# LEAPFROG: RPAS Module Training

Unmanned aircraft systems


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# INTRODUCTION

# What Unmanned Aircraft Systems are?

Unmanned Aircraft Systems or UAS officially named by Federal Aviation Administration and US Department of Defense:

- Unmanned -> no human inside
- Aircraft -> to comply with airworthiness and airspace regulations
- System -> to emphasize the importance of other elements such as: ground stations, data links and other equipment

UAS can be fully autonomous, partially autonomous or remotely piloted by an operator

# Other names usually used to call UAS

- Drones (Dynamic Remotely Operated Navigation Equipment)
- UAV (Unmanned Aerial Vehicle)
- Remotely Piloted Vehicles (RPV)
- Remotely Piloted Aircraft Systems (RPAS)

# Why we need UAS?

***Unmanned aircraft will only exist if they offer advantage compared with manned aircraft***

- ***Dull roles***
  - Extended surveillance can be a boring experience for aircrew, with many hours spent on watch without relief, therefore, loss of mission effectiveness
  - UAS can operate autonomously for long endurance
- ***Dirty roles***
  - Monitoring the environment for nuclear or chemical contamination puts aircrew unnecessarily at risk
  - UAS can be exposed in dangerous environments
- ***Environmentally critical roles***
  - UAS will usually cause less environmental disturbance or pollution than a manned aircraft pursuing the same task
  - Smaller, of lower mass and consume less power, so producing lower levels of emission and noise
- **Economic reasons**
  - UAS cost of operations, maintenance, power are much less
  - Simplifying effect on the design and reduction in cost of the UAS

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# Where can we use UAS?

- Aerial Photography (Film, Video etc)
- Agriculture (Vegetation Monitoring and Spraying; herd monitoring and driving)
- Civil Protections (Physical disasters, Wildfires, Search and Rescue etc)
- Coastguard (Search and Rescue, coastline and sea-lane monitoring)
- Conservation (Pollution and land monitoring)
- Customs and Excise (Surveillance for illegal imports)
- Electricity companies (Powerline inspection)
- Fire Services and Forestry (Fire detection, incident control)
- Fisheries (Fisheries protection)
- Gas and oil supply companies (Land survey and pipeline security)
- Information services (news information and pictures, feature picture eg. Wildlife)

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# Where can we use UAS?

- Lifeboat Institutions (Incident investigation, guidance and control)
- Local Authorities (Survey, disaster control)
- Meteorological services (Sampling and analysis of atmosphere for forecasting etc)
- Military (Surveillance of enemy activity, reconnaissance etc)
- Traffic agencies (Monitoring and control of road traffic)
- Ordnance Survey (Aerial photography and mapping)
- Police Authorities (Search for missing people, security and incident surveillance)
- Rivers Authorities (Water course and level monitoring, flood and pollution control)
- Survey organizations (Geographical, geological and archaeological survey)
- Water Boards (Reservoir and pipeline monitoring)

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# CATEGORIES AND TYPES OF UAS

# The Air-Vehicle

**The type and performance of UAS is determined by the needs of the operational mission and the payloads and sensors needed for the operation:**

- **Air speed**
- **Altitude**
- **Degree of Autonomous (Autopilot, collision avoidance, auto detection etc)**
- **Deployment**
- **Environmental capabilities (Rain, wind, high temperature, snowing, humidity etc)**
- **Hover capability**
- **Maneuverability**
- **Operational Range & Endurance**
- **Over the horizon communication**
- **Size**

# Categorization of UAS

- **With respect to flight characteristics:**
  - Range
  - Endurance
  - MTOM

- **With respect to airframe configurations:**
  - HTOL or horizontal take-off and landing
  - VTOL or vertical take-off and landing
  - Hybrids which attempt to combine the attributes of both of these types

# Categorized by flight characteristics

- ***HALE High altitude long endurance***

**(Over 15000m altitude and 24+ hr enduran**

- ***MALE Medium altitude long endurance***

**(5000-15000m altitude and 24 hr enduran )**

- ***TUAV Medium Range or Tactical UAV***

**(Range between 100-300 Km)**

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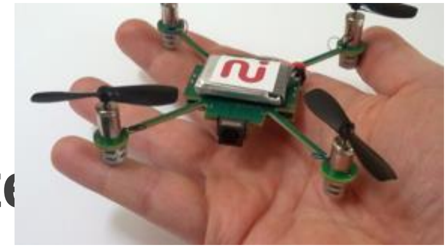
# Categorized by flight characteristics

- *Close-Range UAS*

(Range up to 100 Km)

- *MUAV or Mini UAV* (UAV below or equal mass of 25Kg and capable of ranges of up to 30Km)



- *Micro UAV or MAV* (Wing span no greater than 15 cm approximately and mass equal or less than 3Kg)

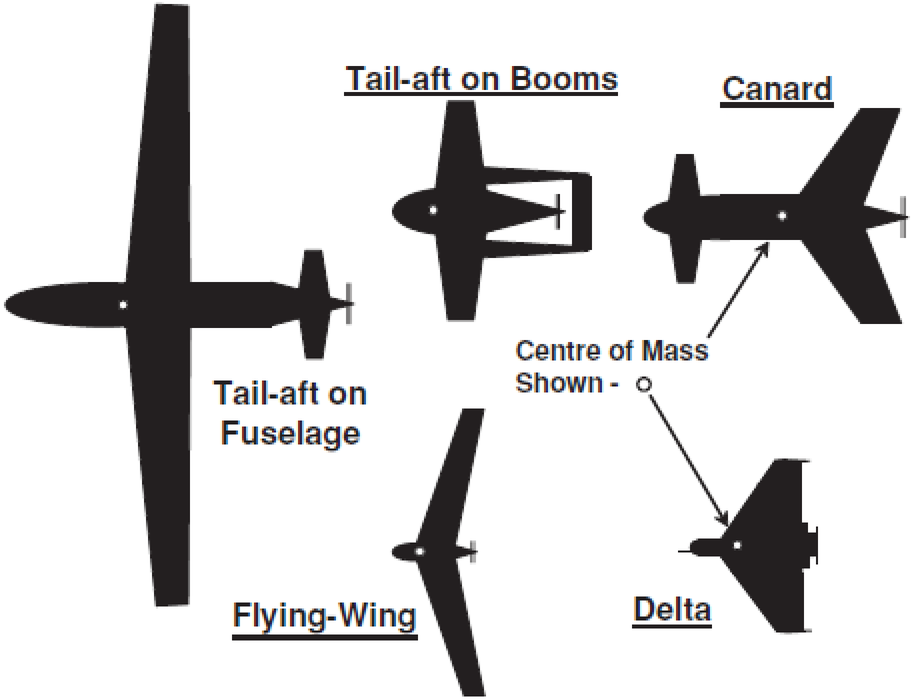
# Categorized by flight characteristics

- ***NAV or Nano Air Vehicles*** **(Tiny size/ir**
**Size usually used in swarms for purpos**
**Radar confusion)**

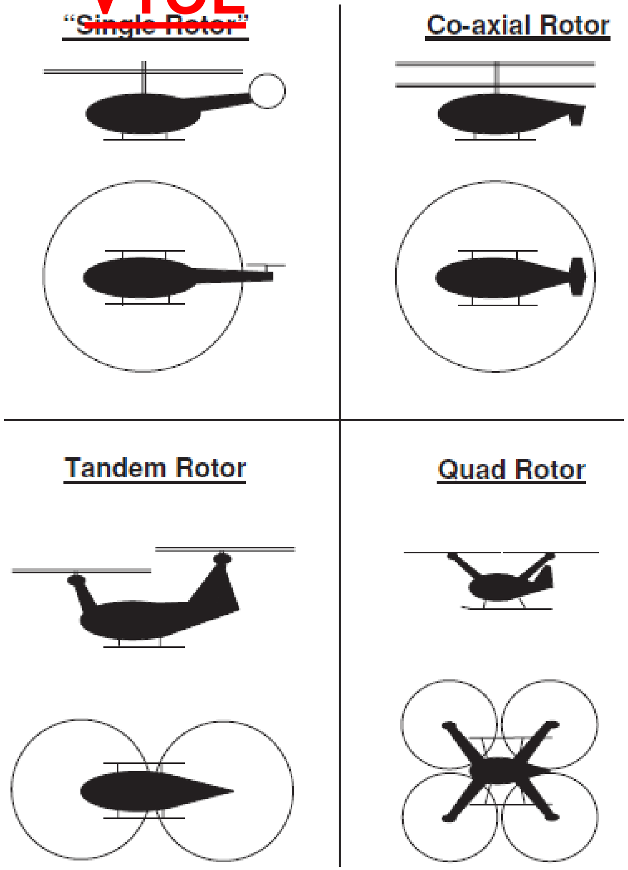
**For emergency response applications we mainly focused in Close-range UAS, Mini UAS and Micro UAS categories since are ideal for such kind of operations.**

