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Abstract

India currently operates close to 50 drones in various military, reconnaissance and intelligence gathering configurations, a number more than that of France, Germany and Italy combined. Internationally certified figures[1] show that India has the second largest number of acknowledged drones in the world after the United States of America. Yet the Directorate General of Civil Aviation (DGCA) does not yet have an official policy towards the civilian application or uses of drones. Nor does India have any enabling administrative and institutional framework for the different kinds of drones that have started appearing in the skies. Drones pose unique policy challenges that transcend conventional domains of national security, safety, consumer technology, aviation, privacy and business practices. Drones also fundamentally question our long-held notions of nationhood, sovereignty and geographical boundaries, as well as our frameworks of geopolitics and statecraft.

This paper will first explore the rapidly emerging global landscape of drones to understand and analyse the various ways in which these autonomously and remotely piloted aerial vehicles are integrating themselves with various aspects of military and civilian domains. Second, the paper will outline the global policy implications of such a rapid proliferation. In almost exclusively equating drones with military operations, its increasing diversity in terms of civilian applications—from micro-drones delivering pizzas to intelligently network smart drones mapping land resources—is not given adequate attention. This leads to several policy blind spots. Finally, the paper will identify specific policy issues related to military and civilian drones that the Indian establishment must address in a comprehensive manner so that the future policy and regulatory environment becomes an enabling framework rather than a mere reactive system of ad-hoc decisions.

Keywords: Drones, Security, Airspace, Aviation

I. Civilian Drones and the Indian Context

India operated its first drone in 1996 when the Army acquired an Israeli Searcher Mark I.[2] Less than two years later, the Indian Air Force and the Indian Navy followed suit. It is a fact that comes as a surprise to many policymakers and experts who would like to believe that India's technical experience with drones is practically non-existent. India has, in fact, a fair amount of expertise in the operation of drones of different complexities, for purposes of intelligence gathering, reconnaissance, military targeting, remote sensing, environmental conservation and even the delivery of pizzas to civilian abodes. Any unmanned aerial vehicle that is autonomously or remotely piloted—either individually or in a networked manner—can be termed as a 'drone.' The technically correct terms are either Unmanned Aerial Vehicle (UAV)or Remotely Piloted Vehicle, both of which are used interchangeably. The military potential of drones in establishing robust Indian security architecture is fairly well established.[3] It is a cost-effective system and platform that integrates ideally with the concept and practice of net-centric warfare that is being pursued actively by all branches of the Indian Armed Forces. Drones remove the immediate human element from aerial warfare, and also allow for more independent and autonomous decision-making at the level of ground commanders. The complexities of an unmanned aerial system lie in creating its electronic brain. Beyond that, the other elements are relatively easier to develop, such as the airframe design, Automatic Take-off and Landing systems, composite airframe, high aspect ratio wing, stealth characteristics, engines and even low observable materials.

India has a reasonably strong indigenous drone ecosystem, in no small measure due to the efforts of government bodies like the Defence Research Development Organisation (DRDO) and National Aerospace Laboratories, research institutions like the Indian Institute of Science, and even individuals like Prof. Rustom Damania after whom Rustom series of drones, including its weaponised versions of Rustom-II and Rustom-H currently under deployment. The Rustom series of drones will eventually replace the Israeli-origin Heron employed by various wings of the Indian security establishment. The integration of drones and UAVs into the larger Indian national security apparatus is inevitable. The global military experience of other countries, notably Israel, does serve as some sort of a blueprint for a set of markers and paths that may be undertaken and the results of which can be measured. What has not been well-documented nor researched has been the increasing proliferation and integration of drones and UAVs into the Indian civilian sector.[4] The following outlines the various forms of integrations that are taking place at a rapid pace.

Agriculture: UAVs are increasingly being deployed for a variety of agricultural operations—from spraying of pesticides and fertilisers to monitoring soil quality, erosion and maturity of crops. Concerned with the dwindling number of rice farmers, the Japanese agricultural policymakers[5] were the first to apply drone technology to the agriculture sector in a concerted manner almost 20 years ago in 1986. Today, remotely piloted helicopters cover "more than 10% of Japan's rice acreage."[6] This single policy decision promoting the use of drones spawned a sophisticated agricultural drone industry, and currently Japanese giants Fuji Heavy Industries RPH2 and Yamaha's RMAX[7]—which are both fully autonomous sprayers—are considered world leaders. There are over 8,000 of these machines being employed by Japanese farmers. In India, as part of the second Green Revolution, especially rice cultivation in the northeastern regions, the government is actively considering seeking Japan's help in deploying drones for farming operations.

Forests and Wildlife: General Atomics, an American defence contractor, has collaborated with the US National Space Agency (NASA) and the US Department of Agricultural Forest Service to create a tactical UAV for fighting forest fires. The same platform has been further integrated with thermal infrared imaging technology, data telemetry and algorithms to successfully track wild animals.[8] Such drones are now being manufactured by Indian companies for increasing use by the country's civilian institutions. IdeaForge is one such company. Its multifunctional and multipurpose Netra UAV,[9] developed in collaboration with DRDO, has been used for tracking a killer leopard in Uttarakhand, for the tiger census[10] and for monitoring the communal situation in Saharanpur.[11]

Mapping and Monitoring: Garuda Robotics, set up in 2012 by 20-year-old Pulkit Jaiswal[12] from Delhi, sells high-end software and algorithms that are integrated with unmanned platforms, customising them for specific tasks like monitoring green cover, 3D mapping, meteorology, ecological audit and soil quality testing. Such customised unmanned platforms are already being deployed by several institutions associated with the Ministry of Earth Sciences and departments of meteorology, urban development, town planning and logistics. During the September 2014 Kashmir floods and last year's June flash floods in Uttarakhand,[13] the National Disaster Management Authority deployed four UAVs to scan affected areas that rescue and relief workers had not been able to reach. At the Panna Tiger Reserve in Madhya Pradesh,[14] meanwhile, drones are used to keep an eye out for poachers.

Earth Sciences: NASA predicts that unmanned aerial systems (which include the UAV, pilot and ground control station) will soon integrate themselves with satellite functions, allowing for detailed 3D mapping and providing better data sets for analysis. NASA further predicts that UAV capabilities will soon include "measurement of geophysical processes associated with natural hazards like earthquakes and volcanoes, aerosols and gas levels in clouds, changes in the stratospheric ozone chemistry, tropospheric pollution and air quality, water vapour, changes in the composition, vegetation, coral reefs and nutrients of coastal zones, emissions from fires and volcanic plumes, oxygen and carbon dioxide levels in the air, vegetation structure, composition and canopy chemistry, glacier and ice sheet thickness and surface deformation, radiation levels, evolution and landfall and physical oceanography, meteorology and atmospheric chemistry."[15]

Law and Order: It may come as a surprise to most analysts that the state of Uttar Pradesh has been one of the more proactive Indian states to deploy drones and UAVs equipped with high-definition cameras and sensors to monitor sensitive communal situations. It now routinely use drones to monitor large public gatherings in Lucknow such as the Ramadam Procession, which incidentally led to the loss of three lives in 2013 during the aftermath of a sectarian clash. State authorities also deployed networked drones at the Kumbh Mela in 2014. Similarly, Airpix partnered with Mumbai police this year to provide the latter data and feeds last year's Ganesh Chaturthi processions. The feeds were relayed to traffic police officers over mobile phones to allow for instant diversions, vehicle and crowd control in real time. Inspiration for the increasing adoption of drones by Indian security establishment for law and order and internal security purposes, of which the anti-Maoist operations is a prime example, comes from the way homeland security in the US has been revamped in the post-9/11 security environment. A recent study by the Advanced Defence Technologies Incorporated[16] found that India has the fastest growing micro- and mini-drones market in the world. Drones equipped with infrared and high-resolution imaging are being evaluated by the Indian security establishment for border surveillance, coastal and maritime security, oil and natural gas pipeline monitoring, securing offshore assets (particularly oil rigs and ports) and urban security.

