UNMANNED AIRCRAFT SYSTEMS: A DISRUPTIVE TECHNOLOGY

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Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur.

–Giulio Douhet

The present day warfare is completely technology oriented. The induction of automated, unmanned or autonomous systems into the defence forces is shaping the new rules of warfare while transforming the existing landscape of warfare. These systems include vehicles which perform diverse functions in military and security arena, such as intelligence gathering, surveillance, reconnaissance, combat support on the ground, in the air and above or below the sea surface. Such systems could be classified as disruptive as they have the potential to shape the conduct of warfare at both strategic and tactical levels and open up new domains of warfare. Moreover, unmanned system technology has the potential to radically change the utilization of the space where they are put into use, and they are already outdating policies and doctrines of the armed forces. As the use of unmanned systems is gaining ground, and research and development is delivering results, these technologies alter the symmetry among competing military powers.

The unmanned systems technology in aviation has gradually exceeded the capability of manned aircrafts under certain theatres, due to their unparalleled performance in persistence, flight longevity, ability to operate in dangerous environment and mission cost effectiveness. These factors have clearly made Unmanned Aircraft Systems (UAS) a disruptive technology in the defence and intelligence operations domain spread across reconnaissance, surveillance, strike and close combat support. An

Unmanned Aerial Vehicle (UAV) is a remote controlled aircraft flown by a pilot at a ground control station or capable of flying autonomously based on pre-programmed flight plans or more complex dynamic automation systems with on-board computer. The U.S. Department of Defense defines UAVs as "powered, aerial vehicles that do not carry a human operator, use aerodynamic forces to provide vehicle lift, can fly autonomously or be piloted remotely, can be expendable or recoverable, and can carry a lethal or nonlethal payload" . The term "Unmanned Aircraft System" is a result of the increasing complexity of these automated systems including the ground stations, communication or data links, payloads and other elements besides the actual air vehicles. So, a UAS is the unmanned aircraft along with the associated support equipment which includes the control station, the data links, telemetry, communications and navigation equipment, etc., necessary to operate the unmanned aircraft.

In the present day military operation, unmanned systems are highly desired by combatant commanders for their versatility and persistence. By performing tasks such as surveillance; signals intelligence (SIGINT); precision target designation; mine detection; and chemical, biological, radiological, nuclear (CBRN) reconnaissance. UAS provides an additional capability to the commander to conduct day or night reconnaissance, surveillance, and target acquisition (RSTA), rapid battle damage assessment (BDA), and battlefield management (within line-of-sight (LOS) of the ground control station (GCS)) in high-threat or heavily defended areas where the loss of high-value, manned systems is likely and near-real-time information is required. . The UAS technology is classified as being disruptive since it has the potential to radically change the utilization of airspace.

The UAS find diverse applications in security (such as border patrol and perimeter security); and environmental, emergency response for missions varying from surveillance (oil rigs and pipelines) to storm and weather monitoring to search and rescue to emergency management (wild-fire monitoring, suppression) to damage assessment during natural disasters

Components of the UAS

The UAS is an integration of aerial vehicle, the payload and its ground control station. The vehicle is the platform to deliver the payload near the target or over the targeted area. The vehicle does not deliver the message

or the data: it just gets the payload to the desired location, and therefore payload is the most important element of the whole UAS. Subsequently, the propulsion system of the vehicle depends upon the mission, for instance electric engines are a suitable for silent operations whereas long distance or high altitude operations need jet engines.

Evolution of UAS Technology

The concept of remotely controlled aerial vehicle has evolved significantly since its first use as a weapon during the Second World War by Germany, under the name German FX-1400 or "Fritz". Post war, the technology witnessed little development. In 1982, during the Lebanon war, the Israel Air Force pressed its weaponized UAV, the Pioneer into operations. The operational success of Pioneer triggered the interest of the US in UAVs which eventually led to procurement and intense research. During the Vietnam War, the Ryan 147 reconnaissance UAV provided the armed forces with imagery which helped in identifying precise locations of surface-to-air missile (SAM) sites, enemy airfields, ship activity in Haiphong Harbour, and detailed battle damage assessment (BDA). The US military's first major expenditures on UAVs began after the Vietnam War, when the Air Force used small, long range, experimental drones called Fireflies in conducting reconnaissance. The US Navy acquired the Pioneer UAV from Israel and used it to provide tactical-level intelligence during Operation Desert Storm in 1991. In Desert Storm, the Pioneer played an important role in target designation, damage assessment, and reconnaissance for both the US Navy and Army. The success of the Pioneer in Desert Storm led to the Department of Defense spending over 3 billion USD on UAV programs during the 1990s.

