UAV 101

Dr. Jiawei Yuan
Assistant Professor
University of University of Massachusetts Dartmouth

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What are UAVs?

- UAV = Unmanned Aerial Vehicle (commonly known as a drone)

- An aircraft without a human pilot on board and is capable of sustained flight including a platform structure, aerodynamic elements, method of propulsion, and control system.

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Image source: ref [2]

Toys

- **Cost**: $25 - $100
- **Uses**: recreational

Sponsored

4DRC V8 Mini Drone for Kids Children RC Quadcopter with 3 Batteries Longer Flight Time, Altitude Hold, Headless Mode,...

4.4 out of 5 stars 16

$32.99 ~~$35.99~~

Save 5% with coupon

prime FREE Delivery **Sun, Jan 24**

Ages: 14 years and up

Sponsored

SNAPTAIN A10 Mini Foldable Drone with 720P HD Camera FPV WiFi RC Quadcopter w/Voice Control, Gesture Control,...

4.5 out of 5 stars 2,363

$49.99 ~~$59.99~~

Save 5% with coupon

prime FREE Delivery **Sun, Jan 24**

Ages: 14 years and up

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Tools

- **Cost**: $500 - $10,000
- **Payload**: 50~60lbs max
  - E.g., Vulcan UAV Airlift
- **Uses**:
  - Photography
  - Mapping
  - Survey
  - Inspections
  - Data sensing
  - Package Delivery

  …

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Military

- **Cost**: $million+
- **Payload**: 500lbs+
- **Uses**:
  - Intelligence
  - Surveillance
  - Weapons delivery

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Image source: ref [3]

History of UAV

- UAVs are initially driven by military applications, later leading into civilian applications.

- The earliest recorded use of a UAV for warfighting occurred in July 1849
  - serving as a balloon carrier in the first offensive use of air power in naval aviation.

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History of UAV

- World War I
  - The first pilotless aircraft were built using A. M. Low's radio control techniques
  - In 1918, Charles Kettering develops the Kettering Aerial Torpedo ("Bug") for US Army

- Interwar period
  - The early successes of pilotless aircraft led to the development of radio-controlled pilotless target aircraft in Britain and the US in the 1930s
  - In 1931, the British developed the Fairey Queen radio-controlled target from the Fairey IIIF floatplane

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History of UAV

- World War II
  - Radioplane Co. (later Northrop) builds thousands of target drones for US military
- 1944 - 1945
  - Germans develop and use V-1 and V-2 "Buzz Bomb" *lethal drones*
- 1955 – 1975
  - Extensive use of reconnaissance UAVs by US military for low-altitude real-time photography

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History of UAV

- 1982
  - Israelis neutralize Syrian air defense system using UAVs for reconnaissance, decoys, and jamming
- 1985
  - US Navy and Marine Corps purchase & deploy Pioneer UAV system
- 1990s
  - US Air Force finally jumps into UAVs and takes over control of all US military UAV programs and assets
- 2000s
  - US military deploys Global Hawk during Iraq war

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What is UAS?

- **UAS**: Unmanned Aerial System
  - UAV
  - Payloads
  - Ground control station
  - Communication links between them

- A complete UAV-based system designed and deployed for a particular objective.