# Categorized by airframe configuration

## Fixed wing - HTOL




## Rotor craft - VTOL



# Fixed wing (High wing)

**Advantages:**

- Provide higher lift
- Very statically stable (since fuselage i underneath) -> easy to fly for the operator
- Good for engine location

**Disadvantages:**

- More frontal area than mid-wing -> more drag
- Lower ground effect -> more drag -> required longer runway to take off

More drag means more power is required

# Fixed wing (Low wing)

**Advantages:**

- Better take-off than High wing due to ground effect
- Lower drag
- Higher lateral control

**Disadvantages:**

- Produces less lift
- Higher stall speed -> lower airworthiness
- Needs longer landing runway due to ground effect

# Fixed wing (Other)

- **Mid wing**
  - Features stand somewhere between High wing and Low wing

- **Flying wing or "tailless" and Delta wing**
  - By removing the horizontal and vertical stabilizers the overall drag is reduced
  - High induced drag (Drag due to Lift)
  - Reduced effective tail-arm (reduced directional stability)

- **Canard**
  - Horizontal stabilizer is mounted forward of the wing
  - More aerodynamic efficiency
  - Stall has much less impact
  - Directional stability is less readily achievable (no rudder)

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# Fixed wing Launch, Recovery and Retrieval Equipment

- **Launch: A runway is needed, otherwise, a ramp launcher has to be used in order to accelerate the UAS => restricted and more difficult launching**
- **Recovery: A runway is needed or a "soft" terrain is required (grass), otherwise, a parachute can be deployed or a large net is used to catch the aircraft => restricted and more difficult recovery**
- **Retrieval Equipment: unless the UAS is lightweight enough to be man-portable, a means is needed to carry the UAS back to its launcher**

# Rotor crafts (Quadcopters)

## Advantages

- Relatively cheap to manufacture -> commercial price
- Great maneuverability
- Powerful enough to add accessories
- Greater thrust and power versus tricopters

## Disadvantages

- Not as powerful as a hexacopter or octocopter
- If a motor fails the UAS will definitely crash

# Rotor crafts (Hexacopters)

## Advantages

- Greater overall power, speed and elevat
- Safety provided through additional mot
- Higher overall payload
- Great control and flight speed

## Disadvantages

- Priced higher than a quadcopter
- Larger in size, making the copter harder to fly in tight spaces
- Motor parts are more expensive if they need to be replaced

# Rotor Crafts (Octocopter)

## Advantages

- Very fast and agile
- Reach exceptionally high elevations
- Extremely powerful
- Can hold heavy payload equipment
- Very safe and stable (high degree of redundancy)

## Disadvantages

- Big in size
- Expensive compared to the hexacopter and quadcopter
- Battery life is often far less

# Rotor crafts (Other)

- **Single Rotor**
  - Most commonly used crewed rotorcraft
  - Extremely asymmetric - complication and complexity of the flight control algorithms
  - Tail rotor relatively fragile and vulnerable to striking ground objects

- **Tandem Rotor**
  - Configuration is more symmetric in control than 'single rotor' and more power efficient
  - Not structurally efficient

- **Coaxial Rotor**
  - Almost perfect aerodynamic symmetry
  - Very stable during turbulence


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# Rotor craft Launch, Recovery and Retrieval Equipment

- **Launch: can be taken off vertically -> very easy launching**
- **Recovery: can land almost anywhere ->very easy recovery**
- **Retrieval Equipment: unless the UAS is lightweight enough to be man-portable, a means is needed to carry the UAS back to its launcher**

# Fixed wing or Rotor craft?

*Fixed wing:*

- Capable of very high speeds
- Generate lift from the wings and can fly with single engine/motor -> very efficient in terms of power consumption
- Can glide due to the wings requiring minimal power
- Capable of very long endurance
- Capable of extremely long ranges
- Very safe even if the engine/motor fails it can operate an emergency landing safely
- Can carry very heavy equipment

BUT

- Requires a runway for take off and landing or a ramp accelerator
- Hard to fly requires a lot of training
- And of course it cannot hover!

# Fixed wing or Rotor craft?

*Rotor Craft:*

- Capable of VTOL -> Can be deployed from anywhere
- Can move in any direction quickly
- Can fly in very tight spaces between obstacles
- Can hover over important areas
- Much more easy to fly even a beginner can fly a multi rotor craft

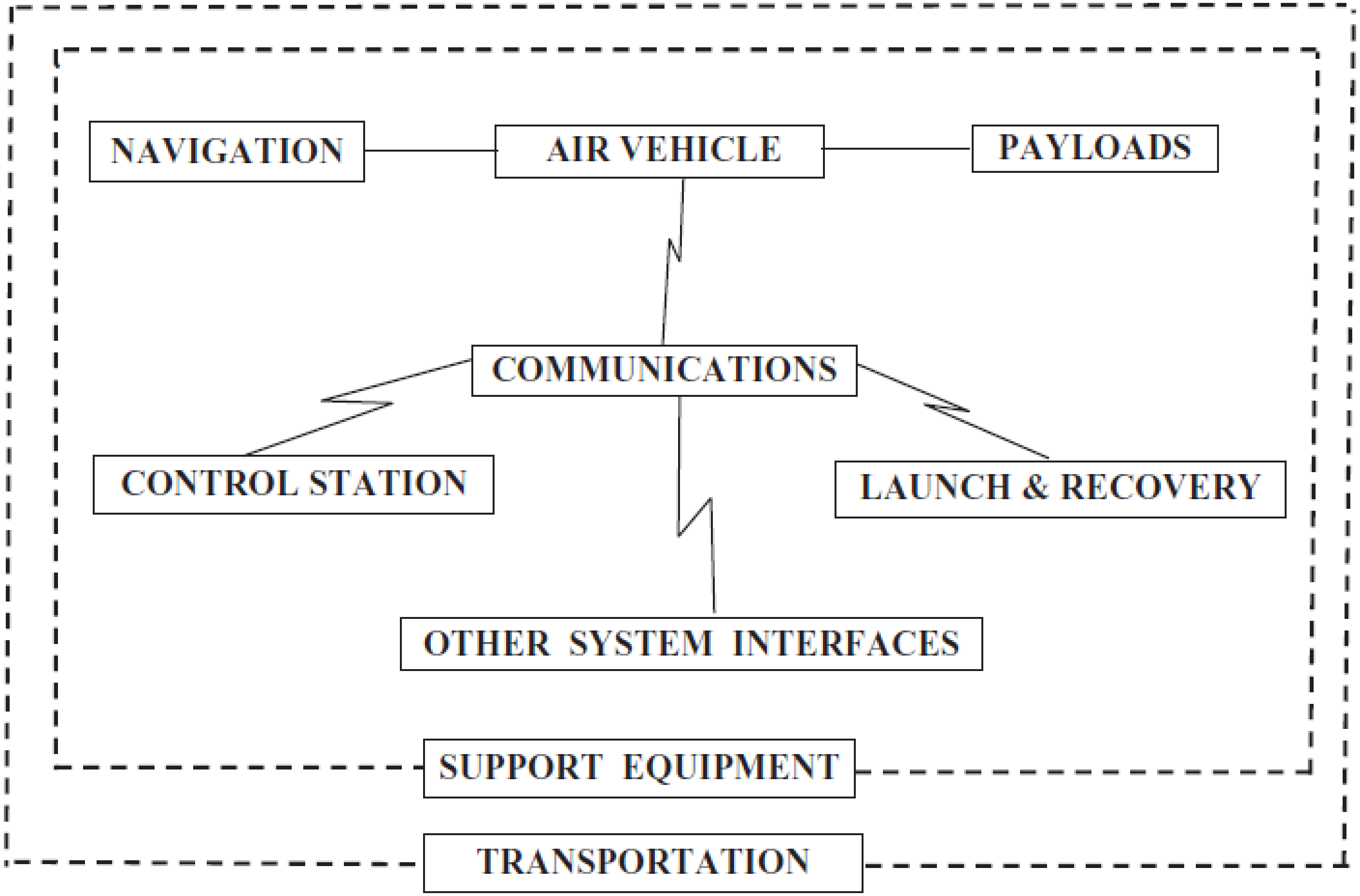
BUT

- Generate lift only from its engines/motors -> high power consuming/demanding
- Is not capable of carrying heavy payloads
- Relatively short range and endurance compared to fixed wing due to battery limitations

