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STUDY OF INDIAN UNMANNED AERIAL VEHICLES

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ABSTRACT

An Unmanned Aerial Vehicle (UAV) is a powered aerial vehicle that does not carry a human operator.UAVs are a component of an Unmanned Aircraft System(UAS)- a ground-based controller and a system of communications between the two.Theflight of UAVs may operate with various degrees of autonomy-either under remote control by a human operator or autonomously by onboard computers. UAVs have become an integral part of military and civil society. They have proven to be useful in dull, dirty, dangerous, and demanding missions, thus saving lives. They act as a force multiplier for military and as a facilitator for civil work. India started research in UAVs in the early 1980s with Aeronautical Development Establishment (ADE) as a leading organization. The portfolio of ADE UAVs has expanded since then,which includes aerial targets and aircraft for surveillance and reconnaissance. This paper presents the journey of India's UAVs from past to present and giving a glimpse of their future.

Index terms— *India's Present UAVs, specifications, challenges to future UAVs.*

NOMENCLATURE

ADE – Aeronautical Development Establishment
DRDO – Defense Research and Development Organization
MALE – Medium Altitude Long Endurance
QR – Qualitative Requirement
RADAR – RAdio Detection and Ranging

I . INTRODUCTION

UAS usually have the same elements as systems based upon manned aircraft,but with the airborne element, i.e., the aircraft is designed from its conception to be operated without an aircrew aboard. The aircrew, with its interfaces with the aircraft controls and its habitation, is replaced by an electronic intelligence and control subsystem. Unmanned aircraft must not be confused with model aircraft or with the 'drones', as it is often referred by the media. A radio-controlled model aircraft is used only for sport and it must remain within the sight of the operator. The operator is usually limited to instruct the aircraft to climb or descend and to turnto the left or to the right. On the other hand, the drone aircraft will be required to fly out of sight of the operatorand has zero intelligence.It is launched into a pre-programmed mission on a pre-programmed course and a return to the base. It does not communicate, and the results of the mission,likephotographs, are usually not obtained from it until it is recovered at the base.

A UAV,onanother hand, will have some greater or lesser degree of 'automatic intelligence'. It can communicate with the operator and transmit the payload data, such as electro-optic or thermal TVimages,together with its primary state information like- position,airspeed,heading, and altitude. It will also transmit information as per its condition, which is often referred to as 'housekeeping data',covering aspects such as the amount of fuel,temperature of engine components, electronic systems, etc.

A distinct advantage of UAVs is their cost effectiveness.They can be developed,produced,and operated at low costs, compared to the cost of manned aircraft. The relative savings in engines,airframes,fuelconsumption,pilot training,logistics,and maintenance are enormous.

DRDO started developing UAVs in the early 1980s, and Aeronautical Development Establishment(ADE),Bengaluru, is the nodal lab. First UAVs developed by ADE in the 1980s were thefoundation of present-day UAV Program. The first-generation UAVs developed by ADE were technology demonstrator and enabled qualitative requirement (QR) from Indian Air Force.

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II . INDIA'S PAST UAVs

2.1 ULKA

The first air-launched vehicle missile target designed and developed by ADE was Ulka. It was dropped from manned aircraftand was capable of 6 minutes of flying.

Figure 1: ULKA- Air launched target

The first air-launched target designed and developed by ADE had the following specifications: [Table 1].

Table 1: **Missile Target Specifications**	
Launch weight	360 kg
Power-plant type	Solid booster
Speed (in Mach number)	M = 0.7 to 1.1
Range	70 km
Operating altitude	100 m to 9 km
Endurance	5 minutes

Though Ulka was first generation UAV of India, it was able to simulate the speed and altitude characteristics of approaching, receding, or crossing ofavariety of aircraft using false RADAR signatures. It was also used for defensive training of surface-to-air missile crews against anti-ship missiles, and for development testing and evaluation of air defensesystems. It was easy to air-launch by usingavariety of aircraft, which served as a plus point, and reducing the cost and effort in designing and developing a separate craft for launching the UAV. It was also the first aerial vehicle in India to have a canard configuration.

2.2 KAPOTHAKA

The second UAV was Kapothaka, which was capable of conventional takeoff and landing, with an endurance of up to 90 minutes. It was used for reconnaissance in the operation Brasstak. It has the following specifications: [Table 2]

Table 2: **Kapothaka Specifications**	
Total length	3.67 m
Wingspan	4.5 m
Total weight	130 kg
Engine	Conventional twin-boom configuration 26 BHP (Piston engine)
Maximum speed	180 km/hr
Payload weight	20 kg
Endurance	90 minutes
Service ceiling	3000 m

It has a very small, low RADAR cross-section and is launched by a wail with rocket assistance. The UAV is equipped with TV boom tail unit integrated with ____.In addition to aluminum, composite materials like glass-fiber reinforcement plastics (GFRP) were used in building the body of the UAV.