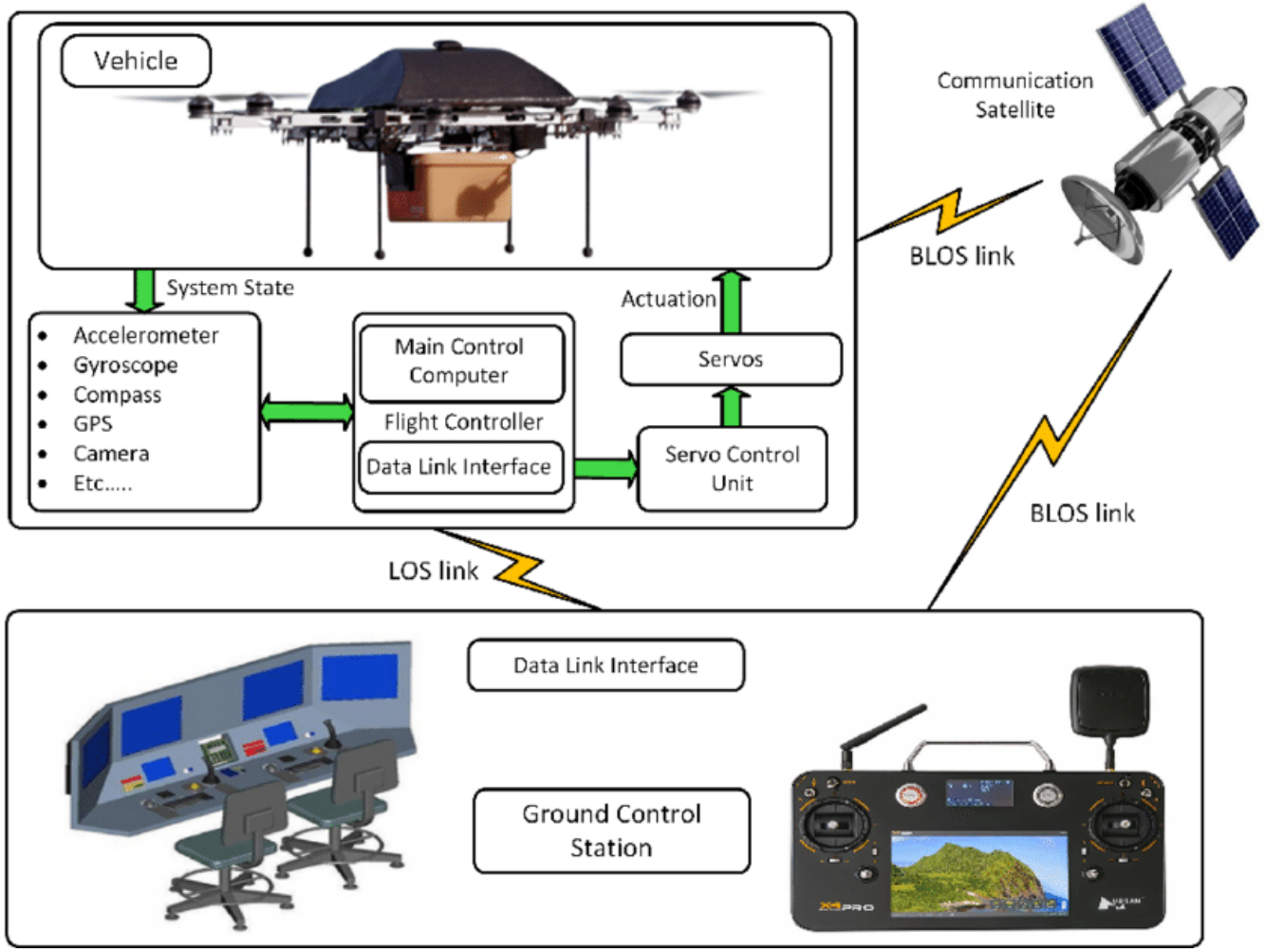

Image Source: ref [1]

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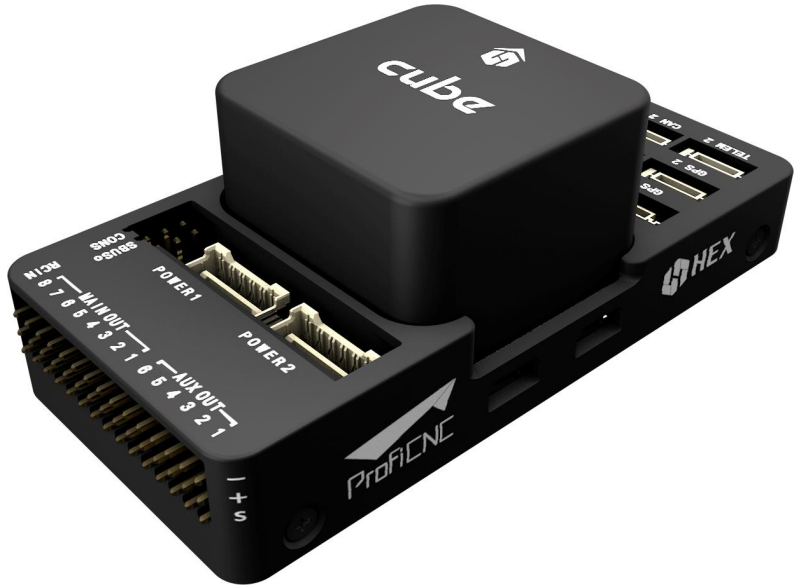
Flight Control Methods