**SO IF HOVERING AND PRECISION IS A MUST FOR THE OPERATION THEN WE CHOOSE ROTORCRAFT BUT WE NEED TO APPRECIATE THE MUCH LOWER ENDURANCE AND RANGE**

# SYSTEM COMPOSITION

# UAS System Composition Diagram

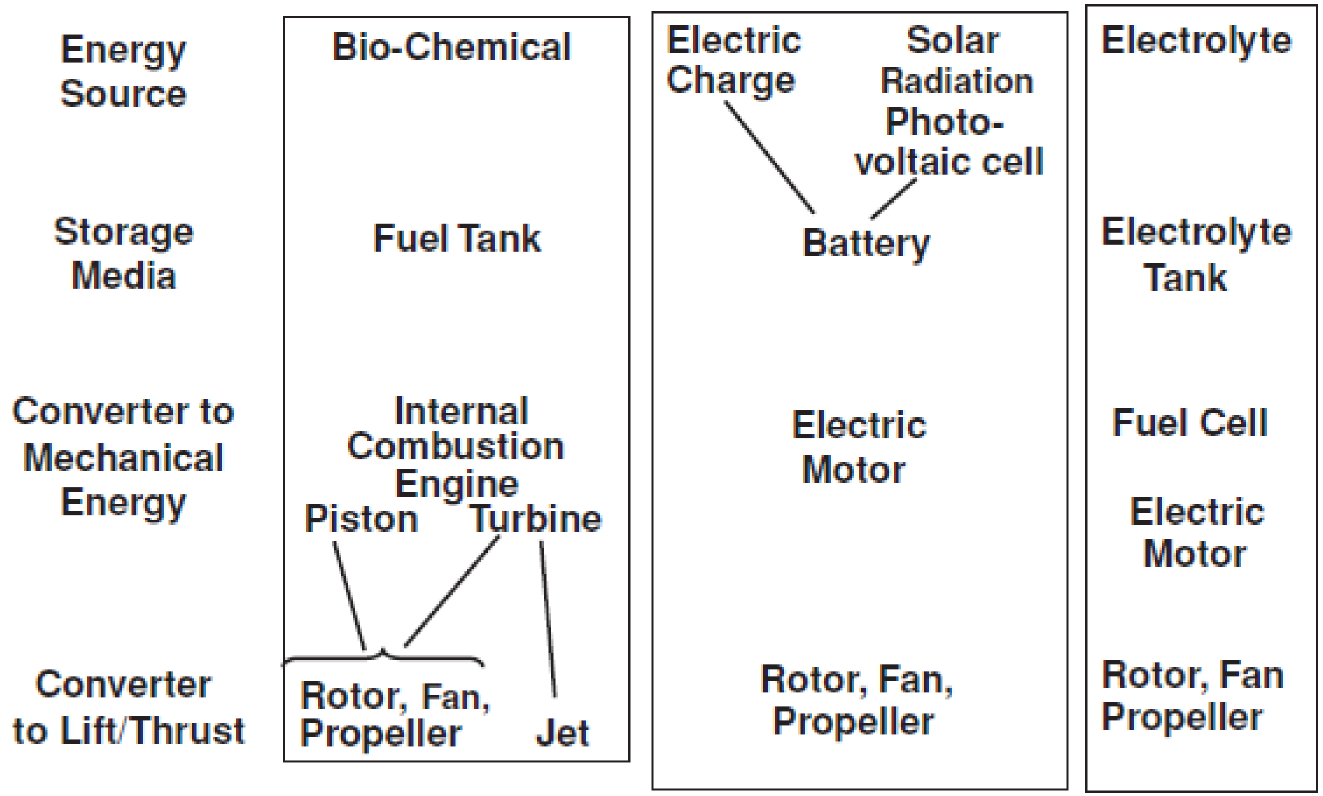


# System composition

- **Air vehicle**
  - Carries all the mission payloads to its point of application
  - Carry subsystems that are necessary for it to operate
    - Communications link
    - Stabilization and control equipment
    - Propulsion system
    - Basic airframe structure and mechanisms
    - Navigation equipment
- **Control Station**
  - The control center of the operation and the man–machine interface
- **Payloads**
  - Sensors that are attached to the UAS and provide some kind of information to the operator
- **Launch, Recovery and Retrieval Equipment**
  - Launch equipment
    - Ramp (if Vertical take off is not applicable)
  - Recovery equipment
    - Parachute (if Vertical landing is not applicable)
  - Retrieval equipment
    - Unless the aircraft is lightweight enough, a means is required to transporting the aircraft back to its launcher
- **Communications System**
  - Provide the data links (uplink and downlink) between the CS and the aircraft
- **Interfaces**
  - The sub-systems must be able to operate together to achieve the performance of the total system
- **Support Equipment**
  - Ranges from operating and maintenance manuals, through tools and spares to special test equipment and power supplies
- **Transportation**
  - Carry case or sometimes a special vehicle is required

# PROPULSION TYPES

# Propulsion diagram



# Propulsion Electric


Advantages

- Reliability
- Very easy to use, just charge the batter
- Minimal Maintenance
- Low cost in terms of battery charging a

parts (eg motors)

Disadvantages

- Depends on batteries
- Restricted flight endurance due to battery capacity
- Waterproof sealing is not that easy

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# Propulsion Piston Prop

## Advantages

- Capable of very long enduran
- Waterproof

## Disadvantages

- Requires frequent maintenance
- Relatively costly compared to electric propulsion
- Not as reliable as electric propulsion (cold weather)
- Preparation required to start the engine

# Propulsion Jet

## Advantages

- Capable of extremely high speeds
- Waterproof

## Disadvantages

- Very low endurance
- Extremely high cost in terms of maintenance, parts and operation
- Not as reliable as electric propulsion (cold weather)
- A lot of preparation is required to start the jet engine
- Very hard to operate extensive knowledge is required

# EQUIPMENT AND PAYLOADS

# Control Station or Ground Station

- Usually based on the ground or in a vehicle (Car, truck, boat etc)
- Usually is the center of which the UAV mission is pre-planned
- The operators “speak” to the aircraft via the communications system up-link to direct its flight profile and operate various types of mission payload that it carries
- Control Station usually also house communication with other external systems such as acquiring weather data, transfer information from or to other systems in the network, tasking from higher authority and the reporting of information back to that or other authorities

# Control Station or Ground Station

# Payload

The type and performance of the payloads is driven by the needs of the operational task. These can range from:

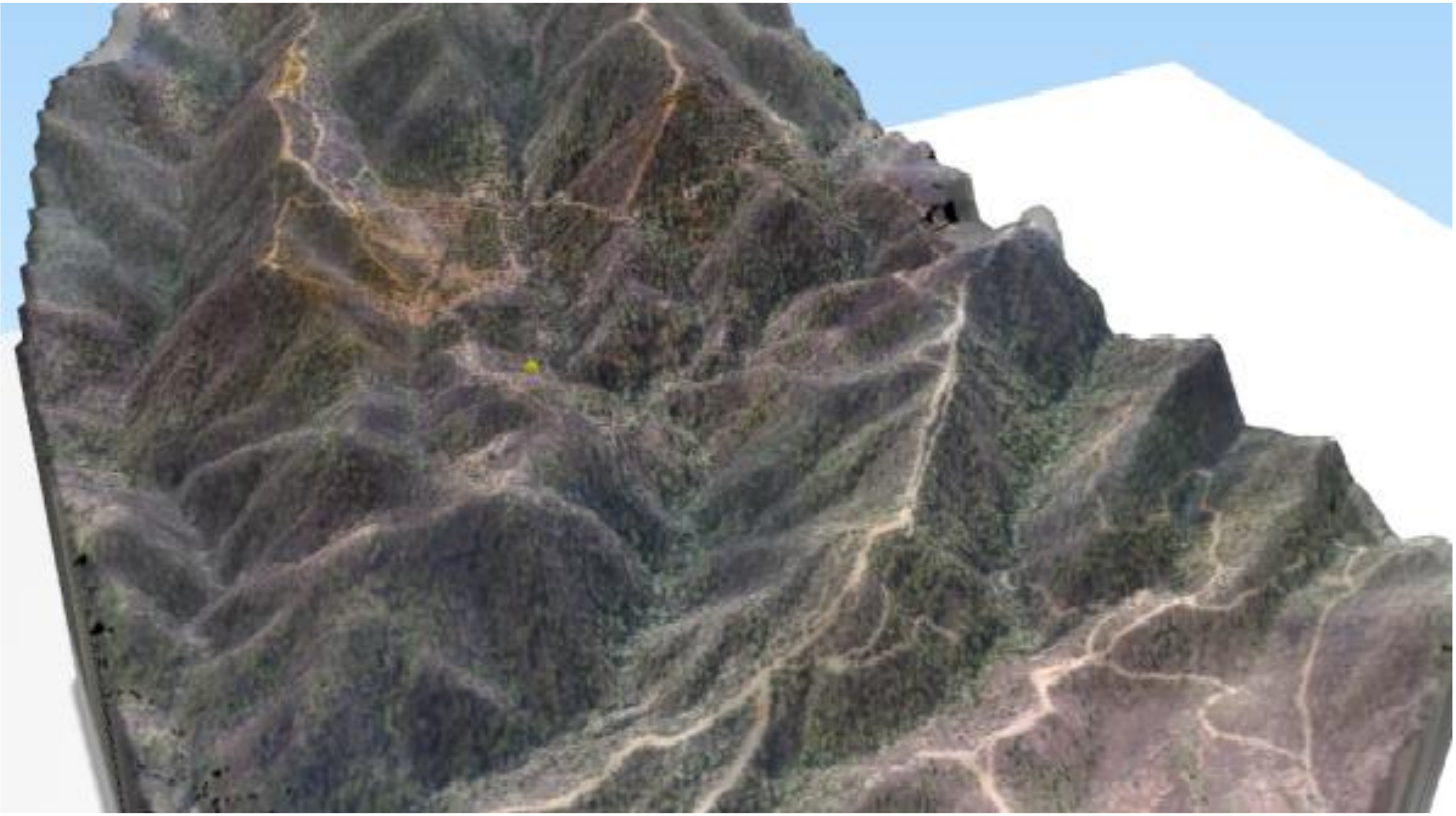
- Relatively simple sub-systems (eg. fixed video camera with a fixed lens having a mass as little as 200g)
- A video system with a greater range capability (eg. Employing a longer focal length with zoom facility, gyro-stabilised and with pan and tilt function
- More sophisticated UAS can carry a combination of different types of sensors. These can be processed and integrated to provide enhanced information (eg thermal imaging cameras, radar scanner systems etc)

# Electro-optic Payload Systems

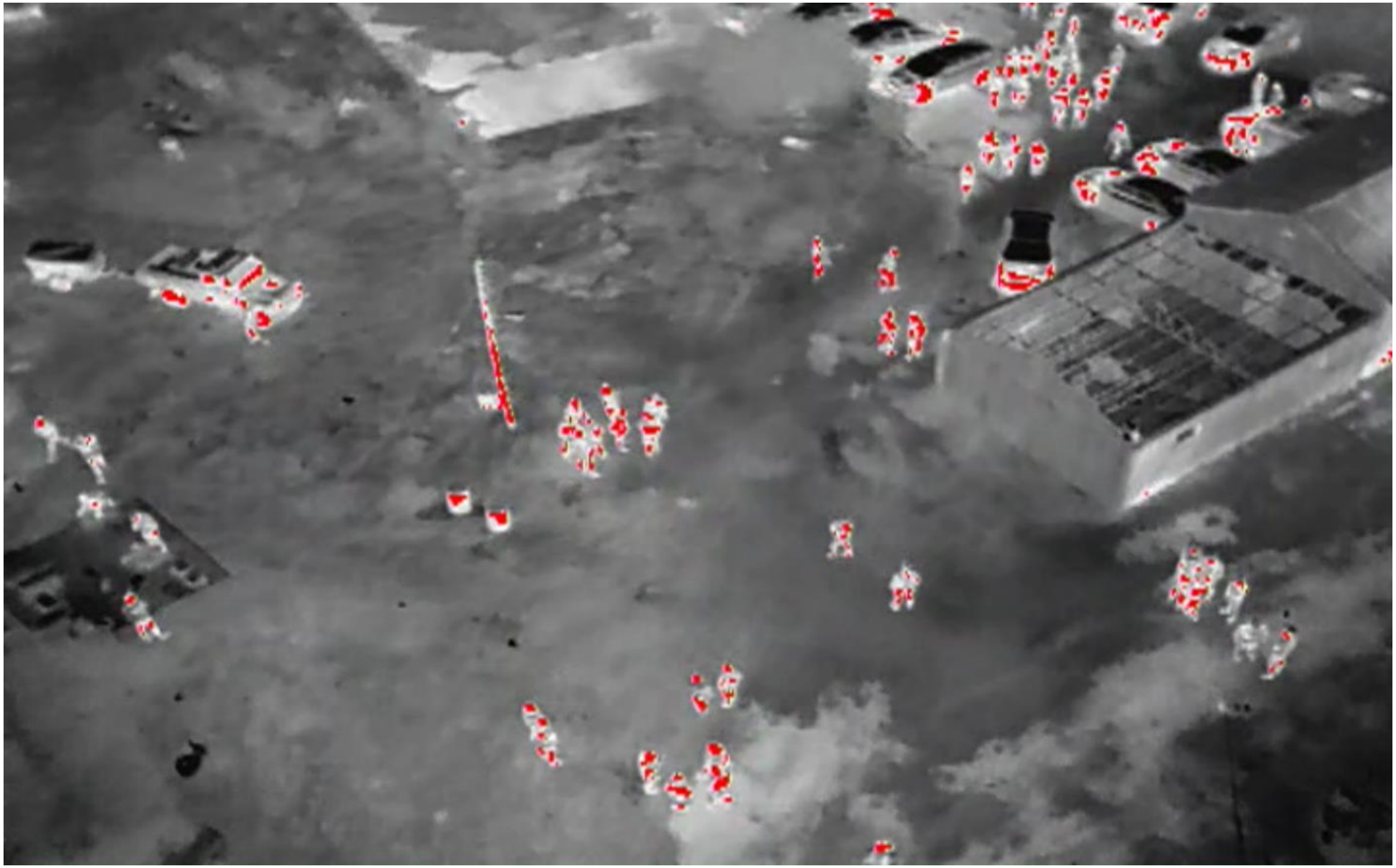
- **‘Optical’ or ‘visible light’ cameras**
  - Can only ‘see’ as long as there is external light in the field of view. The effectiveness is restricted or eliminated in partial/total darkness, smoke, rain, humidity conditions etc)
- **Low light cameras**
  - Function in the same manner as normal cameras but can operate effectively at as much as 1/10$^{th}$ of the light necessary for the normal cameras
- **Thermal Imagers**
  - Use the infra-red spectrum and can operate in total darkness, smoke, rain, humidity with high rate of success. Use non-visible waves and can see the heat emitted by each body without the requirement of light

# Optical camera -Monitoring rescue scenario in Lailapa exercise 2016

# Optical Camera - 3D topographic map of Lefkara mountains



# Thermal Camera



# Normal Camera vs Thermal Camera


# Camera Specifications

## Resolution

- The higher the resolution of a camera is -> the higher the quality of the image/video will be -> more data/detail is captured -> the higher the probability is to identify or recognize something