Media and News Coverage: During the recently concluded coverage of the 2014 general elections, several media companies used drones extensively for covering large political rallies and producing camera angles to which Indian audiences had never been exposed before. The rapidly plummeting cost of drones, mainly brought about by Chinese drone manufacturer DJI, allowed several Indian startups to offer drone aerial photography and video services.[17] Funaster and Quidich are two Indian startups that now extensively provide different kinds of media services based on drones and UAVs. Quidich also had a tie-up with Indian media house *Headlines Today* to cover election rallies and events in various cities like Varanasi, Muzaffarnagar, Vadnagar and Amethi.

Drones are no longer esoteric and confined to military precision strikes. There is no doubt they are here to stay. UAVs of different capabilities are going to become increasingly integrated with day-to-day civilian existence. It is not inconceivable that surveillance and monitoring drones of today may be integrated with software and algorithms in the near future to read credentials (i.e., identity cards) and be equipped with facial-recognition capability. Indeed, the ecosystem for integrating drones with the emerging digital governance, financial, transactional and electronic commerce frameworks already exists. What it requires is technical integration through a set of overarching protocols for drones to become an integral part of the emerging digital society. Such technocentric reality is imminent. What is not keeping pace is the policy and regulatory framework in India. It is critical for India to adequately understand, modulate and moderate this new reality of UAV technology.

II. Emerging World of Drones: Policy Challenges for India

Even the most meticulously researched scenarios about the future of drones are, at best, a calculated guess. There is no sure way of knowing how drones are going to integrate with the future built and non-built environment. There is a distinct possibility that they may evolve into autonomous and independent systems capable of taking real-time, on-the-spot decisions. But there is still no clear idea whether they will turn into networked systems contributing to collective human intelligence or become a hub artificial intelligence in themselves. This conundrum—the inability of humans to accurately forecast the emerging terrain of drones—is best brought out by a tiny division in the massive Federal Aviation Administration (FAA)[18] of the United States. The unit, called the unmanned aircraft systems office, is mandated by US Congressional law to map, document and track all UAVs flying in American airspace by September 2015. The FAA experts had earlier predicted that the American skies would be filled with 30,000 drones by 2030, but this was before Amazon displayed a workable model for package delivery by drones and before powerful New York Mayor Michael Bloomberg unveiled his controversial Domain Awareness System[19] to use micro-drones for general day-to-day surveillance. The experts are now forced to rework their estimates and figures. According to one estimate by the Association for Unmanned Vehicles Systems International, American skies will be home to at least 30,000 drones by the end of 2015 itself, with close to 15 million drones crowding the skies by 2030. China, meanwhile, is already delivering packages using drones. Recently, delivery company SF Express was forced to admit that it was using drones to deliver packages in Dongguan, a city of about eight million people, when pictures surfaced on Chinese social media websites. Interestingly, the local authorities were in the loop and actually gave permission to the company. Each drone can carry up to 6.6 pounds and fly at about 330 feet.

Drones were also successfully used by an Indian pizza company, Francesco's Pizzeria, to deliver food to the rooftops of houses in Mumbai on an experimental basis. In contrast to the Chinese local authorities, the Mumbai police ended up banning the use of remotely piloted vehicles for commercial purposes due to the lack of any 'clear guidelines'[20] from either the Directorate General of Civil Aviation (DGCA)[21] or the civil aviation ministry.

Within the aviation and aerospace sector, the remotely piloted vehicles market is the fastest and strongest growing sector in the last five years. The Australian Government's Civil Aviation Safety Authority predicts that the civilian drone market will outstrip the defence drone market in terms of revenues in the next two decades.[22] A 2014 study done by the Teal Group, an American defence and aerospace consulting firm, estimates that institutional and non-institutional spending across the world on military and civilian drones will "more than double over the next decade from current worldwide expenditures of US$5.2 billion annually to US$11.6 billion, totalling over $89 billion in the next decade".[23] Not only the sheer number but the variety of drones proliferating the airspace today is also mindboggling. A quadracopter used by Amazon with a flight ceiling of 300 feet, with an ability to fly as low as 100 feet, is a drone. So is a remotely piloted plane used by enthusiasts with a flight ceiling of 1,000 feet. There also exist micro-drones that fly very close to the ground, increasingly used by media companies and extreme sports enthusiasts to record and transmit perspective footage, some of which would be dangerous or next to impossible to achieve by human crews. There are drones that fly at the altitude band used by commercial passenger aircrafts (between 25,000 and 40,000 feet), as well as unmanned vehicles, mainly owned and operated by military establishments and contractors, which fly at over 60,000 feet. Over the last few years, most institutions dealing with autonomous piloted vehicles have settled upon two major classification systems: One based on functional categories and the other on range and altitude.

On the basis of functional categories there are six kinds of UAVs:

1. **Target and Decoy:** Examples include the Northrop BQM-74 Chukar; India's Lakshya, which is officially designated as a Pilotless Target Aircraft; Abadeel III of Pakistan; and the Russian Lavochkin La-17, which incidentally was Soviet Union's first UAV in 1953.
2. **Reconnaissance:** Examples include AAI RQ-7, Northrop Grumman RQ-180, India's DRDO Nishant and Israel's IAI Hunter.
3. **Combat:** Examples include Israel's Harop, Eitan and AP-10PCAS; India's DRDO Rustom-II; British Taranis; Dassault Aviation's nEUROn, being developed by a consortium of European nations; Russia's Skat; and, the most well known, the American MQ-9 Reaper and RQ-1 Predator.
4. **Logistics:** Domino's Pizza's specialised drones manufactured in China called DomiCopters, and Amazon's octocopters and quadracopters.
5. **Research and Development:** Examples include Brazil's Acauã VANT, Dassault's AVE-D Petit Duc and AVE-C Moyen Duc.
6. **Civil and Commercial UAVs:** Examples include Aeronautics AISR for oil and natural gas exploration, Aerostar for media operations, Iris+ for personal use, AirDog for sports, Orbiter UAV for law and order missions and Dominator UAV for multiple civil and commercial operations.

The PacAberporth Unmanned Systems Forum classification is probably the most comprehensive categorisation of remotely piloted vehicles in terms of range and altitude:

1. **Hand-held:** 2,000 feet (600 metres) altitude, about 2 km range. Examples include Puma Dorin, Black Hornet and Raven.

2. **Close Range:** 5,000 feet (1,500 metres) altitude, up to 10 km range. Examples include MQ-8B Fire Scout, Russia's Zala 421-08 and Israel's Tadiran Mastiff.
3. **NATO Type:** 10,000 feet (3,000 metres) altitude, up to 50 km range. Examples include IAI Heron and NEANY Arrow.
4. **Tactical:** 18,000 feet (5,500 metres) altitude, about 160 km range. Examples include Schiebel Camcopter S-100 and Orbiter.
5. **MALE:** Medium Altitude, Long Endurance. Up to 30,000 feet (9,000 metres), range over 200 km. Examples include Dominator, MQ-1 Predator and Chengdu Pterodactyl I.
6. **HALE:** High Altitude, Long Endurance. Over 30,000 feet (9,100 metres), indefinite range. Examples include the solar powered Zephyr, RQ-4A Global Hawk and AeroVironmen Pathfinder and Helios.
7. **Hypersonic:** High-speed, supersonic (Mach 1–5) or hypersonic (Mach 5+) 50,000 feet (15,200 metres) or suborbital altitude, range over 200 km. Examples include the experimental Defense Advanced Research Projects Agency's Falcon and the SR-72.
8. **Orbital:** Low earth orbit (Mach 25+). Examples include the experimental Boeing X-37 OTV (Orbital Transport Vehicle).

