E-BIRD TECHNOLOGY FOR TIGER CONSERVATION

DEVELOPMENT AND INTEGRATION OF UNMANNED AERIAL VEHICLES AS SURVEILLANCE AND MONITORING TOOL FOR PROTECTION OF TIGERS AND CAPACITY BUILDING OF THE FRONT LINE STAFF

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Development and Integration of Un-manned Aerial Vehicles as Surveillance and Monitoring Tool for Protection of Tigers and Capacity Building of the Frontline Staff

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PREFACE

The utilization of new and advanced wildlife monitoring technology is moving the worldview of wildlife protection and management. These digital technologies are helping wildlife researchers and conservationists around the globe to screen and oversee wildlife with more precision and efficiency. Un-manned Aerial Vehicles or UAV's, also known as 'drones' (self-propelled aircraft that does not have a pilot on-board), one such technology that is increasingly occupying operational space. These appear to offer a versatile, precise and economical solution to many challenges in wildlife conservation including monitoring and law enforcement. The usage of drones are vast in habitat mapping, wildlife population estimation and monitoring of other biological features. The data obtained from these aircrafts are more precise and most importantly, it is cost effective and time saving. UAV's are considered to be particularly useful with respect to direct conservation applications to rapidly monitor and assess inaccessible areas or terrains that are very difficult to reach from the ground. Drone-based monitoring is very beneficial when used in combination with modelling approaches to predict the spatial and temporal patterns of illegal activities. The UAV technology is also effective in the improvement of research methods in the future; this may reduce research cost associated with a reduction in time and manpower needed for a field survey. Integrating experiences from over the globe and from this ongoing activity (which is first of its kind in India), drone technology is probably going to turn into a backbone in the field of wildlife surveillance, monitoring and protection. This is additionally prone to open up novel applications for field managers and new ventures for innovation gatherings, which would additionally empower the spread of technology-based answers for wildlife management in India.

This interim project report demonstrates the customization and development of UAV models, integration of UAV technology, experimentation and implementation of UAV units in a phased manner, capacity building of frontline staff and technology transfer to the tiger reserves, vulnerability assessment, mapping of poaching and conflict-prone areas and undertaking need and feasibility analyses for the integration of technology in tiger reserves across the country.

We are extremely grateful to the Wildlife Institute of India (WII) for providing us with laboratory facility and the National Tiger Conservation Authority (NTCA) which is spear heading the project. We are also thankful to World Wide Fund-International (WWF) and Conservation Drones (CD), for initiating the preparatory process in collaboration with other organizations and experts, and customising UAV's for test flying in Panna Tiger Reserve, Madhya Pradesh. We are also thankful to the Director and Dean of Wildlife Institute of India, and Member Secretary of NTCA.

-Project Team

SUMMARY

UAV: Un-manned Aerial Vehicles also known as Remotely Piloted Aerial Vehicles (RPAV), have the potential to solve many problems related to wildlife research and conservation. UAVs are small and medium-sized aircraft, which are equipped with advanced electro-optics (EO) such as thermal, night-vision and various other sensors for remote-sensing and surveillance activities.

Objectives: The project was conceived as a new initiative, collaboratively by Wildlife Institute of India and National Tiger Conservation Authority in order to (1) integrate Un-manned Aerial Vehicle (UAV or Drone) for surveillance in selected tiger reserves based on pilot testing experience in the reserve, (2) undertake need and feasibility analyses for integration of Drone technology in tiger reserves, (3) map locations of poaching and conflict-prone areas, which would serve as a basis for drone implementation, (4) experiment and implement specialized drone units in a phased manner, and (5) build capacity of frontline staff for integration of drone technology as a part of regular management efforts.

Procurement: UAV customization was supported with a parallel process of procurements. Commercially available drones were utilized which are freely available in the market for technology familiarization and hands-on training of field staff as well as to carry out data collection.

Customization: Project team involving three Engineers (Aeronautical, Mechatronics and Mechanical) has developed locally customized units of UAVs at Wildlife Institute of India. So far, One Quad-copter, One Fixed-wing and One Delta-wing model UAV have been customized and used for various field activities. The development of a hybrid VTOL model and a Hexa-copter is under development.

Aerial Survey: UAV based survey and data collections on habitat, wildlife populations, and surveillance in poaching sites, conflict sites and fires prone areas have been completed in Panna, Sathyamangalam, Kaziranga, Dudhwa and Rajaji Tiger Reserves.

Need Assessment for Up-scaling: A questionnaire was prepared focussing on Poaching, Conflict, Forest Fire, Weed presence, Anthropogenic Pressure and Encroachment and has been distributed to all the tiger reserves. Data will be collected range-wise from every beat-guard and according to the data obtained, maps will be prepared prioritising the sensitive areas of respective reserves for implementation.

Capacity Building and Technology Transfer: Series of field training sessions were conducted in Panna, Dudhwa, Sathyamangalam and Kaziranga Tiger Reserves, and this included hands-on training to frontline staff on how to use the UAVs in surveillance and monitoring purpose. UAV units were transferred to the forest department of Panna and Dudhwa Tiger Reserves.

Introductory Manual: The project team has published a manual which contains detailed and elaborative information on UAV fight dynamics, characteristics and operation methods with its classification and uses. It was launched in Corbett Tiger Reserve in presence of NTCA members and field directors from various tiger reserves of India.

1 INTRODUCTION

1.1 UN-MANNED AERIAL VEHICLES

A protected area is a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long term conservation of nature with associated ecosystem services and cultural values. (IUCN, 2008). Despite their important role in conservation, often it is difficult to cope with increasing variety of challenges. Hence, there is a demand for cost-effective, versatile and practical initiatives to attend a disparity of requirements to guarantee conservation, together with a huge vary of natural solutions (Gonçalves, J et al. 2016), technological advances, and techniques or modern application of existing technologies.

In the last decade, drones (also known as un-manned aerial systems, remotely piloted aircraft systems, RPAS, UAS, UAV) have been the subject of an increasing interest in both the civilian and scientific space, and indeed proved as a new era of remote sensing (Melesse, A. et al.2007) for the study of the environment (Whitehead, K.; Hugenholtz, C.H, 2014). Drones offer a relatively risk-free and low-cost method to observe natural phenomena at high spatio-temporal resolution in a systematic way (Rodríguez, A et al. 2012). For these reasons, drones have recently become a major trend in wildlife research (Linchant, J. et al 2015, Christie, K.S. et al 2016) and management (Mulero-Pázmány, M. et al 2014, Koh, L.P.; Wich, S.A 2012, Chabot, D.; Bird, D.M., 2015).

The achievement of drones can be mostly clarified by their extraordinary flexibility to carry various sensors and gadgets. The extent of utilization decides the best mix of aerial platform and payload. In spite of the fact that drones come in a wide range of shapes and sizes, fixed-wing and rotary wing aircrafts are popular for capturing video and still photography. These customer evaluation drones combined with lightweight cameras and multispectral sensors can deliver proficient mapping arrangements at a small amount of an expense than past photogrammetric techniques. Medium size drones can be equipped with compact thermal vision cameras, hyperspectral sensors and laser scanning such as LiDAR, with great prospects for wildlife ecology, vegetation studies and forestry applications respectively (Schofield, G.et al 2017, Nasi, R et al, 2015, Wang D et al 2017). Additionally, large aerial platforms can lift heavier payloads and represent an appropriate solution for integrating complex systems with the capacity to remotely assist sampling, hold cargo or deliver assistance. A brief summary on types of drones is given below:

Types of UAV:

- **Fixed-Wing UAV:** A UAV which resembles a scaled down version of a real aircraft and uses the main fixed wings to generate lift. These aircrafts require a clear area to take-off and land.
- **Rotary-Wing UAV:** These UAVs generates lift using rotating wings or propellers. These aircrafts can take-off and land vertically and can hover in air.
- **Hybrid UAV:** These specialized UAVs have the abilities of both fixed wing and a rotary-wing aircraft. It can take-off and land like a rotary-wing UAV and fly like a fixed-wing aircraft.

Classification of UAV in accordance with Propulsion System:

- **Battery-operated UAV:**
  Electric motors used to rotate the propeller is powered by a rechargeable battery (Li-Po, Ni-Mh batteries). These UAVs are easy to maintain and operate.
- **Internal Combustion (IC) Engine:**
  This power-source is a two stroke miniature engine which uses petrol or methanol. They produce lot of noise and need maintenance.

Classification of UAV In Accordance With Maximum All-Up-Weight as per DGCA Guidelines:

i) **Nano**: Less than or equal to 250 grams.
ii) **Micro**: Greater than 250 grams and less than or equal to 2 kg.
iii) **Small**: Greater than 2 kg and less than or equal to 25 kg.
iv) **Medium**: Greater than 25 kg and less than or equal to 150 kg.
v) **Large**: Greater than 150 kg.

1.2 UAV IN WILDLIFE RESEARCH AND MANAGEMENT

The uptake of UAVs in environmental research has been remarkable. In their short history UAVs are emerging as powerful tools in wildlife ecology and can provide novel remote-sensing data at fine spatial and temporal scales (Anderson, K and Gatson K; 2013). UAV's has been used in applications as diverse as monitoring breeding success of canopy-nesting birds (Weissensteiner, M. H., et al.2015) to surveying elephants (Vermeulen, C., et al. 2013). Predictions of the future for UAV technology are based on the perception that the accuracy of data collection, collection efficiency, and cost effectiveness using UAVs typically exceeds those of traditional methods (Koh, L. P. & Wich, S. A, 2012; Anderson, K and Gatson K; 2013, Marris, E.9, Bryson, M., 2014). In wildlife population monitoring applications, it is desirable for population estimations to be accurate; that is to ideally gather an estimate which is close to the actual population number. In wild

populations where the true population size is typically not known (Yoccoz, N. G., Nichols, J. D. & Boulinier,2001), it is not possible to directly assess the accuracy of any counting method. However, it is possible to assess the precision of a count method, defined as the variance between replicated counts by different counters attempting to count the same sample (Gregory, R. D., Gibbons, D. W. & Donald, P. F, 2004). Regular precise counts facilitate the detection of small magnitude population fluctuations owing to the lower type II error rate in statistical analysis that comes with comparing measures with smaller variance (Gerrodette, T., 1987). Applications of UAS technology are diverse and growing, ranging from sampling airborne microbes to locating wildlife poachers, to providing data on cetacean behaviour and body condition. As the technology and regulatory frameworks improve, research applications are diversifying rapidly, and studies incorporating this technology are likely to proliferate in the future. Manned fixed-wing aircrafts and helicopters that are currently used as tools for surveying animals and plants for research, conservation and management purposes may increasingly be replaced by UAVs in numerous applications. While manned aircrafts are also effective in covering large areas they are very expensive, they disturb wildlife, and are the leading cause of work-related deaths among biologists (Sasse DB. 2003, Wiegmann DA and Taneja N. 2003, Watts AC, Perry JH, Smith SE, et al. 2010). Recent technological advances in UAV, combined with increasingly sophisticated remote-sensing equipment, are facilitating ecological research that may be safer, more cost-effective, and less invasive than traditional methods.

1.3 APPLICATION OF UAV IN INDIA

Innovation progression pursues an exponential development trajectory. Each new innovation begins off with a couple of trial models that produce favour among general society. Drowsy development with steady enhancements is the standard, until an affectation point, caused either because of advancement in centre innovation or disclosure of new applications, prompts exponential development in reception.

From the Internet to electric vehicles, we may be in a brilliant time of innovation headway. The universe of Un-manned Aerial Vehicles (UAVs) is no special case. The absolute first endeavours to devise a contraption that could fly without anyone else were accounted for in 1849, when Austrians assaulted the city of Venice with inflatables loaded down with explosives. In the event that we search for an increasingly current definition, the main pilotless flying machines were planned towards the apocalypse World War I by the US Army: vehicles called 'Kettering Bugs' which were intended to fly as flying torpedoes utilizing gyroscopic controls to shell adversary lines. In around the 1930s, the US and British armed forces autonomously built up the principal radio-controlled (RC) aeroplane. Towards the finish of the twentieth century, flying RC aeroplanes as a leisure activity developed

considerably, while other non-military business applications were likewise investigated by governments and partnerships alike far from the open eye.

The automation technology achieved its emphasis point in 2013 when Amazon declared that it would look to try different things with drones to make deliveries. Since at that point, we have seen a blast in the utilization of drones in the retail and business space. Un-manned aircrafts are being investigated widely over a variety of enterprises, including, yet not restricted to, development, land, web-based business, farming, utilities and vitality, monetary administrations, and media and amusement.

Customer and business rambles have developed exponentially because of merger and quick headway in two totally various advancements: radio correspondence and cell phones. It is rudimentary that radio correspondence help in controlling the airship, though more curiously, the approach of cell phones has prompted a precarious decrease in the costs of different hardware like microcontrollers, chips, accelerometers, cameras and different sensors. These have empowered catching of information, the utility of which is being enhanced by the accessibility of better figuring abilities.