- Autonomous: includes on-board computer systems to function as autopilot
  - Flight control, navigation, obstacle avoidance, etc.
- Manual: no inherent system for flight control or stabilization
- Semi-autonomous: manual control with stability assist



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Payloads

- In short, the payload is the weight a UAV can carry.

- It is usually counted outside of the weight of the UAV itself and includes anything additional to it, e.g.,
  - image acquisition (still/video cameras, film, CCD, day/night, FLIR)
  - sensors
  - Weapons
  - relays – of data communication links
  - packages for delivery

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Ground Control Station (GCS)

- The complete set of ground-based hardware systems used to control the UAV
  - Human-Machine Interface
  - Computer
  - Telemetry
  - Video capture card and aerials for the control
  - Video and data links to the UAV

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Ground Control Station

- Fixed Installation and Vehicle Mounted GCS

- Portable GCS

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Image source: ref[4]

Communication Links

- Provides one- or two-way communications between pilot and air vehicle

- Uplink: command & control data from pilot/GCS to UAV
  - Relatively low data rate of a few kHz

- Downlink: status and telemetry data from UAV to pilot/GCS
  - Can support high data rate (e.g., 10 +MHz) for sensor data

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Ground Support Equipment

- Test & maintenance equipment: e.g., meters, diagnostics.
- Fuel supply: e.g., petroleum, batteries.
- Refueling equipment: e.g., pumps, battery chargers.
- Spare parts: e.g., propellers, blades, control components
- Transportation

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UAV Application Areas

- Civilian: recreation and commercial
- Military: reconnaissance, weapons delivery, and training
- Government: intelligence, surveillance, and reconnaissance (ISR)

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ISR

- Intelligence
  - the product resulting from the collection, processing, integration, analysis, evaluation, and interpretation of available information concerning foreign countries or areas.
  - information and knowledge about an adversary obtained through observation, investigation, analysis, or understanding.
- Surveillance
  - the systematic observation of aerospace, surface or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic or other means.
- Reconnaissance
  - a mission undertaken to obtain by visual observation or other detection methods, information about the activities and resources of an enemy or potential enemy, or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area.

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ISR

- Law enforcement / criminal justice
- Search & rescue
- Border patrol
- Port security
- Homeland security
- FBI
- USDA
- NASA

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Image source: [8,9]

Material Handling

- Package delivery
  - E.g., Amazon Prime Air approved by FAA in 2020
- Emergency medical delivery
- Water sampling (algae)

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Image sources: [11]

Aerial Imagery

- Real estate
- Traffic flow monitoring
- News reporting
- Filmmaking
- Disaster reconnaissance
- Site tracking
- Surface mining operations
- …

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Image sources: [5,6]

Industrial Inspection

- Aerial inspection of infrastructure, equipment, or hardware for defect identification

Examples:

- Civil infrastructure: bridges, roads, sewers, dams
- Electric power: facilities /structures, right-of-way encroachment
- Wind turbine: blade erosion & damage
- Communication towers
- Oil/gas lines, wells, off-shore platforms

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Image source: [10]

Remote Sensing

- Remote sensing is the acquisition of information about an object or phenomenon without making physical contact with the object.