The above two categorisations are comprehensive in accounting for and understanding the current terrain of drones. But they are inadequate in explaining and positioning the new and emerging micro-drones that are entering the arena of civilian operations and applications in a big way. Some of these micro-drones are no bigger than a human fist, yet have the capacity to reach altitudes of 1,000 feet or more with a loitering range in excess of five kilometres. The policy and regulatory framework is so vague, often deliberately obtuse, particularly in India, that many of these micro-drones are often sold over the counter without any checks or paperwork.

In India many of these micro-drones are imported from China by small retailers and sold as toys.[24] Interestingly, the radio bands used by these drones often clash with police frequencies and interfere with other bands dedicated to mobile and aviation communications. The remotely piloted vehicles used by the military establishment of various countries are accounted for with a reasonable degree of accuracy, with International Institute for Strategic Studies (IISS) data showing that the United States alone has 679 drones in service of 18 different types.[25] Out of these, 14 are identified as 'heavy.' For instance, there are over 100 MQ-1B Predator heavy drones.

Interestingly, India has the second largest number of acknowledged drones in operation after the US. But it is likely that Israel and China use a much larger number and variety of drones than India, although their secrecy policy ensures that only an estimate can be made of the total number in operation. One IISS estimate puts the number of operational drones in China at over 300, though it has been not been independently verified. The verified and internationally certified number of drones being operated by some countries is given in Table 1.

Table 1: List of Countries with an Open Inventory of Drones

Country	Service	Type	Weight	Number
United States	Army	RQ-7A-Shadow	Medium	236
United States	Air Force/Air Force SOCOM/Air National Guard	MQ-1B Predator	Heavy	172
United States	Air Force/Air Force SOCOM/Air National Guard	MQ-9 Reaper	Heavy	97
United States	Marine/Marine Reserves	RQ-7B Shadow	Medium	36
United States	Air Force/Navy	RQ-4B Global Hawk/ RQ-4A Global Hawk	Heavy	27
United States	Army	RQ-5A Hunter & MQ-1C Grey Eagle	Heavy	19
United States	Navy	RQ-2B Pioneer	Medium	35
United States	Army	CQ-10 Snowgoose	Heavy	28
United States	Army	RQ-5A Hunter	Heavy	20
United States	Army/Air Force/Navy	MQ-8B Fire Scout, RQ-170 Sentinel & I-Gnat	All Varieties	9
France	Army	Sperwer	Medium	20
France	Air Force	Harfang	Heavy	3
Germany	Army	KZO	Medium	6
Germany	Air Force	Heron	Heavy	3
Italy	Air Force	RQ-1B Predator	Heavy	5
India	Army	Nishant	Medium	14
India	Army	Searcher Mk I/II	Medium	12
India	Navy	Heron	Heavy	4
India	Navy/Air Force	Searcher Mk II	Medium	30 (est)

Source: International Institute for Strategic Studies (IISS)

* Russia (Tu-300 Korshun, Tu-143 Reys, Tu-243 Reys/Reys D), China (BZK-005, WZ-5, ASN-105, ASN-206, ASN-104, WZ-50, WZ-6, CH-1 Chang Hong, Chang Kong 1, Firebee), Israel (Hermes 450, Heron, Heron-TP, Harpy, RQ-5A Hunter, Searcher Mk II), Turkey (Falcon 600, Firebee, CL-89 Gnat, Heron, Gnat 750), Iran (Mohajer IV, Shaheed-129) and Pakistan also operate a substantial number of drones. Israel has some of world's most advanced drones, while China is fast catching up with the West.

III. Policy and Regulatory Framework for India

The impending, almost inevitable, arrival of drones into daily lives raises three issues that need to start being seriously debated from a policy and regulatory angle.

1. Airspace and Safety

From an operational perspective, 'airspace' can be defined as the “collection of procedures, regulations, infrastructure, aircraft, and personnel that compose the national air transportation system”.[26] The history of modern human flight has been a curve of bigger, faster and higher. Airspace, by default, has come to mean at least 10,000 feet. Except for landing and take-off, for airlines, air traffic controllers, aviation authorities and policymakers, 'airspace' refers only to 25,000 to 35,000 feet (the standard cruising altitude for most civilian aircrafts). Micro-drones and small UAVs redefine airspace. Some octocopters and quadracopters, as mentioned earlier, cruise at less than 100 feet while other go up to 3,000 feet. Drones are being increasingly integrated with the core operations of commercial, logistical, retail, law and order and media sectors. Such integration raises some fundamental questions that require a major policy rethink on airspace management and control and overall safety of aerial vehicles, such as:

i. How and who will coordinate unmanned and manned flights in a mixed airspace?
ii. Will each drone be issued a unique identification number or code?
iii. How will drones be legally regulated? For instance, would a separate act, like the Motor Vehicles Act, be required?
iv. What happens if two drones collide and someone is hurt or killed? There is obviously a need to reorient the current insurance regulatory framework.
v. What about cybersecurity of the drone airspace?

The prevailing Air Traffic Control (ATC) system operates on the basis of ground level radars (a command centre) monitoring the movement of planes, and communicating directly with the pilots and co-pilots on direction, altitude, navigation, vehicle and traffic control and collision avoidance. Apart from the constant guidance and inputs from the ATC, pilots either visually try and spot aerial vehicle or use the Traffic Collision and Avoidance System (TCAS)[27] to avoid untoward incidents. UAVs have to integrate with the current system. There are four policy challenges facing Indian decision-makers for facilitating this necessary integration.

The first challenge deals with the structure of the ATC and the network of ground-based radars that are currently not equipped to track all kinds of drones, especially micro- and small drones and drones flying below 1,000 feet. Two specific interventions are required here. The first is technical, and requires a phased integration of a new generation of radar and communication systems that is able to spot and engage with drones of all specifications and dimensions. The second is to train ATC staff to understand the operational nuances and logistical requirements of different kinds of drones to ensure their effective management.

The second challenge lies in the physical and electronic identification of drones. The current aircraft numbering system[28] is inadequate to accommodate the vast variety. Since drones are increasingly becoming part of a networked environment, it is critical to give each drone a unique electronic code, akin to an Internet protocol address, for quick, easy and clear identification. There are two critical steps required to start this process. The first is to create a regulatory and policy framework where definitions of private, civilian and military airspaces are clearly defined for UAVs using functional specifications such as their flight envelope, purpose and loitering capacity. In this regard, the European Union's policy and approach document towards the regulation and management of UAVs is an excellent starting point.[29] The second step is to create specific sets of civilian and military protocols, rules and regulations that not only effectively demarcate the boundaries of operations between military drones and civilian ones, but also evolve a digitally generated naming and identification convention that is easy to retrieve and is integrated with existing ATC infrastructure.

The third challenge is to ensure that drones and UAVs have at least a certain commonality of protocols and functions with existing manned civilian, commercial and military regulations and protocols for aerial vehicles, especially with regard to communication, collision avoidance processes and air corridor sharing. All UAVs, irrespective of function, size or specifications, must be fitted with TCAS. Additionally, all such vehicles must be fitted with a real-time air corridor monitoring system, which should allow the ATC to engage with a drone directly in case of emergencies. For this challenge to be effectively addressed, there is firstly a need to comprehensively revamp the DGCA to move its focus from an exclusive mindset of licenses and airworthiness certifications to one of creating proactive policy roadmaps and regulatory ecosystems. The second is to create a completely separate institutional framework and a unit that looks at the civilian UAV sector in an autonomous manner. Both these measures will create the necessary framework for establishing clear-cut boundaries, as well as commonalities of operations between manned and unmanned civilian vehicles for various purposes.

