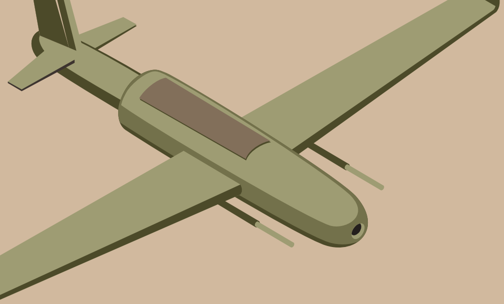


Unmanned Aerial Vehicle (UAV)

Prepared by: Muhd Hafizuddin
Matric No: 1916353

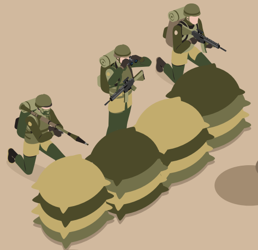


TABLE OF CONTENTS

INTRODUCTION

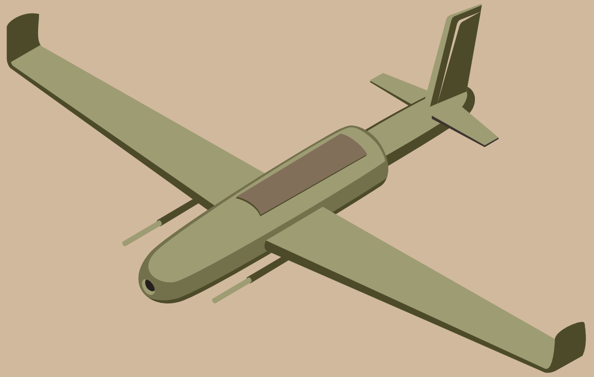
- UAV stands for Unmanned Aerial Vehicle which often known as a drone
- It is operated without a human pilot on board and controlled remotely by human operator on ground or can fly autonomously
- It comes with a variety of shapes and sizes from small one that can fit in palm of hand to the large military grade that can carry heavy payloads
- UAVs are used in many applications including military, aerial photography and videography, mapping and surveying, agriculture, environmental monitoring and more.
- UAVs are usually equipped with the camera and multiple sensors to enable it collecting the datas and image from different perspectives and altitudes.

Elbit Systems Hermes-450

Northrop Grumman Bat

01

History of UAV



Year 1948, US Air Force

The Firebee 1:

- First jet-propelled drone
- drone featured swept flight surfaces and a circular nose inlet.
- The initial models had distinctive "arrowhead" shaped endplates on the tailplane.
- Could be air-launched from a specially modified launch aircraft
- Used for a jet-powered gunnery target.

Year 1973, Israeli Defence Force

Tadiran Mastiff:

- Featured with data link system
- Equipped with miniaturized electronics that fed live and high-resolution video coverage of the targeted area
- Used for surveillance purpose
- Long flight endurance of over 7 hours

History of Drones/UAVs

1849, Air Balloons
Austrians used balloons to drop bombs during attack on city of Venice

1918, Kettering Bug
Designed to drop bombs on targets during WWI. The war ends before the Bug was used.

1935, Queen Bee
Created in UK, this drone was used by military for moving target practice

1937, Curtiss N2C-2
Used by US Navy as radio controlled aircraft

1941, Radio Plane by Reginald Denny
During WWII, Reginald Denny from US created first remote controlled aircraft called Radioplane.

1964 - 1969 The Lightening Bug
It was created for surveilance during Cold War by US

1973, Mastiv UAV & IAA Scout
Israel developed both unpiloted surveillance machines.

1982, Battlefield UAVs
A major milestone. Israel changed the way world was seeing Drones. Destroyed many Syrian aircrafts with minimal loss using UAVs.

1986, Reconnaaissance Drones
A joint venture between US and Israel produced RQ2 Pioneer, a medium size reconnaissance drones.

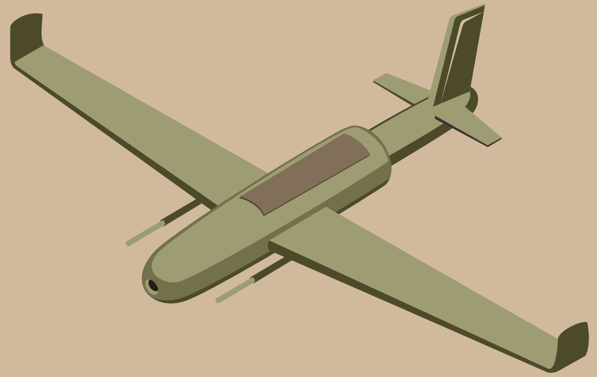
2001, Predator
Designed in US, this drone is used for surveillance

2003 - Present Commercial Drones
Commercial Drones gain popolarity in construction, real estate, search and rescue, etc.

2014, Product Delivery by Drones
Amazon CEO announces the drone delivery plan, opening the door for product delivery use.

02

Main Components of UAV

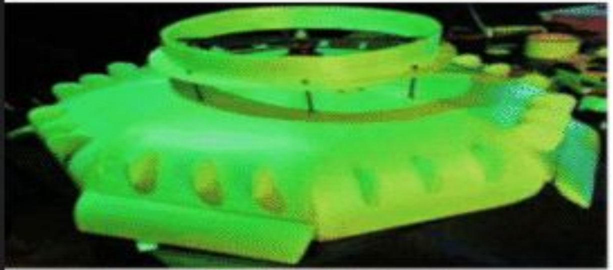


Robotic Design


DJI Phantom-Quad copter


Quad copter


Quad Air


Flying Saucer


Hexa copter


AR-Drone quadcopter


Octo copter


Quad-rotor MAV


MAV-T Hawk


Flapping-wing MAV

Multi-rotor UAVs	Fixed-wing UAVs
	
Image: Copyright 2019, Carcinus Ltd	Image: Copyright 2019, Carcinus Ltd
Multi-rotor UAVs are available in a range of configurations[2] with a single or sometime multiple rotos per arm, including: • Bicopter (rarely used); • Tricopter; • Quadcopter; • Pentacopter (rarely used); • Hexacopter; and • Octocopter.	Fixed-wing UAVs are available in a range of configurations[3], including: • Swept / delta wing; • Monoplane; • Biplane; and • Fixed-wing Vertical Take Off and Landing (VTOL).

