Preparing for takeoff: How the government sector can leverage drones

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DRONE FEDERATION OF INDIA



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Foreword

Technology today has disrupted every facet of how people work, live their lives and engage with others. While private businesses are being transformed by technology, governments are also increasingly relying on technological innovation to drive change and improve governance.

One such technological innovation is the drone or unmanned aerial vehicle (UAV), which is poised to play a huge role in the government space. Today, multiple governments across the world have started using drones for tasks which previously required physical presence/many people.

In India too, the Central Government, as well as some state governments, has taken up pilot projects to demonstrate use cases and evaluate the use of drones for their specific requirements.

With the launch of a policy on drones, the Government of India has taken the first step to regulate and monitor drone usage and operations in the country. The provisions of the policy, together with the Digital Sky Platform, are sure to usher in a new era of drone-enabled operations in various facets of life.

Sreeram Ananthasayanam

Partner, Government and Public Sector PwC India The UAV market in India is predicted to grow to USD 885 million by 2021, with India soon becoming one of the largest consumers of drone technology in the world and thus the perfect destination for the global drone industry. For rapid and large-scale innovation, the industry and regulators have to work together to develop a safe and scalable unmanned aviation industry.

The Central Government as well as various state governments in the country are moving ahead in leveraging this niche technology to enhance transparency and accountability. This technology has the potential to not just transform governance but also create ample job and business opportunities in the country.

As an industry-led professional body, we are happy to bring out this white paper in association with PwC. We hope that this paper helps in increasing awareness of drone technology, its applications and policies among government stakeholders. Clear understanding of this technology will help to build a sustainable UAV industry in the country.

Rahat Kulshreshtha President Drone Federation of India



Executive summary

Technology is changing the face of the world in multiple ways, and industries across the globe have been defining new ways to do business by utilising these technological advances.

One such next-generation technology is UAVs/drones, which are increasingly gaining attention. Multiple industries are utilising drones for myriad tasks—from surveillance to monitoring of projects, from detection to prevention, and from improving current methods/processes to transforming and innovatively handling new requirements.

Governments too have started embracing this nextgeneration technology for improving governance, reaching out to citizens, and leading their country's transformation to greater agility, responsiveness, and transparency.

This paper looks at the technology aspects of drones and the various components that constitute the machine. It details various use cases that have been piloted across the globe and in India, specifically in the government sector. It then details various ways in which governments in Indian states could utilise drones in specific sectors, ranging from agriculture to tourism.

Finally, it recommends an approach that the government sector can follow for successfully utilising this innovative technology, along with the key considerations to select the right type of drone(s) for a specific use case.



Introduction

Unmanned aerial vehicles (UAVs), more commonly referred to as 'drones', are basically aircraft without human pilots that have been in operation since the early 1900s. Though initially used only for target practice by military groups, they were later equipped with real-time surveillance capabilities to monitor troop movements behind enemy lines.

With the digital revolution bringing in tiny microprocessors and abilities for long-distance communication, the role of drones expanded to not only more specialised military operations but also civilian applications. In recent years, the market for drones has grown dramatically with a projected annual reach of 11.5 billion¹ USD by 2024, registering a CAGR of approximately 20%. This is primarily attributable to the technological evolution that caused a significant reduction in the cost, price and size of drones, hence enabling democratisation of aerial observation. This further led to an explosion in the applications of this technology beyond their traditional use for defence purposes, and to widespread non-military commercial use ranging from photography to pizza delivery.

Despite innumerable uses and the high level of acceptance of this technology, governments the world over continue to face the challenge of striking the right balance between adoption of drones and ensuring the safety, privacy and security of their citizens. India recently released regulations for the use of drones for commercial purposes, under which licence requirements are defined based on the weight and flying height of the drones. Also, restrictions have been placed on flying drones near airports and sensitive establishments. Privacy and protection of personnel, property and data are given due importance.

According to the regulations,² rules are defined for the drones on the basis of their weight:

Weight classification	Drone category
<=250 gm	Nano drones
>250 gm and <=2 kg	Micro drones
>2 kg and <=25 kg	Small drones
>25 kg and <=150 kg	Medium drones
>150 kg	Large drones

Nano drones can fly up to 50 feet and would be exempt from seeking one-time approval, including a Unique Identification Number (UIN).

Understanding drones

How do drones work?

Operationally, a drone can either be (1) remote controlled by a pilot sitting out of a remote location or (2) preprogrammed to operate automatically without any human intervention.

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Remote controlled drones

A transmitter is used to send radio signals to the receiver inside the drone, which interprets the signal and transmits it to the flight control board and subsequently to electric speed controllers (ESCs) for action.³ An ESC is an electric circuit responsible for varying motor speed and direction; these controllers also act as a dynamic brake.

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Pre-programmed drones

Drone Waypoint GPS Navigation is an advanced satellite navigation device that allows a drone to fly on its own, with the flying destination or points pre-planned and configured into the remote control navigation software. It instructs a drone where to fly, at what speed, and at what height, and can also be configured to hover at each of the defined points.

There are two ways of piloting a drone – either through line of sight (visual observation) or through first person view (FPV). In the case of first-person view, the drone transmits a video image from an on-board camera through radio frequency, which is received on the ground on a personal video display (screen/video goggles)

In terms of the data activity flow, 'data capture' is done during flight time through remote pilot or GPS. This data is then stored and transferred from the drone to the base, and then analysed to draw insights.





Electric speed controller (ESC)⁴ Controls the amount of voltage received by the motors, in order to control the speed of each propeller. This system allows the drone to manoeuvre.

Battery



Lithium polymer (LiPo) battery is rechargeable and light, and provides power to electric motors.

Flight control board

Receives information from the receiver and sends signals to electric speed controllers.



Electric motor

Converts electrical energy into mechanical energy.

Transmitter (TX)

Enables user to control aircraft from a distance using radio signals.

Propeller

Blades/fans generate power through conversion of rotational movement to either lifting or forward movement

Receiver (RX)³

Intercepts radio signals from the TX and converts them into alternating current pulses which produce information that is transmitted to the flight control board.



Some of the other components that assist in the operation of drones are listed below:

Gyroscope: Three and six axis gyro stabilisation technology provides navigational information to the flight controller to ensure flying and hovering are stable. It measures angular velocity and orientation.

Accelerator: It determines the position and orientation of a drone in flight. Accelerators have thermal sensing capabilities, which play an important role in stabilising onboard cameras.