The fourth challenge is to standardise and improve the quality of the construction of drones. Today, there are practically no standards for the manufacture of small and micro-drones, resulting in UAVs with an exceptionally high failure rate. At a 2010 Congressional hearing in the US on evolving a more comprehensive policy on drones,[30] FAA Vice President for System Operations Nancy Kalinowski said:

> The Customs and Border Protection… accident rate [among drones] is 52.7 accidents per 100,000 flight hours. This accident rate is more than seven times the general aviation accident rate (7.11 accidents/100,000 flight hours) and 353 times the commercial aviation accident rate (0.149 accidents/100,000 flight hours)…the high accident rate…suggests the need for current safety levels and quality of construction to be increased before full integration into the national airspace.[31]

The unregulated Indian policy and legal environment for civilian drones has allowed several local and foreign drone operators to sell UAVs of suspect quality. Since there is no classification of civilian drones either according to altitude, capacity or functional specifications, UAVs with possible safety implications have proliferated in the Indian market under the guise of recreational and educational vehicles. To create a more transparent set of rules and regulations to begin with, the manufacture, assembly and import of all civilian drones, including those for recreational purposes, must be brought under the existing policy frameworks for manufacturing and electronic manufacturing. In the longer run, the entire manufacturing, technology transfer and import policies for drones must be tightly integrated with the emerging set of cyber and digital policies. A drone, all said and done, is an integrated electronic and digital product.

These four challenges have to be tackled together to evolve a comprehensive future-ready policy framework. Such a framework is needed to redefine the processes and protocols associated with airspace and ATC. It will also bring about a higher standard in the quality of construction, testing and maintenance for UAVs.

2. Drone Infrastructure

Drones require a reconceptualisation of current understanding regarding connectivity and infrastructure. Historically, the first instance of any connective infrastructure for human society was roads. All other connective infrastructure—from warehouses, ports, rail networks, web networks, highways and even aviation—follow the specific logic of a hub and spokes model first evolved by the road network. Micro-drones primed for use in a day-to-day urban environment break this logic pattern decisively. They are, for all practical purposes, the first autonomous peer-to-peer connective infrastructure that do not need a hub. Each drone is an independent hub and a spoke at a same time.

This revolutionary potential of the drone is already being exploited by a few social entrepreneurs to deliver medicines in remote places in Africa and Latin America.[32] The docking and charging stations cost less than what building a kilometre of road costs today.[33] Each of these drones can be wirelessly programmed, reprogrammed and monitored to deliver the medicines. Additionally, each drone is equipped with a self-diagnostic kit that tells it when to charge and if a software or hardware component is malfunctioning. The potential of drones clearly has major implications for an infrastructure-deficit country like India. The application of micro-drones is endless: From services ranging from provision of essential medicines to remote healthcare centres, cost effective door-to-door delivery models for retail chains and, obviously, surveillance. There is an urgent need to establish a network of physical infrastructure for drones and UAVs, mainly to cater to their increasing use for transporting essential materials to far-out places and use in the urban areas to cut downtimes and surmount problems of traffic and congestion. In such a scenario, a few questions need to be considered:

i. What sort of physical infrastructure is required for drones?
ii. Who decides, and how does one decide, the feasibility of using drones for specific tasks?
iii. How can drones be integrated with India's push for broadband infrastructure and focus on developing highways and roads?
iv. What kind of an ecosystem is required for developing an indigenous drone industry?

The first policy challenge is to establish specifically earmarked docking and recharging stations across the country for small and micro-drones. Most of these drones are either electrically and battery operated or work on alternative energy means like solar energy. Creating such a network of docking stations helps establishes a hub and spokes distribution model for logistics and retail chains, both commercial and governmental, which will help transcend India's traditional constraints of rail and road networks. The docking and maintenance stations will require their own power sources, an entire band of UAV engineers, maintenance crew and a complete supply chain system for parts, electronics and networking solutions.

The second policy challenge is to support and evolve a domestic drone industry that understands specific Indian challenges. Today, most of the drones are imported and then customised. The nuts and bolts of an indigenous drone industry, however, are already present in India. There is a fairly robust design and development base in India. There is also a parts ecosystem, and an emerging indigenous electronics base of chips and digital controllers. Moreover, India already has a strong software base. There is now a need for an integrated policy—one that ties in with the Manufacturing Plan of 2011 and the New Policy on Electronics 2012[34]—that encourages an independent and self-sustaining base for producing UAVs of various capacities.

The third policy challenge is to integrate the various aspects of civilian drone management and regulation into one single department, or at the very least bring them together in a single window clearance format. The issues of integrating UAVs with existing systems of commerce and governance transcend boundaries of civil aviation, internal security, law and order, company affairs, electronic commerce and digital economy, privacy and safety, and external security. A crucial component of resolving this challenge satisfactorily is to reorient the role of DGCA from that of an agency focusing exclusively on providing various forms of certifications for flight operations, air worthiness and the final

Certificate of Authorisation to becoming a true regulator on the lines of a Securities Exchange and Board of India and Telecom Regulatory Authority of India. In this respect it would be a good idea to look at the policy measures being taken in the US to expand the regulatory mandate of the FAA[35] to slowly integrate drones with the existing manned aviation network. Today, the FAA has a separate division that is exclusively mandated to oversee and manage the integration of drones into various daily aspects of social, political and economic life.

3. Privacy

The third issue is one of privacy. Taken together with CCTVs, web monitoring programmes and real-time satellite imagery, drones complete the picture of 360 degree surveillance. Drones have an ability to provide an external and aerial view that is immediate, intimate and real-time. Drones also have the capability of being extremely maneuverable, being able to duck into lanes and bylanes, and the ability to cling on to walls, climb fences and generally do things that an autonomous vehicle can do today. This unique ability to be a flying object as well as a ground-based vehicle raises particular policy issues. New York Mayor Michael Bloomberg summed it best when, under attack during a radio programme for his plan to start deploying drones in the Big Apple, he said, "What's the difference whether the drone is up in the air or on the building?...Intellectually I have trouble making that distinction."[36]

It is precisely in this blurring of differences where the greatest threat to privacy lies. Micro-drones are possibly the last and the most crucial, flexible link that was needed to tie in every single piece of visible and invisible surveillance software and hardware. Drones fundamentally alter the distinction between public and private space, between information and intrusion, and finally between humanity and machines. Current legal, policy and techno-social thought processes are lagging behind in grasping these transformations. Micro-drones require an absolutely new human thinking, one that has to acknowledge and understand that the set of interconnected technologies of today constitute the artificial intelligence of tomorrow that will no longer be completely in human control. It is in this context that there are two fundamental challenges that are worth considering and debating.

The first challenge confronting Indian policymakers is to substantially rework the Information Technology Act of 2000,[37] which was amended in 2008, to be ready for a future that is going to be increasingly based on an 'Internet of Things.' Drones are at the cutting edge of this phenomenon. Attention, for example, has to be paid to Section 66A of the IT Act,[38] which has potentially made it possible for any tool, instrument or hardware using digital technology to come within the ambit of the Act by the specific wording of its clauses and sub-clauses. It states:

> Any person who sends, by means of a **computer resource** or a **communication device** (*emphasis added*),
>
> (a) any information that is grossly offensive or has menacing character; or
>
> (b) any information which he knows to be false, but for the purpose of causing annoyance, inconvenience, danger, obstruction, insult, injury, criminal intimidation, enmity, hatred, or ill will, persistently makes by making use of such computer resource or a communication device;
>
> (c) any electronic mail or electronic mail message for the purpose of causing annoyance or inconvenience or to deceive or to mislead the addressee or recipient about the origin of

> such messages shall be punishable with imprisonment for a term which may extend to three years and with fine.

