sent to deliver the actual weapon load. However, technically it is feasible to deploy UAVs to carry out the actual attack. The enemy air defence system could be saturated by the appropriate deployment of UAVs.

Surveillance/Reconnaissance[7]

UAVs have the potential to collect intelligence data throughout the day and night from anywhere in enemy territory, regardless of weather, and feed the command post. UAVs have definite capabilities of flying close to the target, long dwell and loitering, and if provided with low observable capabilities, these machines could overfly the target even if it is heavily defended.

Using UAVs as Communication Nodes

Multiband multimode communication relay and switching nodes will contribute to the force enhancement role of the three Services. The value of such support will be manifest in every offensive operation when a tactical communication network is limited in keeping pace with the fast moving forces, not only in physical speed but in power, frequency, bandwidth, available channels and avoidance of interface. In the Indian terrain—mostly in the hills—with the forces widely dispersed, the beyond line-of sight communications will benefit the most by the application of UAVs.[8]

Air-to-Air Combat

Air-to-air combat has been restricted due to human limitations. The manned fighters could sustain certain "G" force only for a specific period. Every fighter aircraft designed so far has had this limiting factor. But the unmanned fighters will not have any such restrictions and, as a result, their manoeuvrability will be far superior to that of the manned fighters. Therefore, high "G", high-speed interceptions would be a definite possibility. UAVs could be employed in both defensive and offensive roles.

Operational Analysis[9]

The major air powers of the world understand that UAVs are coming of age, despite setbacks in many fields. The technology has matured. Many people wonder why they are not being more widely used. Some talk about a pro-pilot bias; others have a different perception and say that UAVs are incapable of performing a mission as well as the equivalent manned aircraft since they are unable to respond to the combat environment's dynamic changes. This perception assumes that UAVs are no more intelligent than cruise and ballistic missiles. It does not take into account the possibility of a real or part time operator or the quality of feedback that the UAV sensors will provide. Unlike non-lethal UAVs, unmanned systems carrying lethal

munitions could have devastating effects in the case of an accident or system-related malfunction. There are also some opinions which directly challenge the UAV's capability to perform traditional manned aircraft missions, and feel that this could be a direct threat to the air force as an institution. In certain quarters, it is argued that the air force accepted the induction of UAVs when it was faced with the infringement of traditional air force missions by the other Services. It is also true that today accidents or mistakes do not justify death or destruction. Society has become more sensitive to death and destruction as the information age provides real-time reporting of world events. In addition, technology has legitimised precision warfare and criminalised collateral death and destruction resulting from the use of lethal force. An autonomous system has no way of knowing how the situation may have changed since it received its mission orders. The biggest problem will arise in case internal disorder takes place; the UAV will not be correct for such situations and may contribute to the danger.

These are the reasons why air forces are faced with the complex questions of how many UAVs to buy, and for which missions? An analysis of these will show a definitive route for the air forces to follow. In broader terms, it should be defined as to what the air force wants to accomplish by adding UAVs to its force structure. Is it to supplement manned missions and reduce training cost? Is it to save money? Because there is no doubt that the unit cost of a UAV will be much less than that of a manned machine. Is the UAV to be assigned missions which are dangerous for manned missions? Each of these questions has to be carefully studied and the viability of UAVs has to be established.

Operational Concepts/Tasks and Missions.[10] Defining tasks and missions for the UAVs is very important and is considered a major problem area for the air force. Such operational concepts drive the vehicle design and performance characteristics. And a hard look is necessary to ascertain whether the technologies have matured enough to support the design and performance goals.

Technology Matching Operational Needs.[11] While delineating the concepts, the relationship between UAV missions and operational requirements must be defined. The requirements should be defined in terms of high, medium or low altitude tasks. In addition, low observable characteristics, endurance, speed, payload, and weapon systems have to be defined. Also, the sensors and other mission systems must be related to each of the operational tasks, indicating both the criticality of a given mission system to a task and the availability of the technology to support the mission.