Inertial measurement units (IMUs): IMUs use magnetometers (compasses) that sense changes in direction and feed data into processors to indicate direction, orientation and speed.

Tilt sensors: Combined with gyroscopes and accelerators, they provide input to flight control systems for maintaining flight level. These are essential for applications requiring high stability—for instance, in cases of surveillance or for delivering fragile goods.

Current sensors: They monitor and optimise power drain, safe charging of internal batteries and detect faults with motors or other parts of the system.

Magnetic sensors: Electronic compasses provide critical information to inertial navigation and guidance systems.

Types of drones

Although drones come with different state-of-the-art technologies packed into their lightweight frames, they vary considerably in terms of size, weight, payload capacity, flight time and functionality, depending on the purpose for which they are being deployed. The weight of the drone and the battery attached are important determinants of its flight time.

There are primarily two types of drones: (a) fixed-wing drones and (b) rotary drones. Rotary drones can either be single-rotor drones or multirotor drones.

Drones are often loaded with various sensors, such as in-built GPS navigation systems, TV cameras, image intensifiers, radars, infrared imaging equipment and lasers to help round-the-clock monitoring and targeting. Drones for military use are also equipped with laser-guided missiles.

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Parameters	Fixed wing	Single rotor	Multirotor
Weight	Heavy	Heavy	Light
Payload capacity	2 to 5 kg	3 to 15 kg	2 to 10 kg
Flight time	1 hour or more	1 hour or more	20–45 minutes
Hovering capabilities	Cannot hover	Can hover	Can hover
Expertise required	Hard to fly	Very hard to fly	Easy to use
Key uses	Large area survey and mapping	Area survey and mapping, spraying applications	Surveillance, photography, inspection

Note: The above parameters are defined and projected based on commercial applications only.

How are governments deploying drones?

Due to ease of operations, limited human intervention and accuracy of results generated, drones have widespread civilian applications. They are currently being used across the world for bringing transformational changes in the fields of agriculture, urban planning, disaster management, infrastructure, transport, surveillance, mining, forestry and many others.

Industry use cases



Agriculture

- United States: Precision farming assessing optimal quantity of water and fertilisers to be used
- · China: Spraying pesticides on crops
- Netherlands: Detection of cannabis on fields
- · Gujarat and Rajasthan, India: Land and crop health monitoring
- · Andhra Pradesh, India: Soil testing



Transport

- United States: Inspection of railway lines under construction or maintenance
- Germany: Railway infrastructure monitoring to combat graffiti-spraying gangs
- United Kingdom: Detecting and fixing potholes on roads
- Iran: Road traffic surveillance to make decongestion plan
- Mumbai, India: Highway traffic monitoring and penalising for traffic rules violations



Healthcare

- African countries Rwanda and Tanzania: Medical deliveries of blood units, vaccines and contraceptives
- United States: Transportation of blood samples to labs for testing
- Tanzania: Monitoring and assessing malaria vector habitats



Urban development

- Singapore: Developing 3D models for heritage sites to guide restoration work
- Gurugram, India: Geo-referencing for land records management
- Chennai, India: Digital mapping for accurate property tax collection



Forest and wildlife

- Kenya: Aerial monitoring to prevent illegal poaching of elephants
- Australia: Surveillance of swimming spots to prevent unexpected shark attacks
- Pench National Park, India: Aerial monitoring of forests to control poaching and tree felling
- New Delhi, India: Central government plans to use drones for tiger census



Security

• United States: Security provision at Boston Marathon; drones are deployed at various sporting events





- · Philippines: Monitoring and auditing mining firms
- · Australia: One of the mining companies using drones to inspect their equipment and mining pits
- · Gujarat, India: Monitoring inaccessible areas around the Sabarmati bed to track illegal sand mafia



- · Drones were deployed during Typhoon Haiyan in Philippines, Hurricane Sandy in Haiti, flooding in the Balkans and the earthquake (2008, 2014, 2015 and 2016) in China
- · Europe: Drones were found to isolate people much faster than traditional ground-based rescue teams



Oil and gas

- · Norway: An oil and gas company used remotecontrolled drones to inspect its gas processing plant
- · Oklahoma, United States: A multinational conglomerate used drones equipped with infrared cameras to identify leaks in the gas pipeline⁵
- · Madhya Pradesh, India: GAIL has deployed drones on a pilot basis for aerial surveillance of the HBJ pipeline in Chambal ravines6



Telecom

- · United States: Inspecting cell sites in difficult to reach areas or disaster-affected areas for information on damaged equipment
- · United States: Assessing damage to telecom infrastructure post Hurricane Harvey and manage repair efforts
- · Texas, United States: One of the largest telecommunication firms used drones to inspect telecom towers



Insurance

· United States: Damage assessment for claims in the aftermath of Hurricane Harvey. Also, conducting home assessments for quick claim settlements.



Tourism

- · Norway: The tourism board has commissioned dronebased video to showcase the beauty of the city of Trondheim and its outskirts
- · Australia: The health of the Great Barrier Reef is being monitored using drones
- · Corbett National Park, India: Monitoring of tourists to ensure minimal disturbance to wildlife



Application of drones in various countries

Tanzania

The Government of Tanzania is exploring the application of drones primarily for inspection and monitoring purposes. Some of the key use areas are listed below:



Disaster management

To enhance geospatial mapping during natural disasters like floods, Tanzania is using GPS-enabled technology which assists in gathering substantial information on floodplains and the movement of water to avoid loss of life and property.



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Healthcare

Wildlife

The Government of Tanzania is planning to initiate the use of drones for delivering medicines to meet unexpected demands, ensure delivery in bad weather, critical situations and in case of any unforeseen disaster.



Land mapping

Drones are being deployed to help in land mapping in rural areas to avoid clashes between farmers and cattle herders over natural resources like land and water. Through aerial surveys, drones capture high-resolution images, which the government can use to identify as well as digitise actual boundaries of disputed land. Drones are being deployed in Tanzania's national parks to curb poachers and poaching activities, thus saving the lives of thousands of animals and birds who live or take refuge in these areas.

Canada

Drones are being extensively deployed by the Government of Canada to assist the police and maritime operations. Some key use cases are listed below:



Police operations



Canada's Police Department is extensively using drones to efficiently conduct various police operations such as for probing traffic collisions, searching for missing persons, and investigating robberies and homicides. Many wildfire services in the country, such as BC Wildfire Service and Alberta Firefighting Service, have been using UAVs for recon missions, smoke and fire detection, ranging operations and rescue operations as well.