The use of the words 'computer resource' and 'communication device' embeds the possibility of any land or air vehicle, whether manned, semi-autonomous or completely autonomous, using any form of digital technology, which for all practical purposes is a computer resource, to come within the purview of the Information Technology Act. Specifically then, Section 66A can possibly be used to argue that any company offering civilian services using a drone is actually an intermediary. It is in this context that special focus must be given to rethinking those portions dealing with liabilities for intermediaries, security protocols, encryption of sensitive records, disclosure norms, storage and access of sensitive data, and retention of information by intermediaries, private bodies and government agencies.[39]

For instance, the terms 'grossly offensive,' 'has menacing character,' 'causes annoyance or inconvenience,' 'grossly harmful' and 'disparaging' that are part of Section 66A have been misused by executive agencies. In March 2013, a Parliamentary Standing Committee on the 2011 IT rules noted how the vague and ambiguous language of Section 66A has led to harassment. Policymakers would do well to adhere to the Supreme Court judgment in the 1982 A.K. Roy vs. Union of India case,[40] where the court ruled that

> …the impossibility of framing a definition with mathematical precision cannot either justify the use of vague expressions or the total failure to frame any definition at all which can furnish, by its inclusiveness at least, a safe guideline for understanding the meaning of the expressions used by the legislature…

In integrating itself with the existing digital and internet infrastructure, drones bring to the fore the fundamental inadequacies of existing legislative, policy and regulatory framework for an emerging digital economy and digital society. A UAV, whether for civilian purposes or military requirements, is a networked digital product. It brings together various digital components, algorithms and codes into meshed layers of interfaces that allow human beings to autonomously control the vehicle. A civilian drone, in particular, has to be treated as a digital product and service, and to that end and extent it needs to be integrated with the existing and emerging policy and regulatory environment for information technology, digital governance, and cybersecurity and cyber infrastructure.

The second challenge is to redefine the existing legal framework with reference to what constitutes the correct way of collecting evidence, especially its admissibility in a court of law in the context of Indian attempts to define a comprehensive and proactive policy and regulatory framework for privacy. For close to 10 years now India has been trying to arrive at a legal and policy balance between 'right to privacy' and 'reasonable restrictions.' In 2006 India made the first serious attempt at legislatively clarifying the approach towards privacy and personal data with the introduction of the Personal Data Protection Bill in Parliament along with the Information Technology Amendment Bill. Though the bill lapsed in Parliament, it cut through the legal thicket to chart out specific conditions under which personal data cannot be collected or disclosed. The Information Technology (Amendment) Act, 2008, based on the bill introduced in 2006, added two sections—43A and 72A—providing for civil and criminal liabilities relating to Privacy. Section 43A focuses on the nuts and bolts of 'reasonable security practices' for sensitive personal data and information, while Section 72A provides for a jail term and a fine to any person, body corporate or institution that causes 'wrongful loss or wrongful gain' by divulging the personal information of another person.[41] These two sections specifically defined 'personal data' as any information that is capable of singularly identifying the person. Everything from birth registry details, hospital records, financial and census information, mobile number, social networking details, educational records to death certificate, and even a person's sexual orientation can possibly be interpreted to mean 'personal data and information.' The introduction of civilian drones pushes forth a completely new dimension to the debate, and it is within this new context that the draft Privacy Bill 2011 needs to be located. Fundamentally, the foundations of robust privacy legislation for an ecosystem that will increasingly use civilian UAVs will have to be based on an expansive definition of 'privacy,' 'personal information' and 'sensitive personal information.' Such definitions have to be necessarily multifaceted and future-proof. If the Privacy Bill is to become an omnibus bill, under which other bills relating to electronic service delivery, profiling and use of civilian drones have to position themselves, it is necessary to clearly define sensitive personal information.

Currently, the draft bill quite rightly defines UID, PAN and banking credit and financial data under Section 12 as 'sensitive personal information.' Section 12(1), however, also says the processing of such information has to be managed by a Data Controller with a prior authorisation and cannot be sub-contracted to a Data Processor. Such a framework inadvertently makes every business institution—including drone companies offering services ranging from mapping to pizza delivery—a Data Controller. This might seem minor when compared to the fact that the Bill does not specify a framework of privacy regarding the increasing use of a person's biological markers as a layer of protocol and security for the use of new-generation digital products and services, including those now being increasingly provided by civilian drones.

In order to facilitate the inevitable entry of civilian drones into daily lives, Indian policymakers must take a comprehensive relook at several Indian cases like the People's Union for Civil Liberties vs. Union of India;[42] State of Maharashtra vs. Bharat Shanti Lal Shah and others;[43] Shashank Shekhar Mishra vs. Ajay Gupta;[44] and K. N. Govindacharya vs. Union of India. These cases defined privacy and reasonable restrictions at a time when technology was not as omnipresent. It would also not be a bad idea to examine the case history relevant to drone surveillance and the American Fourth Amendment, especially how the Katz vs. United States (1967) case,[45] which established a legal and juridical standard for the interpretation of the Fourth Amendment, has been used in recent times to redraw and reorient 'constitutional protections.'[46]

IV. Conclusion

A policy-driven integration of UAVs into the Indian airspace and into the larger processes of governance, development, commerce, economy and society requires significant research into all dimensions of cybersecurity, privacy, safety and existing regulatory and legal frameworks of civil aviation. The urgent need to understand the proliferation of drones in India can no longer come under the purview of debate. There is also an equally pressing need to move away from kneejerk reactions like the blanket ban on the use of UAVs imposed by the Mumbai police. The imperative is to begin viewing them in a dispassionate manner. Their applications in civilian and commercial sectors are far reaching and cannot be discounted in any manner. The military and combat dimensions are also critical, but so are those with regard to earth sciences, agriculture, weather forecasting, disaster management, and transport of medicines and emergency supplies to places with a massive infrastructure deficit. It is in this context that India needs to develop its own comprehensive policy and regulatory framework for drones, not only for operational clarity but also for developing a manufacturing base for an indigenous drone industry, one that becomes a crucial part of India's emerging digital economy.

There are three issues requiring immediate attention before the focus can be diverted to evolving a comprehensive policy and regulatory framework for UAVs. The first is to quickly reorient the processes and procedures of airspace, especially the rules of certification and the monitoring processes of the ATC, to allow for UAVs to start co-existing with civilian and commercial aircrafts. It is only when a certain level of limited and controlled co-existence is brought about that the larger policy issues of a complete integration of UAVs with the existing systems can be unraveled. The second is to evolve a unique identification code for UAVs so that every single drone, whether small or big, is completely accounted for. When all is said and done, drones falling in the wrong hands are a genuine risk for national security and need to be closely monitored. The third is to create a stringent set of manufacturing standards and quality-control processes for drones and UAVs. They have to pass through the same—or at least similar—production processes, certification requirements and airworthiness procedures that manned aircrafts and commercial aerial vehicles are subjected to before they are allowed to take to air.

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Annexure

A Short History of Drones

Stripped down to its bare minimum, a drone is not a high-technology package. The history of remotely controlled and piloted aerial vehicles is over a century old.[47] Most of the components and technology used in drones were invented in the 20th century. The aeronautical gyrocompass, for instance, was perfected by Elmer Sperry[48] and Hermann Anschütz-Kaempfe[49] by 1910, while the ideal airframe construction for remotely piloted vehicles was perfected by Glenn Curtiss,[50] widely regarded as the father of American aviation, when he started experimenting with aerial torpedoes in the run-up to World War I. The gyrocompass underpins some of the most advanced technological innovations of the 21st century. Inertial navigation and stabilisation systems of the Hubble telescope and Inter Continental Ballistic Missile, for example, would not be possible without the technology of gyroscopes.