Multirotor
Geo-MMS Payload Pictured

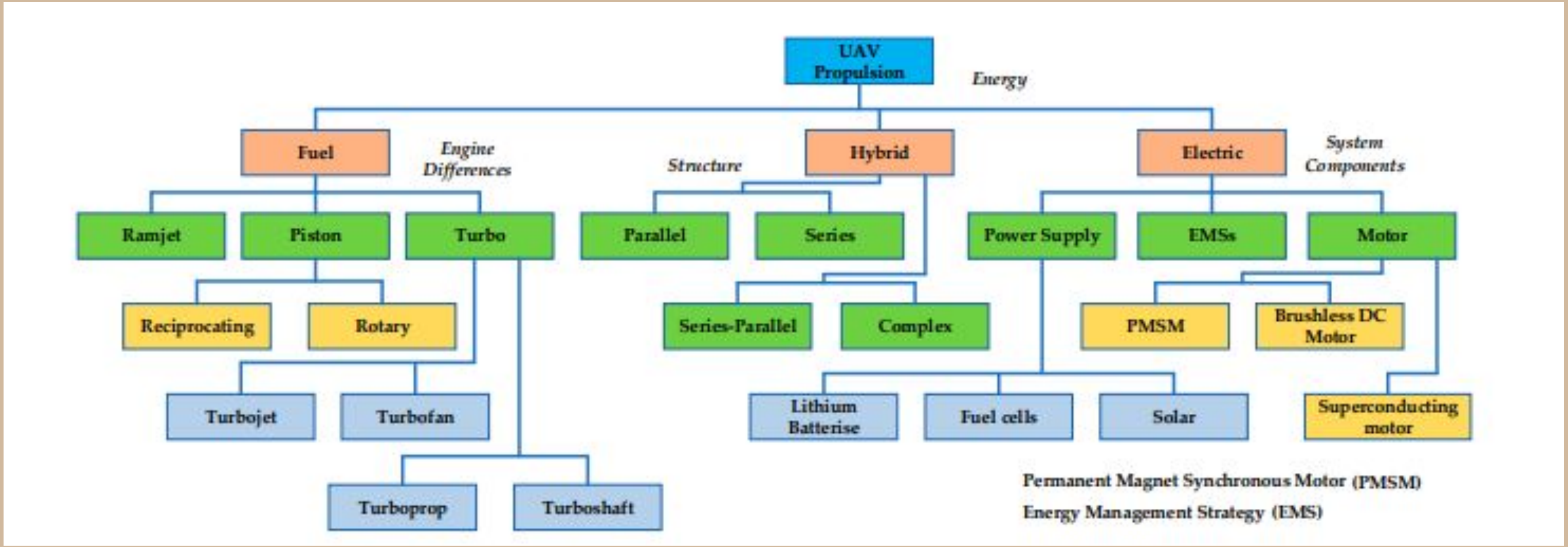
Fixed-Wing

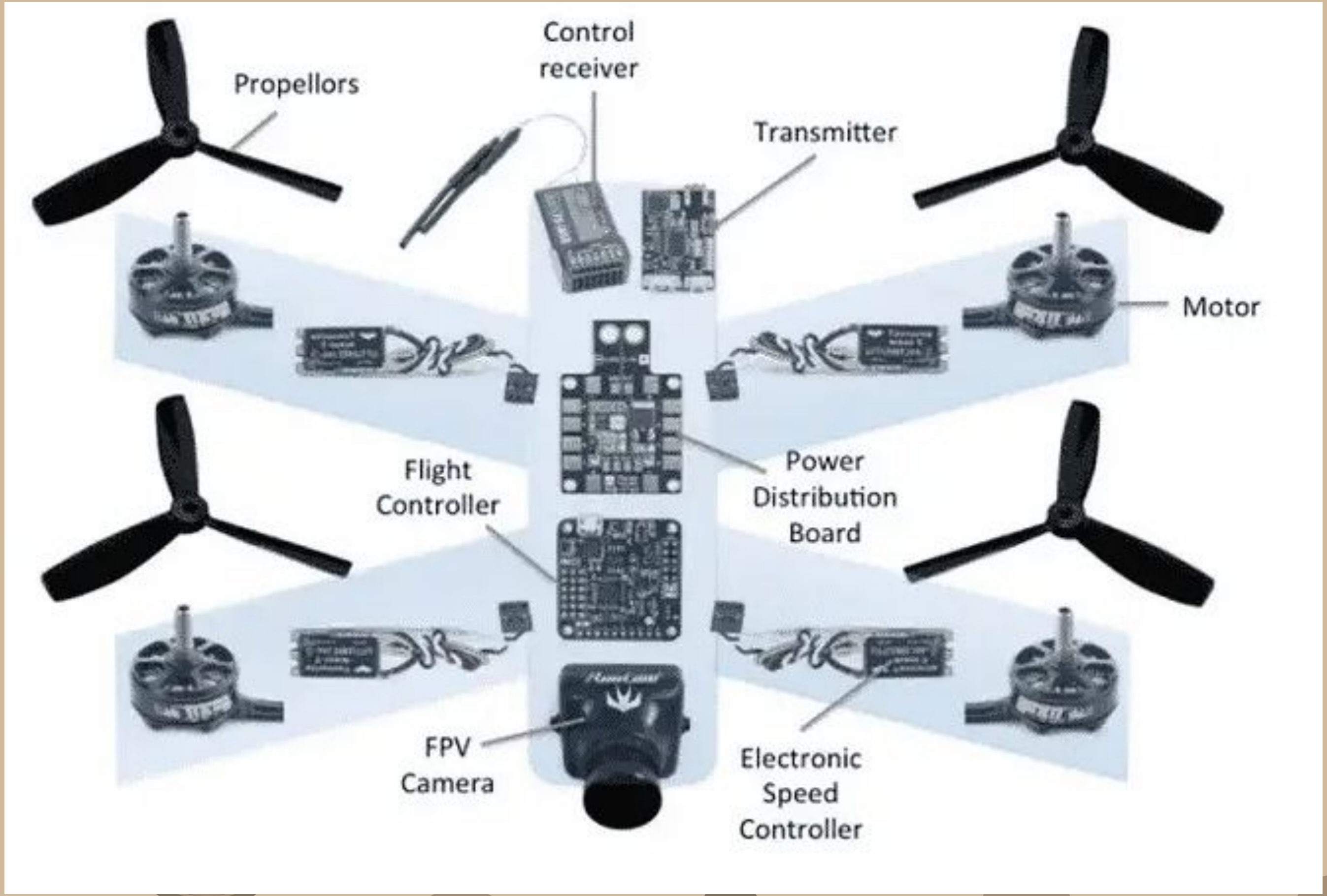
Helicopter/VTOL
Geo-MMS Payload Pictured

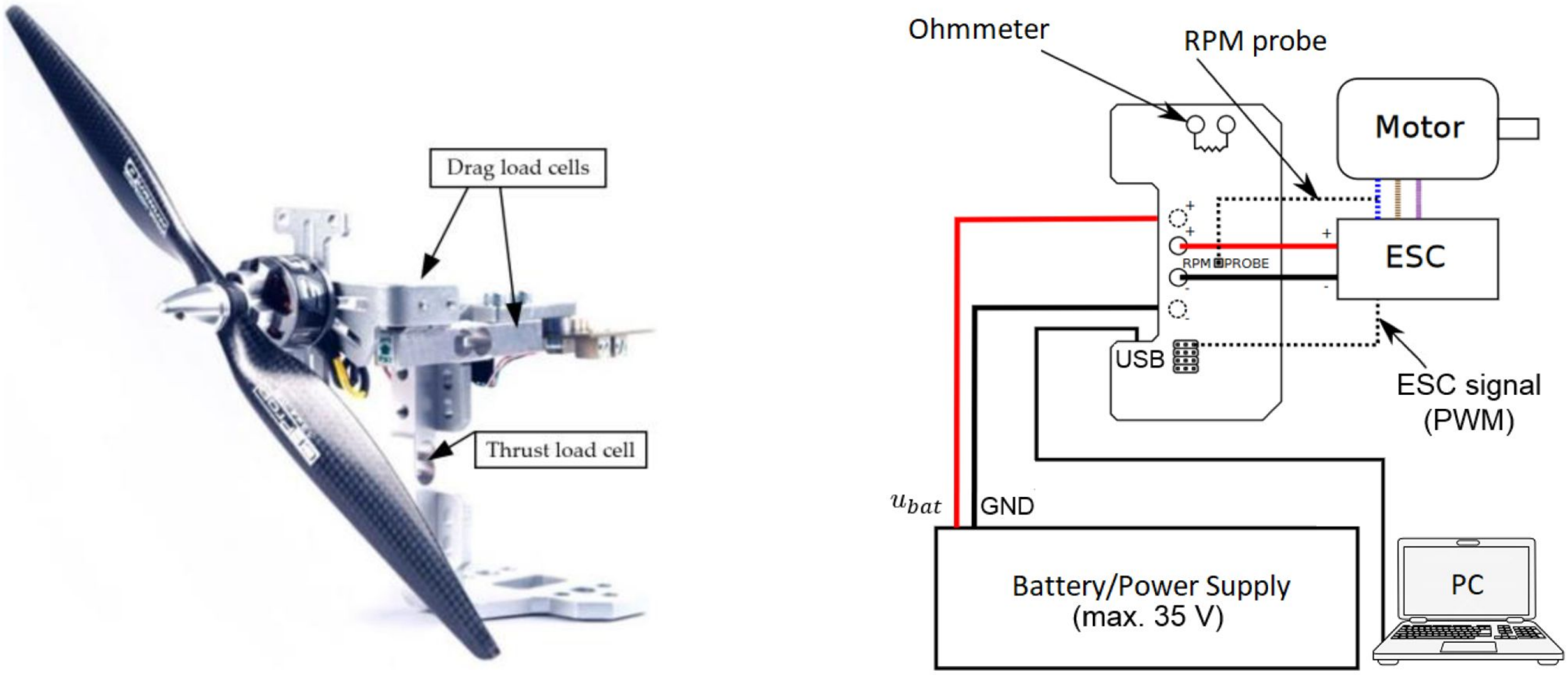
Multirotor	Fixed-Wing	Helicopter/VTOL
Wide selection	Ideal for corridor mapping	Spot takeoff/landing
Ease of use and maintenance	Highly stable	High altitude performance
Affordability and reliability	Long range and flight endurance	Highly stable
Greater maneuverability	Greater area coverage	High payload capacity
Unstable in windy conditions	Throw-launch complexity	Advanced piloting skills required
Limited flight endurance (battery)	Limited payload capacity	Maintenance difficulties
Small space for payload	Takeoff/Landing runway required	High cost