Maritime operations

The National Research Council⁷ of Canada has partnered with Transport Canada, the Canadian Coast Guard and the Royal Canadian Navy to explore, demonstrate, and evaluate the potential of UAVs in coast guard ice-breaking and maritime ice-monitoring operations. UAVs add tremendous support to marine operations by providing beyond visual line-of-sight situational awareness of ice conditions and prominent ice features such as ridges and shear lines, further improving response and monitoring capabilities in the industry.



In agriculture, drones are being increasingly deployed to gather farm and crop-specific data which assists farmers in boosting farm productivity.

Dubai

Dubai, being the centre of UAV deployment in the UAE, is applying drones in multiple areas. Some of the key use cases are listed below:



Police operations

Drone technology has been heavily incorporated in Dubai police operations to monitor traffic and provide live data on areas with traffic congestion and in which traffic accidents occur. Drones have also been used to identify faces of criminal in heavily populated urban areas. For bomb disposal missions, the police has been using drones with water cannons mounted on them to disburse crowds.



Real estate

Across the real estate industry, drones are being used to monitor construction activity as they can produce detailed rectified orthophotos and topographic maps which are much clearer than conventional surveys.



Firefighting

Drones in Dubai are being tested to lift heavy firefighting equipment on to high-rise building floors. The Department of Civil Defense has also been testing drones to patrol high-risk areas, such as industrial zones, and to monitor and record fires.

Orowd monitoring

The Government of Dubai has been using drones to monitor for littering. People who litter are identified with the help of cameras mounted on drones and are immediately fined for not observing rules for cleanliness.



Waste management

Dubai's Waste Management Department has successfully deployed drones in areas such as beaches and landfill sites to spot people who litter.



Application of drones in various countries

Singapore

Singapore has started its Smart Nation project, which intends to exploit smart technology to create new opportunities and transform the way people live. The Singapore government believes that drone technology plays an important role in the transformation of sectors such as infrastructure, public safety, disaster management and farming. Some key use cases for drones in the public sector are listed below:

Maritime operations

The Maritime and Port Authority of Singapore has been using drones to better assess oil spills and monitor its part of the ocean. In addition, drones will soon be used for inspecting incoming ships in a cheaper, safer and less time-consuming manner than manned surveys.



Delivery

island to another.

Drones, being cheaper than manned aircrafts, are deployed by the fire department to replace manual recon missions and ensure safer and more efficient firefighting.

The Singapore government has deployed drones as a

replacement for the manual mailman service. Singapore successfully performed the world's first delivery of mail by

drone. A test flight was conducted to send a letter and a

parcel (a T-shirt), for which the drone crossing from one



Healthcare

Drones are being used to conduct surveys of mosquitoinfested areas and mosquito breeding sites to combat diseases like dengue.

United States

The United States has been at the forefront of testing and adopting drone technology. Some of the key use cases for drone implementation are listed below:



Railway inspection

The Federal Aviation Administration has identified the inspection of network railway lines as one of the cases for the testing of commercial use of drones. Manned inspection is inconvenient and expensive, and inspectors have to deal with insects, toxic vegetation or poisonous snakes. The use of drones will allow for more frequent track inspection which will help in reducing derailments, hence preventing rail accidents and reducing loss of life. The administration is also using drones to inspect bridges, especially the area underneath them, and in some cases even trains themselves.



Search and rescue operations

Drones are being deployed to conduct search and rescue operations to track missing hikers in the Grand Canyon. Also, during Hurricane Harvey, drones were used to spot people in urgent need of help and to deliver rescue ropes and life jackets in dangerous areas.





Precision agriculture

Drones are being tested for use in precision agriculture, to reduce misapplication of limited resources (water, fertilisers and chemicals) and thereby improving crop and farm efficiency.



Security and surveillance

Drones are increasingly being deployed to monitor events, concerts and other high footfall programmes to continuously track crowd movements and identify any suspicious activities.

United Kingdom

The application of drones is being tested in various parts of the United Kingdom in multiple industries. Some of the key use cases are listed below:



Inspection and repair

The use of drones in inspecting, diagnosing and repairing potholes, street lights and utility pipes is being tested in England. This would assist in the timely identification and fixing of small defects and thus pre-empting any large failure or inconvenience.



Oil and gas

Drones are increasingly being deployed to inspect offshore oil and gas infrastructure, which is dangerous, timeconsuming and costly to inspect using traditional methods.



Telecom infrastructure inspection

Tropical Storm Harvey disrupted 17 emergency call centres and 320 cellular sites, and caused massive outages for Internet, TV and phone users, making it difficult for people to contact their families and friends. To re-establish connectivity quickly, drones were used for not just assessing the point of damage but also ascertaining the best route to access the site and supply the equipment required to fix the damage.



Certain government health institutions in England are exploring the use of drones to assist hazardous area response teams, who deal with medical emergencies involving chemical, biological or nuclear materials. The possibility of using drones to deliver blood or organs for transplant is also being looked at⁸.



Application of drones in India



Urban development

- The Government of Andhra Pradesh is deploying drones to monitor the development activities of the capital city region, i.e. Amaravati, through dronebased outputs such as geo-referenced ortho-images, digital elevation models and 3D models at periodic intervals. This covers the progress of multiple projects in and around the capital city area, such as roads, buildings and other infrastructure-related activities.
- The Government of Andhra Pradesh has deployed drones to map and assess the green cover in three selected locations in the state, thereby enabling the government to take necessary measures for maintaining the greenery in those locations. Subsequently, the government has planned to spread this activity across the state and make Andhra Pradesh a green state.
- As a pilot project, the Government of Karnataka is deploying drones for property tax estimation and creation of base map of a city/town for detailed planning and sustainable governance.
- The Chandigarh Administration has deployed drones as part of pilot project to get an aerial view of all properties in Chandigarh. The main aim was to map each and every dimension of all properties in and around Chandigarh, which would enable administrators to detect building violations and encroachments.⁹
- The Government of Tamil Nadu has deployed drones in Chennai for mapping property tax and encroachment of government land. The processed data would also enable officials to estimate the actual property tax¹⁰ and levy penalties on owners who have illegally paid lower dues. In addition, drones will help authorities plan for disaster management.