The concept of a remotely controlled vehicle is even older, having been proposed by the eccentric Serbian genius Nikola Tesla[51] in the last decade of the 19th century. Like several scientific innovations, the concept incubated during a period of war, specifically the Spanish-American War of 1898. The brilliant Tesla invented an autonomously navigable boat, which he called a teleautomaton.[52] Its military and civilian potential, like numerous conceptual breakthroughs to date, were realised only later. The teleautomaton would eventually become the first working model for the modern torpedo and the later-day sea-skimming antiship missiles. After the First World War the aerial torpedo was sought to be refined further by Charles Franklin Kettering.[53] His autonomous vehicle came to be fondly referred to as the Kettering Bug. Though it was abandoned because it did not fulfill the extremely ambitious target of flying 80 kilometres with a 90-

kilogramme payload, the Kettering Bug can arguably be referred to as the first unmanned aircraft. But it was still not a 'remotely piloted vehicle' in the modern sense, as it required to be fed a pre-designated flight path. The world's first remotely controlled and piloted vehicle, similar to the modern drone, was the Messenger that was created by American army engineers working with Sperry. The Messenger was built as a relay vehicle and it could be piloted from the ground for two hours and had a range of 145 kilometres. These are very respectable figures even by modern standards. However, the biggest contribution to unearthing the combat potential of drones came from Nazi Germany, when their military establishment developed the V-1 flying bomb[54] in 1940. It fundamentally shifted the paradigm of warfare from one of immediate physical contact and attrition to another that could be remotely waged and controlled from a distance. The German missile "[hit] almost 25% of its targets causing the Allies to lose 2,900 aircrew…[leading] Allied forces to conclude that the V-1 offered a 4:1 return on investment."[55] The genetic material for the current crop of military drones—the American Predator[56] and Reaper,[57] the British Taranis[58] or India's Autonomous Manned Research Aircraft (AURA)[59]—can be directly traced to this German paradigm of remote targeting and precision warfare.

The concept of a target drone, now an integral part for testing air defences, anti-aircraft guns and missiles, can be directly traced to the de Havilland Queen Bee[60] produced by the British military and aviation scientists in 1934. In fact, the term 'drone' came to be associated with remotely piloted vehicles after the Queen Bee because of its apiarian connotations. The Queen Bee also inspired the development of the Radioplane, initially for gunnery and anti-aircraft target practice and then for recreation and leisure. The first model airplane for enthusiasts was developed by Hollywood actor Reginald Denny,[61] and today's radio frequency controlled multidirectional model planes and octocopters and quadracopters, some available for as little as INR 500 (less than $10), can trace their lineage to Denny's airplane. Cold War geopolitics gave an impetus to the development of a set of technologies for monitoring, reconnaissance, high-altitude flying, engines and airframes. The most critical advances were in the field of autonomous navigation, especially the integration of satellite radio communication with the inertial navigation systems. Such integration allowed ground crews of remotely piloted aerial vehicles to have a fair degree of autonomous control, allowing such vehicles to be mounted with "125-mm or a 70-mm film cameras, flares for use with night time photography, Infrared (IR) sensors… and a Side Looking Airborne Radar … capable of transmitting imagery back in real time via a ground sensor."[62] By the middle of the 1980s such systems were gradually replaced by GPS-based navigation and control systems.

The decade of the 1970s and the period of the early 1980s saw a decisive movement towards exploring a more proactive role for remotely piloted vehicles in real-time combat scenarios. The United States and Israel were the pioneers in this reorientation, often acting together and in a concerted fashion. For the United States, the bruising Vietnam War provided the context, while for Israel, its war with Syria and the constant skirmishes with West Asian neighbours provided a pressing imperative to expand the potential of drones. Charting the later-day developments in the arena of drones, especially the politico-economic context within which Israel developed a leadership position in drone technologies, Rebecca Sanders writes:[63]

> …during Operation Peace in 1982, aircraft over the Syrian-occupied area of Lebanon destroyed surface-to-air missile batteries by deploying unmanned decoys that the Syrians attacked, wasting resources and divulging the locations of the batteries for targeting by Israeli fighters… in both Lebanon and Syria, Israel was among the first nations to employ such vehicles regularly for

> reconnaissance in combat, demonstrating that when used effectively they can help achieve combat objectives…

One of the first joint projects between the close allies US and Israel during the late 1980s led to the development of the Hunter[64] and Pioneer[65] series of UAVs, which were used with great success in the first Gulf War to spot enemy fire. The two remotely piloted aerial vehicles were also successful in beaming real-time intelligence and ground-level information to US commanders during the Balkans conflict of 1994 and the Kosovo intervention of 1999. It was during this time that both the American and Israeli scientists and enterprises started tackling the problems of flight endurance, which is the ability of the remotely piloted vehicle to stay for long durations in the air without refueling or landing. They also started exploring the possibility of using such vehicles outside the conventional rubric of military applications. The research on drones in the 1990s consequently concentrated on two areas. The first was on new materials and methods to keep the drones flying for a period of 24 hours and more and at over 50,000 feet. The most prominent example of this integrated focus was NASA's and AeroVironment Corporation's solar-powered Pathfinder[66] and Helios[67] aircrafts of the late 1990s. The second was on miniaturisation of drones, with an effort to utilise them for civilian and non-military applications. Both these trajectories were aided in no small measure by the revolution taking place in inter-related fields of electronics, chip design and fabrication, internet protocols and networking, digital data links, mobile communication and aviation design.[68]

The geopolitical context and thrust for both these developments were provided by the end of the Cold War and the emergence of new asymmetric threats, most notably terror organisations operating on a global scale. The 9/11 attacks and the subsequent war on terror provided a specific backdrop to the twin urges of militarisation and miniaturisation of UAVs. The miniaturisation of drones was originally intended for real-time battlefield intelligence. It is best exemplified by the extremely successful Puma Dorin and Raven, both personal aerial reconnaissance vehicles extensively used by American soldiers in Afghanistan and Iraq. The current trend of increasing proliferation of micro-drones in daily life—from Amazon's experimental quadracopters and octocopters looking to deliver goods at doorsteps to small and autonomous radio-controlled planes fitted with sensors and cameras monitoring urban traffic and forest cover—can be directly traced to the development of man portable drones for military personnel. The most visible and the first lethal symbol of the militarisation of the drones is the Predator UAV fitted with a laser guided antitank Hellfire missile,[69] which was used quite successfully by the US forces in Pakistan, Afghanistan, Iraq and Somalia to take out terror units and terrorist leaders. The US is the world leader in armed combat drones, with the X-47B[70] having no counter anywhere in the world currently. But there are at least five countries—United Kingdom (Taranis), Russia (Skad/Chirok),[71] Israel (Harop/Harpy),[72] China (Lijian)[73] and India (AURA/Rustom-II)[74]—that have fairly well-documented advanced combat drone programmes. Additionally, there are reports about Iran, Turkey, South Korea, Brazil and Japan having their own secret combat drone programmes.

The emerging landscape of drones is fundamentally different from that of the previous generations. The paradigm shift taking place is the manner in which the ecosystem of drones—military, civilian and recreational—is increasingly becoming part of larger digitally networked, real-time intelligence and analytics systems. This process is integrating drones into daily lives, throwing up administrative, policy and strategic challenges that could not have been foreseen even a decade ago. The digital integration of UAV with various other complimentary systems has turned it into an Unmanned Aerial System.

Endnotes:

1. Please see *The Military Balance: The Annual Assessment of Global Military Capabilities and Defence Economics* published by International Institute for Strategic Studies in 2014.
2. The IAI Searcher is a reconnaissance UAV developed in Israel in the 1980s. It replaced the IMI Mastiff and IAI Scout UAVs in service with the Israeli Army.
3. Please refer to: http://www.firstpost.com/india/on-modis-us-wishlist-drones-for-indias-defence-internal-security-1583025.html. Retrieved on September 24, 2014.
4. Please refer to: http://www.nextbigwhat.com/drones-india-297/. Retrieved on September 23, 2014.
5. Please refer to: http://uvs-international.org/phocadownload/03_5ac_Relevant_Information/Applications_Civil-UAV-Applications-in-Japan.pdf. Retrieved on September 24, 2014.
6. Newcome, Lawrence R. (2004), *Unmanned Aviation: A Brief History of Unmanned Aerial Vehicles*, Reston, Virginia, American Institute of Aeronautics and Astronautics, pg 127.
7. Please refer to: http://rmax.yamaha-motor.com.au/videos. Retrieved on September 24, 2014.
8. Johnson, L., S. Dunagan, B. Lobitz, D. Sullivan, R. Slye, and S. Herwitz. (2003) (mimeo), 'Collection of Ultra High Spatial and Spectral Resolution Image Data over California Vineyards with a Small UAV', *International Symposium on Remote Sensing of the Environment*, November 10-14, 2003, Honolulu, Hawaii.
9. The Netra is an Indian, light-weight, autonomous UAV for surveillance and reconnaissance operations. It has been jointly developed by the Defence Research and Development Organisation's Research and Development Establishment and IdeaForge, a Mumbai-based private firm. The UAV was featured in the hit Hindi movie *3 Idiots*.
10. Please refer to: http://www.thehindu.com/news/national/drones-to-guard-indias-forests-and-wildlife/article6286830.ece. Retrieved on September 24, 2014.
11. Please refer to: http://time.com/3084645/india-drones-security-humanitarian/. Retrieved on September 24, 2014.
12. Please refer to: http://www.nextbigwhat.com/pulkit-jaiswal-garuda-drones-297/. Retrieved on September 24, 2014.