UAS	Aerial Vehicle/Platform	Airframe
		Propulsion system
		Flight control computer or system
		Precision navigation system
		Sense & Avoid System
	Payload	Electro-optical Sensing Systems and Scanners
		Infra-Red Systems
		Radars/ Synthetic Aperture Radar
		Dispensable loads (Munitions, flares)
		Environmental sensors

Ground Control System or Station	An avionics flight display Navigation Systems System Health Monitoring and Prognostics Display Graphical Images and Position Mapping Secure Communications Systems Inward Data Processing

Components of the UAS
(Source: www.uavs.org)

The big break for UAVs came in the mid-1990s, when Advanced Concept Technology Demonstration program (ACTD) at the Pentagon, responsible for funding and testing innovative technologies, decided to invest in them. The Predator endeavour began with a 30-month ACTD contract awarded in January 1994.

The technology built around UAVs was put into exercise during the Global War on Terror, Operation Enduring Freedom, and Operation Iraqi Freedom, enabled with combat capability in addition to intelligence, surveillance and reconnaissance specific payloads. The demand for Predator UAVs equipped with Hellfire missiles surged in the aftermath of terrorist attacks on the World Trade Centre in September 2001. The weaponized variant of Predator was put into services in Afghanistan and Iraq by the US Air Force and the Central Intelligence Agency. Predators destroyed several Iraqi mobile radar units in preparation for the arrival of US ground forces, just prior to the Operation Iraqi Freedom. At operational level, the UAVs are utilized for direct support of military operation or search and strike missions, being used as surveillance platform as well as weapon system. By 2007, the US armed forces began utilizing UAVs in counterinsurgency operations in Iraq and the resultant demand for drones skyrocketed.

The demand for UAS is further augmented by the changing regional geopolitical landscape. For instance, the Poland's Air Force plans to expand its fleet of UAVs for reconnaissance and surveillance missions, in the wake of Russia's annexation of Crimea. South Korea is also in the process of acquiring Global Hawk Block 30 UAVs, to improve the country's military surveillance capabilities. The geopolitical developments have led countries like Iran and Syria to invest in research and development of UAS. The volatile political situation in the neighbourhood, insurgency within the

national borders and terrorism or cross border infiltration have also compelled India to deploy procured UAS, while moving towards a robust growth of indigenous UAS design, development and manufacturing.

Military Roles for Unmanned Aircraft Systems

The UAS are configured and optimized for a wide spectrum of military operations depending upon the mission objective. The systems can undertake simple operations for reconnaissance or attack on fixed ground targets, as well as challenging tasks involving attack on mobile ground targets or air-to-air combat. The operations vary in degree of difficulty, accuracy and precision. The aerial vehicles of an UAS are deployed for a cross-section of missions which could be broadly categorised as:

1. Situational Awareness

UAVs were initially deployed for Intelligence, Surveillance and Reconnaissance (ISR) missions owing to their advantages over manned aircraft in high loiter time and endurance. In ISR configuration, the UAV may carry an Electro-Optical camera, Infrared Sensor or a Synthetic Aperture Radar as payload to generate imagery. UAV can now carry Synthetic Aperture Radar (SAR) which can pick out manmade objects not readily visible to Infrared or Electro-Optical cameras. SAR can "see" through dust, fog, rain and sandstorms, making it particularly useful for military surveillance and reconnaissance. Situation Awareness is a capability area where unmanned systems in all domains have the ability to contribute significantly into the future to conduct Intelligence, Surveillance, Target Acquisition and Reconnaissance related tasks.

2. Armed Reconnaissance and Suppression of Enemy Air Defenses (SEAD) or Electronic Warfare:

Under the ISR configuration, UAVs are capable of generating desired imagery for the area of responsibility, but the commanders depend upon missiles or attack aircraft to launch an assault. In the case of time-sensitive targets, the response time for attack is critical to mission success, so an armed UAV is capable of launching attack is highly desired. An armed UAV could be capable of attacking a fixed or mobile target on the ground or in the air. Such a capability equips the UAV to suppress the Enemy Air Defenses while carrying an Electronic Intelligence (ELINT) payload. The Predator platform being integrated with the laser-guided Hellfire-C missiles has helped the U.S. in

neutralizing high-value targets from Al-Qaeda in Afghanistan and Yemen.

3. Counter Air

A more difficult future task for an UAV could be air-to-air combat. Although UAS offensive operations to date have focused on ground targets, UAVs are being designed to carry air-to-air weapons and other systems that may allow them to undertake air superiority missions.