The Haryana Forest Department has inducted two drones to monitor wildlife and prevent illegal activities like tree cutting, encroachment and road construction in the Aravalli Range.¹¹ The drones are equipped with night vision cameras and flown up to a height of

 The Government of Maharashtra has deployed drones to enhance the transparency and credibility of forest governance.¹² It approved the use of drones to track the health of forests, encroachments, tree felling, forest fires, poaching, status of water bodies, biodiversity protection, and mangrove conservation.

250 m with a speed of 60 mps.

- The Government of Tamil Nadu has deployed five drones (in the Nilgiris, Coimbatore, Dindigul, Hosur and Tirunelveli) equipped with thermal detectors and infrared rays for real-time monitoring of animal movement and to prevent the spread of forest fires. Also, the buzzing sound created by drones at 131 decibels is used to drive away elephants, which normally requires the effort of 50–80 individuals.¹³
- In August 2015, the Union Ministry of Environment, Forest and Climate Change cleared a project¹⁴ by the National Tiger Conservation Authority (NTCA) and Wildlife Institute of India (WII) to deploy drones in select forests around the country for monitoring and surveillance.





Transport

- Indian Railways has used drones for monitoring the 25-km long Seawoods-Belapur-Uran¹⁵ corridor. Drones are being used to capture and analyse data. The outputs and insights have helped railway officials to present the project progress to their decision makers without undertaking field visits.
- The National Highways Authority of India (NHAI) has deployed drones in the Salem-Chennai green corridor expressway project to ensure accuracy with respect to the extent of land required for the project.¹⁶ This survey was aimed to estimate the affected number of coconut, palm and mango trees, other crops and properties.
- As a pilot project, the Government of Maharashtra has deployed two drones to monitor weekend rush hour traffic and accidents on the 95-km stretch between the Lonavala Exit and Khalapur Toll Plaza¹⁷ and on the six-lane Mumbai-Pune Expressway. The drones are flown at an altitude of 30 m from 12 p.m. to 4 p.m. Based on the data collected, 15 trucks were fined for violating traffic rules.



Agriculture

- A general insurance company deployed drones in a particular district in Maharashtra for assessment of crop damage due to floods in 2016¹⁸, instead of deputing its personnel to visit the field and assess the crop damage.
- The Government of Maharashtra has deployed drones over fields in the Marathwada¹⁹ region for carrying out crop loss assessment due to deficit rainfall, thereby ensuring timely intervention and compensations to farmers. Based on the successful results, the government has proposed mapping 51 villages of the Marathwada region under a pilot project.
- As a pilot project, the Government of Karnataka is deploying drones for identification of crop type, estimation of crop acreage, assessment of crop health and crop yield forecasting by establishing standard operating procedures that are envisaged to be followed by the agriculture department in Karnataka.
- The individual farmers of Andhra Pradesh's capital region are deploying drones to spray crop pesticide/ fertiliser in limited crop areas. Based on the results, famers are planning to extend this mechanism to other crops and areas.



Application of drones in India



Disaster management

- The National Disaster Management Authority (NDMA) deployed four drones to scan areas where search and rescue teams could not access in flood-hit Uttarakhand. These drones carried out a reconnaissance of 50²⁰ locations to assess damage.
 Further, the State Disaster Management Authority has procured a fleet of 10 drones for rescue operations.
- The National Disaster Relief Force used drones in Mandi,²¹ Himachal Pradesh, to trace 24 engineering students from Hyderabad who were swept away by the Beas river.
- The National Disaster Relief Force has deployed drones to survey the landslide site at Malin in Ambegaon taluka.²¹ The drones covered a 2.5 km radius and livestreamed visuals to the control room.
- The National Disaster Relief Force used drones to help their teams spot stranded people in forests, hills and other isolated areas who were dislocated from Badrinath and Kedarnath during the Uttarakhand floods. Around 190 stranded people²² were spotted by drones.
- During the Nepal earthquake, several agencies deployed drones for search and rescue operations and to map toppled monuments,²³ ruined heritage sites and devastated homes.



Oil and gas

 GAIL (India) Limited has deployed drones on a pilot basis for aerial surveillance of its pipelines in Chambal ravines²⁴ in Madhya Pradesh. They are used to patrol the gas pipeline and detect abnormal physical activity like encroachment or intrusion.



Security and surveillance

- The Crime Branch of the Thane Police Department deployed drones to confirm suspicions and gather evidence of bootlegging in a village.²⁵ The drones identified three locations and drums, planks, mixing tubs, furnaces, raw materials, etc., and thus helped the department officials to conduct raids.
- As part of a pilot project, the Government of Karnataka is using drones for crowd and traffic surveillance for effective planning decisions by the state police department. In addition to surveillance, the police department is also performing video analytics.
- The Tamil Nadu Police Department may be the first force in the country to deploy drones for murder investigation, in an area that was inaccessible and covered with thick bush. Two drones weighing 1.5 kg and 10 kg were used for 6 hours to reconstruct the crime scene by creating 3D images.²⁶



- The Government of Andhra Pradesh deployed a drone for monitoring of stockpile storage, 3D mapping and volumetric analysis of limestone over a period of time.
- The Karnataka Police Department has procured and deployed 12 drones equipped with 18.2 MP cameras and night vision capability which fly at an altitude of 1 km for about 30 minutes to detect illegal sand mining²⁷ from 5 km away.
- In Jharkhand, drones are deployed for boundary and safety zone inspection of coal and iron mines, counting of vegetation in reclaimed areas, and profiling of quarry and dump for volume calculations.²⁸

How can the Indian government leverage this technology?

India is a geographically diverse country with a majority of its population residing in rural areas, some of which are remote or hard to access. Thus, at times, they deprived of essential services. Drones can be used to substantially impact public service delivery and governance, improving vital indicators across all fields.



Insurance



Telecom







Disaster management



Tourism



Agriculture



Urban development



Potential use cases





Forest and wildlife



Healthcare





Some of the key sectors where drones can be effectively deployed by the government are discussed in the following sections. The agriculture sector in the country is plagued by issues of plateauing yield, imbalanced use of fertilisers, over-exploitation of groundwater and improper irrigation. Besides this, crop diseases, pest attacks and degradation of soil fertility further reduce the agricultural output. Lack of mechanisation for timely detection of these issues and course correction, farmers often suffer significant losses, which severely affects their already low purchasing power.



Agriculture

How can drones help?

Crop health monitoring

Routine surveillance using high-resolution, geo-referenced, orthomosaic 2D maps, spectral imagery and visual imagery can be used to capture the growth cycle and assess crop health to detect any potential problems swiftly as well as to assess damage and contain crop losses. Site-specific crop damage reports can be generated for appropriate action. This will help governments to ascertain an appropriate compensation plan for farmers.