UAVs vs Manned Flights Assessment. Careful and critical assessment has to be made for each manned flight, so that UAVs can be employed correctly to replace manned flights in each identified mission. It is, however, not necessary that the replacement has to be on a one to one basis. A manned flight, if necessary, can be carried out by many UAV flights, provided the time permits. The ultimate decider would be the fact that UAVs perform missions more cost effectively than manned flights and that too in a very hostile environment. Force structuring analysis is

needed by the air force to evaluate the effectiveness of UAVs. Detailed simulation of the performance at the system and sub-system levels will be appropriate. Any mission level model with applications of both manned and unmanned flights could be compared before UAVs are inducted in actual operations. This will also be helpful to assess the survivability rate of UAVs.[12]

Functioning of Command and Control[13]

Positive control of UAVs would require the important C³I functions, including that of the human operators to intervene quickly to regain control of an errant autonomously controlled vehicle. And in this way, UAVs can be integrated successfully into air force air operations. The need is to interface UAV capabilities with the existing and emerging infrastructure of the Command and Control system. Each mission will have its own needs, design considerations, onboard sensors, computers and weapon systems. New ideas in autonomous controllers and associate systems that support and collaborate with human operators in a hierarchical command structure and new concepts for passing targetting and intelligence data from the sensors to shooters are to be addressed for proper utilisation of this new but effective tool to wage a future air war. It has to be ascertained whether the present or emerging C³I architecture is adequate for the introduction of UAV into the force structure of the air force. The main challenge in the realm of Command and Control for these machines would be positive control in shared airspace with manned flights. The technology requirements would be powerful software and hardware to sustain real time onboard mission planning for the complex UAV missions that are anticipated in any future conflict dominated by air power.

Survivability of UAVs[14]

The survivability of UAVs is a critical issue. Certain losses of this low cost technology may be acceptable in comparison to its manned counterpart, but loss of cost effectiveness may not be acceptable to the operational community. Therefore, the survivability features must be brought in, in the case of each UAV design. This may have to be balanced carefully among cost, mission requirement, life cycle cost, and maintainability. The UAV design has to take into account two different dimensions of high density threat, where a manned mission could be a futile exercise but where some loss may be acceptable. And, the other end of the threat spectrum would be the little or no threat environment. Longer endurance, an inherent capability of all UAV operations, could make it less su . ivable but a multiple number of these less known air assets may compensate to an extent.

All UAV designs or procurement will require the appropriate mix of signature control, tactics, emission control and onboard counter-measures. In this respect, the design consideration has to take the route of any manned aircraft. Threat avoidance is the central issue of all manned or unmanned missions, which is why UAV missions

also should be planned carefully, with appropriate priority given to all the factors necessary for effective air power planning. A manned and unmanned mix for any mission will entail a new mission planning system, not applied in any air battle fought in recent history. The Kosovo War could have been cited as an example of such application, but the airspace in Kosovo was not as hostile as it could have been.

UAV Signature Control. There is no doubt that the best way to reduce the vulnerability of the UAV would be to reduce the radar signatures. That is why the UAV design will require the appropriate mix of signature control in the areas of radar cross-section, infra-red signature, acoustic signature and visual signature. This would include the shape of the vehicle, radar-absorbing paints or materials, radar-absorbing structure, infra-red signature reduction techniques, low observable sensor apertures, engine inlets, engine nozzles and other external components. Most of these technologies have already been applied to certain manned fighters in various shapes. Selective technologies for UAVs need proper application in the most cost effective manner. Cost overrun, while incorporating technology, may not be an acceptable solution. However, self-protection can be achieved by several methods such as onboard passive and active electronic counter-measures and, in unique situations such as encounters with major pop-up threats, near time intervention by the mission controller. And again, in each specific UAV system design, the trade-offs, usually based on costs of alternative systems, must be made to assure that the selected self-protection capabilities are clearly cost effective. It may be mentioned here that developing an all round survivable UAV could not have been an easy task.

Unmanned Tactical Aircraft[15]

Considering the rapid changes in technology, the unmanned tactical aircraft (UTA) concept has been adopted by air power exponents. This is a new concept intended to demonstrate the technology that will be the next logical step in the level of autonomy. Synergy among many information technologies is likely to have a pervasive effect on the evolution of the UAV concept as a whole. R.W. Galling has stated that the exploding general area of information technologies includes several enabling technologies. These futuristic technologies are:

- Photonic devices may replace or augment many electronic devices.
- Acoustic charge transport devices will enable more complex signal processing than the current technology.
- Full spectrum ultra-resolution sensors with focal plane arrays will lead to surveillance systems having increased resolution.
- Knowledge based systems will operate in real time and be directed by human speech. Expert systems will allow the UAV to make independent decisions regarding the fulfillment of its mission, and use reasoning to develop an alternate course of action.