2.3 INDIA'S PRESENT UAVs

At present,ADE has many UAV programs going on. Lakshya and Nishant have already inducted unto Indian Armed Services. ADE is developing the UAVs as per the need for service. There are UAVs catering for

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the needs ofasoldier(micro UAV) to thetopmost command (MALE and UCAV).Training needs are being catered by use of tactical (gun firing correction,geo-localization,etc.) and targets (for missiles,gun firing etc).at present network-centricwarfare,surveillance and reconnaissance play a major role in decision making ADE has developed multiple UAVs to be used as eyes in the sky.

2.4 LAKSHYA

PTA plays an important role in the development of indigenous weapon systems and also in training and assessing weapon systems and operators. PTA-Lakshya was the result of DRDO's today development plan and today successfully meets the requirement of all three defense forces and supports DRDO's weapon system development programs. The specifications are: [Table 3]

Table 3: **Lakshya Specifications**

All up weight	705 kg
Endurance	50 minutes
Operating Mach number	M= 0.56
Operating altitude	1500 m
Maximum speed in clean configuration	M= 0.65
Maximum altitude with clean configuration	9000 m
Maximum altitude with two bodies	5000 m
Minimum operational altitude	300 m
Rate of climb (at sea level)	25 m/s
Length	2385 m
Wingspan	3 m
Airfoil	NACA 64A-008
Powerplant	1A* - HAL PTAE – 7 Turbojet
Launch	Rocket assisted
Recovery	2 stage parachutes

The main feature of this is that makes it at once cost-effective and versatile is the tow target system. It can carry two tow targets on wing-mounted pylons. Tow targets which trail the mother aircraft by 1.5 km provide the real target while keeping the mother aircraft safe enabling reusability of Lakshya. They are modular in construction and easily configured to mission requirements. Tow targets house radar,visual and infrared augmentation devices and provide realistic enemy aerial threat simulation.Zero-length launcher and parachute-based recovery system allowlakshya to be launched from land or ship and can be recovered safely on land or sea. An advanced digital version of Lakshya, known as Lakshhya-2, is also ready with mobile launch platform,autonomouslaunch,higher endurance, and programmed low-level flight capabilities.

2.5 NISHANT

The NishantUAV system is conceived with mobility as an important requirement. The UAV is launched using a hydro pneumatics launcher and recovered with aero conical parachute and impact attenuation system. The high degree of automation built into the system reduces piloting skill requirements to a minimum during critical faces of launch and recovery. The aircraft carries stabilized payload for both day and night missions. An onboard flight control and navigation system make the aircraft fly in autonomous waypoint navigation mode.

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Figure 2: Nishant UAV

Its distinctive features are as follows:

- Day /night capability training vehicle.
- Battlefiels reconnaissance and surveillance.
- Target tracking and localization.
- Artillery fire correction andall-terrain mobility.
- Target designation(using integral laser target designator).

Table 4: **Nishant Specifications**

Payload	45 kg
Length	4.63 m
Wing span	6.57 m
All up weight	375 kg
Maximum speed	185 km/h
Cruise speed	125 km/h
Range	160 m
Service ceiling	3600 m
Launch	Mobile hydropnumatic launcher (MHPL) system
Recover	Parachute and landing bags
Launcher	Hydro-pneumatic

2.6 PANCHI

The highlight of NishantUAV system is its capability to be launched from anywhere and recovery in remote areas. However,the launching and recovery loads experienced by the air vehicle put a severe limitation on its number of landings and turn around servicing.Panchi is a wheel-less version of Nishant with modifications to the airframe like landing gear, better fuel capacity,higher powered engine, etc. It can operate from airstrips like conventional aircraft.

Figure 3: Panchi UAV

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Table 5: **Panchi Specifications**	
Endurance	6 hours
Service ceiling	4500 m ASL
Cruise speed	125-180 kmph
Command range	200 km
All up weight	375 kg

III . INDIA'S FUTURE UAVs

Future of warfare is withoutaman intheloop. At present, there is one UAV for every 175 manned aircraft and one hour of UAV flight for every 300hours of manned flight. This is going to change dramatically in the coming years. It is estimated that by 2040s the UAVs and manned aircrafts will be equal in numbers and flight hours. To achieve this,UAVs have to developed many capabilities such as long endurance, combat readiness, and verticaltakeoff and landing, so that they can be compared with the present fighter jets. DRDO has come up with a long-term technology perspective plan (LTTPP). ADE has initiated programs for solar UAV, UCAV and rotary UAV which will cater for these futuristic missions.

3.1 RUSTOM-1

It is an all composite,self-propelled,slow speed, medium-altitude, long endurance UAV used in multi-missions as day/night battlefieldreconnaissance,surveillance,artillery fire correction,target tracking, and localization.It is designed for conventional takeoff and landing by an external pilot (EP) and mission control bytheinternal pilot(IP) from a user-friendly ground control section.

The airframe based on RUTAN long ez manned aircraft has a canard configuration fitted with a 160 hpLycoming O-320 engine and a fixed pitch propeller.