Soil health assessment

Soil quality can be monitored using parameters such as soil moisture through remote sensing, which can help develop fertility maps, and consequently assist in planning for more optimal crop rotation or irrigation.

Improved resource utilisation

Ascertaining areas within a field that are most fertile or those that require additional water/fertilisers or chemicals can help farmers to optimise their resource utilisation. These limited resources can accordingly be deployed in different parts of the field in different quantities.



The increase in population has heightened the demand for housing and other infrastructure. It has, therefore, become essential that smart solutions are implemented for urban city planning. To achieve this, clear visibility on land usage is required to put in place sustainable expansion plans, which becomes difficult with the existing technology.



Urban development

How can drones help?

City survey

Geo-referenced, orthomosaic maps processed from high-resolution aerial images can be deployed for land use monitoring and mapping to ascertain wet lands or kharab lands. Illegal land encroachment can also be detected in this way.

Improved urban planning

Increased visibility of developmental and expansion activities with accurate alignment of roads, canals and drains can assist in urban planning. Moreover, digital elevation models help in understanding terrain stability while planning highways or residential ventures.

Project monitoring

Thorough inspection and monitoring of construction projects for bridges, buildings, telecom towers, etc., can be undertaken to assess their delivery status, and plan any corrective action if required.

Project quality assessment

Thermal imagery, 3D virtual models and videography can help to ascertain the stability of critical structures built, while time-lapse records can help analyse planned work versus executed work. Karnataka has the highest number of incidents of forest encroachment in India, with a total of

187,000 hectares of forest found to be encroached.³¹



The population explosion has dramatically increased the number of on-road vehicles, leading to intense traffic congestion, especially during peak office hours. Besides this, severe waterlogging occurs across cities during the monsoons, further worsening traffic condition.



Traffic management

How can drones help?

Road surface condition monitoring

Roads with heavy traffic movement can be routinely inspected to identify potholes or waterlogged areas, which often lead to accidents. For example, a drone can monitor the Delhi-Chandigarh or Bengaluru-Mysuru highway and provide a quarterly report on road condition. This data can be used by the Public Works Department for tendering maintenance contracts.

Improved traffic management

City traffic maps can be created to get real-time information on traffic jams, accidents, etc., which will help in planning appropriate diversions to decongest specific areas. Furthermore, video analytics is expected to drive decision making and assist in traffic management and route planning.

Traffic feedback

Real-time information on both vehicular and pedestrian traffic movement and congestion will enable evidencebased decisions on new roadway constructions, traffic signal requirements, pedestrian signal requirements, etc.



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India is home to a large number of tigers, leopards, panthers and elephants. Though it welcomes a large number of tourists to its many national parks and reserves every year, it continues to struggle to maintain its wildlife and forest areas, with multiple cases of illegal poaching being registered every year.



Forest and wildlife

How can drones help?

Wildlife conservation

Poaching and illegal trade can be curbed through roundthe-clock monitoring of threatened species in national parks (e.g. Bandipur, Ranthambore).

Managing human-wildlife conflict

Regular surveillance of both protected and unprotected forest areas for wildlife movement will reduce the possibility of human and wildlife conflict.

Forest protection

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Heat maps generated through thermal sensors can detect forest fires, while time-lapse studies of forest cover can highlight deforestation, afforestation and encroachment.



Some of the challenges that plague the healthcare space include establishing and maintaining the right infrastructure, ensuring a robust public health delivery system for all citizens, ability to actively manage disease programmes using high-quality data for scientific decision making, and maintaining the general well-being of citizens by offering a clean and healthy environment.



Healthcare

How can drones help?

Epidemic control

Thermal imaging, combined with topographic, weather and population density data, can help in developing heat maps to ascertain breeding zones for mosquitoes carrying dengue, malaria, chikungunya, etc.

Cleanliness and hygiene

Information on exposed garbage piles, open drains and sewers, dead animals on roads, etc., can be captured and used to control health hazards.

Healthcare delivery

India, with its varied topography from hills to dense forests to marshy river deltas, can use drones for timely delivery of essential medicines, test kits and vaccines to these hard to reach areas.





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The metro cities in India host multiple public events for which security planning requires considerable time and efforts. Moreover, real-time monitoring of crowds at these large gatherings, along with strategic security deployment, is often challenging.



Homeland security

How can drones help?

Real-time surveillance

Crowd monitoring can be done at public events such as political rallies, concerts, and exhibitions, and during religious festivities for identification of any suspicious or potentially unsafe activities or situations.

Security planning

3D models can be constructed for a location to conduct safety planning, identify traffic diversion routes and map deployment of security personnel across the area.



India continues to face significant challenges in tracking, monitoring and curbing illegal mining activities, limiting encroachment on mining boundaries, and keeping a check on the illegal sand mafia.



Mining

How can drones help?

Mineral scouting

Visual, hyperspectral and thermal sensors assist in mineral scouting for type of mineral available and the location. They also help in quantity estimation of mineral extraction.

Managing encroachment

Routine monitoring can help detect mine boundary violations and check the activities of the illegal sand mafia.

Contract monitoring

Mining contracts, based on volume of minerals extracted, can be monitored using aerial photos taken at separate time intervals for effective enforcement and implementation.





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India has multiple remote and inaccessible areas due to their unique topography and hence requires robust disaster management systems and processes to control loss of life and property in the event of a natural calamity.



Disaster management

How can drones help?

Real-time surveillance

High-resolution live video feed of disaster-struck areas can be used to create 3D models for efficient decision making.

Search and rescue

Heat maps can be generated to determine the exact locations of survivors and livestock for effective rescue operations.

Delivery of essential goods

In hard to reach disaster-struck areas, food supplies, water, medicines, etc., can be dropped quickly without endangering more human lives. This will also result in significant cost and time savings as compared to a manned aircraft system. Onshore and offshore oil and gas facilities require frequent inspection and maintenance to ensure safety and avoid failure. Inspection of hard to reach areas often involves shutting down of operations and sending an inspector into hazardous areas with a camera, which puts human lives at risk.



Oil and gas

How can drones help?

Emergency response

Information on pipe leaks and spills can be made available readily for quick and effective response without endangering human lives. Moreover, evacuation operations can be closely monitored.