Propulsion system

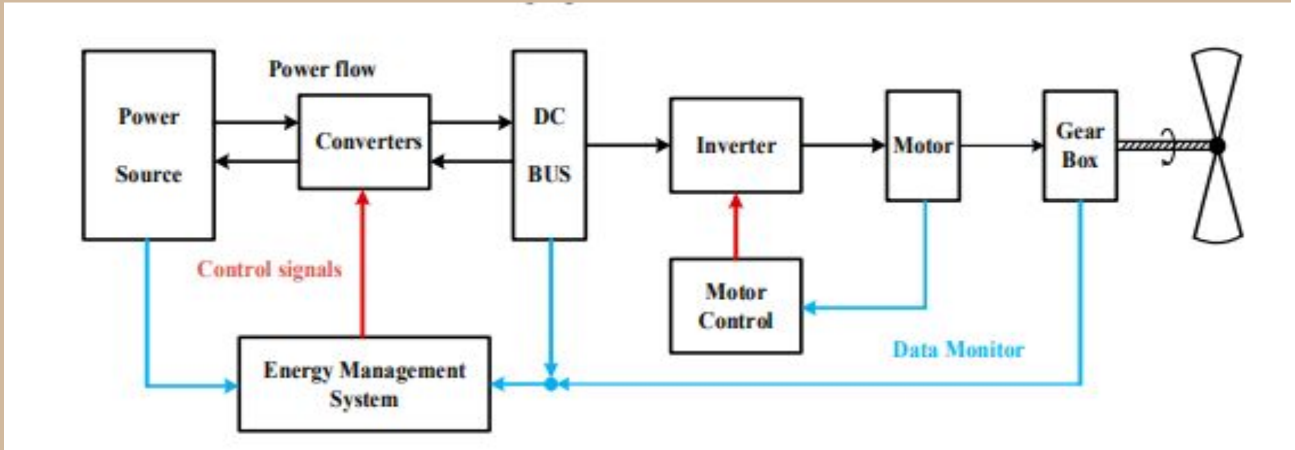
- UAVs have three types of propulsion systems, namely the fuel, hybrid fuel-electric, and pure electric, respectively
- Among them, traditional fuel propulsion systems can be divided into several categories such as piston, gas turbine, and ramjet engines according to the different of power units
- Traditional fuel propulsion systems have the advantages of high payload, long-endurance extensive range, and rapid resupply
- The hybrid propulsion system consists of an engine and an electric motor working together to generate the power required for aircraft flight, effectively saving about 30% of fuel consumption compared to the traditional fuel propulsion system
- The pure electric UAV propulsion system uses only electric motors as the power source device and thus has the advantages of low carbon emissions, low pollution, low cost, and high energy utilization
- Pure electric UAVs have a more comprehensive range of energy sources and can use new energy sources, such as lithium batteries, fuel cells, supercapacitors, solar energy. etc.

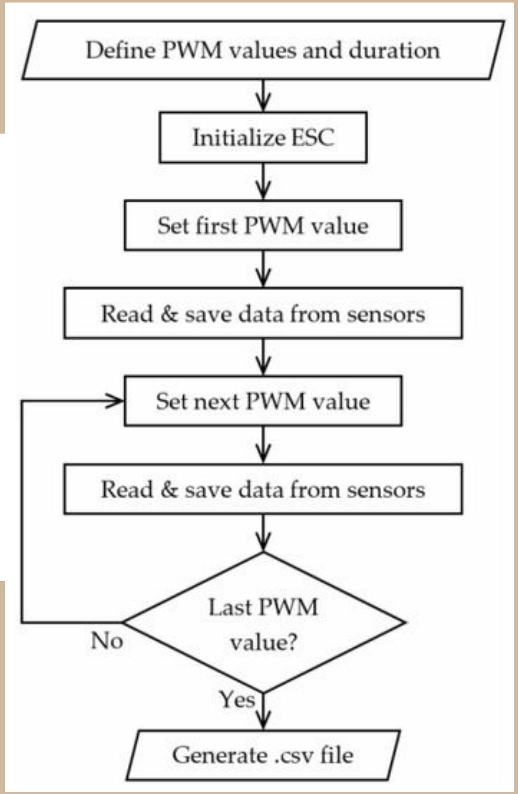

UAV Propulsion
Energy
Fuel
Engine Differences
Structure
Hybrid
Electric
System Components
Ramjet
Piston
Turbo
Parallel
Series
Power Supply
EMSs
Motor
Reciprocating
Rotary
Series-Parallel
Complex
PMSM
Brushless DC Motor
Turbojet
Turbofan
Lithium Batterise
Fuel cells
Solar
Superconducting motor
Turboprop
Turboshaft
Permanent Magnet Synchronous Motor (PMSM)
Energy Management Strategy (EMS)