## BUT

- The more data we need to process the longer the hardware needs to do the job and more time is required for the signal to down-link to the control station -> as the UAS is farther, the higher resolution video will require more time to reach the control station leading to a lag in reception

## Lenses

- Lenses indicating the horizontal and vertical angles of the field of view of the camera

# Camera mounting

- Cameras can be fixed in position without the ability to move (cheap and bad configuration, vulnerable to any disturbance as well as restricted to UAS orientation)
- Cameras can be mounted in a gimbal for stabilization purposes. The gimbal uses gyroscopes and accelerometers to resist in any external disturbance as well as to UAS movements and keeps the camera extremely stabilized.
- Cameras can be mounted in more sophisticated gimbals that allow pan and tilt controlled movements and can be controlled by the operator

# Combination of Thermal Imager and Normal Camera



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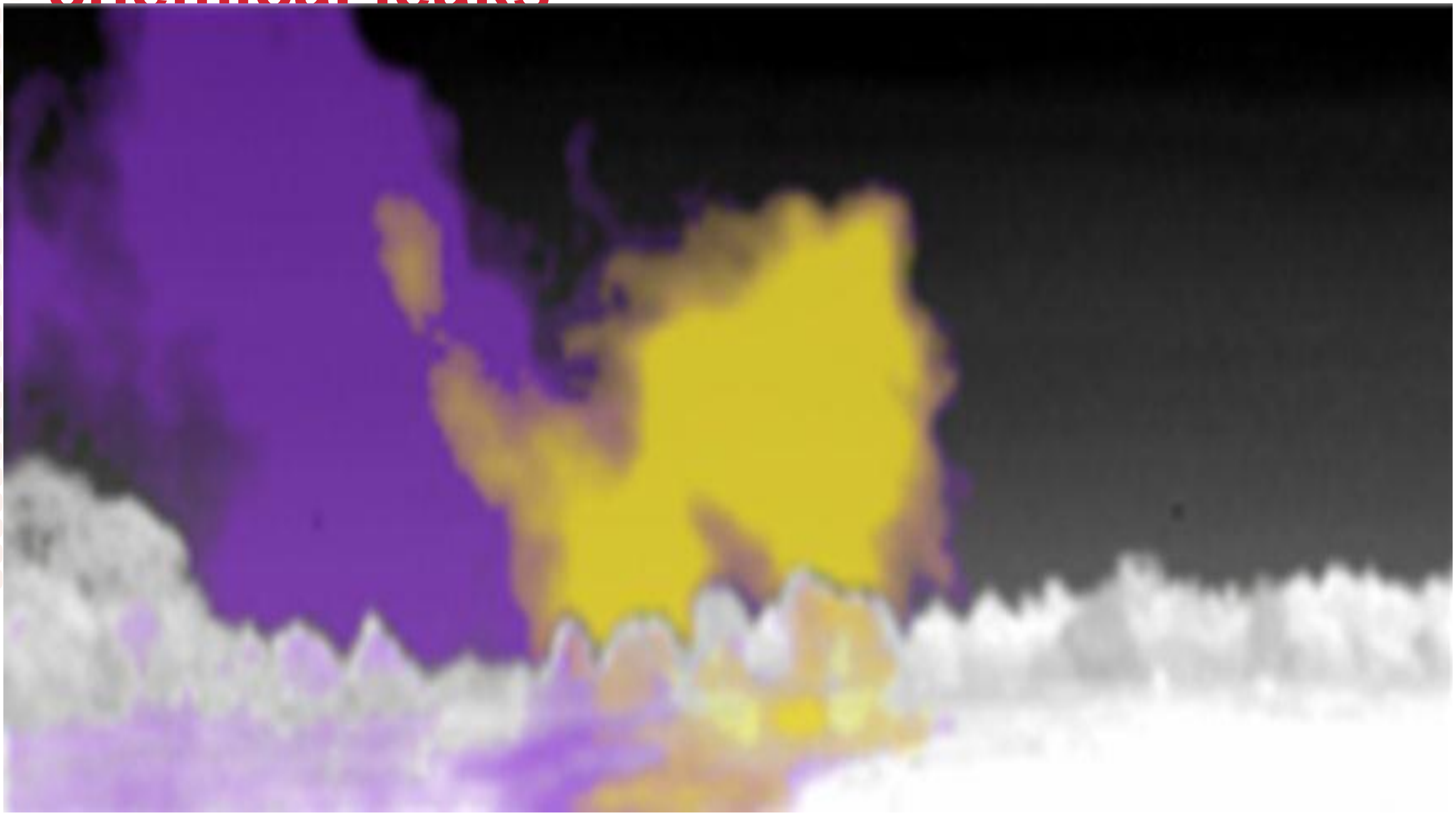
# Mapping Payloads

- **Hyper Multi Spectral imagers**
  - Could be used to identify chemical leaks/spillage or other dangerous substances
- **LiDAR (Light Detection And Ranging)**
  - Could be used to create high detail topographical maps or 3-D maps of urban areas (eg highly precise flood maps)
- **SAR (Synthetic Aperture Radar)**
  - Provides detailed imagery of the ground day or night through cloud, fog, and smoke. SAR can detect metal objects or changes that can help mitigate disasters in their early stages (eg monitor a swelling river before it floods or monitor a slow but steadily advancing landslide)

# Hyper Multi Spectral – Illustration of chemical leaks



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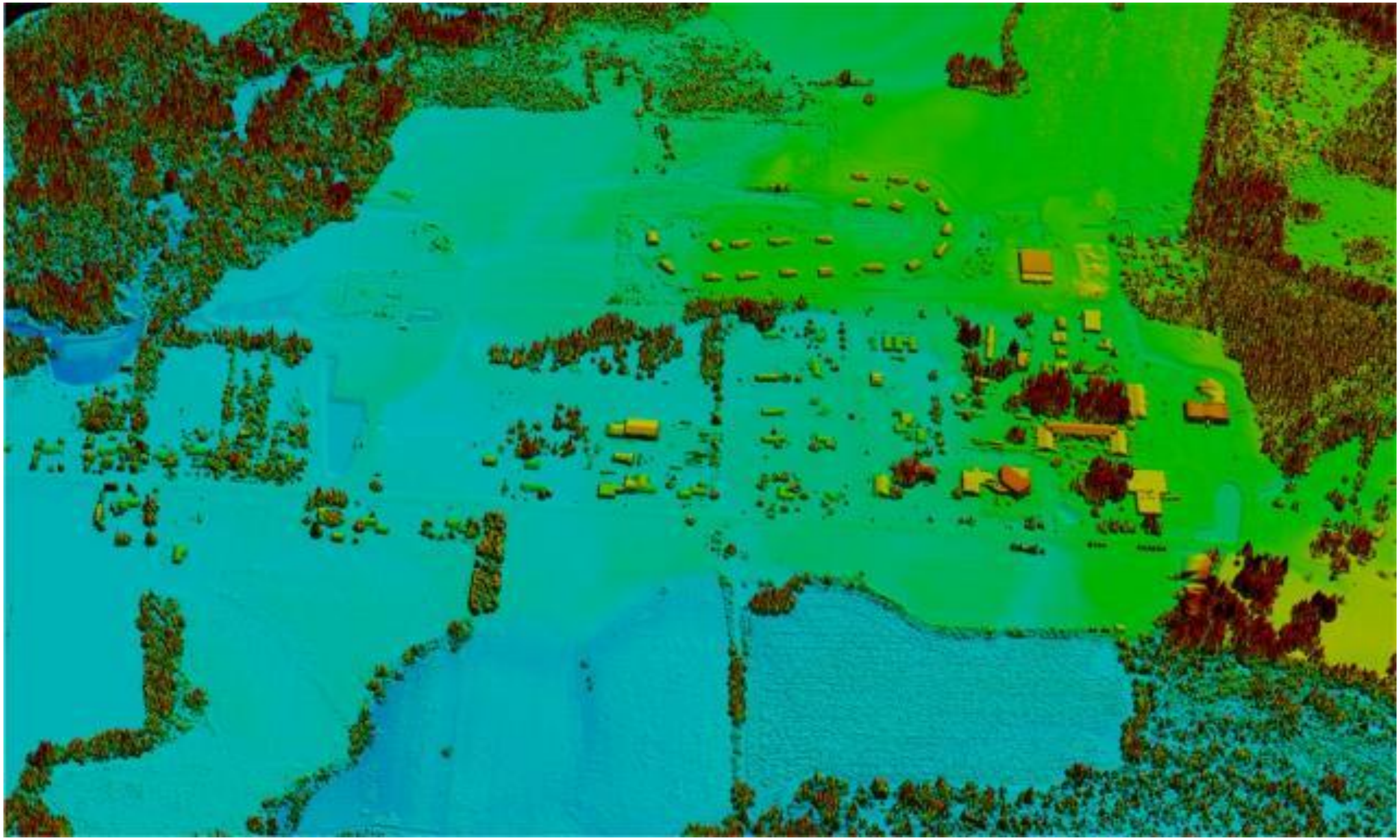
# LiDAR - 3D Mapping of flooded area