Asset safety monitoring

Routine monitoring of assets will ensure that any repair requirements are highlighted and addressed timely, significantly reducing the downtime and generating considerable cost savings.

Security

Drones can improve security by providing a 360-degree



The explosive growth in mobile and Internet penetration in India has added considerably to infrastructural needs in the telecom space. This development in infrastructure will become increasingly difficult to manage if the dependency to conduct inspections, assess damages and provide seamless service to consumers continues to be on individuals.



Telecom

How can drones help?

Routine inspection

Drones allow for auditing and inspecting of telecommunication assets, including towers and wireless infrastructure, through high-resolution imagery and video, thus reducing the need for tower climbers. They assist in identifying any damages, making repair and maintenance activity quick.

Structural preservation

Drones assist not only in locating erosion, cracks and general wear and tear but also in detecting unseen electrical malfunctions by using infrared imaging. Any vegetation overgrowth that intrudes on telecom lines can also be quickly identified and managed.

Infrastructure planning

Telecommunication towers and cables can be geotagged to ensure effective infrastructure planning and ease of monitoring.

To maintain competitiveness in the insurance industry, it is paramount that claim settlement is done quickly and accurately for enhanced customer experience, robust pricing mechanisms exist and that strong systems are in place for protection against frauds.



Insurance

How can drones help?

Claim management

Drones can be used to assess damage in a timely and cost-effective way and allow for short claim settlement cycles.

Improved pricing

Risks can be effectively managed through more tailored pricing. Drones can collect information about a property before the issuance of a policy to identify vulnerabilities and hence assist in more accurate and customised pricing.

Protection against fraud

Before and after images of the insured property can assist in establishing the exact nature of damages. They will discourage fraudulent activities by highlighting the damages that existed prior to the adverse event and hence cannot be covered under the claim.



India, with its rich history and cultural heritage, is unable to fully exploit its tourism value due to its negligence of archaeological sites, inability to control littering and maintain cleanliness, and widespread safety concerns around public places.



Tourism

How can drones help?

Tourism marketing

A high-resolution 360-degree view of tourist locations allows for virtual reality tours to generate interest in tourist sites.

Asset monitoring

Monitoring public assets and ensuring cleanliness of heritage sites such as the Taj Mahal, Red Fort and India Gate, using real-time videography and penalties for violators will help prevent littering and preserve the beauty and tourism value of these monuments.

Improved security

Assessment of tourist movements through time-lapse videos can assist in managing tourist traffic effectively and avoiding any security issues such as stampedes.



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Implementing drone technology

Implementation of drone technology requires an inclusive and collaborative approach that involves aspects like governance, strategic planning, security, regulation and proper awareness. Successful implementation requires participation from various stakeholders.

Recommended action plan

Need

assesment

This suggested action plan will help governments to fundamentally transform and address key problems through the use of drone technology in a cost-effective way and to deliver high-quality solutions.

Setting the vision

Project planning Development of request for proposal/expression of interest



Setting the vision

It is essential to define a clear vision for the use of drone technology to achieve the desired transformation. For this, coherent articulation of the present scenario with details on the key problems faced by various departments and the requirements that need to be addressed is necessary. Strong commitment from organisational leaders along with a high-quality project team, is imperative to generate actionable insights from the use of drones for driving key decisions.

Need assessment

An effective need-based assessment of the current scenario has to be undertaken before the adoption of such a project. This will involve (a) conducting consultative discussions with various stakeholders to develop a detailed understanding of the problems and requirements of various departments to identify specific use cases for drone implementation and (b) identifying the best practices in the industry that need to be incorporated prior to project initiation.

Project planning

It is essential to understand the technology carefully before implementing the project. A future-oriented view must be taken to ensure that issues such as budget for maintenance, technology upgrade and scalability are deliberated well in advance.

Development of request for proposal or expression of interest

Once the appropriate use cases are shortlisted, the relevant government department can either float (a) a request for proposal inviting single or multiple bidders for empanelment to implement drones for specified use cases or (b) an expression of interest for various drone companies to actively engage with the government and share their expertise and previous engagement details. This will assist in selecting the most suitable vendor(s) for the specified use cases.

Project management

To ensure successful implementation of the project, it is essential that the selected vendor and system integrator (SI) are properly on-boarded. The project expectations and timelines must be pre-defined and clearly communicated to ensure that project objectives are met timely as per the identified use cases. Key considerations

The following parameters must be carefully considered while taking a decision on the adoption of drones in any industry:

Identification of the appropriate use case for the implementation of drones

Although drones have potentially widespread applications, it is imperative to ascertain the right use case for their successful implementation. Below is a list of the key applications of drones that must be analysed to assess if drones are the right technology to deploy to solve a specific problem:

Security and surveillance

Crowd surveillance and management, traffic surveillance and management, monitoring of ongoing infrastructure projects such as housing schemes, irrigation-based projects, roads and highways construction projects, promotional activities for tourism, etc.

Survey and mapping

Land survey, terrain mapping, land use and land cover, volumetric analysis, agriculture land survey and monitoring, engineering-related data calculations, etc.

Inspection

Inspection of infrastructure and assets such as electrical power stations, telecom towers, oil and gas pipelines, drinking water pipelines, etc.

Spraying

Spraying of insecticides/pesticides on diseased crops, garbage dump areas, mosquito breeding areas, etc.

Delivery

Delivery of goods to hard to reach or risky areas

Despite considerable advancement over the years, drone technology is still at a nascent stage in some areas and hence, it is difficult to deploy in fields requiring advanced GPS for last-mile delivery, a superior obstacle avoidance system or detection of any changes below the surface.

2 Assessment of commercial aspects

In terms of the business model and operations, the following aspects need to be looked into:

Drone-as-a-service

Suitable for clients that need aerial data collection and insights, but don't necessarily want to invest in their own drone fleet.

Lease or buy

While leasing may involve less capital outlay and better maintenance support, buying offers more control. Usage frequency in terms of routine usage, periodic usage or ad hoc on-need usage would also influence this decision.

- 1. Drone operations: Drones need to be operated by licensed drone pilots in order to capture data. The scope of data analysis can rest with the lessor or with the lessee.
- 2. Data analysis: The data captured by the drone will have to be analysed in order to derive useful insights. This requires high-end hardware and software along with skilled manpower. The scope of data analysis can rest with the lessor or with the lessee.
- Support and maintenance: The burden of repairs, maintenance and upgrade of the drones can rest with the lessor or with the lessee. It is an important consideration as drones deployed in difficult geographical and weather conditions may suffer damages.
- 4. Lease terms: In case the drones are taken on lease, the payment model could be one-time upfront payment for a specific period, or pay per use or pay per hour.