The drone space in India is making up for lost time with that in different countries and increasing impressive energy. As per research, the Indian UAV showcase is ready to develop at a growth rate of 18% amid 2017–23. In spite of the fact that these numbers will keep on being driven by the long-range UAV portion, medium and smaller than normal UAVs are likewise ready to enrol solid development. Information given by the Stockholm International Peace Research Institute (SIPRI) demonstrates that with 22.5% of the world's UAV imports, India beat the rundown of UAV importing countries. Once more, these are numbers basically for military purposes, and business rambles are demonstrating solid development too. As indicated by the study directed by BIS Research, it is anticipated that the market for business end-utilization of automation may override the military market by 2021, in total hitting roughly 900 million USD.

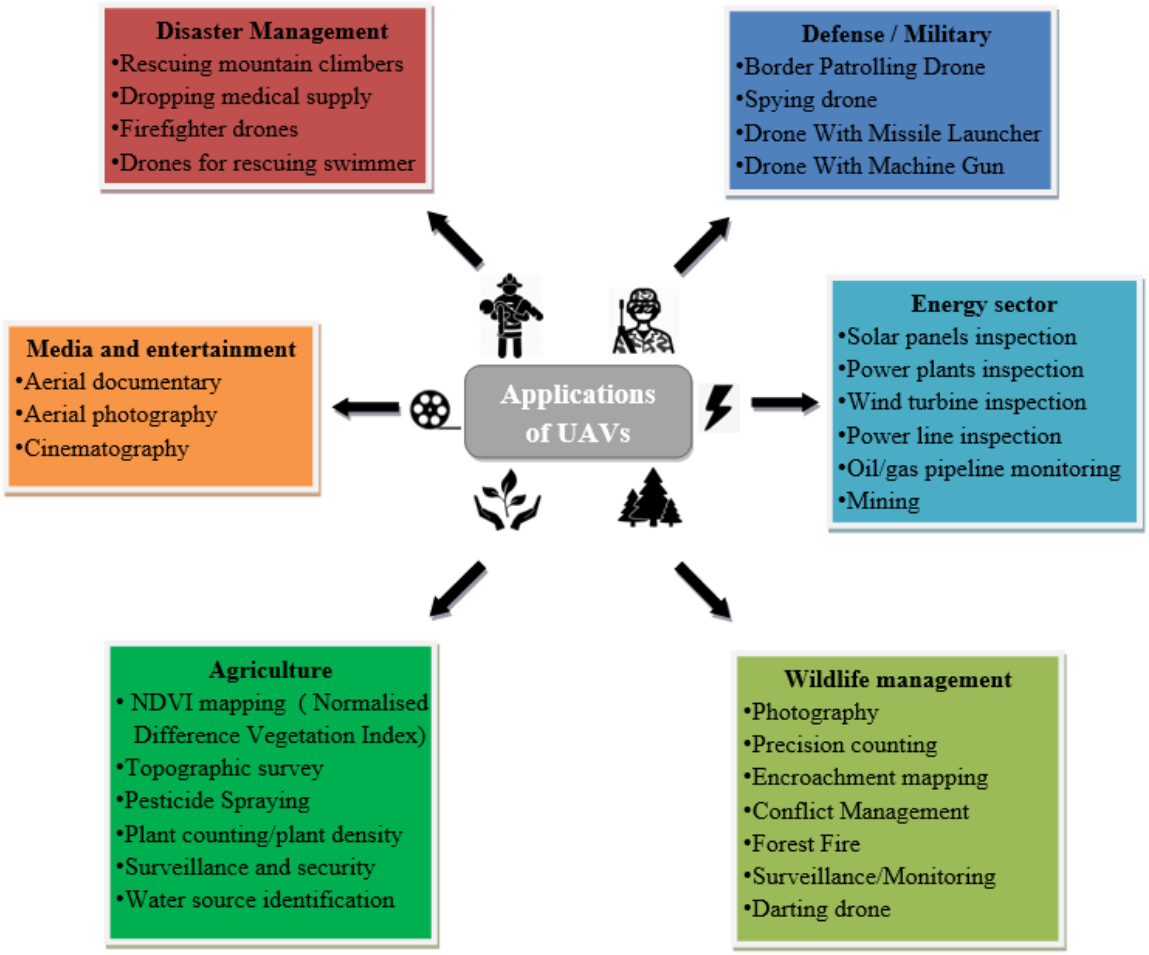


Figure 1: Applications of UAVs in India in different industrial sectors

2 RATIONALE

Drones are proving extremely beneficial in places where humans cannot easily or safely reach, or where we are unable to perform functions in a timely and efficient manner. There is a growing body of literature on the use of drones for monitoring species and their habitats. Drones have been used successfully, amongst others, to monitor a wide range of species from birds and reptiles to elephants and marine species such as turtles, whales, dolphins and dugongs. Mapping habitat allows an assessment of habitat extent, condition and suitability. Similarly, modelling the spatial and temporal abundance of species provides insights into vegetation dynamics and ecosystem processes or disease transmission and persistence.

There are many tiger conservation landscapes in India where it is humanly impossible or very difficult to undertake surveillance activities in significant parts of the area. Application of modern tools and techniques have long been integral part of wildlife research and management, the most popular being the wireless communication used by the forest officials on regular basis and camera trapping and telemetry technologies in several research and conservation projects. Given that wildlife populations move beyond the protected boundaries especially the large animals such as rhino, tiger and elephant and that many of these animals are target of poachers, so to protect these large animals advanced sophisticated technological solutions are required. In this context, Aerial Vehicles (both manned an un-manned) have been used in the Western countries for surveillance, population monitoring and crisis management. In India, manned aerial vehicles have been used occasionally for animal count and forest mapping. In 2012 Kaziranga Tiger Reserve introduced drone to save the one horned rhino from poaching. This technology has already been tested in Panna Tiger Reserve, Central India with credible success in collaboration with Wildlife Institute of India (WII) and National Tiger Conservation Authority (NTCA), in collaboration with World Wide Fund-International (WWF) and Conservation Drones (CD) in 2013-2014. The EBIRD project was initiated in 2017 and have been implemented in Panna, Dudhwa and in Kaziranga Tiger Reserve. The pan country approach of the project would enable understanding of and comparison between different conflict scenarios and testing efficiency of emerging technologies in meeting the diverse challenges of tiger conservation in India.

3 OBJECTIVES

1. To integrate Un-manned Aerial Vehicle (UAV or Drone) for surveillance in Panna Tiger Reserve, Madhya Pradesh based on pilot testing experience in the reserve.

2. To undertake need and feasibility analysis for integration of UAV in representative tiger reserves of the country with reference to poaching risk and conflict management strategies.

3. To map locations of poaching and conflict-prone areas in the tiger reserves, which would serve as a basis for technology integration.

4. To experiment and implement UAV technology in a phased manner in the representative tiger reserves for day-time aerial surveillance in strategic locations, night patrolling, mapping and monitoring of encroachment or degradation, data collection from camera traps and tiger monitoring involving RFID technology.

5. To undertake capacity building of field staff for technology transfer and implementation of UAV technology as a part of the regular management strategy.

4 STUDY AREA

The project has targeted all the Tiger Reserves of the country, but initial efforts have been made in representative reserves in all tiger landscapes in different phases. The specific needs in each of the sites would be determined based on need and feasibility analysis subject to clearances from the concerned agencies such as Director General of Civil Aviation (DGCA) and Ministry of Defence (MoD). For the up scaling of the project a need assessment form has been circulated in all the tiger reserves (TR) of India. So far we have received the data from Panna TR, Dudhwa TR, Bhadra TR and Satkosia TR. The assessment form has been circulated to all the tiger reserve in the country with the permission of NTCA.

No.	Landscape Complex	Names of Tiger Reserves	States
1	Shivalik Hills and Gangetic Plain	Corbett	Uttarakhand
2		Dudhwa	Uttar Pradesh
3	Central India and the Eastern Ghats	Ranthambore	Rajasthan
4		Panna	Madhya Pradesh
5		Melghat	Maharashtra
6		Simlipal	Odisha
7		Nagarjunasagar-Srisailam	Andhra Pradesh
8	Western Ghats	Bandipur	Karnataka
9		Sathyamangalam	Tamil Nadu
10		Parambikulam	Kerala
11	North East Hills and Brahmaputra Flood Plains	Kaziranga	Assam
12		Namdapha	Arunachal Pradesh
13	Sundarbans	Sundarbans	West Bengal

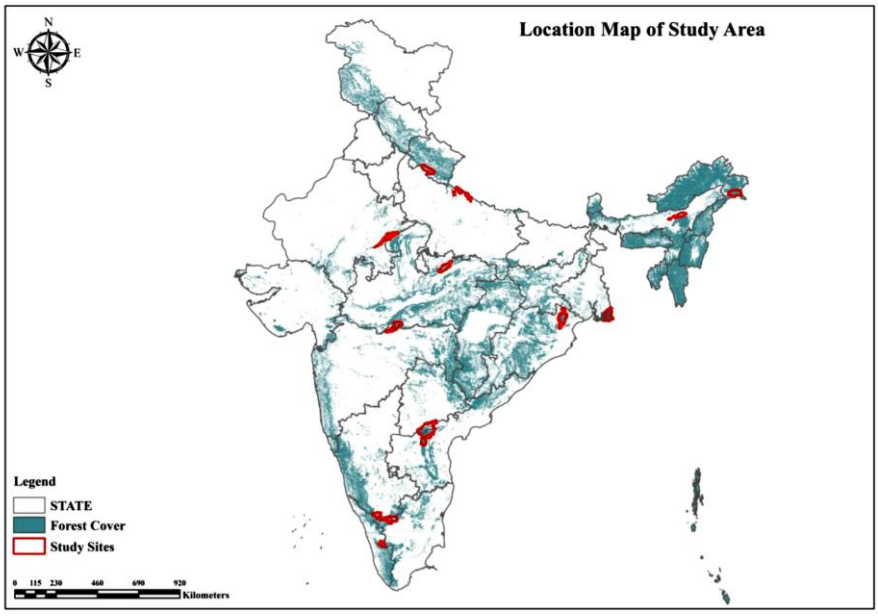


Figure 2: Study sites of the project E-BIRD

5 APPROACH AND METHODOLOGY

5.1 PRE- PROJECT ACTIVITIES

5.1.1 Kaziranga Tiger Reserve

Kaziranga has been facing a long conflict against rhino poachers who slaughter the creatures for their horns, which have enormous costs in some Asian nations. The fundamental market for the horns is China where it is utilized for making medication and adornments while in Vietnam many believe it has cancer-curing and aphrodisiac qualities. 21 rhinos were slaughtered in the year 2012 by poachers in Kaziranga while another 15 have been accounted for dead in 2013. A 2012 enumeration in the recreation centre put the quantity of the rhinos at 2,290 out of a worldwide one-horned rhinoceros populace of 3,300. The species tumbled to extinction in the mid-1990s and is presently recorded as "vulnerable" by the International Union for Conservation of Nature, one indent up from "endangered." Frightened by the spurt in rhino poaching occurrences, the Assam government has given over examinations to the Central Bureau of Investigation.

Figure 3: UAV launched at Kaziranga Tiger Reserve in 2013

To fight back with the situation Assam forest department introduced "Drone" (Maza) technology in 2013. For the first in India, UAV technology was used for the protection of wildlife on an experimental basis. Former Assam Forest Minister Rockybul Hussain took the opportunity to launch it in the reserve to control poaching activity and surveillance during the monsoon season. This was an initiate of NTCA, WII, WWF and Conservation Drones. This essentially marked the beginning of UAV use in wildlife management in India.

5.1.2 Panna Tiger Reserve

In Panna Tiger Reserve, two types of UAVs were used viz. Caipy and Vanguard, which were customised for use in Panna Tiger Reserve. Caipy has a wingspan of 850mm, the weight of 650g, a flight time of 30mins, a cruise speed of 45-50kmph and can optimally fly about 20km, powered by a rechargeable battery. Whereas Vanguard had a wingspan of 1400mm, the weight of 2100g, a flight time of 60mins, a cruise speed of 65kmph and can optimally fly for 40km, powered by a rechargeable battery. These UAVs carry GoPro video camera. The flight paths were programmed by marking waypoints in Google Earth map and

were transferred to the autopilot of the airplane. In addition to autonomous flight based on the programmed routes, the planes were also controlled manually through telemetry modem. These planes are capable of including other devices on board and with some modification; these can carry mapping camera and tracking devices. The usefulness of these UAVs was further enhanced by manual launching in the field even in remote places with minimal landing opportunity and the rechargeable batteries could be charged even with car batteries. In Panna, after receiving permission from concerned authorities, the preparatory process was initiated in collaboration with specified organizations and experts, and UAVs were customized for test flying. This process was done in August 2013 and could be completed at the end of December 2013. During the six months period from January to June 2014, UAVs were flown on two occasions – one for demonstration during 10-11 January 2014 by the expert team, and another for test flying during 27-30 June 2014 by WII team. During the pilot project period, there were 09 flights during the first occasion and 12 flights during the second occasion, with flight distance ranging from 2km to 12km within the tiger reserve boundary.

During the two missions, one in January and another in June 2014, the UAVs fitted with GoPro video camera were able to detect forest conditions, movement of vehicles, people moving and working in the forest, small built-up areas, water bodies and large-bodied human movement in the forest and detection of larger ungulates in the reserve. This is significant given that the flights were made at an altitude of more than 100m.

The planes could negotiate severe wind and the autonomous system performed exceptionally well to the extent that even after the loss of telemetry connection, the plane completed its long mission of 14 minutes and returned to the landing location.