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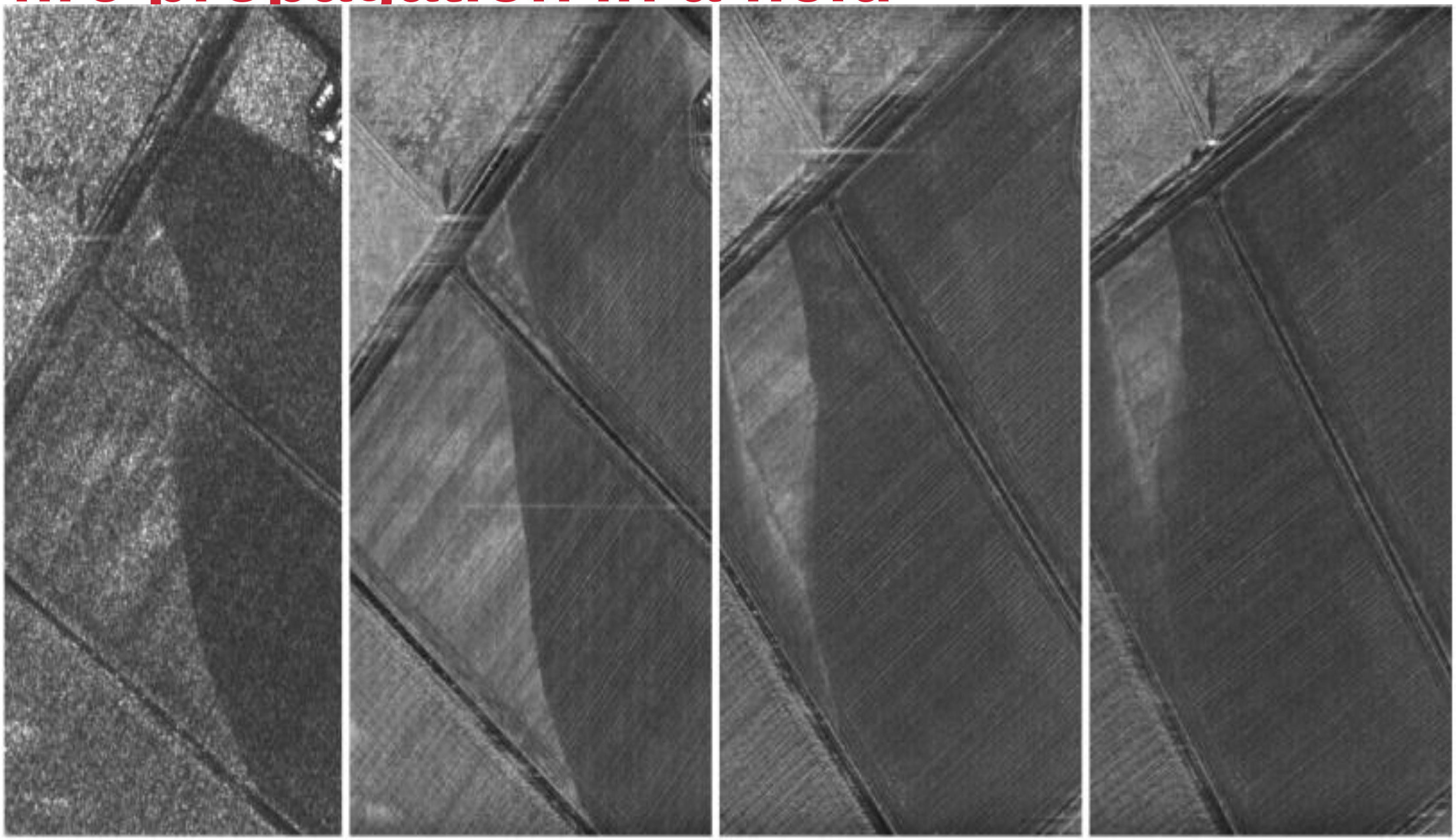
# Synthetic Aperture Radar - Illustrates fire propagation in a field



# Communication Payloads

- **FM repeater**
  - Emergency radio stations could be broadcast through a drone
- **Cell phone tower**
  - Drones can act as a cellular tower in the sky to quickly reestablish cellular signal over an area that has experienced cellular infrastructure damage.
- **Wireless ground sensors**
  - Could be a mobile data link to capture information from ground sensors and transmit it back to the command center. Ground sensors can be used to monitor water flow, water depth, motion detection for security, and the movement of earth in a landslide situation, amongst other applications.

# Other Payload

- **Pollution monitoring**
  - Device that take air samples and gives information about nuclear, toxic or any kind of chemicals existed in the area
- **Public address system**
  - A loudspeaker and a camera can be integrated in the UAS
- **Radio relay system**
  - A UAS positioned in an appropriate altitude, carrying a payload of radio receiver, amplifier and transmitter can significantly increase the range of radio communication
- **Electronic intelligence**
  - A UAS carrying a radio receiver capable of frequency scanning can intercept radio transmissions for intelligence purposes or any cell phone signal for possible missing person
- **Magnetic anomaly detection**
  - A UAS can use such an equipment for various purposes including the location of, for example, sunken wrecks at sea

# Other Payload

- **Collision avoidance systems**
  - Can be carried for autonomous purposes in order to avoid obstacles such as trees buildings etc
- **Light equipment**
  - Lights can be used to send signals (Mors) or even alert attention of people for a specific purpose
- **Smartphones**
  - Smartphones have extreme capabilities and can be used as a payload in a UAS to send messages to people underneath
- **Dispensable payloads**
  - UAS can be used to carry and drop payloads such as life-rafts, first aid kits etc
- **Laser pointer**
  - Could be used to direct first responders to a specific location
- **Sniffers**
  - Can be used to assess air quality to identify high concentrations of chemicals

# COMMUNICATIONS

# Communication

**Communication between UAS and Control Station is divided in two categories up-link and down-link. The tasks of the data links are usually as follows:**

1. **Uplink (from the CS to the aircraft):**
    - Transmit flight path tasking which is then stored in the aircraft automatic flight control system
    - Transmit real-time flight control commands to the AFCS when man-in-the-loop flight is needed
    - Transmit control commands to the aircraft-mounted payloads and equipment
    - Transmit updated positional information to the aircraft
2. **Downlink (from the aircraft to the CS):**
    - Transmit aircraft positional data to the Control Station
    - Transmit payload imagery and/or data to the Control Station
    - Transmit aircraft housekeeping data, e.g. battery voltage to the Control Station

# Communication

**The communication between the GCS and aircraft and between the aircraft and GCS may be achieved by three different media:**

- **By Laser (not used anymore)**
  - Limited range
  - Unreliable
- **By Fibre-Optics**
  - High security
  - Low Range
  - Military
  - Very limited and restricted
- **By Radio**
  - Ultimate Range
  - Widely used
  - Can be encrypted

