SUPPORT SYSTEM (AR): TYPES OF SENSORS AND CHARACTERISTICS, ALTERNATIVE POWER, HUMAN MACHINE INTERFACE.

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Canva

SENSOR TYPES AND CHARACTERISTICS

Sensor Type	Purpose	Characteristics
IMU (Inertial Measurement Unit)	Measures acceleration and angular velocity	Combines accelerometers and gyroscopes; essential for stabilization and control
GPS / RTK GPS	Positioning and geolocation	RTK provides centimeter-level accuracy using differential correction
Barometer	Measures atmospheric pressure	Infers altitude; lightweight, often fused with GPS
Magnetometer	Heading and orientation	Detects magnetic field; helps determine yaw
LIDAR	Obstacle detection, 3D mapping	Uses laser pulses to measure distance; high precision and resolution
Cameras (RGB/IR)	Visual navigation, object detection	RGB for optical flow, IR for thermal imaging; critical for photogrammetry
Ultrasonic / ToF	Proximity sensing and ground altitude	Short-range but fast; used in low-altitude flight

ALTERNATIVE POWER SYSTEMS

Power System	Description	Applications
Li-Po Batteries	High power density, lightweight	Small to medium drones
Hydrogen Fuel Cells	Higher energy density, zero-emission	Long-endurance and high-altitude UAVs
Hybrid Power Systems	Combines batteries with internal combustion engines	VTOL and heavy-lift UAVs
Solar Panels	Harvests solar energy during flight	Fixed-wing UAVs with high-altitude loitering

HUMAN-MACHINE INTERFACE (HMI)

The HMI connects human operators with the aerial robot's control and data systems. Depending on the autonomy level, interfaces vary in complexity.

Interface Type	Description	Characteristics
Ground Control Station (GCS)	Provides manual/automated control, real-time telemetry	Desktop, laptop, or tablet-based with mission planning UI
Mobile App-Based Interface	Simplified interface for commercial drones	Touchscreen with live camera feed
Voice/AR Interfaces	Hands-free or immersive control (experimental)	Used in research or battlefield scenarios
SATCOM-Enabled Cockpits	Used in military-grade systems for BVLOS ops	Full cockpit-style control system

DJI MATRICE 300 RTK

Sensors:

- Dual IMU, dual barometer, and magnetometer for redundant state estimation
- RTK GPS for centimeter-level navigation
- Downward/forward/backward obstacle avoidance sensors (vision + ultrasonic)
- Compatible with LIDAR, thermal, and multispectral cameras

Power System:

- Dual hot-swappable Li-Po batteries (TB60); capacity: 5935 mAh each
- Smart battery management with pre-flight diagnostics and auto-discharge
- Max flight time: ~55 minutes (with standard payload)

DJI MATRICE 300 RTK

HMI:

- DJI Smart Controller Enterprise
  - HD live video transmission (OcuSync Enterprise)
  - Integrated flight planning via DJI Pilot 2 app
- Fully autonomous waypoint missions and AI-based object tracking
- USB-C and HDMI output for field operability

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Sensors:

- EO/IR turret for day/night surveillance (MTS-B sensor suite)
- Synthetic Aperture Radar (SAR) for ground imaging through weather/clouds
- Laser designator and rangefinder for targeting
- Inertial navigation + GPS integration for high-accuracy flight

Power System:

- Honeywell turboprop engine (950 hp) – aviation-grade fuel
- Extremely long endurance: >27 hours
- Backup battery for avionics and failsafe operations

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HMI:

- **Ground Control Station (GCS) with dual-console**
  - **One for the pilot, another for the sensor operator**
- **SATCOM and line-of-sight radio links**
- **Secure, encrypted communication channels with real-time battlefield integration**

PARROT ANAFI AI

Sensors:

- 48 MP HDR camera with 6x zoom and AI scene analysis
- Dual IMU, barometer, GPS + GLONASS
- Ultrasonic + time-of-flight for close-proximity sensing
- Built-in GNSS RTK module available for precision mapping

Power System:

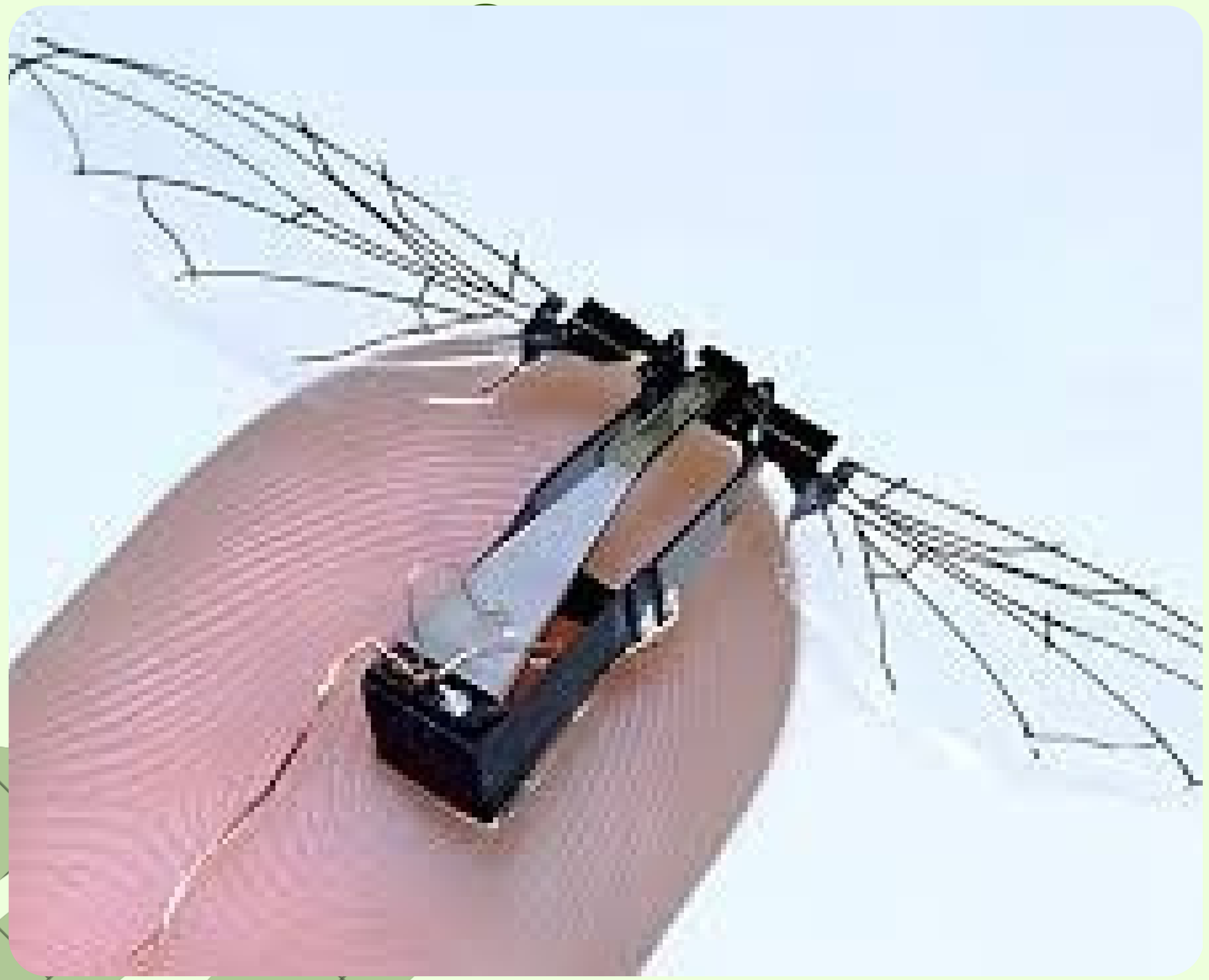
- Intelligent Li-Po battery with thermal regulation and safety cutoff
- Max flight time: ~32 minutes
- USB-C fast charging support

PARROT ANAFI AI

HMI:

- Parrot FreeFlight 7 app (4G LTE connectivity)
  - Real-time HD video streaming over 4G networks
  - Autonomous flight programming with terrain-follow mode
- Integration with Pix4Dcloud for photogrammetric analysis and 3D modeling

ROBOBEE (HARVARD)