The output included a series of video clips that require vetting by the Ministry of Defence as per its Office Memorandum that was issued while granting permission for the pilot project. Now that these units have already been successfully tested, the UAVs may be used for surveillance activities along the Ken River and in escarpment areas, which are otherwise highly challenging, rather ineffective, to monitor based on conventional methods.

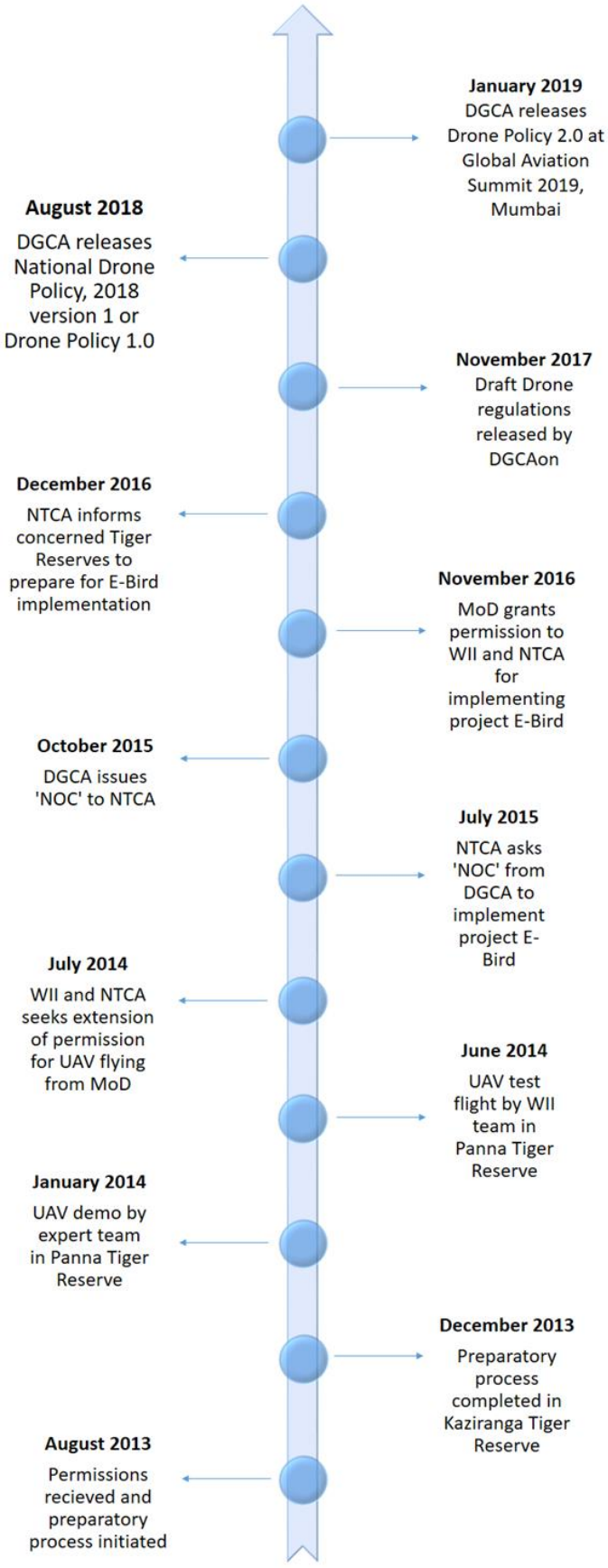
The reserve management could use such UAVs for monitoring intrusion along the Ken River, fire incidences, human movement in selected localities, specifically in the critical core areas and could collect pictorial evidence of unauthorized human activities in the forest. Monitoring of encroachment and habitat degradation activities are also possible. This information would be habitat protection in the core and buffer areas in the context of the Wildlife Protection Act (1972).

5.1.3 Legal Process

1. The E-Bird project was initiated in 2013 after the grant of special permission by Directorate General of Civil Aviation (DGCA) and Ministry of Defence (MOD) to National Tiger Conservation Authority (NTCA) for the operation of drones over unregulated airspace.

2. On 2014 a public notice banning the use of UAS in the country was released. The notice for the first time recognized the menace of drones and acknowledged the underlying safety and privacy issues in it. It concluded by stating that, till the time new regulations are issued, no non-governmental agency, organization, or any individual will launch a UAS in Indian Civil Airspace for any purpose whatsoever

3. In pursuance to the above, the Directorate General of Civil Aviation (hereinafter referred to as the 'DGCA') on November 1, 2017, released a draft regulation stipulating the requirements for Operation of Civil Remotely Pilot Aircraft System.



CHRONOLOGY OF EVENTS

5.2 CUSTOMIZATION

Commercially available drones are usually designed and developed for the masses without focusing on specific needs of the end user which includes repair and replacement, technical help, necessary instructions, sensor up gradation and various other factors.

This technology being advance is really sophisticated based on actual aerodynamic flight principals and avionics, which has to not only function in harsh condition forested land but also carry out the task for which it's deployed. The flying platform is an automated un-manned flying device which requires precision and management of complex calculations that is developed with time after multiple tests flights, fine-tuning and calibration.

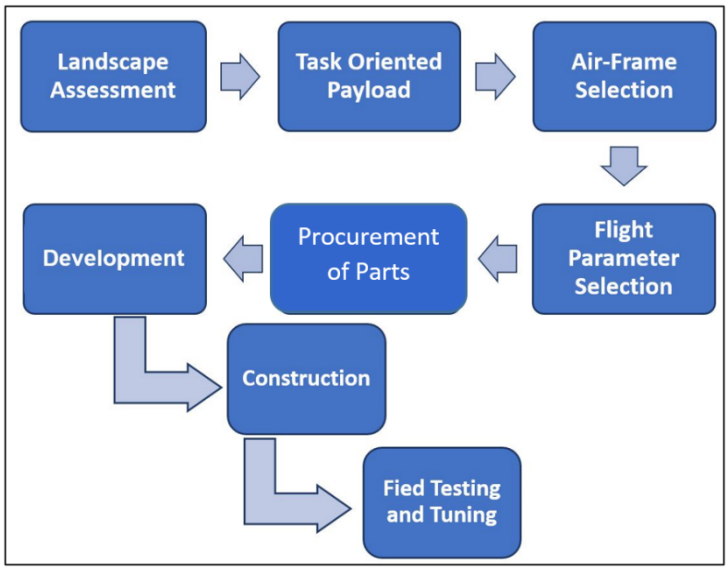


Figure 4: The flowchart here explains the customization process devised in order to understand the method behind the commissioning of our drones.

In order to develop a UAV for forest-related applications, steps involved include:

- Visiting the targeted field areas, for assessment of topographical, climatic, and elevation factors necessary for range estimation and deciding take-off/landing spots.
- The area assessment also decided on aircrafts payload selection, which is based on flora and the audacity of the task the aircraft might carry out in future.
- After the payload selection, a suitable airframe was decided to carry that payload and perform the flight.
- Understanding the specifications, calculations are made using eCalc software and simulating flight parameters in computer.
- Procurement of parts are carried out simultaneously, for further processes.
- Finally, the Development of drones begin with the construction in Technology lab and conducting multiple flight tests to calibrate and fine tune the aircraft.

A fleet of Remotely Piloted Aircrafts Systems (RPAS) operated by E-Bird Team

E-Brid Delta-Wing S1: This aircraft was developed in-house at Wildlife Institute of India, for larger area surveillance/monitoring and for a longer flight duration. The aircraft is capable of autonomous flight and can follow a pre-designed flight path by uploading waypoints to the flight computer.

Speed	50 kmph
Flight Time	20 minutes
Range	8 Km
Camera	Detachable GoPro series cameras
DGCA category	Mini

E-Bird Copter Q1: This aircraft was also developed in-house at Wildlife Institute of India for carrying out an automated larger mapping, as well as monitoring missions where vertical take-off and landing is the major requirement

Speed	75 Kmph
Flight Time	30 Minutes
Range	12 Km
Optics	Detachable GoPro series cameras
DGCA category	Micro

E-Bird Copter H1: This Hexa-copter which will operate utilizing the thrust from six BLDC motors is still under development. The aircraft after completion would come under the small category as drafted by DGCA criterion and would function as a heavy lift drone with much larger flight time and greater wind resistive flying. The proposed aircraft would be carrying an advance version of Electro-Optics including thermal/night vision sensors with zooming as well as object tracking abilities. Further development also includes the construction and attachment of the CO2 cylinder induced tranquillizers to the same flying platform.

Speed	60 Kmph
Flight Time	45 minutes
Range	15 Km
Payload	2 Kg maximum
DGCA category	mini
weight	8-10 kg

Raptor-A long-range fixed-wing model named Raptor is in development phase. With a wing-span of 2 meters and having flying endurance of 45 minutes, this aircraft is ideal for long-range monitoring and surveillance missions.

Speed	60 Kmph
Flight Time	45 minutes
Range	35-40 Km
Payload	Detachable GoPro series cameras
DGCA category	Mini
weight	2200 grams

Tail-sitter -The development of a Hybrid or VTOL drone is being carried out in Technology lab. This flight system is a combination of fixed-wing and a multi-rotor, which gives it the capability to take-off and land like a multi-copter and has a flight range of a fixed-wing aircraft. Initial flight tests of this model are going on, and tuning of flight parameters being done parallel.

Speed	45Kmph
Flight Time	20 minutes
Range	20 Km
Payload	Detachable GoPro series cameras
DGCA category	Micro
weight	900 grams

TBS Vanguard-It is another Delta wing aircraft with a wingspan of about 1400 millimetres and has effective displacement range of about 40 kilometres with live video transmission. This drone was developed by Team Black Sheep (TBS) and Conservation Drones, especially for forest and wildlife applications. A pilot project was initiated during January 2014 in Panna Tiger Reserve, where TBS Vanguard and TBS Caipirinha delta wing models were flown over selected locations in the reserve.

Speed	65 Kmph
Flight Time	60 minutes
Range	35-40 Km
Payload	Detachable GoPro series cameras
DGCA category	Mini
weight	2100 grams

TBS Caipirinha- This aircraft is a small range delta wing model which was also procured from conservation drones for quick deployment small distance monitoring

Speed	45-50 Kmph
Flight Time	30 minutes
Range	20 Kilometers
Optics	Detachable GoPro series cameras
Weight	650 Grams
DGCA category	Micro

5.3 PROCUREMENT

The customization was supported with a parallel process of procurements, so that capacity building and the data collection task could be carried out with efficacy. Some, commercially available drones were utilized that were freely available in the market for technology familiarization and hands-on training of field staff as well as to carry out the task of data gathering.

During the process of procurements, the team faced certain restrictions in terms of imports, customs and permission procedures, which led to the consumption of essential time kept for development and construction. The upcoming Drone Policy 1.0 to Drone Policy 2.0 saw significant amendments in between, which were of decisive in nature such as the Above Ground Level (AGL) limitations and Visual Line Of Sight (VLOS) operation, necessary for civilian airspace flying.

Initially, four DJI Phantom 4 pro plus and two fixed-wing delta models were procured for phase 1 of the project. The DJI drones are simple and effective to fly and really easy for a beginner to learn flying, therefore, they are used for training and data collection purposes.

Phantom 4 Pro Plus: This aircraft developed by Dà-Jiāng Innovations was procured and used as a tool to train the forest guards due to its easy operation and controlled flight manoeuvres.