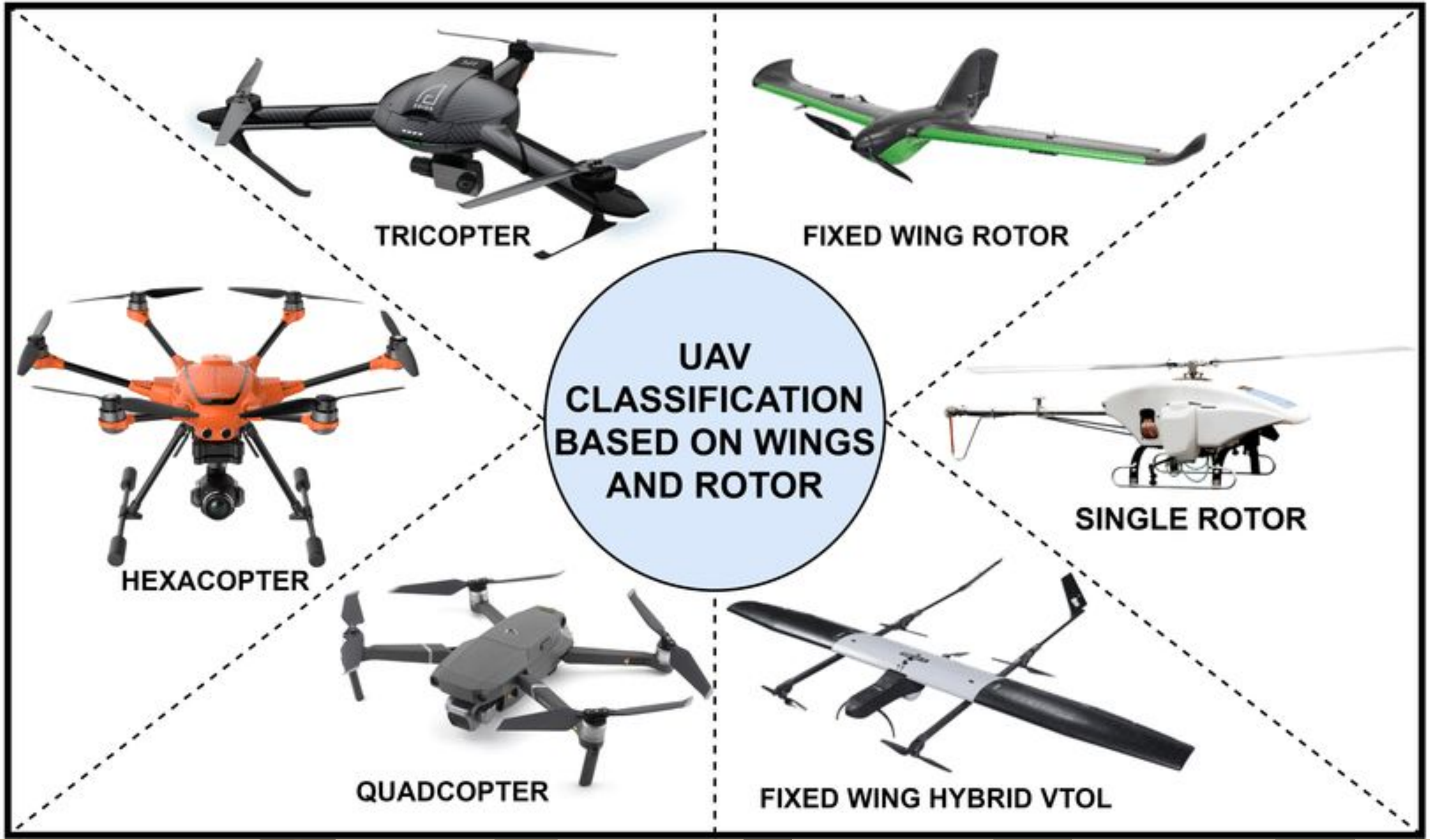

Propellors
Control receiver
Transmitter
Motor
Power Distribution Board
Flight Controller
FPV Camera
Electronic Speed Controller


Drag load cells
Thrust load cell
Ohmmeter
RPM probe
Motor
ESC
RPM PROBE
USB
ESC signal
(PWM)
u_{bat}
GND
Battery/Power Supply
(max. 35 V)
PC

(a) (b)


Power flow
Power Source
Converters
DC BUS
Inverter
Motor
Gear Box
Control signals
Motor Control
Data Monitor
Energy Management System


Define PWM values and duration
Initialize ESC
Set first PWM value
Read & save data from sensors
Set next PWM value
Read & save data from sensors
Last PWM value?
No
Yes
Generate .csv file

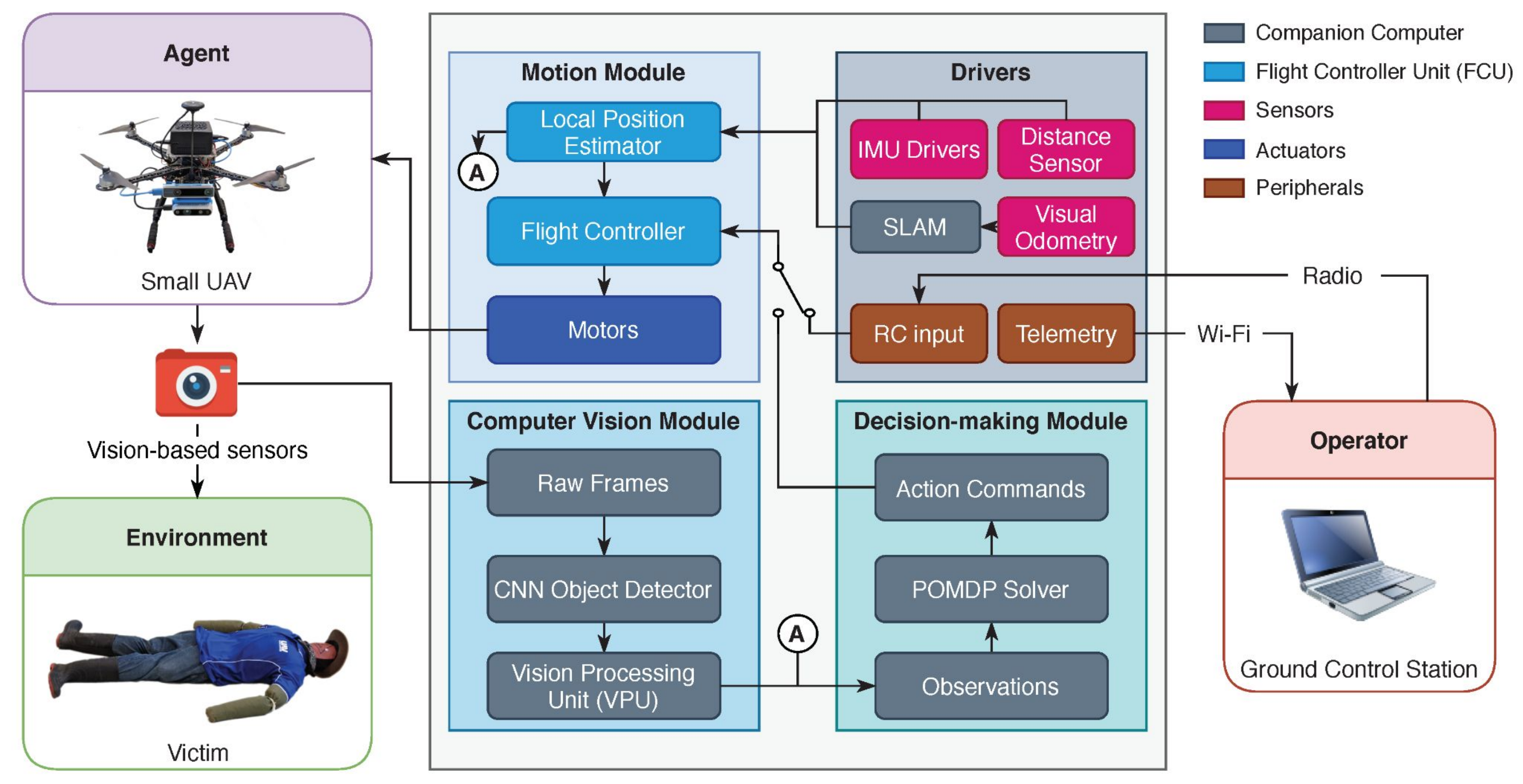

TRICOPTER
FIXED WING ROTOR
UAV
CLASSIFICATION
BASED ON WINGS
AND ROTOR
HEXACOPTER
SINGLE ROTOR
QUADCOPTER
FIXED WING HYBRID VTOL