# Radio Frequencies

| Band Name (Frequency) | Abbr. | ITU Band | Frequency | Wave Length | Typical Uses |
|---|---|---|---|---|---|
| Extremely Low | ELF | 1 | 3-30Hz | 100,000km-10,000km | Submarine Communications |
| Super Low | SLF | 2 | 30-300Hz | 10000 - 1000km | Submarine Communications |
| Ultra Low | ULF | 3 | 300-3000Hz | 1000 -100km | Comm. in mines |
| Very Low | VLF | 4 | 3-30kHz | 100-10km | Heart Monitors |
| Low | LF | 5 | 30-300kHz | 10km-1km | AM Broadcast |
| Medium | MF | 6 | 300-3000kHz | 1km-100m | AM Broadcast |
| High | HF | 7 | 3-30MHz | 100m -10m | Amateur Radio |
| Very High | VHF | 8 | 30-300MHz | 10m-1m | TV Broadcast |
| Ultra High | UHF | 9 | 300-3000MHz | 1m-100mm | TV, phones, air to air comm. 2-way radios |
| Super High | SHF | 10 | 3-30GHz * | 100-10mm | Radars, LAN * |
| Extremely High | EHF | 11 | 30-300GHz * | 10mm-1mm | Astronomy * |

* Note that these are microwave frequencies and are also used in domestic devices

# Radio Frequencies

| IEEE | | EU, NATO, US ECM. | |
|---|---|---|---|
| BAND | FREQUENCY RANGE | BAND | FREQUENCY RANGE |
| HF | 3 to 30MHz | A | 0 to 0.25GHz |
| VHF | 30 to 3MHz | B | 0.25 to 0.5GHZ |
| UHF | 0.3 to 1.0GHz | C | 0.5 to 1.0GHz |
| L | 1 to 2GHz | D | 1 to 2GHz |
| S | 2 to 4GHz | E | 2 to 3GHz |
| C | 4 to 8GHz | F | 3 to 4GHz |
| X | 8 to 12GHz | G | 4 to 6GHz |
| $K_U$ | 12 to 18GHz | H | 6 to 8GHz |
| K | 18 to 26GHz | I | 8 to 10GHz |
| $K_A$ | 26 to 40GHz | J | 10 to 20GHz |
| V | 40 to 75GHz | K | 20 to 40GHz |
| W | 75 to 111GHz | L | 40 to 60GHz |
| | | M | 60 to 100GHz |

# Radio Frequencies

## Lower Frequencies (Beyond Line of Sight)

- Higher penetration through obstacles (trees, buildings, hills etc)
- Requires large antennas
- Quality of the signal is not as good as higher frequencies (for video)

## Higher Frequencies (Line of Sight)

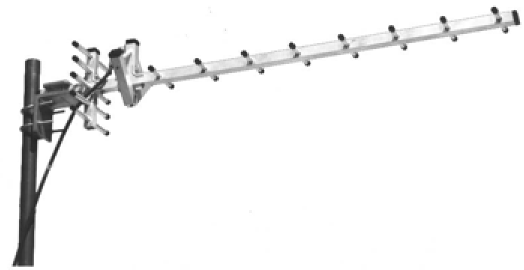
- Lower penetration through obstacles (requires Line of Sight)
- Large antennas are not required (portability)
- Quality of the signal is better (for video)

# Radio Frequencies

- **UAS control**
  - Most common frequencies
    - 2.4GHz (Most widely used)
    - 5.8Ghz
    - Other frequencies can be used but are not very common
- **Video link**
  - Most common frequencies
    - 900MHz
    - 1.2GHz & 1.3GHz
    - 2.3GHz & 2.4GHz
    - 5.8GHz
  - Analog or Digital Signal

# Antennas Specifications

- **Directional**
  - High gain antennas
  - Can receive or send signals only in very narrow/strict direction
  - Can achieve very high distance communication



- **Omni-directional**
  - Low gain antennas
  - Can receive or send signals in all directions
  - Cannot achieve very high distances

- **A combination of two**
  - A diversity receiver is used to operate bet directional and omni-directional simultaneous depending on which antenna has the better signal reception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# Radar Tracker

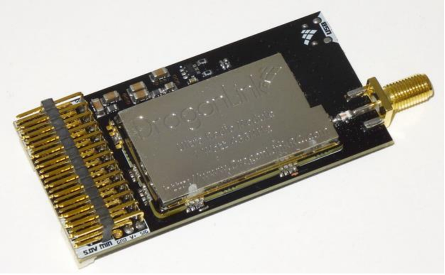
Radar trackers can be used to automatically direct directional antennas to the position of the UAS and track it. This ensures minimum possibility for loss of communications

# Transmitter power rating

**Higher transmitter power can increase range but is more power consuming**

- **UAS controls**
  - 2.4GHz amplifier can be added to the transmitter to increase range


- **Video link**
  - 250mW
  - 600mW
  - 1200mW



**Usually 600mW is more than enough and by choosing the appropriate antennas it can give ranges of up to 20Km with 5.8GHz video transmitter!**

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# Important aspects for radio frequency

- Video link communications and UAS control communication MUST operate at DIFFERENT frequencies (avoid interference)
- NEVER turn the transmitter on without an antenna attached to it (the transmitter can be burned)
- ALWAYS turn the UAS on AFTER the transmitter and turn the UAS off BEFORE the transmitter (avoid interference to the UAS communications between other external signals)

# Video link

- **Analogue**
  - Relatively average quality (not high definition)
  - No lag to the video output
  - Extreme range
- **Digital**
  - Relatively new technology
  - Capable of ultra high definition quality
  - A small lag exists as the range increases
  - Average range

# First Person View (FPV)

- **Single display**
  - Smartphone
  - Tablet
  - Monitor

- **Multi display**
  - Monitors indicating different information eg. thermal and normal cameras

- **FPV glasses**

# Integration

**Together with the video link, integrated data can be superimposed in the video down link. These can include flight data, battery capacitance, navigation data etc**


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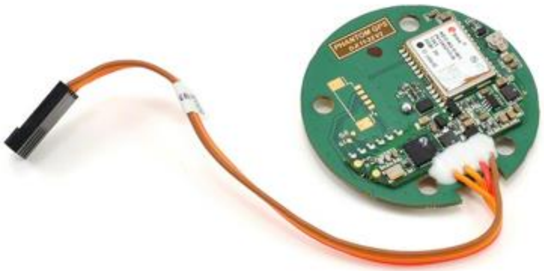
# NAVIGATION

# Navigation

It is necessary for the operator to know where the aircraft is at all times. It is also necessary for the UAS on itself to know its position for autonomous purposes:

- In case of a pre-programmed mission partially/fully
- In case of an emergency (return to home