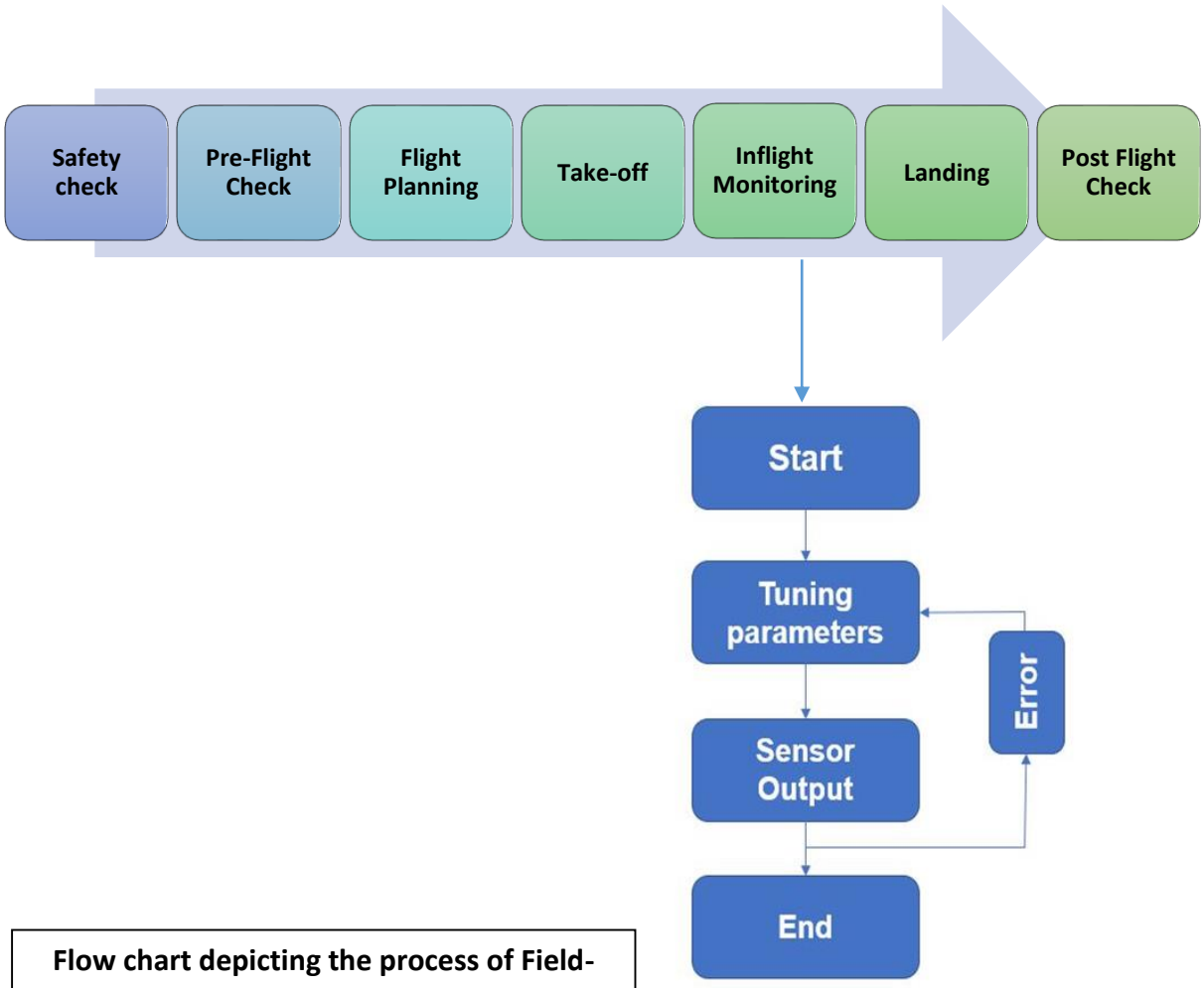
Speed	72 Kmph
Flight Time	25 minutes
Range	7 Km LOS
Optics	24 mm lens,1inch sensor camera 20 MP RAW and JPG images,60 fps/4K video
DGCA category	Micro

5.4 FIELD TESTING

The process of field testing included multiple flight tests, and flying the aircraft through actual field condition to make necessary changes in terms of its technical aspects and operational strategy. The essential data which are generally termed as flight parameters were recorded after each flight and errors generated were rectified within its flight computers, with several errors were minimized to nominal and aircraft was calibrated with suitable values for efficient flying.

The behaviour of aircraft was also analysed at different field locations with different payloads for future up-gradation and the changes in its flying patterns were observed. Multiple flight modes such as Guided, Auto, Stabilized and Manual were also tested in and perfected in field.

The climatic conditions such as temperature, humidity, wind velocity and the direction played an important role when operating the aircraft, these factors decided the endurance of aircraft which may vary at different locations or field sites.



Flow chart depicting the process of Field-Testing

Field Testing in Panna Tiger Reserve

Field Testing in Sathyamangalam Tiger Reserve

Field Testing in Kaziranga Tiger Reserve

5.5 DEMONSTRATION

Wildlife Orientation-cum-Technique tour for IGNFA IFS Probationers of 2016-2018 Course in Panna Tiger Reserve, Madhya Pradesh. Demonstration of UAV "Drone" at Bargadi, Panna Tiger Reserve (25-10-2017).The display of Un-manned Aerial Systems was conducted at Bargadi base station. UAV technology capabilities, especially for Wildlife applications, were explained. Various flight parameters and process of flight planning were discussed before the launch of the aircraft.

Demonstration of Types of UAVs and autonomous flights over Bargadi Region at Panna Tiger Reserve

Demonstration of Live Video Transmission from a fixed wing aircraft

During flight, the aircraft crashed into a tree due to a bad waypoint input. However, the aircraft was recovered without any damage and was ready to fly again. This crash displayed the structural durability and damage resistant design of aircraft reflecting its ability to withstand field conditions. After retrieving and examining the aircraft, the reason for the crash was analysed and rectified.

Probationers were briefed about the structural integrity of the UAV after recovery of the aircraft

MULTI-COPTER (QUADCOPTER) DEMONSTRATION

A Multi-copter unit, developed and customized in Wildlife Institute of India was demonstrated. Aerial pictures were captured by two on-board high-resolution cameras.

This Quad-copter was capable of autonomous flight with altitude hold feature. The live video transmission system was integrated into this test model. The aircraft was tested till an altitude of 50 meters from the launch site.

DISPLAY TO DELEGATES FROM CAMBODIA

The UAV operation was demonstrated to the delegates from Cambodia, where they were shown the automated flights of Caipy drone, which during the flight, captured aerial data in the form of video footage, along with this live video transmission from the drone camera was also displayed using FPV (First Person View) goggles. Delta-wing aircraft named Vanguard and a multi-copter model was also demonstrated to the delegates, which captured images from the belly mounted camera from an altitude of 35 meters. The display was focused on explaining the capabilities and potential of these aerial companions in field operations.

PRESENTATION AT NTCA MEET IN PERIYAR TIGER RESERVE

The project's objectives, its implementation strategy and the benefits of having drones in surveillance and monitoring tasks was communicated to the senior officials who were part of the **Meeting of Chief Wildlife Wardens of Tiger Range States and Field Director of Tiger Reserves** on 16th September, 2017 at Thekkady, Periyar Tiger Reserve, Kerala. Key points regarding progress of the project, knowledge about UAVs and its applications, and aerial footage samples were shared with the attendees.

UNIVERSITY OF BRITISH COLUMBIA SCHOLARS TRAINING PROGRAM

A special presentation and live demo of UAVs was organized for the foreign students who visited WII during Field School, 2018. Presentation on the uses of UAVs in the field of conservation along with the description of customization of each units was explained. After the session, a hands-on training was organised for the scholars to understand the basics of UAV flight.

DEMONSTRATION TO XXXIV CERTIFICATE COURSE:

Radio-Collar Tracking and Drone Exercise at Rajaji Tiger Reserve was conducted on 15th December 2018, where the utilization of drones for tracking and monitoring was assessed during tranquillizing operation.

TRAINING PROGRAM FOR STAFF FROM GREAT HIMALAYAN NATIONAL PARK :

Drone Technology application and its operational Rules and guidelines were briefed to Field staff from GHNP on 8th and 15th February 2019. The demonstration was a part of an ongoing course for the GHNP at WII, where a brief discussion followed by a hands-on DJI Phantom 4 pro plus was given to the participants from the forest department.

After answering the queries and doubts regarding the drone operation, the trainees were instructed to follow safety guidelines and read about the DGCA rules and regulations for UAV flying over civilian airspace**.**




UAV flight explained to the forest officials to enhance their technical knowledge

GIZDEUTSCHE GESELLSCHAFT FÜR INTERNATIONALE ZUSAMMENARBEIT (ENGLISH: GERMAN CORPORATION FOR INTERNATIONAL COOPERATION GMBH)

E-bird team was a part of Human-Wildlife Conflict Mitigation 2017-19 SFS Induction Course at CASFOS FRI in Dehradun, conducted by GIZ from 29TH April to 4th May 2019. The team displayed as well as demonstrated UAV flights to the young and enthusiastic Trainees from CASFOS, also the application of Drone for tracking of the animal during the tranquillizing operation was worked on and a mock-up task was done for better understanding.

INDIA DRONE FESTIVAL 2019

The Team was a part of India Drone Festival 2019 which was a collaboration of ITDA (Information Technology Development Agency) and DARC (Drone Application Research Centre) on 26th and 27th February 2019 held at ITDA office, Dehradun.

Here the team displayed the potential uses of drones in wildlife application and management as a part of the E-Bird project. This was met with a positive response and project's efforts were appreciated by various government as well as private officials.

The event culminated in discussions with various development and private entities having expertise in drones on general topics referring to the capabilities of drones in sectors apart from wildlife and forest.

5.6 DATA COLLECTION

5.6.1 GROUND SURVEY

Questionnaire Survey

A questionnaire was prepared to collect data on Poaching, Conflict, Forest fire, Anthropogenic Pressure, Weed presence and Human Encroachment for mapping locations of poaching and conflict-prone areas in the tiger reserves, which would serve as a basis for technology integration under the project 'E-bird Technology for Tiger Conservation. The questionnaire was distributed to all the tiger reserves across the country. Data was collected Range wise from all the beat guards. According to the data obtained from each tiger reserves, maps will be prepared highlighting the sensitive areas.

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

E-bird Technology for Tiger Conservation: Development and Integration of Un-manned Aerial Vehicles as Surveillance and Monitoring Tool for Protection of Tiger and Capacity Building of Frontline Staff
(A WII & NTCA Collaborative Project)

Need and Feasibility Assessment Form

Name of the Tiger Reserve .....Number of Ranges.....Vacancy.....
Number of Beats ..... Vacancy..... Whether Drone/UAV needed (and add further details in the Remarks column) .....

S. No.	Range Name	Beat Name	Name, Designation, Age & Education of Beat Guards/Information Provider	(1) Poaching Risk Score	(2) Conflict Risk Score	(3) Fire Risk Score	(4) Anthropogenic Pressure Score	(5) Weed Presence Score	(6) Encroachment Risk Score	Remarks (Specify any particular requirement of UAV or other technologies)

Scoring Method:

For **[1-4]** Score:
0 – Absent (No incidence), **1** – Low (in 5-10 years), **2** – Moderate (once in 2-3 years), **3** – High (Every year).
For **[5-6]** Score: [Weed and encroachment level, consider proportion occupied]
0 – Absent (0%), **1** – Low (5-25%), **2** – Moderate (25-50%), **3** – High (50-75%), **4** Very High – (75-100%)

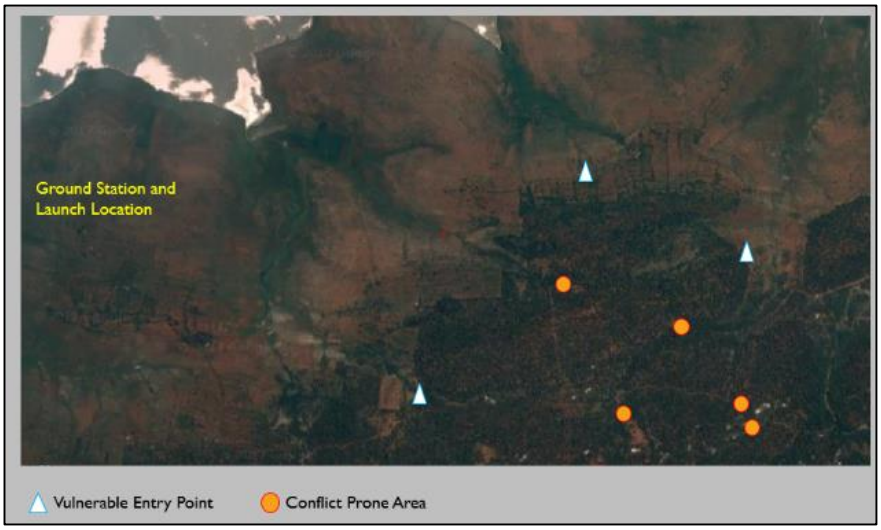
Duly filled form to be returned along with GIS file (shapefile) of the reserve with core, buffer, beat, compartment boundaries, eco sensitive zones and village locations, and posted/ e-mail to: **E-Bird Technology Project Team, C/o. Dr. K. Ramesh, Scientist, Wildlife Institute of India, Dehradun-248001, Uttarakhand. E-mail: ramesh@wii.gov.in Phone: 9412971678, with a copy to NTCA (Use multiple forms if there are more beats)**

(Signature of Competent Authority with designation)
Date:
Contact Number:

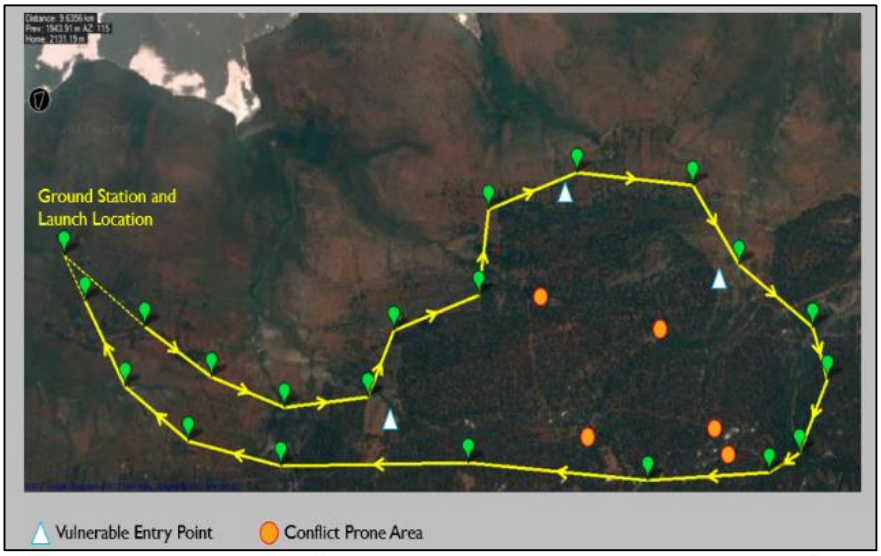
Need and Feasibility Assessment Form

5.6.2 AERIAL SURVEY

Interactions with forest officials, analyzing past records of poaching or conflict incidences and collecting data from field surveys (questionnaires), vulnerable locations and areas are identified and field team visits the area to plan the flight directions and paths which suit the aircraft and avails maximum data capture in form of images and video.