Key considerations

The following parameters must be carefully considered while taking a decision on the adoption of drones in any industry:

3. Types of output that can be expected

It is imperative to select the type of output and level of accuracy required from the aerial data collection and analysis depending on the nature of application. The following are some of the available output types:

2D outputs -

Images

High-resolution images or raw images.

Orthomosaic/orthophoto/orthorectification

Captured images will be stitched together along with ground control points for geo-rectification to form a single image.

Contour

It represents lines of equal elevation relative to a certain point. It is represented in the vector file format and composed of lines rather than pixels.

Videos

High-quality videos recorded by the drone.

3D outputs -

Digital surface model (DSM)

It represents the elevation of the bare earth terrain in addition to the natural (e.g. trees, shrubs) and man-made features (e.g. buildings).

Digital terrain model (DTM)

It represents the elevation of the bare earth without taking into account any over-ground features (e.g. trees, buildings).

3D reconstructed model

It helps to visualise the three dimensionalities of the object of interest.

Digital elevation model (DEM)

It represents the elevation of the earth's surface above a certain datum (e.g. mean sea level).

Point cloud model

It is a 3D visualisation made up of thousands or even millions of geo-referenced points and provide highresolution data without the distortion.



4 Assessment of technology aspects

The following aspects must be considered when deciding on the right drone technology to deploy:

Payload³⁸

Depending on the nature of the application, it is important to select the right payload.

Visual camera: In order to visualise an activity or carry out aerial filming, a drone must be equipped with camera with a suitable pixel resolution. In addition, the camera is required for vision, navigation and control guidance of drones. A visual camera plays a major role in any application using drone technology for surveillance, mapping, inspection, etc.

Hyperspectral camera: Hyperspectral imaging camera sensors come with hundreds of thousands of bands and capture spectral information to identify minerals, vegetation and other materials. Such camera have better capabilities to see the unseen. Hyperspectral cameras are mainly used in the fields of agriculture, ecology, oil and gas, oceanography and atmospheric studies.

Fluid carrying tank: Apart from imaging sensors, drones can also be equipped with a closed tank which contains fluid, such as fertiliser, pesticide or insecticide, for carrying out spraying activities. It has applications in agriculture, firefighting, garbage dump yards, etc.

LiDAR: Light detection and ranging (LiDAR) sensors use light energy, emitted from a laser to scan the ground and measure variable distances. LiDAR is particularly useful in surveying operations to perform 'laser scanning' and generate 3D point cloud images. When compared to other aerial survey methods, drone-based LiDAR collection yields the highest fidelity data. It has many applications in land surveying, utility infrastructure inspection, oil and gas, planning and mining, etc. **Multispectral camera:** Multispectral imaging camera sensors come with 3 to 10 bands that are represented in pixels and are mainly used for agricultural applications to monitor and manage crops, soil, fertilising and irrigation more effectively. A multispectral camera uses blue, green, red, red-edge and near infrared wavebands to capture both visible and invisible images of crops and vegetation.

Thermal imagery: Thermal imagery sensors measure the relative surface temperature of land and objects beyond the scope of human vision. They have many applications, including surveillance and security, water temperature detection, livestock and heat signature detection, construction, mining, heat signature detection in electrical transmission towers and lines, firefighting, search and rescue, etc.

Container carrier: It is not an imaging sensor but is used to deliver goods, packages, etc., to areas that humans cannot access. It has applications not only in the medical industry for delivery of medicines, blood samples, organs but also during disaster relief for supply of food and water, etc.

Specialised features

Drones are increasingly being integrated with more specialised technology features such as obstacle avoidance, which offers protection against crashes; return to home, which allows the drone to return to the flier in case it is going out of range or has low battery; and position hold/altitude hold features. Due consideration needs to be given to ascertain the requirements for each of these features for the purpose of the project.



Key considerations

The following parameters must be carefully considered while taking a decision on the adoption of drones in any industry:

Motors

Capacity of motors is an important determinant of the height as well as flight time of drones. Brushless motors, though more expensive, are quieter and have a longer life span compared to the brushed ones.

Range

It indicates how far a remote controlled drone can fly before the controller loses navigation abilities. Drones with different ranges can be deployed for different use cases.

Endurance time

It is the ability of the drone to stay in motion before the battery drains outs. Different drone types have different endurance times. It is imperative to choose the endurance time based on the nature of application.

Battery

Battery life, its charging time and availability of replacement batteries influence the operability of the drones greatly.

Control

Drones can be controlled using either a remote or automatic drone navigation system. A remote controlled system allows for line of sight view and navigation as per the controller's preference, whereas in cases where the drone needs to follow a designated path, say for inspection or surveillance work, automatic system is useful.

GPS

Some drones have inbuilt GPS capabilities which continue to monitor and record the location of the device and allow for better navigation, manoeuvring and hovering abilities. Such drones have applications for geotagging locations and capturing geo- referenced data.

Height and speed

To capture a live football match, the drone may be required to reach a height of 300 feet and move at a fast speed, whereas for crop monitoring, a height of 40 feet with a relatively slow speed may be enough. It is therefore important to find a drone which reaches the required height and speed.

Camera

While selecting the right camera technology for the drone, the following questions must be addressed:

- · in-built camera versus separately attached camera
- camera with ability to record and store images/videos for later access versus camera with a first-person view system allowing for live transmission to a screen or smartphone
- camera quality required in terms of megapixels, video resolution and angle control which provides movability
- only day imagery required versus need for thermal or infrared imaging for capturing images at night
- need for gimbal, a mechanical camera stabilisation system that allows for capturing smooth videos and sharp photos even with fast movements or high winds. For cases where high-resolution aerial images are required, such as for wildlife tracking or search and rescue operations during a natural calamity, this technology is quite useful.

Assessment of deployment aspects

If opting for drone-as-a-service business model, it is important to consider whether to empanel one organisation for all use cases under implementation or to consider different organisations for different applications based on their expertise. This is important as start-ups in the drone industry would specialise in one or two areas as opposed to being able to qualify across all selection parameters.

6 Assessment of procurement aspects

Since drone technology products are primarily offered by start-ups, while designing the RFP, it is imperative that due consideration be given to appropriate norms to ensure adequate participation and appropriate vendor selection.



7. Compliance with Directorate General of Civil Aviation (DGCA) regulations²

The country-specific guidelines for operation of drones in India were released on 27 August 2018; they will come into effect from 1 December 2018. The implementation of drone-based services for both government and commercial applications needs to be carefully studied to ensure that the selected use cases adhere to the defined policies. The end user shall ensure that the service provider obtained necessary clearances from the authorities. The list of agencies which has authority over drones and their operation is as follows:

DGCA:

Clearance for importing drones, issuance of UIN, issuance of Unmanned Aircraft Operator Permit (UAOP) and suspension/cancellation of UIN/UAOP in case of violations

Directorate General of Foreign Trade: Licence for importing drones

Ministry of Home Affairs: Security clearance

Ministry of Defence:

Permission for aerial survey/imageries/videography/still photography over restricted/prohibited areas

Indian Air Force:

Air defence clearance and monitoring of remotely piloted aircraft (RPA) movements in the country

Wireless Planning and Coordination (WPC) Wing, Department of Telecommunication:

Licence for operating drones in de-licensed frequency bands, i.e. Equipment Type Approval (ETA)

Bureau of Civil Aviation Security:

Permissions for drone operation in security programmes

Airports Authority of India:

Approvals for flight plan and monitoring of RPA movements in the country

Local police office:

Enforcement of violators as per applicable Indian Penal Codes (IPCs)

The Digital Sky Platform² is the portal where all applications pertaining to drones and their operation will be processed. The following aspects are governed under the regulations:

Drone import and registration

It is mandated to get clearances from relevant authorities for importing (if applicable) and registering each drone with a UIN for easy recognition and management.

Regulatory approvals

There are definitive procedures to be followed and approvals to be undertaken for drone implementation based on parameters such as drone category, flying altitude, equipment capabilities, flying range, payload and purpose of operation by the operating agency from listed government authorities and local security agencies.

Safety/security

It is mandated to follow certain safety and security measures and inform relevant authorities in case of loss of drone or any unforeseen incident occurrence.

Pilot licensing

The regulations have defined necessary requirements for pilot training, licensing and approvals for operating drones. It must be ensured that the selected implementation partner has the necessary expertise.

Drone accessories

It is mandated that drones be equipped with necessary serviceable components depending on the flying altitude.

No-fly zones

Most countries prohibit flying of drones over airports, military bases and other sensitive buildings for security purposes. Similarly, no-fly zones are listed and the selected use case should not include the no-fly zone.

The minimum standards for manufacturing of drones, legal obligations, insurance and enforcement actions are also highlighted.

Future roadmap for the government to create scalable solutions using drones

The Digital Sky Platform will become the cornerstone for designing UAV programmes for India in the future.

While the Digital Sky Platform will provide the basic infrastructure for various activities related to governance of UAVs, capability enhancement of the overall ecosystem will play a major role in determining the scale of technology adoption in the country. In this regard, governments need to focus on the following critical components to develop an ecosystem that supports large-scale adoption of drones.

Digital Sky Service Providers (DSPs)

At the outset of the programme, the government will build a basic layer of infrastructure that can cater to the governance-related aspects of drone operations and ensure policy compliance. However, there will be adequate room for either the government, the private sector or other bodies to build additional layers over and above the basic platform.

The government will formulate enabling policies for DSPs, who can build their own infrastructure around the platform to provide more value-added services. The government will consider various aspects such as eligibility to become a DSP, breadth of services that can be offered by DSPs, monitoring and compliance related to DSPs, etc., to handle these requests.

The advantage of having a well-laid policy framework for creation of DSPs is that the pace of innovation and richness of the value proposition to end customers can be scaled up significantly. Rapid evolution of the ecosystem can have a profound impact on various areas, as discussed in this report.

Development of sectoral competencies for drones

The creation of DSPs will add another layer of service delivery over and above the Digital Sky Platform. This is bound to have commercial aspects related to the operation of such DSPs but may not necessarily entail sectoral competencies. In this report, various industries and use cases where drone technology can be leveraged have been discussed, and each of these industries and use cases requires a distinct competency for the analysis of data generated by drones.

For instance, the expertise to synthesise insights from the images of a mine will be significantly different than that required for synthesis of images from an agricultural field. The complexity and level of expertise become even more pertinent when greater automation is sought using advanced techniques such as machine learning and artificial intelligence.

Governments may choose to develop competencies in some of the priority sectors where there is an immediate need for drone application and favourable returns on investment. These competencies could be leveraged by multiple government agencies as well as citizens or third parties in case they are granted access.



Formulation of specific business models

A typical drone operation involves various sets of activities, such as physical operation and maintenance of drones, ground activities for UAV operations, and analysis of post-flight data. These activities can be segregated based on stakeholder participation, and various elements of the value chain can be integrated with the help of technology layers over and above the platform.

This can also help in achieving scale in some aspects of the value chain, such as physical operation and maintenance, thereby reducing the cost of operations, which is prohibitive in some of the industries and use cases. In addition to cost efficiency, the government can also consider futuristic models wherein drone operations can be managed centrally without any investment in physical assets.

Multitudes of business models can be built around other elements of the value chain, such as sensors, cameras and methods of data analysis. The exact nature of such business models will unfold with the passage of time, but the government must play a proactive role in shaping the overall agenda through clearly drafted policies so that the technology can be leveraged by citizens, the private sector, government bodies and other entities alike.

Based on these emerging themes, the government should focus on strategically investing in creating a scalable ecosystem to allow for decentralisation of data capture through drones while centralising data processing for specific themes. Further, state governments should actively participate in becoming DSPs to enable decentralised regulatory oversight and, thus, fast-paced policy maturity in the country.

Overall, while the potential for application of drone technology is immense, the critical challenge for the country is achieving scale and overcoming the associated issues. It is on this front that the government has to take a leading role by investing in the ecosystem in order to allow the technology to thrive.



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About DFI

The Drone Federation of India (DFI) is a non-government, not-for-profit, industry-led body that promotes and strives towards building a safer and scalable unmanned aviation industry in India. DFI engages with thought leaders, industry experts, visionaries and policymakers to share their expertise and build a sustainable UAV industry in India.

DFI addresses issues of the UAV industry and helps solve them by forging strong global industry partnerships, extensive research, technology and knowledge transfers, business case studies and pilot projects; engaging with policymakers; and providing our members access to industry insights.

Members of DFI include drone manufacturing companies, drone services companies, drone training companies, drone support companies, hobbyists and enthusiasts.

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