A variety of UAV platforms are in production to suit the varying needs of military missions. They range in size from the "micro" weighing a few pounds to around 7,600 pounds, with service ceiling varying from few feet to 65,000 feet, and ranges of 5,600 km and endurance of up to a few hours to 32 hours. The UAS are being designed for a spectrum of military roles such as resupply, combat search and rescue, and refuelling.

Military Applications of UAS

The experience of warfare in the last decade and half clearly demonstrates that unmanned systems can enhance situational awareness, improve the mission performance, reduce workforce requirements and operational costs, and above all, minimize the risk to military personnel. The various advantages have compelled the top militaries of the world to secure their competitive edge in the changing landscape of the battlefield where unmanned systems are being designed, developed and optimized for perform dull, dirty, or dangerous missions.

- Dull missions are ideal for unmanned systems because they involve long-duration undertakings with mundane tasks that are not suited for manned systems. Good examples are surveillance missions that involve prolonged observation.
- Dirty missions have the potential to unnecessarily expose personnel to hazardous conditions, such as chemical, biological, and nuclear detection missions.
- Dangerous missions involve high risk, and with advances in capabilities in performance and automation, unmanned systems will reduce the risk exposure to personnel.

Security
Security and Control
Aerial Reconnaissance
Chemical, Biological, Radiological and Nuclear Conditions
Battlefield Management
Aerial Traffic and Security Watch
Telecommunications Traffic
Opposing Control Centre Communications

Munitions

Air to Ground Missiles
Guided Shells
Anti-Tank Missiles
Air to Air Missiles
Wide Area Munition Deployments

Monitoring
Waterways and Shipping
Pollution Control and Air Sampling
Chemical, Biological, Radiological and Nuclear Deployments
Impact and Disaster Management
Impact and Disaster Effects Management
Rescue and Clear Up Effort Supervision
Disaster Damage Estimation

Search and Rescue

All Terrain Search and Rescue
Life Raft Deployment
Rescue point marking

Communications

Secure Telecommunications
Telecom Relay and Signal Coverage Survey

Military Applications of UAS
(Source: www.uavs.org)

The US leads the research, development and manufacturing of these systems, as its Army, Navy and Marine Corps operate around eleven thousand UAS in different theatres including Pakistan and Afghanistan. The research, development and manufacturing in the global context is led by numerous enterprises from the private sector: Boeing (USA), General Atomics (USA), Lockheed Martin (USA), Northrop Grumman (USA), Prox Dynamics AS (Norway), Denel Dynamics (South Africa), Israeli Aerospace Industries (Israel) and so forth.

UAS Classification

The configuration of a UAS depends upon the mission. For some missions, endurance is critical while for others, minimal ground equipment is vital. The classification of UAS could be done according to parameters of

mass, range, flight altitude or endurance. Furthermore, categorization could be done according to the mission such as close range, short range, medium range, Low Altitude Deep Penetration (LADP), Low Altitude Long Endurance (LALE), Medium Altitude Long Endurance (MALE) for tactical application; High Altitude Long Endurance (HALE) for strategic missions; or special tasks such as combat, often categorized as Unmanned Combat Aerial Vehicle (UCAV).

As there are many types of missions, there are also many types of UAVs. Each has a broad range of characteristics to allow it to satisfy the requisites of a specific mission. Size (measured by payload capacity) and endurance (maximum flight time) are the biggest differentiators, but mode of flight also matters. Observers sometimes divide the UAV industry into three classes, called Tiers. Although the armed services differ on how to define the tiers, the U.S. Army Tier is as follows :

- Tier I UAVs are highly portable and can be hand launched (many can be carried in a soldier backpack). They are intended to allow small troop units to gather awareness in the vicinity, such the next building or on the other side of a nearby hill. Tier I UAV payload capacity is typically less than three to four pounds and their endurance is an hour or less. They rarely carry more than a single standard definition Electro-Optical camera. Examples of Tier I UAVs are the AeroVironment Raven and the Lockheed Martin Desert Hawk.
- Tier II UAVs can often be lifted by two men and might carry 5 to 30 pounds of payload, which could include several different types of sensors including Electro-Optical, Infrared or SAR radar. These UAVs support larger troop formations with more wide-ranging missions and can operate out to the line-of-sight horizon, with endurance of as much as 12 hours or more. The Insitu Scan Eagle, AAI Shadow, or DRS Sentry are Tier II UAVs.
- Tier III UAVs are almost of the same size of a small passenger aircraft. They carry a wide range of sensors, including sophisticated on-board image and sensor data processing payloads. In recent years Tier III UAVs are increasingly being configured to carry weapons so that they can fire weapons, working in concert with soldiers on the ground to ensure that the target is found and finished. Examples of Tier III UAVs are the fixed wing General Atomics Predator and Northrop Grumman Global Hawk, or the rotary wing Boeing FireScout.