13. Please refer to: http://www.livemint.com/Politics/ZDib5YWR1G2Mcuth1kbwyO/Drones-scan-floodhit-Uttarakhand.html. Retrieved on September 24, 2014.
14. Please refer to: http://timesofindia.indiatimes.com/india/Drones-to-keep-eye-on-Panna tigers/articleshow/28653645.cms. September 24, 2014.
15. Cox, Timothy H., Nagy, Christopher J., Skoog, Mark A., Somers, Ivan A. (2004), *Civil UAV Capability Assessment*, National Aeronautics and Space Agency (NASA), pp 20-21.
16. Please refer to: http://finance.yahoo.com/news/advanced-defense-technologies-adti-sees-133000863.html. Retrieved on September 23, 2014.
17. Please refer to: http://www.theguardian.com/world/gallery/2014/jul/21/aerial-views-of-india-by-drone-in-pictures. Retrieved on September 23, 2014.
18. The Federal Aviation Administration (FAA) is the national aviation authority of the United States. An agency of the United States Department of Transportation, it has the authority to regulate and oversee all aspects of American civil aviation. The Federal Aviation Act of 1958 created the organisation under the name Federal Aviation Agency. The agency adopted its current name in 1966 when it became a part of the US Department of Transportation.
19. The Domain Awareness System is surveillance framework developed as part of Lower Manhattan Security Initiative in a partnership between the New York Police Department and Microsoft to monitor New York City. This allows them to track surveillance targets and gain detailed information about them. The system is connected to 3,000 or more video cameras around New York City. The system will be licensed out to other cities with New York City getting 30% of the profits.
20. Please refer to: http://www.mumbaimirror.com/mumbai/others/Police-ban-Drones-from-city-skies/articleshow/41661016.cms. Retrieved on September 24, 2014.
21. The DGCA is the regulatory body for civil aviation under the Ministry of Civil Aviation.
22. Please refer to: http://www.casa.gov.au/scripts/nc.dll?WCMS:STANDARD::pc=PC_101593. Retrieved on September 23, 2014.
23. Please refer to the 11th edition of the *World Unmanned Aerial Vehicle Systems: Market Profile and Forecast* released by Teal Group in 2014.

24. Please refer to: http://online.wsj.com/articles/chinese-drone-maker-dji-unveils-more-powerful-model-1415840471. Retrieved on December 02, 2014.

25. Joshi, Shashank, A.Stein (2013), 'Emerging Drone Nations', *Survival: Global Politics and Strategy*, October–November 2013, Vol. 55, Ed.5, pp 53-78.

26. Weibel, R., R. Hansman, R. (2005), 'Safety Considerations for Operation of Unmanned Aerial Vehicles in the National Airspace System', Massachusetts Institute of Technology, Retrieved on September 23, 2014 @ http://dspace.mit.edu/handle/1721.1/34912.

27. A Traffic Collision Avoidance System monitors the airspace around an aircraft for other aircrafts equipped with a corresponding active transponder. It is independent of air traffic control and warns pilots of the presence of other transponder-equipped aircrafts which may present a threat of mid-air collision. It is a type of airborne collision avoidance system mandated by the International Civil Aviation Organisation to be fitted to all aircrafts with a maximum take-off mass of over 5,700 kg (12,600 lb) or those authorised to carry more than 19 passengers.

28. An aircraft registration is a unique alphanumeric string that identifies a civil aircraft, like a license plate on an automobile. In accordance with the Convention on International Civil Aviation all aircrafts must be registered with a national aviation authority and they must carry proof of this registration in the form of a legal document called a Certificate of Registration at all times when in operation.

29. Please refer to: http://www.law360.com/articles/526107/eu-proposes-privacy-safety-policy-for-civilian-drones, http://www.law360.com/articles/486136 and http://www.law360.com/articles/486136/eu-mulling-privacy-policy-for-civilian-drones?article_related_content=1. Retrieved on December 02, 2014.

30. Please refer to: https://www.faa.gov/news/testimony/news_story.cfm?newsId=11599. Retrieved on September 24, 2014.

31. Carr, Eric Baldwin. (2013), *Unmanned Aerial Vehicles: Examining the Safety, Security, Privacy and Regulatory Issues of Integration into US Airspace*, National Centre for Policy Analysis (NCPA), pg. 17. Retrieved on September 23, 2014 @ http://www.ncpa.org/pdfs/sp-Drones-long-paper.pdf.

32. Please refer to: http://www.wimp.com/dronedelivery/. Retrieved on September 23, 2014.

33. Mitra, Sima (2013) (mimeo), *Autonomous Quadracopter Docking System*, Project Report, Advisor Bruce Land, Cornell University, Retrieved on

September 24, 2014 @ http://people.ece.cornell.edu/land/courses/eceprojectsland/STUDENTPROJ/2012to2013/ssm92/ssm92_report_201305171020.pdf.

34. Please refer to: http://www.orfonline.org/cms/export/orfonline/modules/occasionalpaper/attachments/occasionalpaper52_1403683981001.pdf. Retrieved on September 24, 2014.

35. Please refer to: https://www.faa.gov/nextgen/, http://www.rawstory.com/rs/2014/11/faa-to-issue-new-regulations-on-certification-and-operation-of-drones/ and http://bits.blogs.nytimes.com/2014/11/26/new-f-a-a-report-tallies-drone-sightings-highlighting-safety-issues/. Retrieved on December 02, 2014.

36. Please refer to: http://www.csmonitor.com/USA/Politics/2013/0327/Drones-above-New-York-scary-but-inevitable-Mayor-Bloomberg-says-video. Retrieved on September 24, 2014.

37. Please refer to: http://www.dot.gov.in/sites/default/files/itbill2000_0.pdf. Retrieved on September 24, 2014.

38. Please refer to: http://cis-india.org/internet-governance/resources/section-66A-information-technology-act. Retrieved on September 24, 2014.

39. Please refer to: http://www.governancenow.com/news/regular-story/electronic-snooping-here-stay, http://www.governancenow.com/news/regular-story/net-loss-kapil-sibal-declares-war-social-media and http://www.governancenow.com/gov-next/egov/you-witch-i-will-burn-you-alive. Retrieved on December 03, 2014.

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42. Please refer to: http://judis.nic.in/supremecourt/imgs1.aspx?filename=40835. Retrieved on September 23, 2014.

43. Please refer to: http://indiankanoon.org/doc/698472/. Retrieved on September 23, 2014.

44. Please refer to: http://www.indiankanoon.org/doc/58657750/. Retrieved on September 23, 2014.

45. Please refer to: https://supreme.justia.com/cases/federal/us/389/347/case.html. Retrieved on September 23, 2014.

46. Please refer to: http://www.editorandpublisher.com/Newsletter/Columns/Critical-Thinking--Does-the-FAA-s-ban-on-drone-journalism-violate-the-First-Amendment-. Retrieved on September 24, 2014.