Navigation System

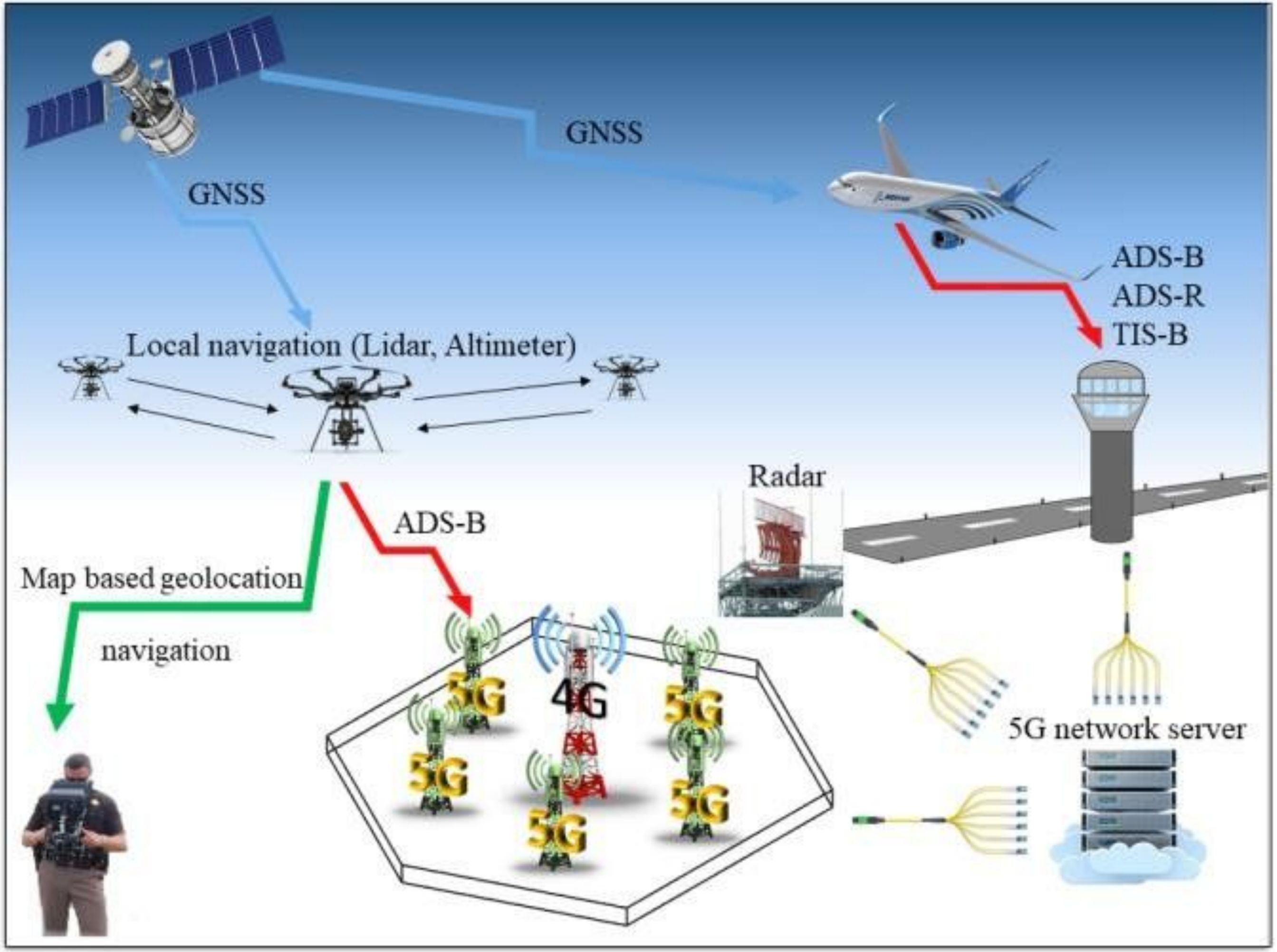
- Drones may use GPS/GNSS receivers, inertial navigation systems (INS), LiDAR scanners, ultrasonic sensors and visual cameras to navigate autonomously. They may also use a navigation technique known as SLAM (Simultaneous Location and Mapping) to create a map of their surroundings and understand their position within it.

- For drones that lack automation, control always rests with the pilot or operator. On lower-cost drones, the pilot uses visual tracking to determine position and orientation. In some cases, this is handled from the ground, based on the pilot's relative position. For drones outfitted with onboard cameras, visual data is relayed to the pilot's screen.

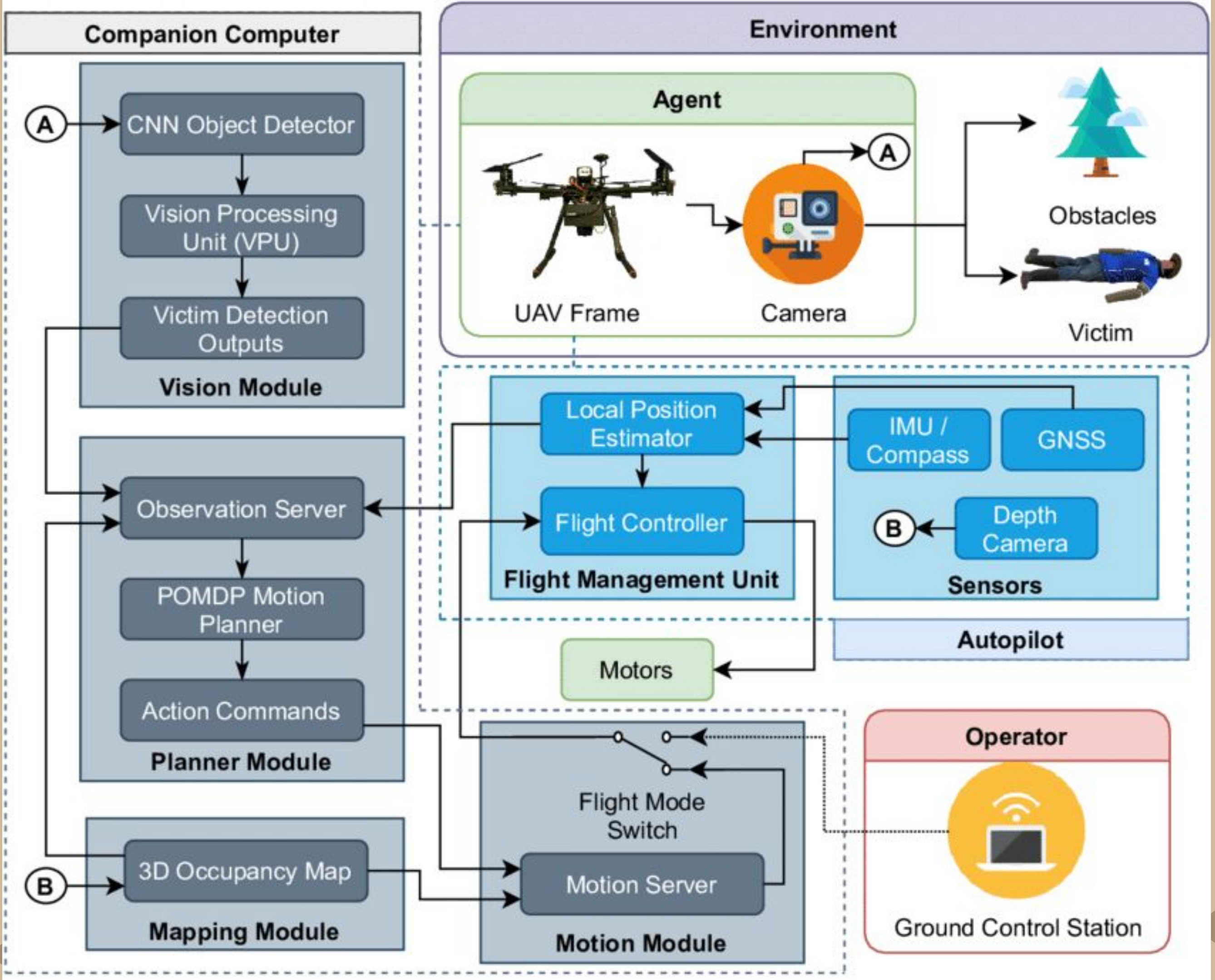
- **More advanced drones use GPS/GNSS receivers to allow for smarter navigation features, including:**
    1. Position hold, which lets the drone maintain a fixed location at a set altitude;
    2. Return-to-home navigation, wherein a drone returns automatically to the press of a button based on its take-off location; and
    3. Autonomous flight, where the flight path is set based on GPS/GNSS waypoints which the drone will follow using autopilot functions.