UAS in Warfare: A Disruptive Technology

UAS has been the most dynamic growth sector of the global aerospace industry in the last one decade. The present day UAS is an amalgamation of advances made in different domains of science and technology, such as composite materials, aerodynamics, communication systems, radars, propulsion systems, precision navigation systems, sensors, digital signal processing and so on. The UAS is emerging as a platform of choice for the commanders owing to three converging trends. First, the aircraft or aerial vehicle is becoming increasingly autonomous, powered by on-board computers; the functions of flight path, targeting and weapons delivery are carried out by the on-board computers. Second, missiles have become more sophisticated and capable of functions, such as target selection, which were previously carried out by the weapons platform. Third, new technologies have made UAVs capable of greater performance levels and quickly adapt to the evolving performance needs. Day-by-day the advancing technology is augmenting the existing capabilities of UAS, primarily led by the military interests these systems are fulfilling; a host of missions like strike mission, suppression of enemy air defence, search and rescue and electronic warfare. Perhaps, seventy-five countries across the globe are known to have deployed or in the process of deploying UAS, and the number of countries possessing armed UAS is also growing.

According to the authors of "Game Changers" publication of the Center for a New American Security, a disruptive technology is "a technology or a set of technologies applied to a relevant problem in a manner that radically alters the symmetry of military power between competitors. The use of this technology immediately outdates the policies, doctrines and organization of all actors." In this context, the UAS has been a key instrument for the US to demonstrate its military power in Iraq and Afghanistan. Over the course of global war on terror, UAS have possibly played a significant role in shaping the outcomes of the war and altering the symmetry of military power in the favour of the US. The technology caught the adversary off-guard, enabling the US forces to not just generate high quality ISR imagery but to launch precision strikes against "time-critical" or "high value targets". In terms of mission effectiveness, since 9/11, the Predator and Reaper have killed more than half of the 20 most wanted al-Qaeda suspects, the Uzbek, Yemeni and Pakistani heads of allied groups and hundreds of militants.

The UAS may not contest the technological aspects of a manned military aircraft, but it is certainly disrupting the facets of ISR and SEAD operations of a manned military aircraft under specific mission requirements. This development is quite evident from the fact that during 2009-10, the Pentagon recommended to curtail the development of the manned F-22 and F-35 aircraft while increasing its procurement of UAVs/UAS. The Global Hawk UAV is part of the US Air Force inventory along with the renowned U-2 high-altitude reconnaissance plane, although, attempts were made earlier to phase out the U-2. The US Air Force is planning to spend up to 4 billion USD in modernization efforts over the next five years on the Global Hawk. Such developments are further validating the preference of UAS over existing ISR platforms, displacing these well-established platforms and emerging out as a disruptive technology.

In his pioneering work on "Disruptive Innovation", Professor Clayton Christensen describes it as a "process by which a product or service takes root initially in simple applications at the bottom of a market and then relentlessly moves up market, eventually displacing established competitors." Drawing parallels from his definition to the defence technology, UAS initially gained the roots in simple ISR applications, at the bottom of the value chain. The manifestation of constituting technologies immensely helped UAS to move up the value chain, and in the present format, the UAS are quite capable of displacing their well-established platforms, the manned aircrafts in the ISR segment, and they are steadily gaining ground in complex missions and combat roles as well. As a result, not just the numbers of UAS in the military inventories has surged, the technology is attracting substantial investments in form of allocation of research and development budget.

Advantages	Disadvantages
Lower cost of operation	Autonomous vehicles lack the capacity for re-targeting
Lower development and manufacturing cost	Short life span
Reduces risk to human life in combat	Limited manoeuvrability
Reduces demand for facilities and manpower	Payload limitations
Enables operational agility or rapid deployment	Large bandwidth requirement for communications, vulnerability to jamming
High mission endurance and loiter time	Lower situational awareness

Advantages and Disadvantages of UAS over Manned military aircraft

Furthermore, the UAS has disrupted the modus operandi of warfare. It

is leading to changes in military tactics in the theatre of battle as well as shifts in doctrines and strategies. The UAS technology has gained substantial traction in the military sphere over the last one decade. Owing to their persistence, cost effectiveness, and flexibility, the technology is disrupting the operational aspects of defence and intelligence organizations across the globe. Although, the military strategy and doctrine is guided by the larger picture of a nation states' threat perception, but it plays a critical role in the development of technology. The recent military strategy documents or technology roadmaps are carrying a dedicated section on the UAS.