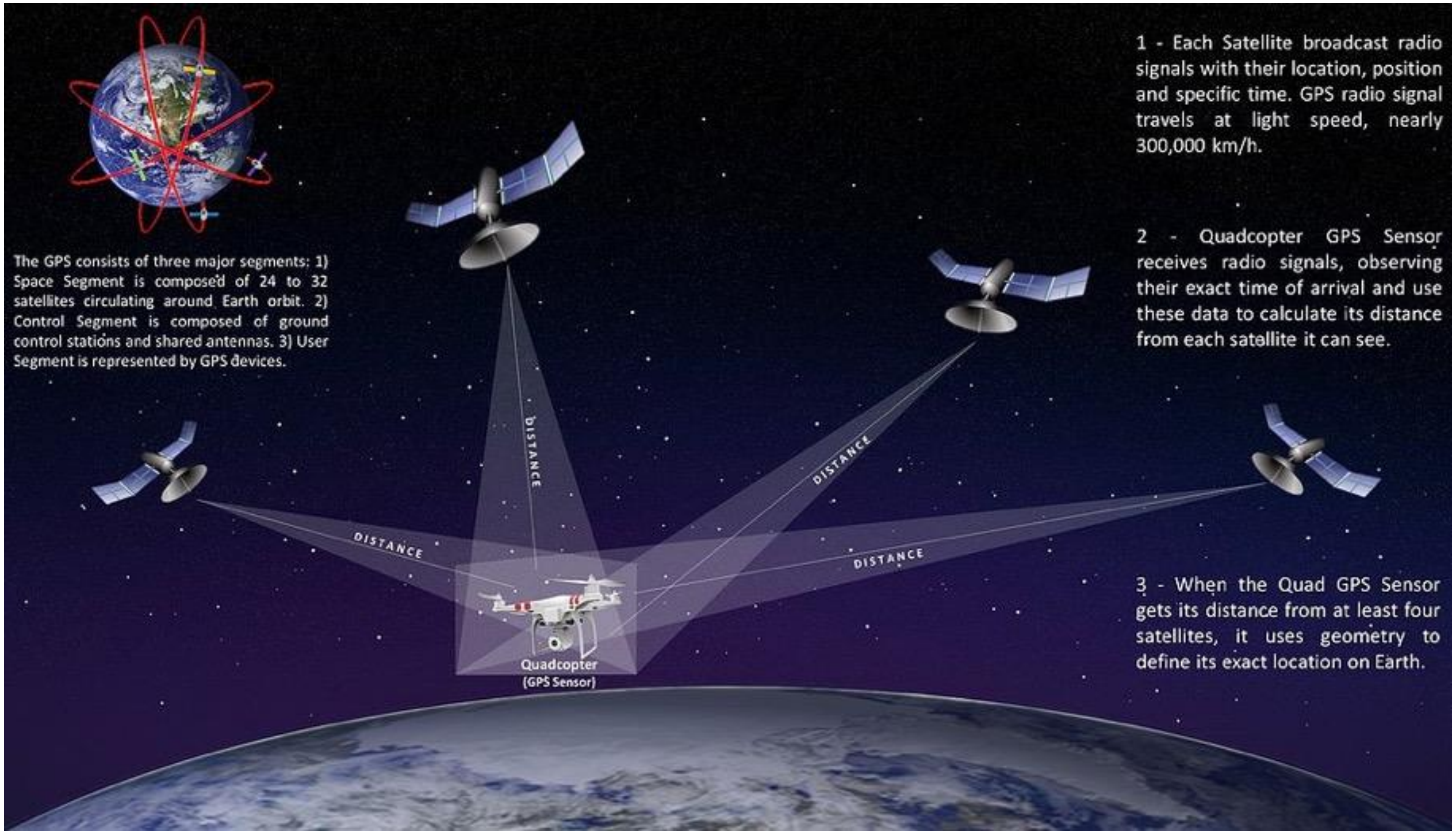



This is achieved by the well-known Global Positioning System or GPS which access positional information from geo-stationary satellites

# Global Positioning System (GPS)

- Requires at least 4 satellites to determine the 3-Dimensional position of the UAS in space
- GPS is integrated with Inertial Measurement Unit (IMU) and compass to provide high level of precision and stabilization
- GPS may have several meters accuracy offset
- Environmental conditions can affect the performance of detecting satellites (eg clouds, rain, solar storm etc)

# Global Positioning System (GPS)



# Navigation

Other methods of navigation include:

- Radar tracking (UAS has a transponder which responds to a radar scanner emitting from the Control Station)
- Radio tracking (the radio signal carrying data from the aircraft to the Control Station is tracked in bearing from the station and the range is determined from the time taken for the signal to travel from UAS to station)
- Direct reckoning (its position can be confirmed by relating visible geographical features with their known position on a map)

# Flight planning

- **Waypoints**
  - Unique points on the map that have their unique longitude and latitude coordinates
- **Pre programmed flight planning**
  - The operator can upload to the UAS a pre programmed flight path in an area of interest by adding waypoints, velocity requirements, holding time over waypoints etc
  - The operator can make any changes in the flight plan during the operation
- **Real time flight planning**
  - The operator can upload waypoints as the UAS is in operation

# Flight planning

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# EXTERNAL CONDITIONS

# External uncontrolled conditions

- **Extreme Cold conditions:**
  - Gyroscopes and accelerometers are affected and can misbehave this applies to gimbals also as they have gyroscopes and accelerometers
  - Batteries performance is decreased (battery voltage decreases quicker) -> shorter flight times
  - Some materials may become brittle (rotorcraft legs or structure links)
  - Air breathable engines may fail to start

**BUT**

  - Cold weather has denser air -> at a fixed RPM the blades of the propeller will produce more lift -> less power consumption -> more flight time/endurance

# External uncontrolled conditions

- **Extreme hot conditions:**
  - Engines or actuators/servos may lose power
  - Electronic components may fail
  - Air is less denser -> at a fixed RPM the blades of the propeller will produce less lift -> more power consumption -> less flight time/endurance
- **Rain and extreme humidity**
  - Can lead to electronic failure
  - Decreases visibility of optical color cameras
- **External frequencies or other communication signals**
  - Can cause interference to the communications (up-link or down-link) which can lead to loss of communications even to catastrophic results
  - Can cause interference to UAS compass or navigation instrument

# CIVIL PROTECTION

# Civil Protection

UAS can have two main roles for Civil Protection:

- First responders or helper UAS
- Informer/Observer UAS

# Helper UAS

Can ship useful payloads depending on the situation:

- Life vest with illumination
- Defibrillator
- General first-aid kit
- Thermal blanket
- Water and food
- Headlight
- A combination of the above depending on the evaluation of the situation (eg a package of 5 thermal blankets and a defib, a thermal blanket food and water)


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# Informer/Observer UAS

- Can monitor the process of an operation (eg first responders progress)
- Can be used to evaluate the situation (eg give information about the volume of the disaster, to monitor how a fire is propagating)
- Can work autonomous to detect something (eg, missing person, colapsed buildings)
- Can provide disaster responders with bird’s eye view of the damage, helping them prioritize their search and rescue efforts

# Informer/Observer UAS


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# Overall Needs - Civil Protection

- Need better situational awareness to allow responders to focus on the tasks that needed attention immediately
- Need the ability to have unique viewing angles for events that are not possible from manned aircraft
- Need quick and highly deployable equipment
- Need to increase operational effectiveness while at the same time decrease operational costs and operational response time

# Needs Examples - Civil Protection

1. **Reconnaissance and Mapping**
   - Need high-resolution visual imaging to help first responders flag critical infrastructure that require securing immediately after a disaster
   - Need high situational awareness of flooded areas or rising waters
2. **Structural Integrity Assessment**
   - Need to gain access to areas too dangerous for risk engineers
   - Need to detect deformations, shifts, and cracks in transportation infrastructure immediately after a disaster
   - Need to detect possible flammable gas leakages to prevent explosions
3. **Temporary Infrastructure / Supply Delivery**
   - Need to serve as temporary airborne warning and control system platforms (send Wi-Fi and cell phone coverage) when required
   - Need to deliver quickly small equipment or supplies (first aid kits, food or water etc)

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# Needs Examples - Civil Protection

4. **Wildfire Detection and Extinguishing**
   - Need to monitor wildfires intensity and directionality
   - Need superior situational awareness at all times during day and night or in low visibility conditions (eg firefighters avoid becoming trapped by enclosing flames or other dangers)
5. **Chemical, Biological, Radiological, Nuclear, or Explosive (CBRNE) Events**
   - Need to reduce human exposure to unsafe environments while providing continuous monitoring and data validation in the most extreme conditions
   - Need to quickly and safely locate sources of contamination/danger
6. **Search and Rescue Operations**
   - Need to provide situational awareness to the rescue command center via real time video link
   - Need to deploy aerial search & rescue quickly
   - Need to eliminate air-crew fatigue (manned aircraft), decreasing their effectiveness in searching and increasing the likelihood of pilot error

# UAS performance capability assessment for Civil Protection

| Capabilities | Necessity | Minimum Requirements |
|---|---|---|
| Air speed | Average | At least 25 Km/h |
| Altitude | Average | At least 100 meter |
| Degree of Autonomous | High | N/A |
| Deployment | High | Easy and Quick |
| Durability & Weatherproofing | Average to High | Medium Winds & Light Rain |
| Endurance | High | At least 25 minutes |
| Hover | Very High | N/A |
| Maneuverability | Low | N/A |
| Operational Range | High | At least 2Km |
| Payload/Carrying Capability | High | At least 0.5-1Kg |

# UAS payload capability assessment for Civil Protection

| Capabilities | Necessity |
|---|---|
| Dispensable Payload | High |
| Gimbal/Camera Stabilization | Very High |
| Light Equipment | Average |
| Low Light Camera | Average |
| Microphone | Average |
| Optical Camera | Very High |
| Pollution Detector | Average |
| Public Address System | Average |
| Radio Relay System | Average |
| Thermal Camera | Very High |

# Thank you very much!

# Any Questions?

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