- Micro-mechanical system will allow reengineering of the existing systems and make them smaller.
- Wafer scale integration of dissimilar technologies will enable integration of UAV payload sub-systems into monolithic blocks of reduced size and weight.
- Technologies that may integrate information processing, chemical and physical sensing fluidic and mechanical actuation, and radiation generation and detection.
- Smart skins with embedded antennae, sensor transmitter receiver signals and information processors may produce aerodynamic, thermal and cost benefits.

The earlier concept of the UAV related to a type of missile only—it followed the programmed path unless something went wrong. The German V-1 bombs were an example. In comparison, modern cruise missiles are much superior technically but the concept remains the same. And as the technology progresses, the idea is to develop these flying machines into radio controlled aerial robots. The operator must fly the aircraft under his control because the aircraft cannot fly by itself. And as the data link is only one-way, the operator or the ground pilot must get all the information needed to pilot the aircraft. The advantage of the system would be complete freedom to fly in any configuration.

Taking off from the earlier concepts, the UTA seeks to have systems that ideally combine the functions of man and machine in the complex environment of the future air battle. The continual adjustment of tasking for the human operator and the autonomous system in response to the changing mission environment is central to the UTA idea. That is why in the case of loss of data link, the UTA's autonomous system would take over more responsibility, subject to the last rules of engagement. In case the rules of engagement require ground station authorisation to release a weapon, and such authorisation is not forthcoming due to the loss of link, the system should proceed autonomously and the ground station must know about that autonomous activity. Such activities automatically place the operator in a very rich information driven environment, definitely greater than that of a manned fighter and also greater than that of the operators of the present UAV systems. The UTA design attempts to include many tactical aircraft missions because this will bring down the cost of tactical operations. Removing the human element from the aircraft may permit extreme manoeuvrability. Targets that are not worth expending a cruise missile on but that are defended heavily enough to discourage a manned strike, are possibly ideal for the UTA concept.

UAVs of the Indian Air Force

In his keynote address at the "International Seminar on Aerospace Technologies: Development and Strategies," at the Aero India, show at Bangalore, in February 2001, Air Chief Marshal A.Y. Tipnis pointed out the following:

> Uninhabiting the aerial platform is already underway for a variety of applications. While the uninhabited combat air vehicles (UCAVs) are in my reckoning, still at least two decades away, the concept has already taken a firm hold. The stand-alone UCAV is not likely to be progressed directly but will possibly evolve as a directed buddy to other manned aircraft. The UCAV has not only the attraction of keeping combat casualties low, but overcomes human limiting stipulations on Grunching manoeuvres, and stringent cockpit environment for protection and survival of the pilot. This will give it a mind stunning performance, with 30G yanked turns at astounding speeds of 15-20 mach. And all that survivability will be high for ensuring mission accomplishment; high survivability will also give it extraordinary resilience, increasing the reusability factor manifold.[16]

Indian Airforce has shown a keen interest in two Israeli UAVs. *Jane's Unmanned Aerial Vehicles and Targets* edited by Kenneth Munson makes a detailed mention of both Heron[17] and Searcher II[18] of Israel.

Airspace Management

The issue of airspace management is the key to successful operations in civil and military environments. The UAVs that the IAF can procure or develop must operate in diverse airspace environments, hence, appropriate approaches to airspace management are essential. For the high altitude long endurance aircraft, it is a relatively long climb to uncontrolled airspace. Such ascents require long climb corridors through controlled and, at times, through crowded airspace. Unless these are carefully planned and monitored, there could be disasters. Lower altitude UAV operations, which may be characteristic of attack aircraft concepts, will involve flight through controlled airspace environments, even in peace-time, for training and exercise missions. In war-time, when airspace environments are extremely crowded in certain areas, additional precautions are necessary. In India, UAV operations factors are generally unknown, and though the IAF has acquired UAVs, it will need to develop rules, procedures and proper planning for utilisation of these assets.

In the Director General Civil Aviation (DGCA) controlled air space, a separate set of rules is required to be formulated for easy operation of these flying machines. The rule of see and be seen can be the best solution. That will involve a chase aircraft or the use of restricted airspace for all UAV operations. Or else, the IAF can obtain a one-time clearance for such operations to outline the desired approach to UAV flight operations, pilot qualifications, etc. The DGCA may be involved in the development of the UAV and outlining its safety requirements.