Identification of vulnerable locations



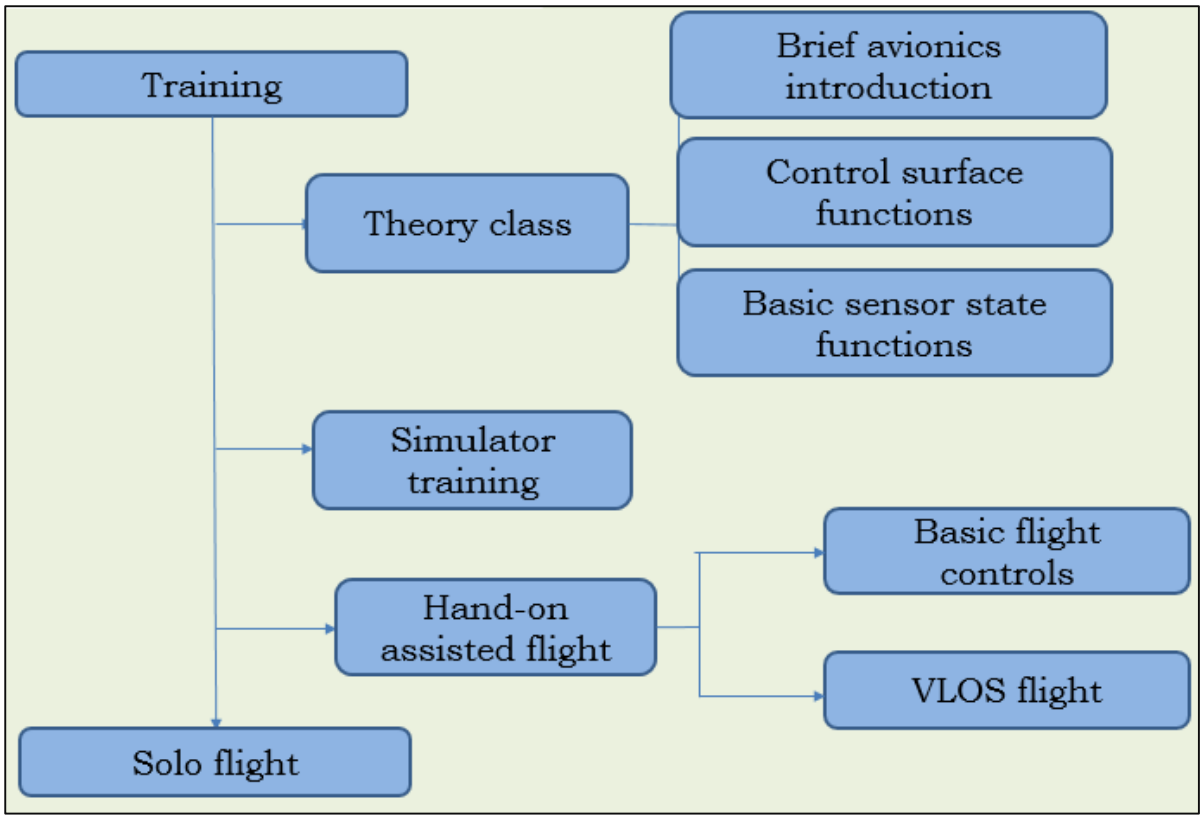
Planning flight paths to monitor those areas

Collections data and evidences of animal and human activities

5.7 CAPACITY BUILDING AND TRAINING

One of the main objective of the project is to train and equip the forest staff with UAV technology. In order to make them capable of handling the UAV operation without supervision, elaborative training has been conducted at Panna Tiger Reserve and Dudhwa Tiger Reserve. The focus of the training is to develop the technical skills of forest officials and construct a network of a trained pool of staff who can understand the future needs and viability. Further changes and upgrades can be incorporated in the UAVs after the feedback from the trained staff, to make them better and suitable for focal areas.

The training sessions are conducted in steps, the flowchart illustrates the procedure for better understanding.



TRAINING AT PANNA TIGER RESERVE:

On 27th April 2018, the UAV team conducted a demonstration for DD Panna (Smt. Basu Kanojiya) and AD Panna (Shri Rajendra Saxena) in Talegano beat. Forest staff who were capable of operating computer have been selected for the training. From 28th -2nd May 2018 the training has been executed.

The pictures that follow reflect the quality of interest displayed by them for learning the new technological tool. A graphical approach is used for the understanding of the basics of UAV flight, remote control features, parts and components, and safety features. This familiarizes the trainees with the nature of the flight and its controllability. Followed by on-field trials, trainees get a hands-on of the UAV and get a chance to take control and learn progressively.

Live display of UAV to Deputy Director and Presentation to the Forest Officials of Panna Tiger Reserve

In-flight controls of the UAV being explained to the trainees followed by hands-on trials

TRAINING AT DUDHWA TIGER RESERVE:

The same training and UAV exercise model was followed at Dudhwa Tiger Reserve, UP. The Deputy Director of the reserve selected beat guards with a technically sound mind for being trained in the UAV operation.

Beat guards taking a hands-on trial for flying as well as flight path planning

Theoretical explaination of the UAV, their operation, safety and handling were given to the forest guards. All the models, quadcopters and fixed-wing aircraft were shown along with their operating procedures and handling.

Basics of UAV flight demonstrated to the forest officials

Hands-on training was given to the forest guards with basic technical knowledge. Along with that, the forest guards were given the models to perform a flight which would later be handed over to the forest department for surveillance and monitoring activites.

Forest staff getting trained to fly UAV through theory and hands-on training sessions

TRAINING AT SATHYAMANGALAM TIGER RESERVE:

In Sathyamangalam, E-bird team has conducted the capacity building program in range-wise manner. So far, the ranges covered are Thukka, Naickan, Palayam, Bhavani Sagar, Hasanur and Talavadi Range. Presentation about how to fly drones with all safety measures was given to the Range officers, Forester and Anti-Poaching Watchers (APW). Hands-on training was also part of the program.

5.8 TECHNOLOGY TRANSFER

Panna Tiger Reserve

On 4th May, the team presented the standard operation procedures for UAVs and safety precaution for handling these units in the presence of then FD of Panna Tiger Reserve (Shri Ravikant Mishra), AD of Panna Tiger Reserve (Shri Rajendra Saxena) and the trained beat guards. At the end of the presentation, two UAV units, i.e. a Phantom 4 PRO+ commonly known as Quad-copter and a Delta-wing model were officially handed over to FD of Panna Tiger Reserve. There was a distinct enthusiasm and participation by the senior officers and field staff for implementation of UAV in Panna Tiger Reserve.

Technology transfer at Panna Tiger Reserve, Madhya Pradesh

Drone Operation by the Field Director of Panna Tiger Reserve

Dudhwa Tiger Reserve

The E-Bird Team marked their second visit to Dudhwa Tiger Reserve for handing over the UAV models to forest department. The team captured the park opening ceremony and along with that, also performed a field trial for the UAV models and collected data.

Two models, one quad-copter (**E-Bird-Copter P1**) and one fixed-wing aircraft (**E-Bird-Plane S1**) along with the E-Bird Technology manual was handed over to forest department on the day of opening ceremony of Dudhwa Tiger Reserve for tourists.

Handing over the Model 'E-Bird-Plane S1' along with E-Bird Technology manual to the forest

6 SYNTHESIS OF OUTPUTS AND OUTCOMES

To integrate Un-manned Aerial Vehicle (UAV or Drone) in Panna Tiger Reserve, Madhya Pradesh based on pilot testing experience during 2013-14.

- Using Quad-copter and Delta-wing Planes, surveys have been completed for habitat mapping in selected sites.
- Targets surveys and data collection have been completed on tiger, vulture, crocodiles and tourism activities.
- Training of staff from all level has been completed and carried out intensive training for a few staff who are now able to fly UAV without external support.
- Technology transfer for specific survey purpose has been completed by handing over one quad-copter and one fixed-wing drone to Panna Tiger Reserve.
- It is informed that ever since the staff started using UAV, fire incidences have come down significantly and the UAV is serving as an excellent deterrent tool.

To undertake need and feasibility analysis for integration of UAV in representative Tiger Reserves of the country with reference to poaching risk and conflict management strategies.

- Questionnaire survey format has been circulated through NTCA to the respective tiger reserves, but the response has been poor, although, during direct interactions and after various classified visits/meetings, it was possible to conclude that all the tiger reserves require this tool to deal with poaching and conflict management, in addition to other managemental inputs.

- During the field training sessions and independent field visits, detailed need and feasibility analyses for the integration of UAV have been completed in Panna, Kaziranga, Sathyamangalam, Corbett, Rajaji and Dudhwa Tiger Reserves. In the upcoming phase, this would be taken up in other reserves as well.

- It is now proposed to undertake Regional Workshop involving Regional Offices of NTCA to expand the scope of UAV integration based on specific requirements and efforts in terms of the cost, trained manpower and technology transfer.

To map locations of poaching and conflict-prone areas in the tiger reserves, which would serve as a basis for technology integration.

- Four sets of questionnaires focussing on Poaching, Conflict, Forest Fire and Encroachment were completed in all Beats based on inputs from Range Officers and Beat Guards.

- In all the surveyed Tiger Reserves (additional sites include Buxa, Dudhwas and Satkosia Tiger Reserves), it was found that poaching and conflict rates are concentrated at buffer ranges.

- Poaching continues to be a major risk and species such as wild boars, chital, sambar, etc. are also in the risk of poaching. These areas expose tigers to poaching.

- Forest fire is a yearly event in most of the ranges. The fire is mostly man-made which damages a good area of the forest every year.

To experiment and implement UAV technology in a phased manner in the representative Tiger Reserves for day-time aerial surveillance at strategic locations, night patrolling, mapping and monitoring of encroachment or degradation, data collection from camera traps and tiger monitoring involving RFID technology.

- Project Team involving Three Engineers (Aeronautical, Mechatronics and Mechanical) have developed locally customized units of UAVs at WII. So far, One Urban Quad, One Quad-copter, One Fixed-wing and One Delta-wing Models have been customized and used in field activities. Work is still in progress on the development of VTOL and a Hexa-copter.

- UAV based survey and data collections on habitat, wildlife populations, and surveillance in poaching sites, conflict sites and fires prone areas have been completed in Panna, Sathyamangalam, Kaziranga, Dudhwa and Rajaji Tiger Reserves have been undertaken.

- Additional inputs related to population estimation, elephant tranquilization and relocation, habitat mapping etc were given to Rajaji Tiger Reserve, Abohar Wildlife Sanctuary and CAMPA Team for Dugong Survey.

To undertake capacity building of field staff for technology transfer and implementation of UAV technology as a part of the regular management strategy.

- Series of field trials and training sessions were conducted at Panna, Dudhwa, Sathyamangalam and Kaziranga Tiger Reserves, and this included hands-on training to frontline staff on how to use the UAVs for surveillance and monitoring purpose.

- The project team has published a manual which contains detailed information a detail elaboration of the UAV's operation, types and its uses. The title of this manual is "E-BIRD Technology Introductory Manual for Managers and Biologists".

- On 4th May, 2018, two UAV units, a quad-copter and a fixed-wing model was transferred to the Field Director of Panna Tiger Reserve for day-time surveillance, monitoring and fire detection operations.

- After a series of training from 15th – 17th November 2018, the team handed over two UAV units (one fixed-wing aircraft and one quad-copter) to Director/Deputy Director of Dudhwa Tiger Reserve for rhino enclosure perimeter monitoring and surveillance of targeted areas.

7 ADDITIONAL INPUTS

7.1 ELEPHANT TRANQUILISING OPERATION

UAVs provide aerial assistance in many monitoring activities for civil as well as military sectors. Using UAVs for special cases like capturing a wild elephant, gives a better observation of the whole operation also directing the teams for further course of actions.

At Rajaji Tiger Reserve, team from E-Bird project, provided aerial assistance as well as used the UAVs as a deterrent tool and displayed the importance of new technological innovations for such a tricky task.

The task was initiated on 20th November, 2018, three teams were formed, two teams with captive elephants (circled red in images) and one team on foot. Darting Team 1 had one veterinarian and forest guards, and Darting Team 2 had one veterinarian and a UAV with its operator on-board. To capture the target elephant (circled yellow in images), communication and coordination between the three teams was maintained with wireless radio-communication devices and the whole task was observed using live-video from quad-copter UAV camera.

Teams ready for deployment

First dart hit was accomplished on 20th November, 2018 and the elephant tried to run away into dense canopy. Teams on elephants followed the target and this entire scenario was recorded by UAV. It was really difficult to reach the target elephant after this and all efforts of the teams were unsuccessful that day.

TARGET ELEPHANT RUNS AWAY AFTER THE FIRST DART HIT

Forest officials were regularly trying to locate the wild elephant and were updating its position constantly. The strategy required the target elephant to be in open ground or in an area which has good visibility and accessibility. Finally, on the fourth day i.e. 23rd November, 2018, forest department's trackers localized the elephant early in the morning and all the teams were then deployed immediately.