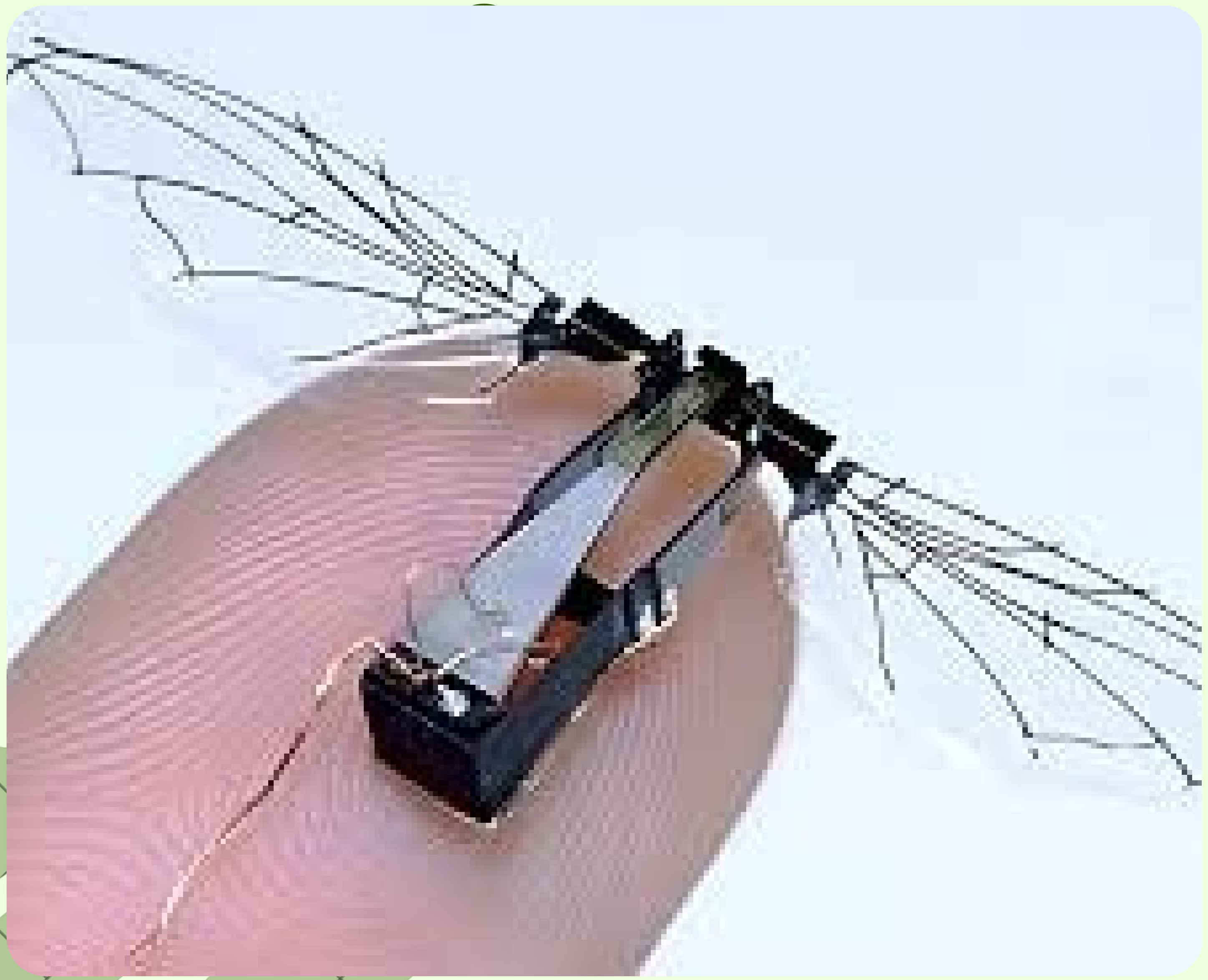
Sensors:

- Microfabricated IMU and optical flow sensors
- Experiments with light sensors for navigation cues
- Extremely size-constrained; limited onboard processing

Power System:

- Laser-powered flight (wireless energy transmission) in lab setups
- Attempts were made with micro-battery and piezoelectric actuation
- Current models require tethering or an external energy supply

ROBOBEE (HARVARD)



- HMI:
  - Controlled via lab-based interfaces with experimental GUI
  - Research-focused control with scripted commands
  - Long-term vision includes swarm control via wearable AR interfaces

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Sensors:

- Multi-sensor fusion: GNSS, IMU, magnetometer, barometer
- Obstacle detection via stereo vision and optical sensors
- Diagnostics sensors for payload health and delivery verification

Power System:

- Swappable Li-ion battery pack
- Flight time: ~45 minutes
- Optional hybrid configurations (R&D stage)
- Designed for rapid deployment in remote locations

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HMI:

- Tablet-based control system (Wingcopter Control Center)
  - Drag-and-drop waypoint assignment
  - Live telemetry + autonomous flight control
- Cloud-based data management and mission logging

CONCLUSION

Support systems form the intelligent backbone of aerial robotics. From basic sensing and control in micro-drones to satellite-linked autonomy in military UAVs, the design and integration of sensors, power sources, and HMIs directly define the capability, safety, and mission applicability of aerial robots.

- The five analyzed examples demonstrate:
- A range of autonomy (manual to fully autonomous),
- Sensor diversity depending on task (thermal, LIDAR, SAR, micro-IMUs),
- And tailored HMIs to fit field use, lab testing, or secure military operations.

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