Agent
Small UAV
Vision-based sensors
Environment
Victim
Motion Module
Local Position Estimator
A
Flight Controller
Motors
Drivers
IMU Drivers
Distance Sensor
SLAM
Visual Odometry
RC input
Telemetry
Radio
Wi-Fi
Computer Vision Module
Raw Frames
CNN Object Detector
Vision Processing Unit (VPU)
Decision-making Module
Action Commands
POMDP Solver
Observations
A
Companion Computer
Flight Controller Unit (FCU)
Sensors
Actuators
Peripherals
Operator
Ground Control Station



GNSS
GNSS
ADS-B
ADS-R
TIS-B
Local navigation (Lidar, Altimeter)
Radar
ADS-B
Map based geolocation
navigation
5G
4G
5G
5G
5G
5G
5G network server



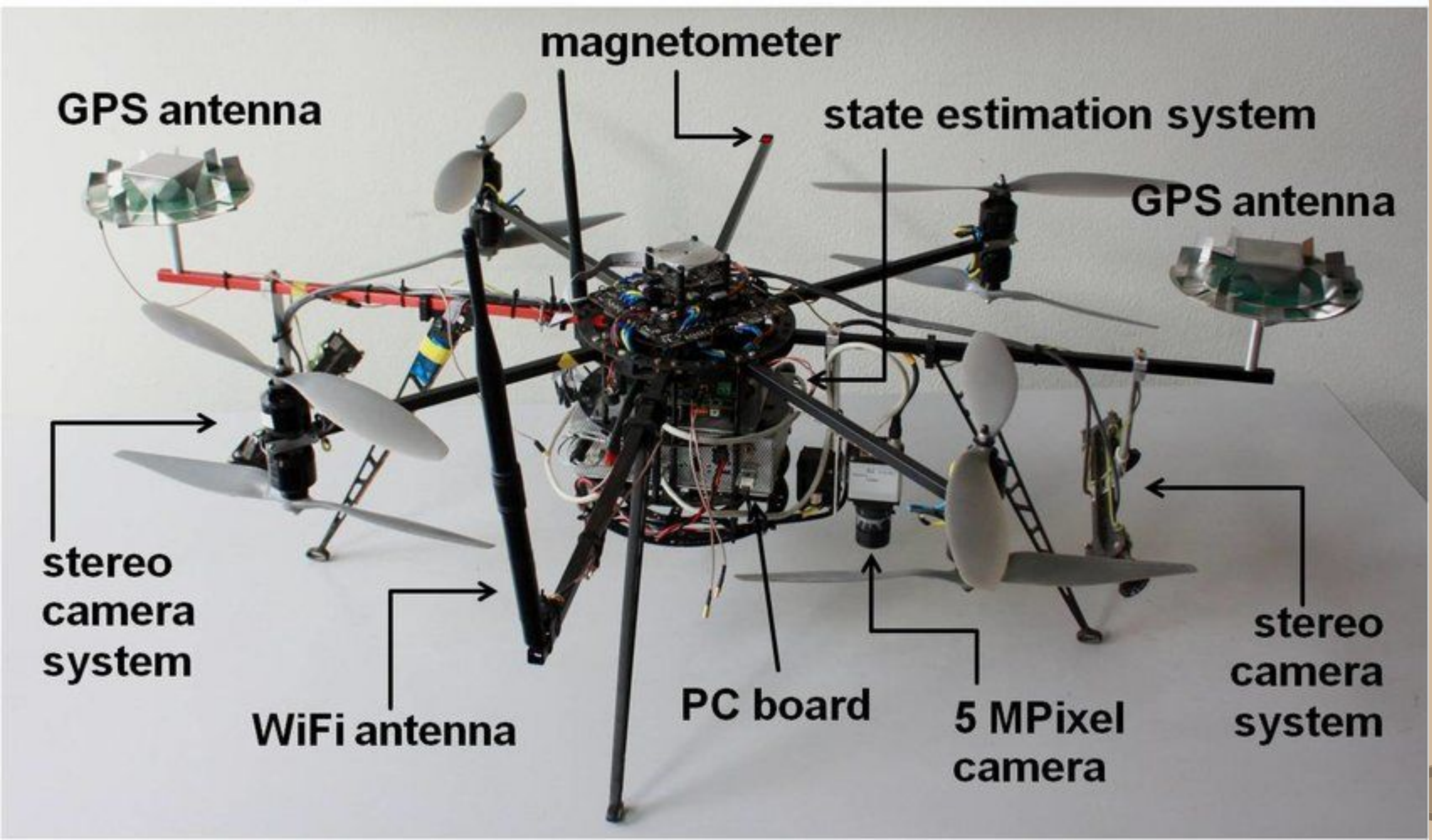
Companion Computer
Environment
Agent
CNN Object Detector
A
Vision Processing Unit (VPU)
Victim Detection Outputs
Vision Module
UAV Frame
Camera
Obstacles
Victim
Local Position Estimator
IMU / Compass
GNSS
Flight Controller
Depth Camera
B
Flight Management Unit
Sensors
Autopilot
Observation Server
POMDP Motion Planner
Action Commands
Planner Module
Motors
Operator
Flight Mode Switch
Motion Server
Motion Module
3D Occupancy Map
Mapping Module
Ground Control Station

Data Collection

Some sensors that used in UAV:

- Optical Camera
- Thermal Sensor
- LIDAR
- Inertial Measurement Units (IMU)
- Pressure sensor

➢ Some UAVs are equipped with a specific sensor that can be used for their specific purpose. For example there are drone that be used to find the buried object using the GPR sensor and there is a drone that is used to create spectral profiles of submerged aquatic vegetation and harmful algal blooms by using the Lightweight portable radiometer


magnetometer
GPS antenna
state estimation system
GPS antenna
stereo
camera
system
WiFi antenna
PC board
5 MPixel
camera
stereo
camera
system


GPS module
Pixhawk Flight Controller
Brushless Motor
Electronic Speed Controller
Pi Camera
Raspberry Pi
Li-Po Battery
LTE modem

Supported LiDAR sensors in the tactical-range

Supported LiDAR sensors for mid-range scanning

Supported LiDAR sensors for long-range scanning

Tactical LiDAR Specifications	
VLP-16	• Horizontal FOV/resolution: 360° / 0.1-0.4° • Vertical FOV/resolution: 30° / 2° • Effective range < 75m • Channels: 16-beams • Returns: 3 • Range accuracy: ±3cm • Scan rate: 5-20 Hz. • Data rate: 300,000 (point/sec) per return • Weight: 830g
HDL-32E	• Horizontal FOV/resolution: 360° / 0.08-0.35° • Vertical FOV/resolution: 40° / 1.3° • Effective range < 75m • Channels: 32-beams • Returns: 3 • Range accuracy: ±2cm • Scan rate: 5-20 Hz. • Data rate: 700,000 (point/sec) per return • Weight: 1.0 kg
M8-Plus	• Horizontal FOV/resolution: 360° / 0.03-0.13° • Vertical FOV/resolution: 20° / 2.8° • Effective range < 75m • Channels: 8-beams • Returns: 3 • Range accuracy: ±3cm • Scan rate: 5-20 Hz. • Data rate: 420,000 (point/sec) per return • Weight: 900g