After hours of struggle, the animal was darted, sedated and transported to Mitthawali, in Ravasan Range

Encounter with Poachers

A group of four individuals were spotted with the UAV during the search for the wild elephant to be captured at Rajaji Tiger Reserve. UAV operator followed these suspects and minutes later they figured out that they are being monitored by the drone. Field Director of the reserve sent officials immediately to capture the suspects.

The suspects could not be caught but the loot was recovered as they were not able to carry it with them. The image that follows shows a zoomed in view of the sacks carried by them and the items in it. Armed forest guards reached the scene and inspected the area for other evidences. UAVs again proved their importance as a surveillance and monitoring tool of modern age and displayed the speed and efficiency with which a larger area can be patrolled in short time.

Sacks stuffed with leaves recovered from the site

Armed Forest Guards inspecting the area

Tusker Chase Away

The first day of the wild elephant capture operation i.e. on 20th November, 2018, teams were successful in darting the animal once after which it ran into dense forest. Tracking and following the animal for hours led the teams to raw area (displayed in images). The elephant was not far but the path of the darting teams was blocked by another wild elephant which was getting curious about the two captive elephants of the teams.

Communicating this problem to the UAV team helped them to get a UAV at the site and tried to deter the animal. A quad-copter UAV was used to make random manoeuvres in order to irritate the wild elephant obstructing the way. With much efforts finally the animal ran away, clearing the path for the darting teams to proceed.

WILD ELEPHANT SPOTTED BY THE UAV

ELEPHANT RUNS AWAY AFTER MAKING RANDOM AND QUICK MANOEUVERS WITH QUAD-COPTER UAV

DARTING TEAMS IN THE BACKGROUND OF THE IMAGE WITH CLEAR PATH TO PROCEED

7.2 SURVEY OF DUGONG AND SEA GRASS:

On the request of the Campa project members, we headed to Thondi on 2nd January to help with the Dugong survey under the "Save Dugong" project. With the guidance of Dr Sivakumar, the surveys were conducted off the coasts of Mallipattinam and Keezhathottam, extending upto Adhirampattinam.

We travelled on the boat in 5-kilometer transects and flew the drone in a radius of 500 meters around the boat at 50 meters altitude from certain points along the transect.

We also checked the feasibility of various flight modes over the ocean in high wind. "Follow Me" mode was used when the drone was at an altitude of 20 meters and 30 meters ahead of the boat. Since aerial assistance is necessary to capture animals which flee due to the noise of the boat. "Active Tracking" was also used to track another boat from an altitude of 40 meters.

On 4th January, we headed towards Kurusadai Island to assist with the training of the staff. The training was on surveying sea grass and involved snorkelling. As the waters were clear and still, we were able to spot the regions covered by grass and corals by flying about 10 meters above the water.

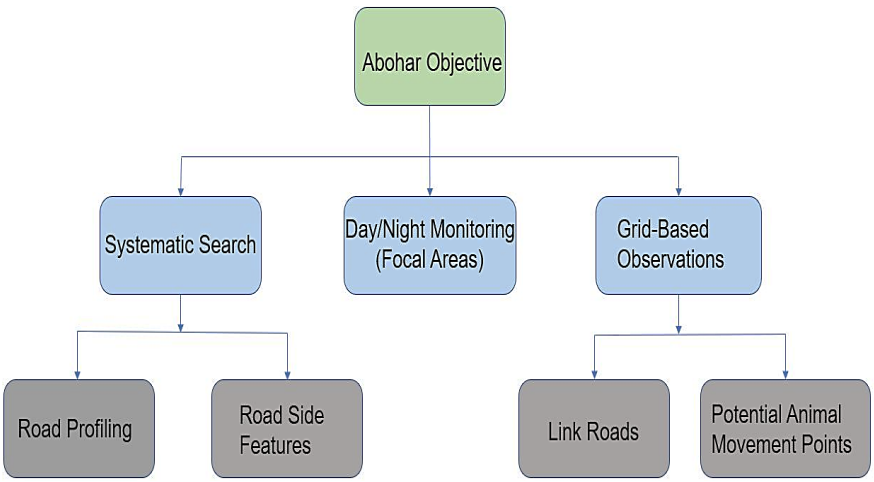
Hasanur

The DFO of Hasanur Range needed to map Mavallam village to assess the development that had taken place. The village was in two major parts – Upper Mavallam and Lower Mavallam. We headed to the highest part of Upper Mavallam and started mapping. The drone covered 580m*450m and was flown at a height of 100 meters above ground. The photos taken were all geo-tagged by default. The photos were then aligned and merged together to form a single image with the ground resolution of 3.22 cm/pixel. We have used the GIS software to stretch the Orthomosaic image.

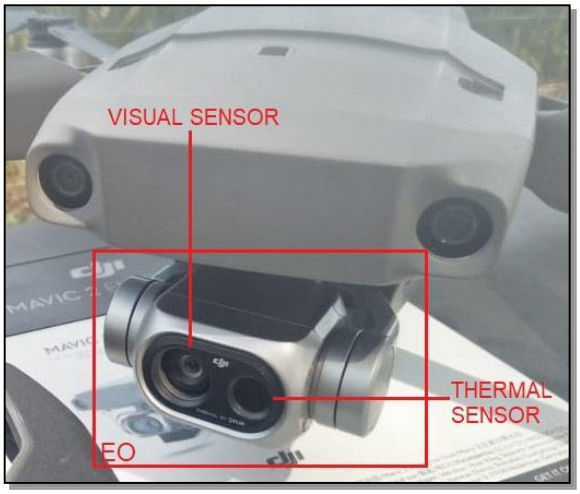
7.3 SURVEY OF IMPACT ASSESSMENT OF ROAD EXPANSION PLAN IN ABOHAR WILDLIFE SANCTUARY, PUNJAB.

Background issue: To reduce the traffic volume and pressure of NH7, the Central Public Welfare Department had passed an upgradation plan to widen the Abohar-SitoGunno-Dabwali road of 50.88 km of NH-354E in Punjab state. As the 17 km length of road passing through the sanctuary which is proposed for widening will have excessive impact on the habitat of the animals, the Chief Wildlife Warden, Punjab, requested the Director WII to suggest corrective measures for habitat connectivity. To assess these impacts and devise corrective actions, as advised by the Director, Wildlife Institute of India, the team from E-Bird Project coordinated by Dr. K. Ramesh, Principal Investigator of the Project was entrusted with the responsibility of undertaking aerial survey with focus on (a) profiling of the entire road stretch, (b) enumerating Black Buck population along the road-side to link the potential crossing points, and (c) collecting more detailed from specific locations where culvet and others structures are being planned. In general, the use of UAV was decided to be on experimental basis and based on the efficacy, this can be up-scaled both within and outside the state.

Approach and Methods: In line with the project objectives and supporting information required, the UAV survey was designed to record features on the entire stretch, falling within the sanctuary. UAV flight was kept at 50m constant height and GPS enabled images were captured to create high resolution video/still data. Once this was done, flights were executed along the road stretch facing each side of the road to count the animals using the habitat along and away from the road. The survey was focused along the entire stretch with 500m blocks so that the counts could be fixed to spatial bin. This was possible with position the camera angle towards left and right side of the road throughout the survey stretch. Based on prior information and empirical data collected by the ground survey team, specific locations were identified, marked and flights were undertaken during day as well as night time using **White Flash and Thermal Camera** and these locations included (a) already identified crossing points, (b) culvets, (c) high animal use areas, etc. Additionally, surveys were also carried out taking a grid of 1-square kilometre on the potential animal movement points and the link road connections along the main road. The overall survey design and focal points are capture in a flowchart for ease of understanding.

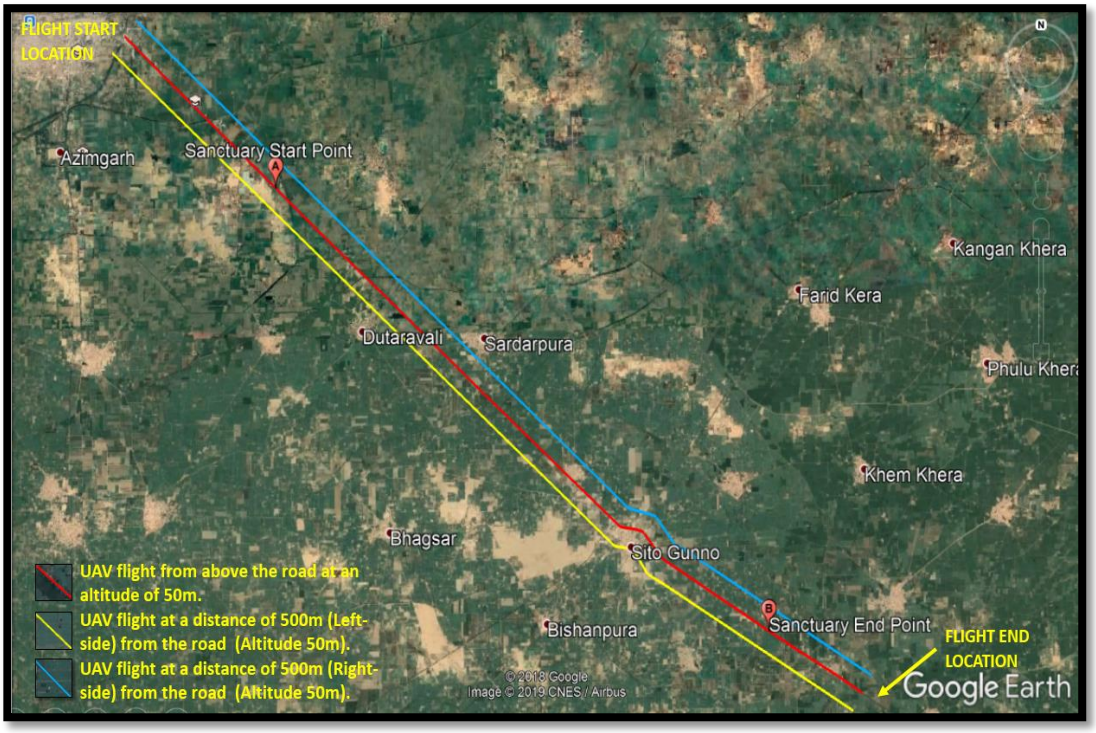


As per internal discussion and after obtaining permission from the competent authority by the State Government, the UAV operation was implemented during 25-03-2019 - 29-03-2019 and used three different models of aircrafts to accomplish the objectives. These aircrafts were categorized according to its general specification such as range, endurance of flight and Electro-Optics (EO), and these were (1) DJI Phantom 4 Pro Plus with White Flash Camera (imported and procured), (2) DJI Mavic 2 Enterprise with Thermal Imaging and Flash light (imported and loaned), and (3) Custom Quad-copter with Go Pro Hero 3 camera (Customised by the E-bird Project at WII).

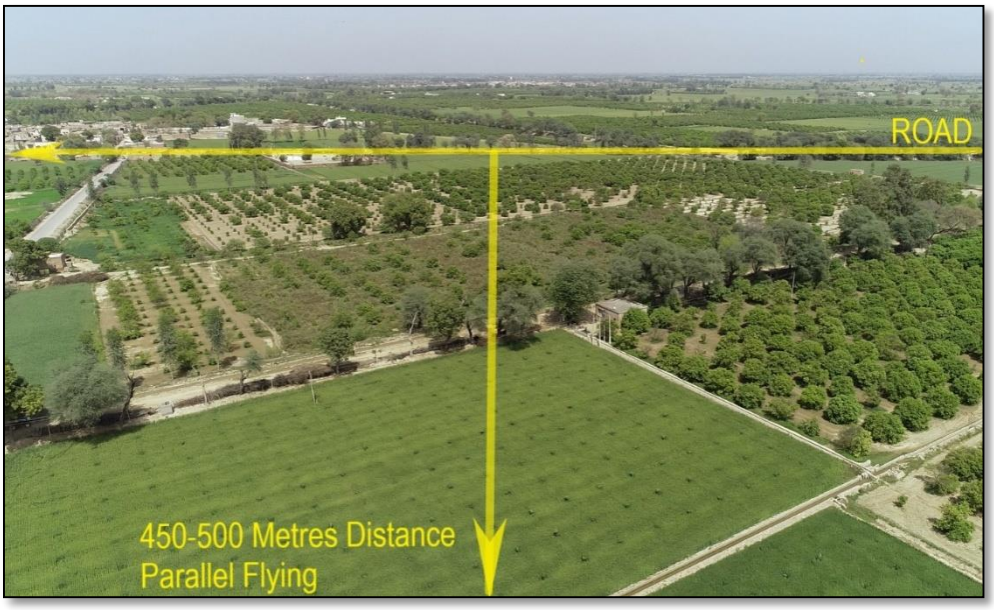


M2ED Thermal optics	M2ED Visual optics
Uncooled VOx Microbolometer sensor	1/2.3" CMOS; Effective pixels: 12M Sensor
HFOV: 57° Aperture: f/1.1 lens	FOV: approx. 85° 35 mm format equivalent:24 mm Aperture: f/2.8 Focus: 0.5 m to ∞ Lens
160×120 Sensor Resolution	ISO Range- Video: 100-3200 (auto) Photo: 100- 1600 (auto)
12 µm Pixel Pitch	Max image size-4056×3040（4:3）；4056×2280（16:9）
8-14 µm Spectral Band, spotlight of 26 Watt, range 30 metres	Recorded at 2.7K：2688×1512 30p

Road Profile: The drone was flown along the top flank of the road covering the whole stretch of 25 kilometres distance. The altitude maintained by the drone at 50 meters covered the Field-Of-View (FOV) of approximately 300 metres horizontally and 150 meters vertically. The flight endurance of 20 minutes covered a distance of 8 kilometres on an average. The map below depicts the flight pattern made on alternated days. During flight, the approximate vegetation cover was also estimated using visual estimation methods.