47. The Austrians used unmanned balloons loaded with explosives during their attack of the Italian city of Venice in August 1849. Most of the balloons were launched from the ship *Vulcano*. The first pilotless aircraft, a target plane, was the Ruston Proctor developed in 1916. It was the first radio controlled plane. The Hewitt-Sperry Automatic Airplane, developed a few months later, became the first complete prototype of an unmanned aircraft. The concept of cruise missiles was derived from this airplane.

48. Sperry also worked closely with Japanese companies and the Japanese government and had a completely unintended role in the development of the deadly Zero aircraft, which was used in the attack on Pearl Harbour. Sperry was honoured by the Japanese government after his death with a biography.

49. German scientist Hermann Anschütz-Kaempfe became interested in the concept of the gyrocompass during his quest to navigate to North Pole using a submarine. In 1905 he founded, with Friedrich Treitschke, the first firm to manufacture gyroscopic navigation instruments.

50. Curtiss was an aviation maverick. He set an unofficial world record of 136.36 miles per hour (219.45 km/h) in 1907 on a 40 horsepower (30 kW) 269 cu in (4,410 cc) V8-powered motorcycle of his own design and construction. The air-cooled F-head engine was intended for use in aircraft.

51. Please refer to: http://orfonline.org/cms/sites/orfonline/modules/analysis/AnalysisDetail.html?cmaid=24285&mmacmaid=24286. Retrieved on September 23, 2014.

52. Teleautomaton was a radio-controlled boat that Tesla displayed with his customary panache in Madison Garden in 1898. Many who witnessed the moving boat accused Tesla of 'black magic.' Some claimed that a well-hidden, trained monkey was driving the boat. Please refer to: http://teleautomaton.com/post/1373803033/how-teslas-1898-patent-changed-the-world. Retrieved on September 23, 2014.

53. Kettering was the holder of 186 patents. Among some of his controversial inventions included leaded gasoline, which was later proven to be a carcinogenic agent and directly linked to stunted mental development among children.

54. The V-1 was an early pulse-jet-powered predecessor of the cruise missile.

55. Newcome, Lawrence R. (2004), *Unmanned Aviation: A Brief History of Unmanned Aerial Vehicles*, Reston, Virginia, American Institute of Aeronautics and Astronautics, pp 41-61.

56. The General Atomics MQ-1 Predator is an unmanned aerial vehicle used primarily by the United States Air Force and Central Intelligence Agency. Initially conceived in the early 1990s for reconnaissance and forward observation roles, the Predator carries cameras and other sensors but has been modified and upgraded to carry and fire two AGM-114 Hellfire missiles and other munitions. The aircraft, in use since 1995, has seen combat over Afghanistan, Pakistan, Bosnia, Serbia, Iraq, Yemen, Libya and Somalia.

57. The General Atomics MQ-9 Reaper (formerly named Predator B) is an unmanned aerial vehicle capable of remote controlled or autonomous flight operations. The MQ-9 is the first hunter-killer UAV designed for long-endurance, high-altitude surveillance.

58. The BAE Systems Taranis is a British demonstrator programme for Unmanned Combat Air Vehicle (UCAV) technology, being developed primarily by the defence contractor BAE Systems. A semi-autonomous unmanned warplane, it is designed to fly intercontinental missions, and will carry a variety of weapons, enabling it to attack both aerial and ground targets. It will utilise stealth technology, giving it a low radar profile, and it will be controllable via satellite link from anywhere on Earth.

59. AURA is an autonomous UCAV, being developed by the DRDO for the Indian Air Force. The design work on the UCAV is to be carried out by Aeronautical Development Agency.

60. It is a radio-controlled gunnery target version of the de Havilland DH.82, better known as Tiger Moth. It used a wooden fuselage of the DH.60 Gipsy Moth model with the wings of the Tiger Moth II.

61. Denny was an English stage, film and television actor and an amateur boxing champion of Great Britain. He served as an observer/gunner in World War I in the Royal Flying Corps, and in the 1920s he performed as a stunt pilot.

62. Newcome, Lawrence R. (2004), *Unmanned Aviation: A Brief History of Unmanned Aerial Vehicles*, Reston, Virginia, American Institute of Aeronautics and Astronautics, pg 71.

63. Sanders, Rebecca. (2009) (mimeo), 'The Obsolescent Wall: Intelligence Surveillance in a Transnational Age', International Studies Association Annual Convention, New York.

64. The IAI RQ-5 Hunter UAV was originally intended to serve as the United States Army's Short Range UAV system for division and corps commanders. It took off and landed (using arresting gear) on runways. It used a gimbaled EO/IR sensor to relay its video in real time via a second airborne Hunter over a C-band line-of-sight data link. The RQ-5 is based on the Hunter UAV that was developed by Israel Aircraft Industries.

65. The RQ-2 Pioneer was originally placed aboard Iowa-class battleships to provide gunnery spotting. But its mission evolved into reconnaissance and surveillance, primarily for amphibious forces. It was developed jointly by AAI Corporation and Israel Aircraft Industries. The programme grew out of successful testing and field operation of the Tadiran Mastiff UAV by the American and Israeli militaries.

66. The Pathfinder and Pathfinder Plus were the first two aircrafts developed as part of an evolutionary series of solar- and fuel-cell-system-powered UAVs. AeroVironment Inc. developed the vehicles under NASA's Environmental Research Aircraft and Sensor Technology programme. They were built to develop the technologies that would allow long-term, high-altitude aircrafts to serve as atmospheric satellites to perform atmospheric research tasks as well as to serve as communications platforms. They were developed further into the Centurion and Helios aircrafts.

67. The Helios prototype was the fourth and final aircraft developed as part of the evolutionary series of solar- and fuel-cell-system-powered unmanned aerial vehicles.

68. Please refer to http://www.india-seminar.com/2014/655/655_r_swaminathan.htm for an understanding of how silicon chips and motherboard design and electronics fabrication played a crucial role in the emergence of Internet and the current digital society.

69. The AGM-114 Hellfire is an air-to-surface missile first developed for anti-armour use. But later models were developed for precision strikes against individuals or groups of suspicious individuals. It was originally developed under the name Helicopter Launched, Fire and Forget Missile, which led to the acronym Hellfire that eventually became the missile's formal name.

70. The Northrop Grumman X-47B is a demonstration UCAV designed for carrier-based operations. The project began as part of the Defense Advanced Research Projects Agency's Joint-Unmanned Combat Air System programme, and is now part of the United States Navy's Unmanned Combat Air System Demonstration programme. The X-47B first flew in 2011, and as of 2014, it is undergoing flight and operational

integration testing, having successfully performed a series of land- and carrier-based demonstrations.

71. Designed and developed jointly by the Russian firms Mikoyan and Sukhoi, the Skat is one of two concept strike UCAVs developed for the Russian Defense Ministry. Skat is a low-observable, subsonic craft powered by a single Klimov RD-5000B turbofan engine, which is a variant of the RD-93 used in the Sino-Pak JF-17. It is designed to carry missiles such as the Kh-31. The Chirok is a hybrid amphibious UAV vehicle in development and uses a patented air cushion, giving it the ability to land and take off from anywhere.

72. The IAI Harop is a UCAV developed by Israel Aerospace Industries. Rather than holding a separate high-explosive warhead, the drone itself is the main munition. This Suppression of Air Defence-optimised UCAV is designed to fly over the battlefield and attack targets by self-destructing into them.

73. Lijian or Sharp Sword was designed jointly by the Hongdu Aviation Industry Group, Shenyang Aviation Corporation and Aviation Industry Corp of China. The project was launched in 2009, and the drone's first ground test was conducted on 13 December 2012. The drone has been compared to the Northrop Grumman-made X-47 series.

74. Rustom-II is a UCAV developed by India on the lines of the American Predator drones. Designing of Rustom-II has been completed, and purchase orders have been placed.

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