Mid-Range LiDAR Specifications	
PUCK-32MR	• Horizontal FOV/resolution: 360° / 0.1-0.4° • Vertical FOV/resolution: 40° / 0.33° * min* • Effective range < 120m • Channels: 32-beams • Returns: 2 • Range accuracy: ±3cm • Scan rate: 5-20 Hz. • Data rate: 600,000 (point/sec) per return • Weight: 925g
VLP-32C	• Horizontal FOV/resolution: 360° / 0.1-0.4° • Vertical FOV/resolution: 40° / 0.33° • Effective range < 200m • Channels: 32-beams • Returns: 2 • Range accuracy: ±10 cm @ 50 m to 200 m • Scan rate: 5-20 Hz. • Data rate: 600,000 (point/sec) per return • Weight: 925g
M8-Ultra	• Horizontal FOV/resolution: 360° / 0.03-0.13° • Vertical FOV/resolution: 20° / 2.8° • Effective range < 200m • Channels: 8-beams • Returns: 3 • Range accuracy: ±3cm • Scan rate: 5-20 Hz. • Data rate: 420,000 (point/sec) per return • Weight: 900g

Long-Range LiDAR Specifications	
CL-90	• Horizontal FOV/resolution: 60-90° / 12 µrad • Effective range: 176 m (500 kHz) to 633 m (50 kHz) • Returns: 4 • Range accuracy: ±1cm • Scan rate: 500, 200, 50 kHz (Programmable) • Weight: 4.1 kg
CL-360	• Horizontal FOV/resolution: 360° / 12 µrad • Effective range: 775 m (50 kHz) to 300 m (500 kHz) • Returns: 4 • Range accuracy: ±1cm • Scan rate: 500, 200, 50 kHz (Programmable) • Weight: 3.5 kg

What is an IMU?

An Inertial Measurement Unit (IMU) is a device that can measure and report specific gravity and angular rate of an object to which it is attached. An IMU typically consists of:

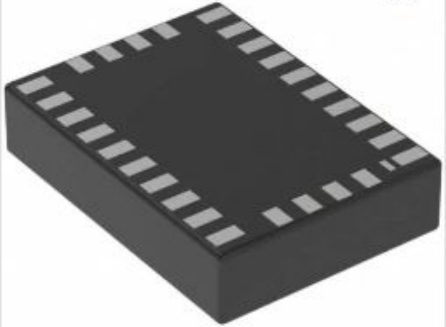
- Gyroscopes: providing a measure angular rate
- Accelerometers: providing a measure specific force/acceleration
- Magnetometers (optional): measurement of the magnetic field surrounding the system

GRADE	COST	GYRO IN-RUN BIAS STABILITY	GNSS-DENIED NAVIGATION TIME	APPLICATIONS
Consumer	<$10	--	--	Smartphones
Industrial	$100-$1000	<10 °/hour	<1 \minute	UAVs
Tactical	$5,000-$50,000	<1 °/hour	<10 \minute	Smart Munitions
Navigation	<$100,000	<0.1 °/hour	Several hours	Military

Table 1 : Performance Grades of Inertial Sensors

MikroElektronika 3D Motion Click Inertial Measurement Unit (IMU) - 9 DoF mikroBus ...

RM 294.11
RS Malaysia
RM 70.00 delivery



CEVA Technologies, Inc. BNO085 Accelerometer, Gyroscope, Magnetometer, 9

RM 79.37
Digi-Key Malaysia
RM 88.00 delivery

Gravity: I2c Bmi160 6-axis Inertial Motion Sensor

RM 43.55 + tax (US$9.90 + tax)
Electromaker.io
RM 106.23 delivery

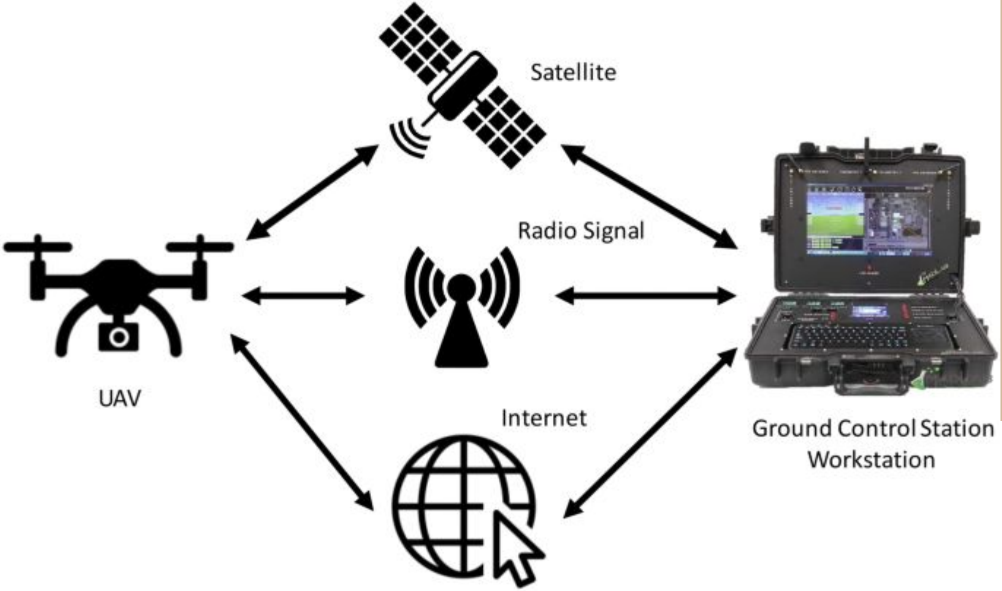
STMicroelectronics iNemo Inertial Measurement Unit (IMU) - 6 DoF Adapter Board ...

RM 89.69
RS Malaysia
RM 70.00 delivery

Data Transmission

Data link uses a radio-frequency (RF) transmission to transmit and receive information to and from the UAV. These transmissions can include location, remaining flight time, distance and location to target, distance to the pilot, location of the pilot, payload information, airspeed, altitude, and many other parameters

Drone communication protocols usually use the same frequency bands used for WiFi transmissions, particularly in the 2.400–2.483 GHz and 5.725–5.825 GHz. A drone equipped with a camera usually transmits a video stream to its control unit through the same wireless channel.



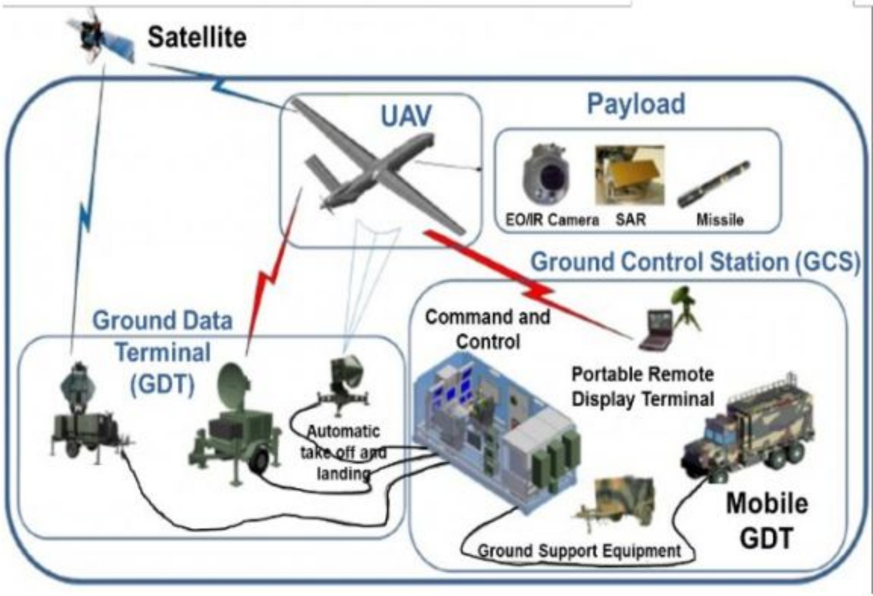


Figure 1. UAV Elements [10]

Power Management

Table 5. Comparison between lithium batteries, fuel cells, and solar cells characteristics.