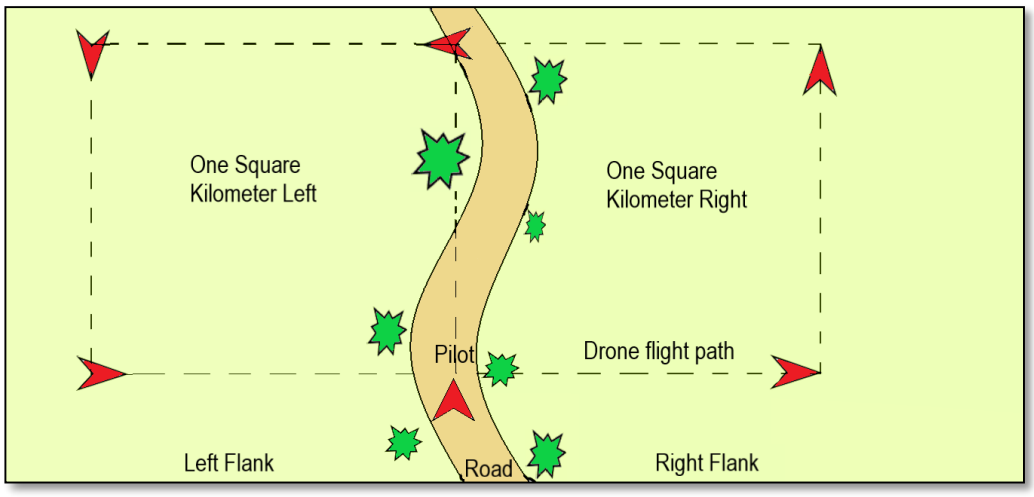


Systematic Search: This was carried out in order to scan the whole perimeter adjoining road and the build-up areas nearby in a systematic and phased manner, to understand the landscape and population distribution of the animal. Drone was flown along both the sides of road flanks with a Field-Of-View focusing towards the road whilst moving parallel to it at distance maintained around 450-500 meters and altitude of 50 meters. This flying was done in order to collect the data 400-500 meters beyond the forested land cover area along the road.

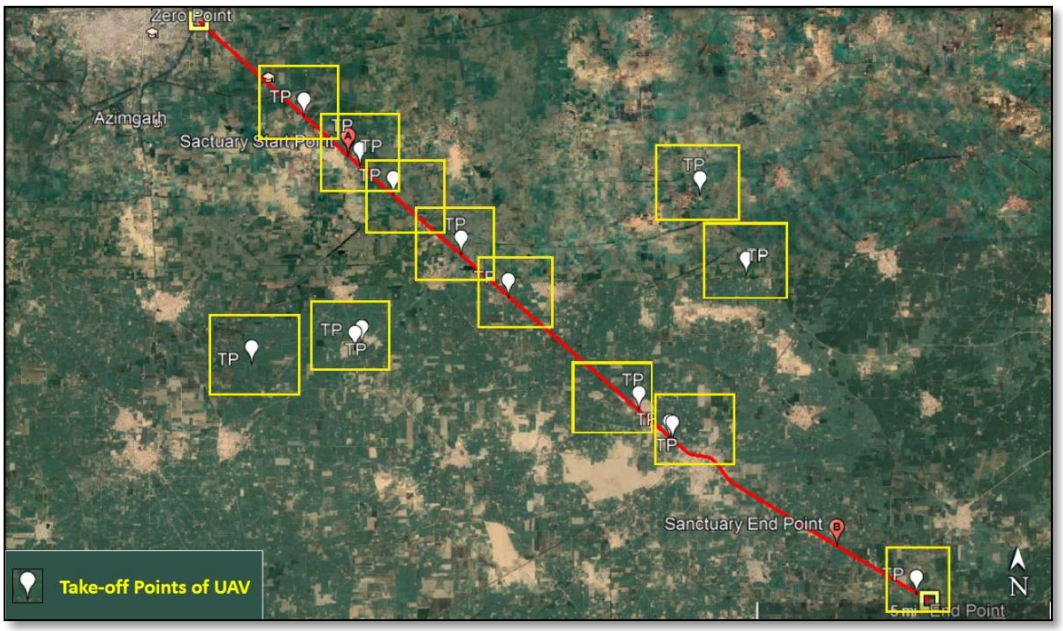


Focal Area Survey: Drone flights were repeated over the same location of reported animal movement for analysing the day and night-time activity and to check on the passage of herds towards the road crossing points. Multiple flights were made late night over certain animal crossing points on both sides of roads to record the data of any potential crossings being made. The electro-optic used was a dual camera module which recorded the video in both thermal as well as in spotlight enabled mode.

Grid Survey: Flights were conducted, taking a grid of 1-square kilometre over the potential animal movement points distributed on sides of road flanks for monitoring the animal activity and to locate their pockets as well as foot trails across the cultivated field and orchards. A methodology was formulated (as shown in figure) according to which an array of flights were planned to scan the area of one square kilometres on both the sides.

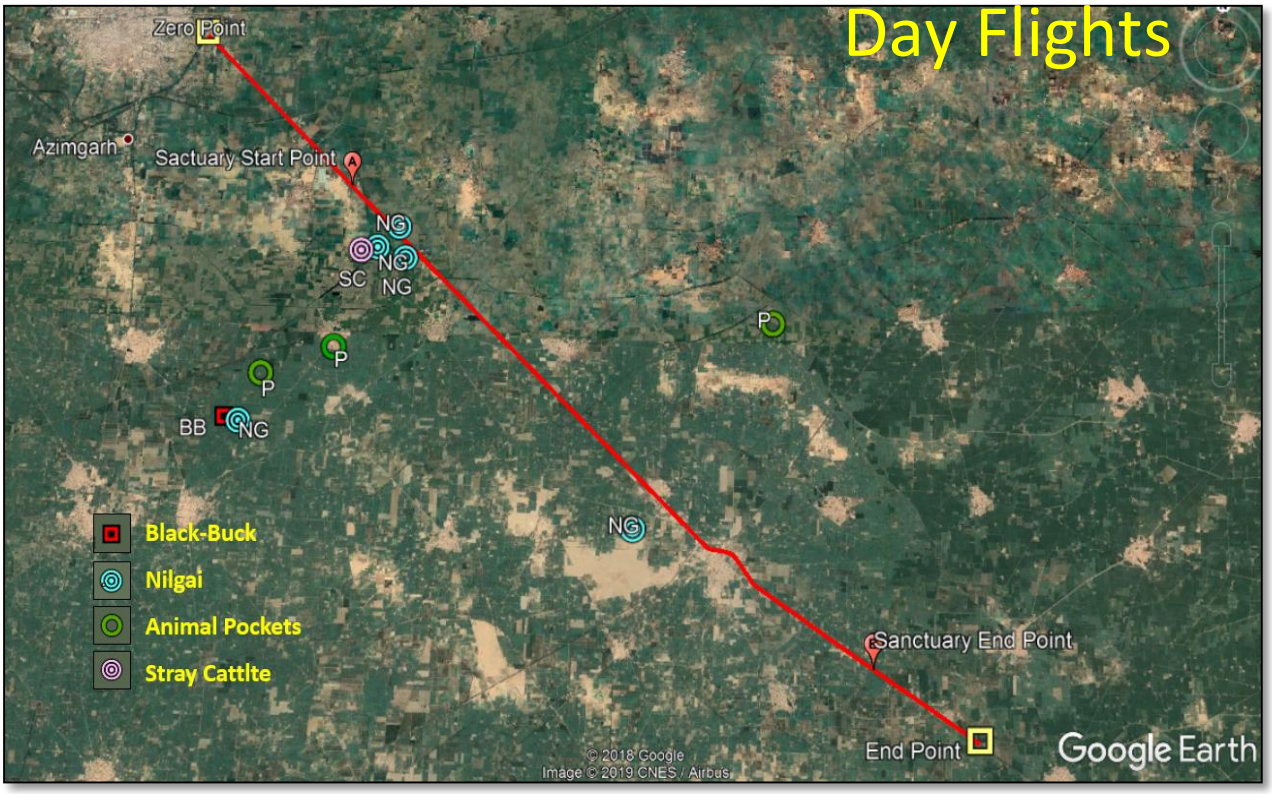


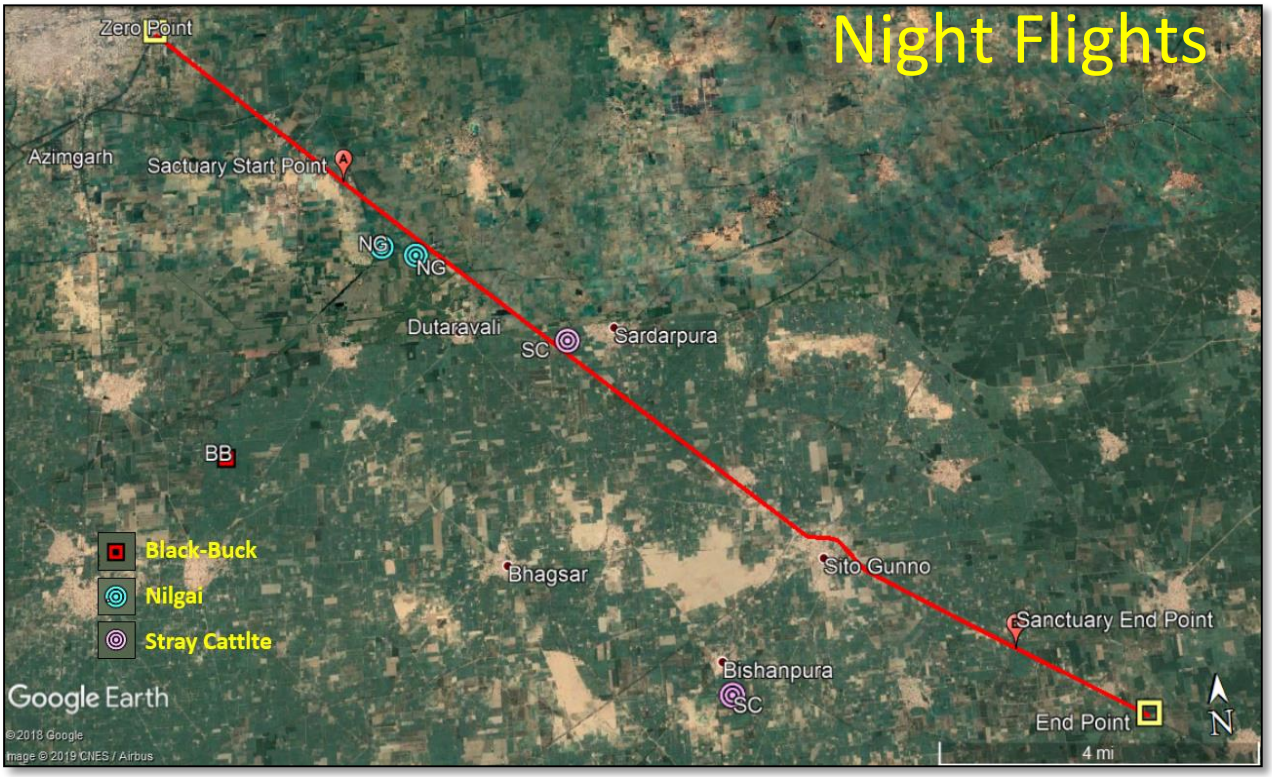
Inputs from the local villagers and by the Abohar forest department contributed to the selection of locations for the UAV to fly and collect evidences.