Table 6: **Rustom-2 Specifications**	
Service ceiling	*9144 m*
Endurance	>24 hours
Wingspan	20 m
Empty weight	1800 kg
Maximum speed	225 kmph
Engine performance	128 Nm at 5800 RPM
Direct line of sight	250 km
Direct line of sight with relay	350 km
Electro-optic payload	Day and night electro-optic sensors
RADAR Payloads	Synthetic aperture RADAR (SAR) or Maritime Patrol RADAR (MPR)
ESM Payload	Elint and Comint
Payload weight	350 kg

IV . MICRO OR MINI UAVs

Micro and mini UAVs,due to their unique features as ultra-low weight/size structures,hoveringcapability, miniature avionics.and easy launch /recovery methods,findincreasing applications in civil/militarysectors,particularly inalow-intensity conflict scenario.

4.1 FIXED WING MICRO AIR VEHICLES

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Black Kite, Golden Hawk, and Pushpak are the micro-air vehicles which come under this category. They have the following specifications:

Table 7: **Fixed Wing Micro Air Vehicles Specifications**	
Propulsion	Electric motor
All up weight	300 gms
Cruise speed	37 kmph
Launch	Hand launched
Payload	CCD day light TV camera
Endurance	30-45 m

Figure 4: Golden Hawk

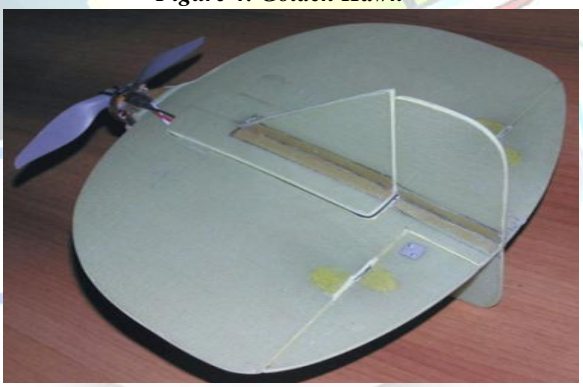

Figure 5: Black Kite

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Figure 6: Pushpak

4.2 MINI UAVs

The miniUAVs are Imperial Eagle and Sly Bird.Thespecifications for Imperial Eagle and Sly Bird as follows:

Table 8: **Imperial Eagle and Sly Bird Specifications**	
Propulsion	Electric motor
All up weight	2-2.9 kg
Cruise speed	40-90kmph
Launch	Hand launched
Payload	DaylightIR camera
Endurance	50-60 m
Recovery	Soft landing

*Figure 7:***Imperial Eagle**

Figure 8: Sly Bird

V .ROTARY UNMANNED AERIAL VEHICLE (RUAV)

Autonomous Rotary Unmanned Aerial Vehicle (RUAV) project is a 10 kg all-up weight,conventional(a single main rotor along with the Auxiliary Tail Rotor) unmanned mini helicopter with a payload capacity of approximately 2.2 kg, including fuel weight of 0.4 kg. A tri-partite MoU was signed among the 3-stakeholder; Hindustan Aeronautics Limited(HAL), Aeronautical Development Establishment (ADE) and Indian Institute ofTechnology, Kanpur(IIT-K).The execution of this project along with HAL and IIT-Kanpur had enhanced the understanding and insight into the various technical issues related to rotary-wing unmanned air vehicle.

VI .SOLAR UAV

As part of ADE's initiatives towards tapping solar energy for use in UAVs,a team is working towardsthedevelopment of solar powered mini UAV. A 3 kg class Fixed Wing Mini UAV (FW-MUAV) developed by ADE, Indian Eagle, has been chosen as a prototype to develop and demonstrate initial technologies for harvesting solar energy.

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VII .MAJOR CHALLENGES FOR FUTURE UAVs

- **Interoperability**: To maximize potential unmanned systems must be capable of operating seamlessly with each other and with manned systems across the air,ground,andmaritime domains.
- **Autonomy:** Future UAVs will be more autonomous and capable of detection,identification, and execution of target.
- **Airship integration**: As the UAV usage increases they have to be integrated into existing civil and military airspace.
- **Communication:** Significant improvement in communication transmission efficiencies; better bandwidth efficiency;transmitter and receivers efficiencies; and in size and weight of communication systems (which requires lee power,andprovide more efficient cooling to operate) is desired.
- **Propulsion and power:**UAVs are propelled by combustionengines whichare powered byjet engines, electric systems, etc. Future UAVs are required tohave fuelcells,solarpower,and hybridpower systems for longer operations.
- **Man-unmanned teaming:** Centralized command and control isrequired toensure functional integration thatsynchronizes manned-unmanned aircraft operations is the need of the hour.

Figure 9: Comparision of Manned and Unmanned Aero Platform in India

VIII .SOLAR UAV

The potential of UAVs is limited only by our imagination. Unmanned Aerial Vehicles are an exciting field in the world of aviation,with new discoveries. Over the next 16 years, UAVs will become a significant component of military,civil,and perhaps even commercial aviation.

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