The Quadrennial Review of U.S. Department of Defense, 2001, emphasized on the role of manned and unmanned long-range precision strike assets. The Quadrennial Review of 2006 recommended the establishment of an Unmanned Aerial Vehicle Squadron under U.S. SOCOM and set a target for the unmanned systems to be 45 percent of long-range strike force by 2025. The expansion plans of UAS for ISR were furthered in the review of 2010. As per the 2014 Quadrennial Review, the US forces are slated to increase the use and integration of unmanned aerial systems for ISR.

In 2005, the US has published its Unmanned Aircraft Systems Roadmap for 2005-2030, with the purpose of guiding the military departments and defence agencies toward a logical, systematic migration of mission capabilities to this new class of military tools. According to Dyke Weatherington, the director of the unmanned warfare and intelligence, surveillance and reconnaissance office at the Pentagon, "the integrated roadmap articulates a vision and strategy for the continued development, production, test, training, operation and sustainment of unmanned systems technology across Department of Defense." The changes in the US military doctrine calls for swift deployment of forces, and UAS are going to be central to the agility of the forces in the future battle field.

Russia has also developed a comprehensive strategy for utilizing unmanned aircraft systems and, more broadly, robotics technology in warfare. The Russian military perceives this strategic approach foremost as "no-contact warfare", described as a war where Russian military can defeat a hostile state without the engagement of regular Russian forces. During the Ukraine conflict, Russia pressed UAS into service for reconnaissance missions, in consistence with its shifting military doctrine of employing "no-

contact warfare".

The Russian defence research unit, Russian Foundation of Prospective Research (RFPR), has identified that UAVs is an area of technology where the Russian defence industry has insufficient competencies. To overcome Russia's shortcomings, the RFPR has prioritized domestic R&D and production, along with foreign technology transfers. Based on the 2013 publication "Russian Military Capability in a Ten-Year Perspective", for Russia, research on UAVs is a high priority. The technological gap has been identified and Russian MoD had to acquire Israel made UAS in 2009.

Israel has been the pioneer of the modern UAS technology. The Israeli military was the world's first operator of a modern unmanned aerial vehicle. The first UAV by Israel made its debut in the 1982 Lebanon War, relaying images of troop movements, it enabled Israel to achieve aerial superiority early on by neutralizing Syrian anti-aircraft batteries. It has been a prominent exporter of UAS technology owing to its prowess in this domain. Israel has four decades of urban warfare experience in Lebanon, the West Bank and Gaza Strip. The geopolitical environment and threat landscape have shaped the military doctrine of Israel towards a small yet effective defence forces, and UAS technology has been central to this under such circumstances.

The cold start doctrine enables the of the Indian armed forces to carry out swift, quick and offensive joint operations with the support of Air Force and air elements of Navy while denying the adversary any time to respond. Such a force posture is going to integrate air support, Network Centric Warfare, Electronic Warfare etc. for swift deployment of forces along its borders. The UAS are already finding utility in border security. India operates Israel made Searcher, Heron and Harop UAVs. In a recent development, India is also going to acquire Heron TP armed drones from Israel for combat operations. The efforts for indigenous design and development have culminated in the form of Lakshya, Nishant and Rustam. The UAS is going to be an integral part of the doctrinal changes in the Indian Armed Forces, which has underscored the need of jointness.

Doctrines are constantly evolving; and they are reviewed or updated from time to time reflecting upon the new concepts, policy directives, advent of new technology, and the changes in geopolitical environment. With

integration of military operations, across the verticals of air, land and sea, UAS are slated to play a pivotal role in shaping the doctrines, strategies and tactics of warfare.

As a technology, the UAS has not just gained attention of military as well as political decision makers; it has gradually made inroads to the strategy and vision for the networked warfare of the future. Nation states are rushing to procure or indigenously develop this technology. Nevertheless, the integration of UAS into the military forces and the responding to the doctrinal changes this technology has brought are the key challenges. As the UAS technology rises up the value chain, it is disrupting manned aircrafts in the ISR segment of military and intelligence operations. It is quite competent to alter the symmetry of military power between competitors. The risks of disruption in warfare are understood and benefits evaluated, as a result the policies and doctrines of all the state actors with military forces are changing with the realities of the threats and technological developments, where UAS has carved out a niche.

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