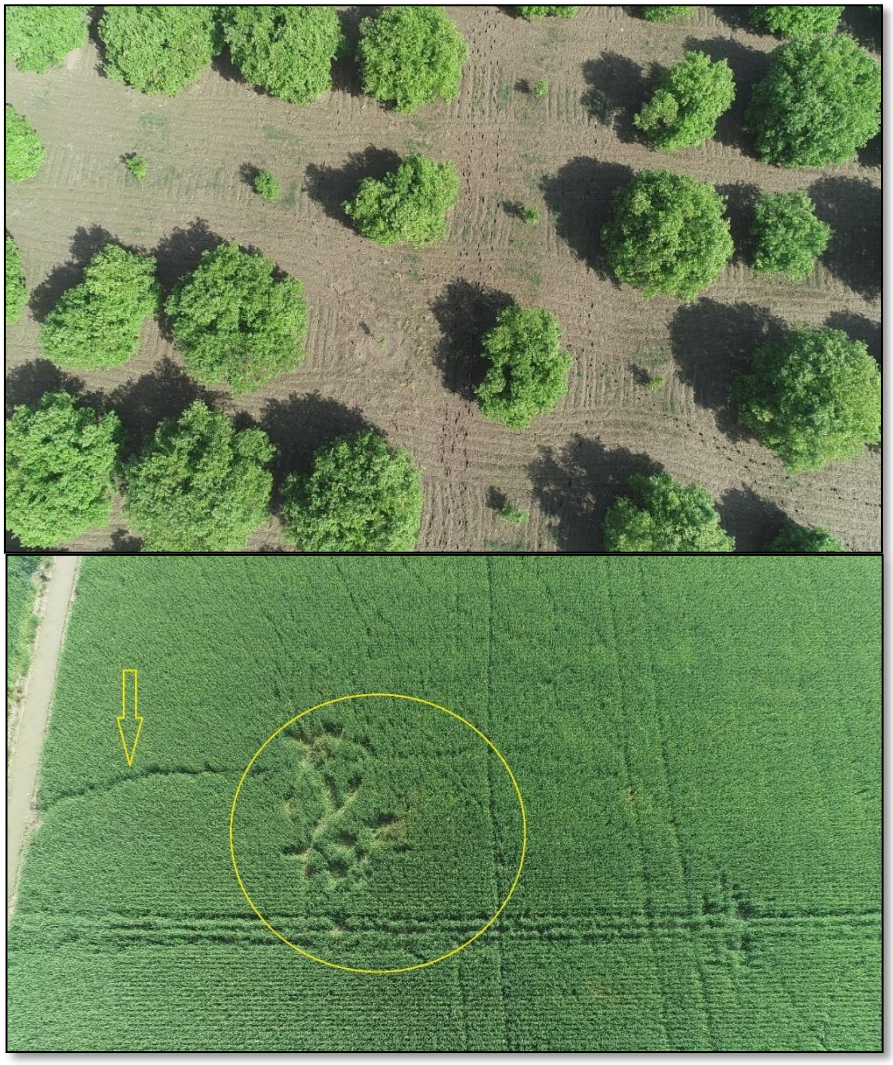
Results and Discussion: It was shocking revelation that the wildlife sanctuary is nowhere close to the one that represents any wildlife sanctuaries in the country. Abohar WLS was simply a agriculture matrix with scatted dry/open habitats where the Black Bucks and Nilgai have taken shelter. These animals are also freely using the agricultural area and were reportedly breeding also. Aerial survey over the entire stretch of the road could document trees along road-side and was totally fenced along the almost entre stretch. The road profile was such that it was a linear plain surface, bordered by the tree cover and there was nothing unique that could be attributed as special area/habitat along the road stretch. Therefore, the profile effort could provide the map of the road along the entire road and is shown in pictures below.

In terms of animal count, the area was not one of the high population areas and therefore, animals could be counted only from few locations. Traces of animal movements after the entire survey was plotted on the map with the reference to day as well as night time flying data as below.





In addition to direct record of animals (a), aerial survey could also document the evidence of animal movements such as hoof marks (b) and animal use area in agriculture fields (c) from a varying altitude of 30-50 metres using the drone flights at day-time.



Black Buck at Rajawali Area: During the survey, Black Bucks were recorded in few herds in Rajawali area and these areas have open habitats (Tibas) amongst large track of agricultural fields. These animals are also sharing space with live-stocks. Because of low density of wild animals in the WLS, aerial survey was effective in capturing the animal distribution and abundance in the areas. The evidences collected during the study period are provided below in the pictures:

Similarly, during night time flight, the animals were counted only in few locations and confirmed that the distribution and abundance of wild animals in this WLS were not wide and abundant. Therefore, the mitigation measures have to be planned keeping in mind current population and future movement if underpasses were created.

In nutshell, there was no wild animals that are currently crossing the road, partly because of the road-side fences and also that the distribution area has shifted to a distance of 3-4 kilometres away. Also, these animals, although use agriculture areas in large number, the activity centres are concentrated in areas where the human settlement and external disturbances are minimal. A herd of black buck was recorded twice around the same field area without any major shift in their movements. The whole area of cultivated land is protected using cobra fencing for perimeter protection, and to avoid the stray cattle from venturing inside. Hence animal movement across the field is restricted. Large group of stray dogs have trained themselves to hunt the black buck by chasing, surrounding and later capturing the animal. Sometimes the wet cultivated field act as a movement barrier, which hinders the swift movement making them an easy prey to the dogs. The area is segregated and not many uncultivated land or locally known as Tibas are left for the animal to sustain and survive in its natural habitat.

Although the aerial survey was effective and could provide definitive information on the animal movement and population status, it would be important to consider large area for survey to ascertain if the animals have moved away due to barrier effects along the road. Also, it is important to regularly monitor these animals as there is seasonal dynamism operate in these animals. Lekking sites need to be identified and protected. In terms of use of technology such as UAV, the survey offered a significant lesson as to such impact assessment for linear project can be effective with such technology and with improved analytical tools, it can quantify biological diversity and thus, provide a basis for informed decision making.

Onsite flight logs recorded during the survey

Date	Flight-Duration		Location Name	Location Co-ordinates		UAV	Video No.	Observations
	Start Time	End Time		LAT (DMS)	LONG (DMS)			
25.03.19	12:40	12:58		29°59'38"	74°25'27"	P4P V2		
25.03.19	13:00	13:12		30°1'56"	74°21'19"	P4P V2		Entire Road Survey conducted from an altitude of 50m
25.03.19	13:15	13:21		30°4'41"	74°17'44"	P4P V2		
25.03.19	13:24	13:30		30°5'34"	74°16'35"	P4P V2		
25.03.19	19:02	19:21	Sanctuary Start Green marker	30°6'9"	74°15'49"	M2 THERMAL		
26.03.19	09:47	10:02		30°3'59"	74°15'45"	P4P V2		Pockets in field located with tracks of animals
26.03.19	10:20	10:31	Rajanwali	30°3'3"	74°14'11"	P4P V2		Found 8 Blacbucks
26.03.19	10:53	11:06	Dotaranwali	30°3'21"	74°16'3"	P4P V2		
26.03.19	12:19	12:25	Sardarpura	30°4'23"	74°22'34"	P4P V2		
26.03.19	18:54	19:11		30°3'3"	74°14'11"	P4P V2		
27.03.19	11:01	11:28		30°5'34"	74°21'47"	P4P V2		
27.03.19	13:25	13:47		29°59'38"	74°25'28"	P4P V2		
27.03.19	13:50	14:12		30°1'57"	74°21'16"	P4P V2		Side stretch of road capture
27.03.19	14:17	14:29		30°6'44"	74°15'4"	P4P V2		
27.03.19	18:44	19:00	Khuban	30°5'36"	74°16'37"	P4P V2		Nilgay Spotted (5 in number)
27.03.19	19:04	19:10	Khuban	30°5'36"	74°16'37"	P4P V2		
27.03.19	23:05	23:15	Accidental Zone 1	30°6'0"	74°16'1"	M2 THERMAL		
27.03.19	23:28	23:36	Sardarpura link entry	30°4'3"	74°18'32"	M2 THERMAL		Cattle spotted (1 in number)
28.03.19	1:13	01:30	Sukhchain Mandir Front Road	30°2'23"	74°20'44"	M2 THERMAL		
28.03.19	09:49	09:59	Raipura Checkpost Front Road	30°5'19"	74°16'18"	P4P V2		Nilgay Spotted (19 in number)
28.03.19	10:27	10:34	Rajawali (Through Dotaranwali Mud Road)	30°3'16"	74°15'56"	P4P V2		Black buck spotted (2 in number)
28.03.19	10:37	10:45	Rajawali (Through Dotaranwali Mud Road)	30°3'16"	74°15'56"	M2 THERMAL		Mavic day flight check

8 FUTURE PLANS

1. Development of key spatial databases such as digital elevation model, forest density, drainage network and road network for each implementing sites and maps of vulnerable locations for poaching and human-tiger conflicts in the tiger reserves.

2. Capacity building of forest officials/staff: national and local level workshop for analysing the need and feasibility of involving such technology in our Tiger Reserves and showcasing the merits and demerits of UAV technology for wildlife applications.

3. Need assessment in country level and spatial prioritization of the areas with management measures.

4. Developing more units to transfer the technology in remaining reserves.

5. Upgrade and customization of advanced units such as Hex-copter and Hybrid VTOL for up-scaling.

6. Development of further guidelines for the safe and efficient operation of UAVs.

7. Ancillary outputs such as camera trap interface and RFID based tracking of tigers that may be taken up in large scale based on the initial success and need in the field.

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10 ANNEXURE

Guidelines by the DGCA for the operation of RPAS in civilian airspace

Drones today are as common for civilian purposes ranging from aerial photography and mapping to delivery of products. This proliferation of use raises a number of regulatory issues including safety – both in the air and on the ground – privacy, and security. So, in order to control this, DGCA issued primary drafts and standard operating procedures in order to regulate it, such that the regulation does not stifle the innovation as well as it does not get un-controlled in its usage.

- The E-Bird project was initiated in 2013 after the grant of special permission by Directorate General of Civil Aviation (DGCA) and Ministry of Defence (MOD) to National Tiger Conservation Authority (NTCA) for the operation of drones over unregulated airspace.

- In pursuance to the above, the Directorate General of Civil Aviation (hereinafter referred to as the 'DGCA') on November 1, 2017, released a draft regulation stipulating the requirements for Operation of Civil Remotely Pilot Aircraft System.

- On 2014 a public notice banning the use of UAS in the country was released. The notice for the first time recognized the menace of drones and acknowledged the underlying safety and privacy issues in it. It concluded by stating that, till the time new regulations are issued, **no non-governmental agency, organization, or any individual will launch a UAS in Indian Civil Airspace** for any purpose whatsoever.

- The circular for first drafted document became available for comments in April 2016, where advance technological inputs were given for safe UAV flying.

- The Directorate General of Civil Aviation (the "**DGCA**") released the much-awaited National Drone Policy, 2018 version 1 or drone policy 1.0 on 27th August 2018. The subject matter of the regulation was 'Requirements for Operation of Civil Remotely Piloted Aircraft System (RPAS)'. The policy came to effect from 1st December 2018. This regulation succeeded two other draft regulations that were issued by the DGCA in April 2016 and November 2017. Both the drafts went open to stakeholders, also a task

force called the *drone task force* was set up that was to provide further recommendations when needed and may even modify the current regulation or create the new ones.

- The Minister of Civil Aviation again released the final draft Drone Policy 2.0 on 15th January 2019. This was also a recommendation and the policy got finalized by a task force led by the Civil Aviation Secretary and the Director General of Civil Aviation. Under Drone Policy 1.0, the potential to exploit drones for commercial purposes was limited, for instance, through Visual Line of Sight (VLOS) requirements. Hence the drafted Drone Policy 2.0 recommended expanding operations to beyond VLOS and beyond the current limit of 400 feet. This policy became an essential tool for forest operation as well because the fixed-wing aircrafts operated by E-Bird team performed Beyond Visual Line of Sight (BVLOS) and also under automated tasked missions.

- Finally in order to regulate and maintain the implementation of format flying a Proposed development of Infrastructure (Drone corridors, Drone ports and UAS Traffic Management (UTM)) was structured.-The drafted Drone Policy 2.0 conceives of drone corridors (a segregated airspace demarcated by appropriate authorities) to keep commercial UAS operations out of non-segregated airspace in which manned aircraft operate. It is also proposed that UTM should be established which would be responsible for managing UAS induced traffic, especially in drone corridors. Further, there should be designated areas known as 'reports' to facilitate the landing and take-off of drones.

- With the structuring of Drone policy 2.0 and after the planning of Un-manned Traffic Management system, the E-Bird also proposed segregated airspace and allocation of various drone ports over protected forest area which would require continuous monitoring and surveillance.

Need and Feasibility Assessment Form

E-bird Technology for Tiger Conservation: Development and Integration of Un-manned Aerial Vehicles as Surveillance and Monitoring Tool for Protection of Tiger and Capacity Building of Frontline Staff
(A WII & NTCA Collaborative Project)

Need and Feasibility Assessment Form

Name of the Tiger Reserve ……Number of Ranges……Vacancy……...
Number of Beats …… Vacancy…… Whether Drone/UAV needed (and add further details in the Remarks column) ……..…

.

S. No.	Range Name	Beat Name	Name, Designation, Age & Education of Beat Guards/Information Provider	(1) Poaching Risk Score	(2) Conflict Risk Score	(3) Fire Risk Score	(4) Anthropogenic Pressure Score	(5) Weed Presence Score	(6) Encroachment Risk Score	Remarks (Specify any particular requirement of UAV or other technologies)

Scoring Method:

For **[1-4]** Score:
0 – Absent (No incidence), **1** – Low (in 5-10 years), **2** – Moderate (once in 2-3 years), **3** – High (Every year).
For **[5-6]** Score: [Weed and encroachment level, consider proportion occupied]
0 – Absent (0%), **1 –** Low (5-25%), **2 –** Moderate (25-50%), **3 –** High (50-75%), **4** Very High – (75-100%)

Duly filled form to be returned along with GIS file (shapefile) of the reserve with core, buffer, beat, compartment boundaries, eco sensitive zones and village locations, and posted/ e-mail to: **E-Bird Technology Project Team, C/o. Dr. K. Ramesh, Scientist, Wildlife Institute of India, Dehradun-248001, Uttarakhand. E-mail: ramesh@wii.gov.in Phone: 9412971678, with a copy to NTCA (Use multiple forms if there are more beats)**

(Signature of Competent Authority with designation)
Date:
Contact Number: