Era of Unmanned Air Vehicles

UAVs or Drones

The category of UAVs
By mission type

- **Target drones:**
  - **Designed for training or weapon experiments**

"Chang Kong-1" NUAA of China

"Fire bee"

The category of UAVs
By mission type

- **Reconnaissance drones:**

RQ-4 “Global hawk”

RQ-170

The category of UAVs
By mission type

- **Attack and reconnaissance drones:**
  - **Armed with AGMs**
  - **Can stay in the air for more than 24 hours**
  - **Detect and destroy, highly effective**

Predator

Pterosaur

The category of UAVs
By mission type

- **UCAV: The master of future sky!**

X-47

The category of UAVs
By mission type

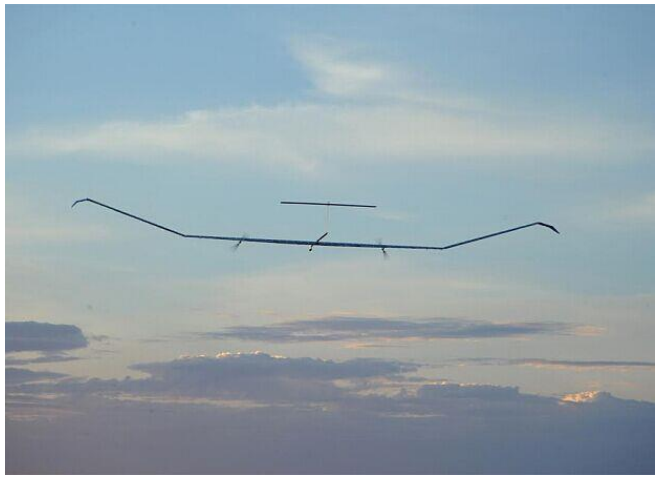
- **Civil UAVs**

- Drone photographing
- Hazard detection
- GIS and mineral detection
- Weather detection
- Road surveillance
- Traffic control
- Telecomm relay
- Parcel delivering services

The category of UAVs
By weight and scale

- **HALE**
  - **Mission range >= 6000KM**
  - **Endurance > 24h**
  - **Cruising altitude >= 18KM**
  - **Take off weight > 1T**

"Global hawk"



Airbus "Zephyr" (90 days of endurance!)

The category of UAVs
By weight and scale

- MALE
  - Mission range >= 1000KM
  - Endurance >= 24h
  - Cruise altitude < 10KM
  - Takeoff weight ~ 1T

"Predator"

The category of UAVs
By weight and scale

- **Tactical drones:**
  - Mission range **>= 200KM**
  - **Endurance >= 4h**
  - **Cruise altitude < 5000m**
  - **Takeoff weight ~ 500kg**

General Atomics “Gnat, USA

The category of UAVs
By weight and scale

- **Mini UAVs**
  - **Range <= 60KM**
  - **Endurance >= 2h**
  - **Cruise altitude < 5KM**
  - **Takeoff weight < 20kg**

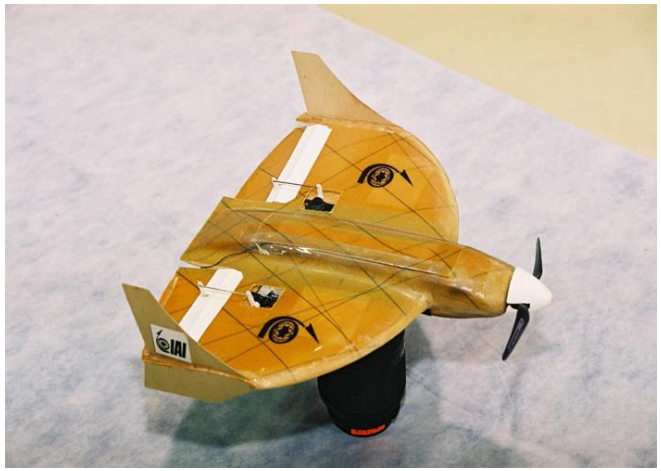
“Raven”

“Draon eye”

“Scan eagle”

The category of UAVs
By weight and scale

- **MAVs**
  - **Range <= 10KM**
  - **Endurance <=1h**
  - **Cruise altitude < 1KM**
  - **Takeoff weight < 1kg**
  - **Size < 1m**



以色列“蚊子”无人机

洛克希德.马丁 “蜂鸟”

美国“黑寡妇”

The category of UAVs
By configurations

- **Fixed wing**
  - **Conventional configuration**

“Hunter”，Northrop Gruman

Feature：Matured design with good stability and wide C.G. range. Relatively heavy

The category of UAVs
By configurations

- **Fixed wing**
  - **Canard**

“Rainbow 3”

Feature: All wings produces lift, wide C.G location. No highly effective flaps are allowed.

The category of UAVs
By configurations

- **Fixed wing**
  - **Tailless aircraft**

"Wasp III", Aeroviroment

Feature: Simple and clean profile. Relatively lighter structure. Very sensitive to the location of C.G. Poor takeoff and landing performance with stability issues.

The category of UAVs
By configurations

- **Rotorcraft**
  - **Helicopters**

“Fire scout”

Feature：Matured design with VTOL. Can be heavily loaded. Significant lower efficiency and maximum speed than fixed wing aircraft. Heavy noise from

The category of UAVs
By configurations

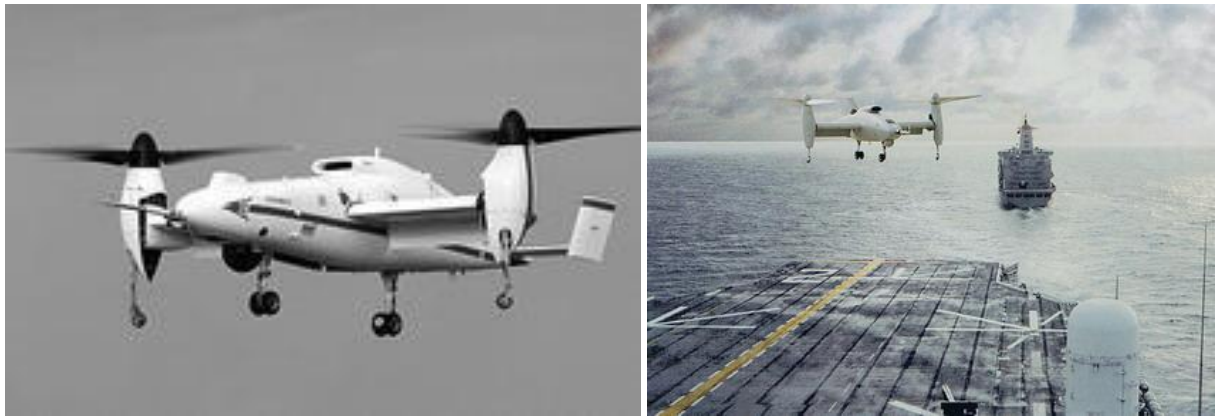
- **Rotorcraft**
  - **Tail sitter**

Google Project Wing

Feature: The most simple configuration that can fly at high speed with VTOL capability. Low power plant efficiency. Difficult to land with high accuracy.

The category of UAVs
By configurations

- **Rotorcraft**
  - **Tilt rotor aircraft**



"Eagle eye", Bell aircraft

Feature: Relatively matured design. Can fly at very high efficiency with VTOL capabilities. Very complex power plant and less reliable.

The category of UAVs
By configurations

- **Rotorcraft**
  - **Tilt rotor aircraft**

Boeing “Dragon fly”

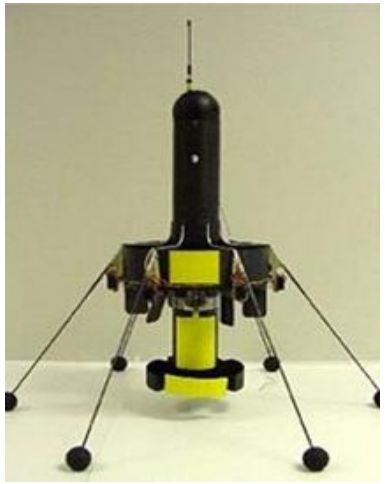
Feature：Fly at high speed with VTOL capability. Very difficult to control during transition.

The category of UAVs
By configurations

- **Rotorcraft**
  - **Ducted fan**

"CYPHER", Sikorski

"T-hawk", Honeywell



HELISPY

Feature: VTOL aircraft. Excellent hovering efficiency and low speed flight performance. Heavily loaded with stability issues. Heavy and expensive structure.

The category of UAVs
By configurations

- **Rotorcraft**
  - **Quad rotor/ Multi rotor**

Feature: Very simple and stable. Not efficient. Difficult to be enlarged. Short endurance and small payload capability. Very suitable to MAVs

The category of UAVs
By configurations

- **Flapping wings**

“Humming bird”，Lockheed

Feature: Highly efficient at low Reynolds number and mini scale. One of the best choice for MAVs

Modern UAVs

Launch and recovery

- Take off/Landing on runway

Predator

Pros: Highly reliable
Cons: Need runway

Modern UAVs
Launch and recovery

- Ejection

Boeing “Scan eagle”

Highly reliable and needs no runway

Modern UAVs
Launch and recovery

- Launch by rocket

NWPU ASN-206

Highly reliable and needs no runway

Modern UAVs
Launch and recovery

- **Hand launch**

AeroVironment "Raven"

Needs no runway, but only suitable for mini-UAVs/MAVs

Modern UAVs
Launch and recovery

- Recovery by parachute/nets/robe

NWPU ASN-206

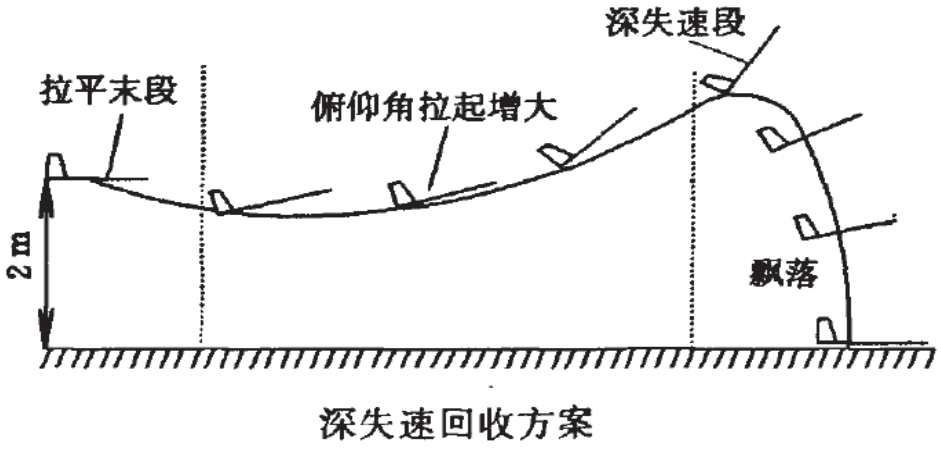
Northrop “Bat”

Boeing “Scan eagle”

Simple, reliable, needs no runway

Modern UAVs Launch and recovery

- Recvoery by deep stall



深失速回收方案

Aerovironment公司“Raven”

Can land in very narrow space. Only valid for MAVs

Modern UAVs
Launch and recovery

- VTOL

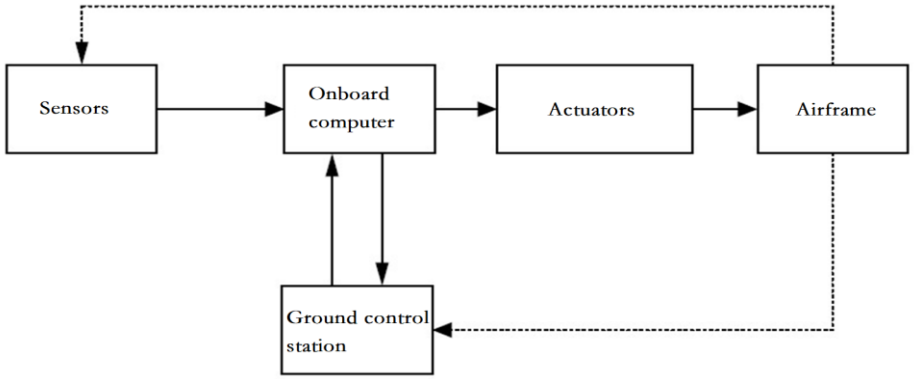

Pros: Needs no airport. Can takeoff and landing anywhere
Highly flexible.
Cons: Very complex system.
Weight penalties
Performance penalties

Development of UAVs

Avionics

- **Flight control system**

- Attitude control
- Navigate and mission plan
- Automatic takeoff and landing
- Mission payload control



Development of UAVs
Avionics

- **Remote control and sensing**
  - Ground station, data link and image transmission
- **Sensors**
  - Gyro and accelerometer
  - Navigation
    - GPS
    - INS
    - Optical/Imaging (Light, Infra red, Night vision)
    - Laser/ultrasonic

Development of UAVs
Propulsion systems

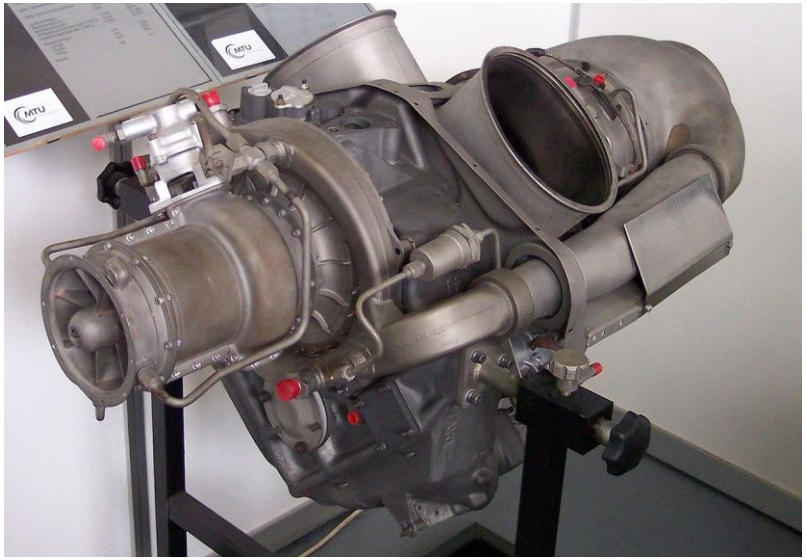
- **Jet engine (Ram jet, Turbojet, Turbofan)**

Rolls Royce AE3007 Turbofan engine and Global hawk

Suitable for large scale or high speed UAVs

Development of UAVs
Propulsion systems

- **Turboshaft and turboprop engine**



Fire Scott and its Rolls Royce M250 Turboshaft

Suitable for large to medium size UAVs

Development of UAVs
Propulsion systems

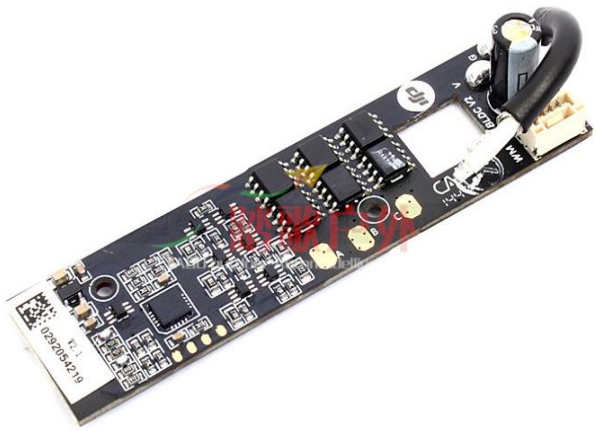
- **Piston engine (4 stroke, 2 stroke and rotary engine)**

Sweden APID 60 and its Rotron Wankle engine

Suitable for medium sized UAVs

Development of UAVs
Propulsion systems

- **Electrical motor**



DJI drone and its brushless motor

Quiet and high efficiency. Suitable for small and miniature UAVs

Development of UAVs
Energy systems

- Kerosine（Turbo-engines)
- Gas（Piston engine)
- Methanol （ Piston engine ）
- Batteries（Electrical aircraft)
  - Nickel cadmium, Nickel metal hydride battery
  - Lithium iron
  - Li-Po
  - Fuel cell
  - Solar power

	WH / kg
Ni—Cd	25
MH-Ni	50
Li-ion	125
Li-Po	150-200
$H_2 - O_2$ Fuel cell	500
Gas (20% efficiency)	2600

Energy density （WH/kg）

Development of UAVs
Future of UAVs

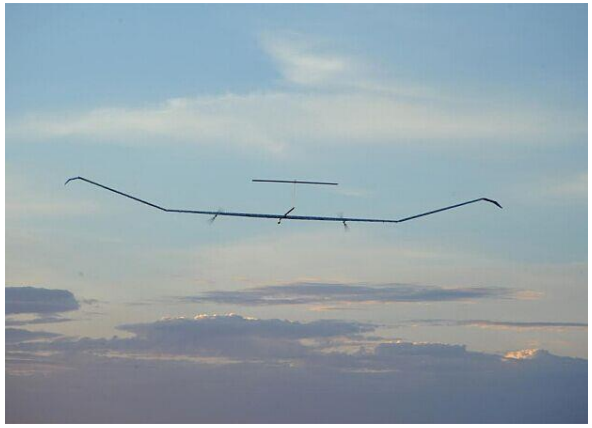
- **UCAV**
  - **Excellent, all-round stealth performance**
  - **High L/D configuration**
  - **Excellent Maneuverability**
  - **Highly intelligent, it can automatically complete many difficult tasks, such as autonomous take-off and landing / landing, automatic aerial**

Autonomous refueling

X-47 Autonomous takeoff and landing

Development of UAVs
Future of UAVs

- **Longer endurance and range**
  - **Solar powered drones can keep afloat for 3 months**
  - **Small UAVs have been able to fly across the Atlantic**
  - **The fuel powered UAV can stay in the air for more than 40 hours**



空客的无人机可滞空90天

飞越大西洋的小型无人机（航程3020km）

全球鹰航时41小时，曾不间断从美国飞越太平洋，抵达澳大利亚

Development of UAVs
Future of UAVs

- **Messo-scale UAVs / MAVs**
  - **In the future, the MAVs will aim at the size of flies and mosquitoes, but it is difficult to achieve at present due to the development level of electronics, batteries, motors**

Robot mosquito

Development of UAVs
Future of UAVs

- **Explosive growth in the civil market**

DJI Spirit

Fixed wing UAV

Zano Drone

- The consumer level drone has getting more and more popular
- They feature simplicity, low price, high degree of intelligence, low entry threshold

Development of UAVs
Future of UAVs

- **Explosive growth in the civil market**

Amazon Prim air

Parcel delivery drones

- Active in the field of logistics and transportation, agriculture, surveillance and control

The market for UAVs

- **Military market:**
  - **UCAV will dominate the future sky**
  - **Unprecedented large-scale participation in the battle field**
  - **Small and mini-UAVs will occupy the majority of the market, but most of the funds are concentrated in medium and large UAVs**
- **Civil market:**
  - **Can be used in aerial photography, disaster monitoring, line patrol, communication relay and express service**
  - **The cost and threshold of use will continue to reduce**
  - **It can participate in social public service and form a UAV service network**