- Remote sensing using UAVs
  - Photogrammetry
  - Precision agriculture
  - Resource management

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Photogrammetry

- The science of making reliable measurements by use of photographs, especially aerial photographs

Examples:

- Aerial mapping: creating maps from aerial imagery
- Aerial surveying: using data to measure physical or geometric characteristics of the earth
- Volumetrics: measurement of materials or spaces in 3D models derived from aerial surveying

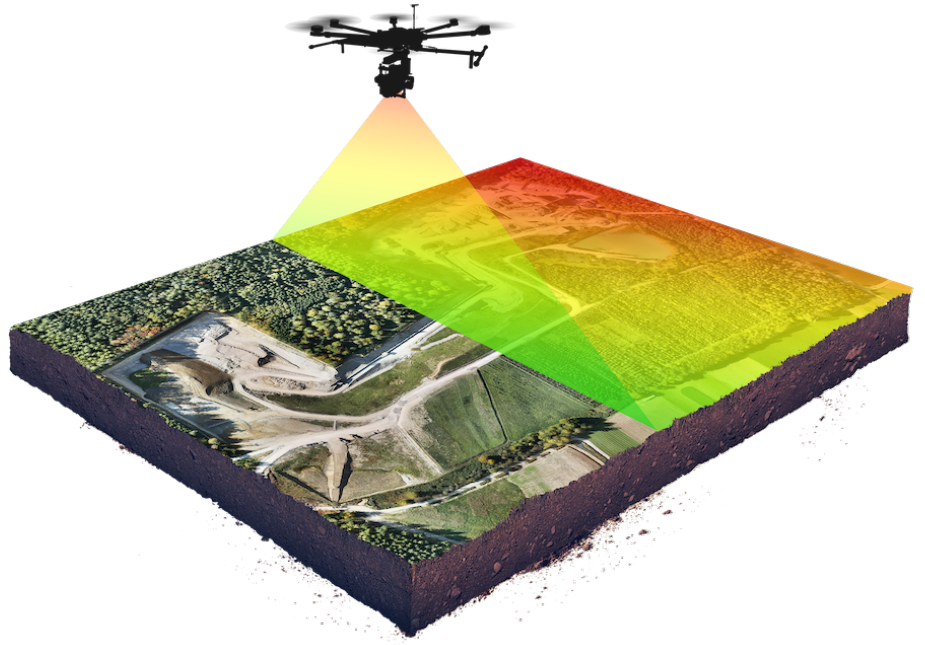

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Image source: [7]

Resource Management

- Monitoring and protection of natural resources

Examples:

- wildlife populations, migration.
- impact of dams, irrigation.
- wildlife reserves
- wildfire containment
- stream pollution
- land erosion

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AUVSI

- Association of Unmanned Vehicle Systems International (AUVSI)

- https://www.auvsi.org/

- The world's largest nonprofit organization dedicated to the advancement of unmanned systems and robotics, represents corporations and professionals from more than 60 countries involved in industry, government and academia.

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Reference

1. Riham Altawy and Amr M. Youssef. 2016. Security, Privacy, and Safety Aspects of Civilian Drones: A Survey. ACM Trans. Cyber-Phys. Syst. 1, 2, Article 7 (February 2017), 25 pages. DOI:https://doi.org/10.1145/3001836
2. https://en.wikipedia.org/wiki/UAVs_in_the_U.S._military
3. https://en.wikipedia.org/wiki/Unmanned_combat_aerial_vehicle
4. https://en.wikipedia.org/wiki/UAV_ground_control_station
5. https://www.welkinuav.com/drones-help-more-for-traffic-police/
6. https://www.lhsfna.org/index.cfm/lifelines/august-2018/using-drones-to-monitor-construction-safety/
7. https://zssglobal.com/drone-mapping
8. https://cbjlawyers.com/law-enforcement-drone-technology-covid-19/
9. https://defensesystems.com/articles/2014/07/21/natick-cargo-pocket-isr-drone.aspx
10. https://www.customtruck.com/blog/natural-gas-pipeline-inspection-application-of-drones-will-prove-to-be-game-changer/
11. https://dronebelow.com/2018/08/29/research-proposes-new-emergency-drone-network-in-denmark/

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