Type	Efficiency	Power	Work Temperature/°C	Power Density	Cycle life	Specific Capacity/mAh/g
LiPO4 [101]	90%	N/A	−20–60	549 Wh/kg	>2000 times	150
LCO [101]	95%	N/A	−20–55	200–250 Wh/kg	500–1000 times	145
NCM [101]	95%	N/A	0–45	588 Wh/kg	>1000 times	110–120
AFC [100]	60%	10–100 kW	50–200			
PAFC [39]	40%	1–100 kW	160–220			
MCFC [39]	45–50%	100–400 kW	620–660	>500 Wh/kg	5000–20,000 h	N/A
SOFC [39]	60%	300 kW–3 MW	800–1000			
PEMFC [39]	35–60%	1 kW–2 MW	60–80			
Solar Battery [102]	10.1–25%	10 W–50 MW	Best at 25 °C	80 W/kg *(Solar Impulse 2)* [103]	20 Year	N/A

Table 6. Comparison between fuel cells and solar UAVs characteristics.

Type	Battery Type	Wing Length/m	Battery Power/W	Flight Time/h	Speed/m/s
Sunrise I [104]	Solar Battery	9.76	450	3–4	6–9
Sunrise II [104]	Solar Battery	9.76	600	N/A	10.67
Solong [104]	Solar Battery	4.75	225	>48	12–22
Sky-Sailor [104]	Solar Battery	3.2	90	27	8.3
AtlantikSolar [104]	Solar Battery	5.65	275	81.5	8.6
Spider Lion [104]	PEMFC	2.2	115	3–4	N/A
XFC [104]	PEMFC	3	300	6	N/A
Ion Tiger [104]	PEMFC	5.2	550	48	N/A
Stalker XE [104]	SOFC	3.6	300	8	N/A
FAUCON H2 [104]	PEMFC	3	310	310	10

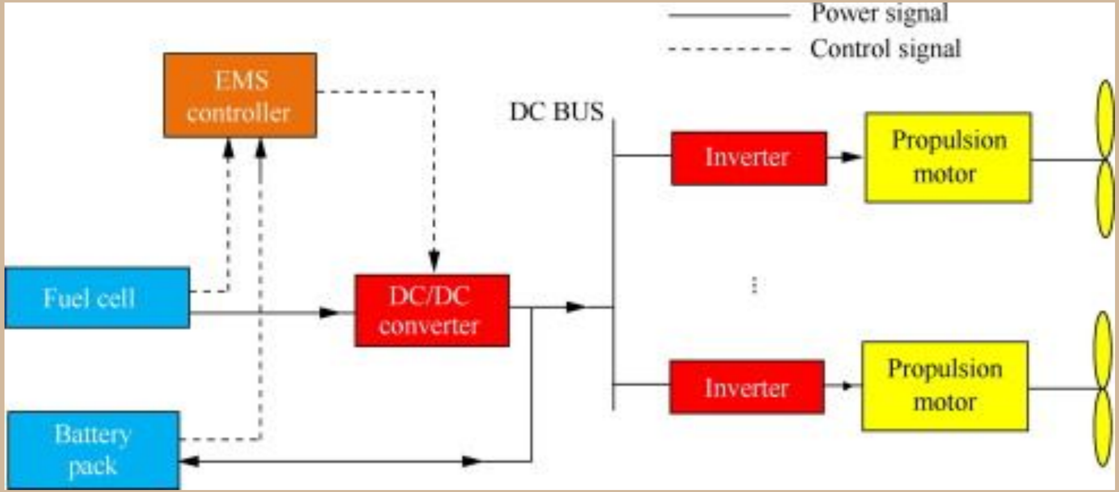


Table 2: Comparison of different batteries [93].

Characteristic	**Ni-Cd**	**Ni-Mh**	**LiPo**	**Li-S**
Specific energy (Wh/kg)	40	80	180	350
Energy density (Wh/l)	100	300	300	350
Specific power (W/kg)	300	900	2800	600

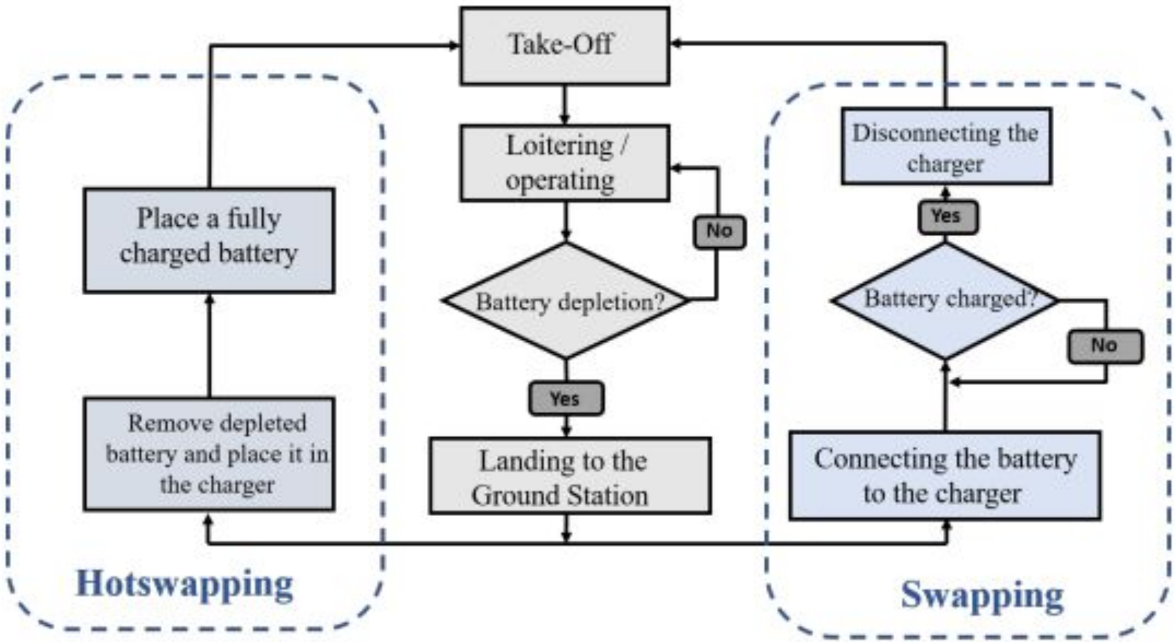
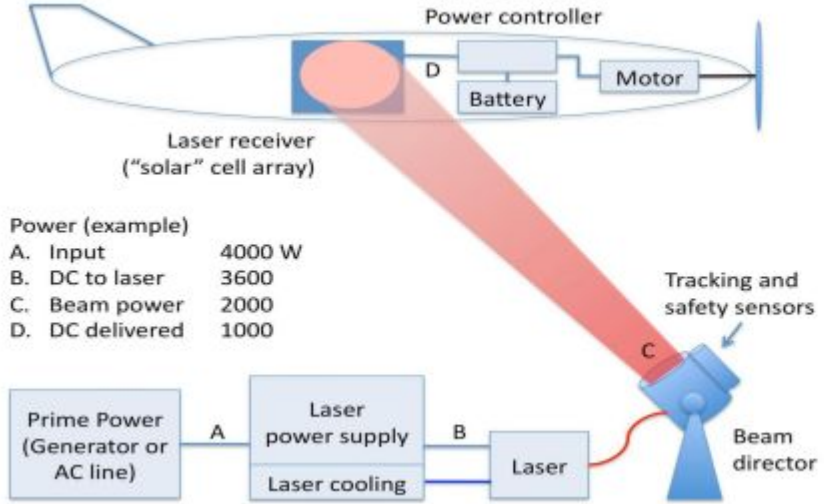


Figure 14: Swapping and Hotswapping Algorithms.

Figure 15: UAV's charging stations [96, 101].



THANKS!

DO YOU HAVE ANY QUESTIONS?

youremail@freepik.com
+34 654 321 432
yourwebsite.com