But military operations in areas for which airspace management is the responsibility of the Air Defence Direction Centre (ADDC) or Joint Air Defence Direction Centre (JADC), as the case may be in the Indian context, there are laid down procedures for airspace coordination. The ADDC/JADC decrees the sole use corridors, designates control authorities (Airborne Warning and Control—AWAC. Control and Reporting Centre—CRC), establishes rules, and provides procedures for the safe passage and orbits of all manned aircraft, long range artillery, air defence

weapons and missiles. Free fire zones and flight corridors are established as a function of the time of day and, hence, a highly dynamic airspace deconfliction process is essential. It is right for the IAF to begin to think through the issue of airspace deconfliction for the broad range of environments and scenarios expected in the future battlefields in the subcontinent.

It is now abundantly clear that the senior leadership of the air force has displayed the vision to introduce an unknown system to be employed in autonomous and complementary roles. Therefore, an aggressive effort will be needed to introduce UAVs to the fighting forces and to integrate the capability into the joint planning structure for the future wars in the subcontinent. A strong vision and development of operational concepts should include UAVs as close complements to manned aircraft. Every effort must be made to clearly define and integrate mission systems, weapons, human systems, communications connectivity, mission planning and self-protection.

UAVs are a new concept as far as the IAF is concerned, which the forward thinking leaders have embraced. Continued high level interest and involvement will be essential during the initial stages of integration and future indigenous development, because one or two failures or mishaps will bring adverse publicity and that may destroy the confidence and future of UAVs with the IAF.

Like in any other battlefield, in the subcontinent also, the battle space will be dominated by a wide variety of platforms and delivery means like the Prithvi missile (for both the army and air force). There is talk of inducting the Agni into the force structure, which will have strategic consequences. Terminally guided or precision guided munitions, improved tanks and aircraft (both manned and unmanned) with precision capabilities will definitely be fielded. Induction of laser aimed weapons, and development of smart and brilliant munitions confirm the trend towards precision fire. This trend would place greater premium on generating synchronised responses from multifarious weapon platforms and delivery means to achieve military objectives. The element of time available for decision-making by military commanders would also be at a premium. And in such scenario, air power is going to play a dominant role, as has been clearly established in both the Gulf and Kosovo Wars. Such deliberations naturally bring in the factor of UCAVs, which are going to play a significant role in augmenting air power. The concept is technically feasible and has been proved in the current air wars. UCAVs can meet the operational needs and fit into a sound plan of operations. The historical bias for manned aircraft should not become a stumbling block in embracing this technology in the futuristic technology driven wars.

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16. Excerpts of the keynote address, Tipnis, n. 2.
17. Israel Aircraft Industries Malat Division, "Searcher MKII, Heron Pchela—IT", brochure distributed during the Aero India Air Show at Bangalore, February 2001). *Heron:* The Heron UAV system is an operational fourth generation long-endurance medium altitude system and is based on leading edge technology. It provides deep penetration, wide area, real time intelligence to national agencies and theatre commanders. The Heron has modular space up to 250 kg for customer furnished equipment and is inter-operable with other Israeli developed UAV systems. Heron can have SAR, maritime patrol radar, satellite data link capability. *Operational Capabilities.* In operational modes, the Heron, has real time payload and UAV control; GPS based interruptible airborne mission controller; full autonomous flight and autonomous return on data link loss. *Data links:* It has direct line of sight data link; UAV airborne data relay for beyond line of sight data link, dual real time command uplink and single real time data and voice downlink. *Launch and Recovery:* Automatic take off and landing. *Endurance:* 40 hours. *Range:* 200-350 km, may go upto 1,000 km. *Altitude:* 30,000 ft.
18. Ibid., *Searcher Mk II:* The Searcher Mk II is the tactical multi-payload UAV system. This can be used for surveillance, reconnaissance, target acquisition and artillery fire direction. Standard payload can be TV and IR combination. *Operational Mode:* The Searcher II has real time payloads and UAV control mode. This has GPS based airborne mission controller mode with real time manual interruption capability. Also this is equipped with autonomous return mode activation on data link loss. *Data links:* Direct line of sight data link. UAV airborne data relay for beyond line of sight data link, dual real time command uplink and single real time data and video downlink. *Launch and Recovery:* Automatic take-off and landing. *Endurance:* 15 hours with range between 200 to 250 kms. *Altitude:* 20,000ft. *Max Takeoff Weight:* 426 kg. *Dimensions:* Length 5.85 metres. wing span 8.55 metres.