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Intelligent Systems &
Robotics Laboratory

UAS FOR FIRE MANAGEMENT: STATE-OF-THE-ART, EARLY WARNING AND TRENDS

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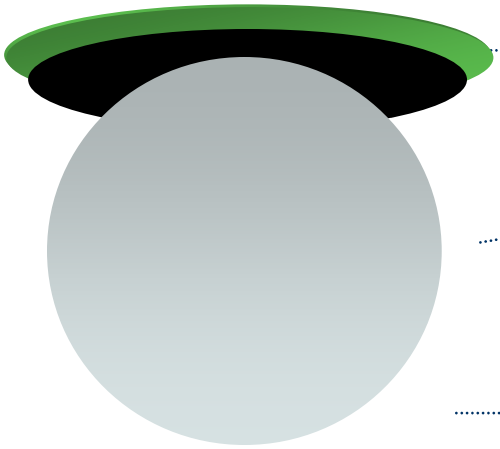
Presentation Outline



- Problem Statement
- Industrial Products
- Academic Research
- Nearhos UAS
  A UAV based automated airborne surveillance system
- Conclusions

Problem Statement

- Forest fires: constant threat to ecological systems, infrastructure and human lives
- Prognoses: half forests by the year 2030
- Annual vegetation destruction by fires
  - Europe: up to 10.000 km^2
  - Russia and North America: up to 100.000 km^2
- 20% of CO_2 emissions into the atmosphere are caused by fires
- Once fire fighters on the scene, the first important task is reconnaissance
  - Data collection and orientation
  - Define tasks associated with the saving of lives and the extinguishing of fire
  - Safe implementation
- Problems associated with the reconnaissance of forest fires
  - Fire covers such a large area that reconnaissance requires touring around the entire affected area
  - Perimeter monitoring hindered by natural conditions, terrain topology and vegetation
  - Circumambulating an area with a radius of 300m involves a distance of almost 2km
  - If commander of fire-fighting operations is at the scene, he is too close to be able to manage the environment. Need for many commanders to view various areas (subjective assessment)
  - The extinction of forest fires is a protracted process in time, immediate area reconnaissance needed

Fire Management

- Air reconnaissance
  - Offers an overview of several thousand hectares of forest
  - Allows intervention measures to be co-ordinated
  - Objectivity in ranking the individual sites in relation to the others
  - Elimination of terrain topology effects that hinder visual access
  - Benefits to smaller fires too
  - Relatively low cost if visual inspection by staff is replaced by acquisition of image data
- Unmanned aircraft vs Manned aircraft
  - High altitude, above and out of the path of air-tankers and helicopters
  - Almost real-time broadcasting of high quality infrared images
  - Continuous operation (refueling after 10 hours of work)
  - Operation at night while other firefighting aircraft are grounded
  - Low cost
  - Ground teleoperation or autonomous operation
  - Great payload capabilities (various systems can be placed onboard)

Unmanned Aircraft Systems (UAS) for Fire Management

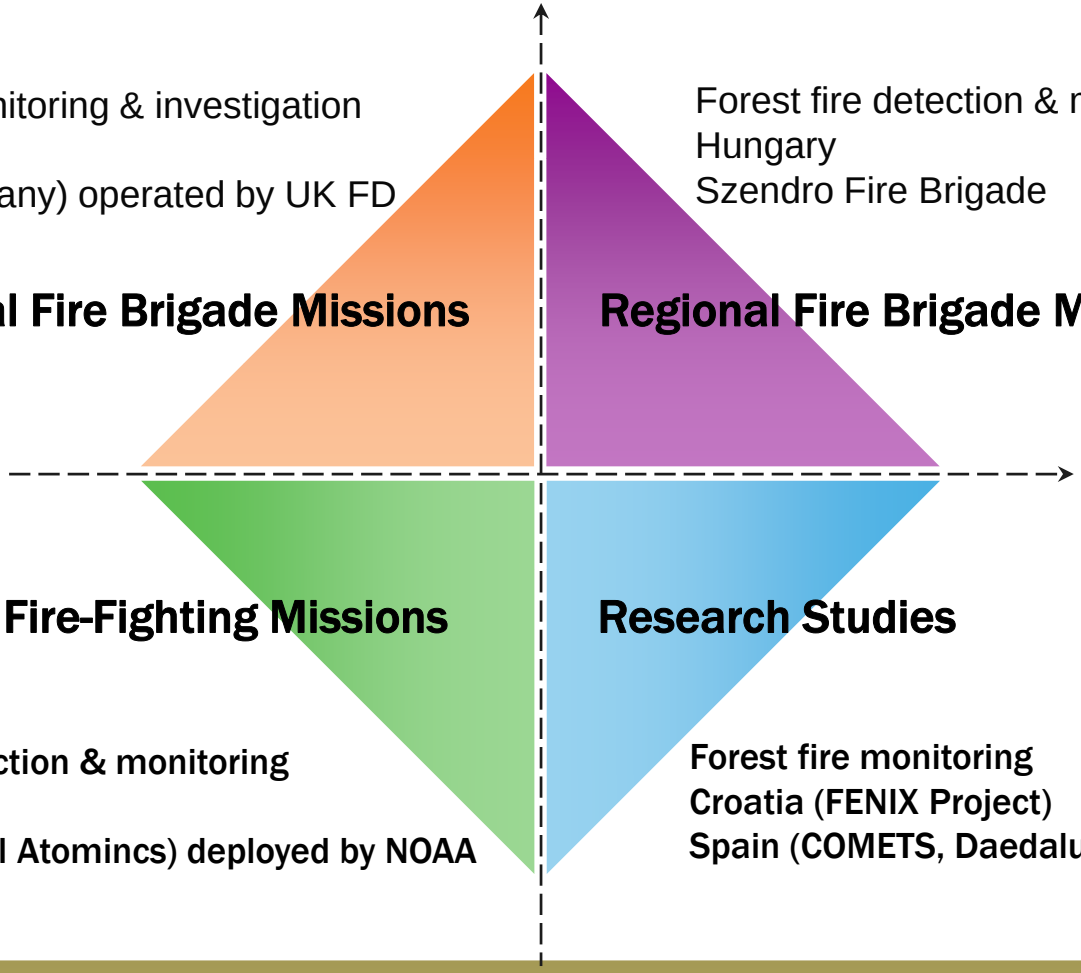
Development

- ✓ Industries (General Atomics, EADS etc)
- ✓ Federal Organizations (NASA, NOAA etc)
- ✓ Academia (Universities, Research Institutes etc)

Types

- ✓ High-altitude, long endurance (HALE)
  - ✓ High payload
  - ✓ Precision instruments, accurate detection
  - ✓ Increased cost
- ✓ Low-altitude, short endurance (LASE)
  - ✓ Low operating and manufacturing cost
  - ✓ Relatively simple launch and recovery
  - ✓ Limited sensor range

Current Applications



Fire-related monitoring & investigation
UK
AirRobot (Germany) operated by UK FD

Municipal Fire Brigade Missions

Forest fire detection & monitoring
Hungary
Szendro Fire Brigade

Regional Fire Brigade Missions

National Fire-Fighting Missions

Forest fire detection & monitoring
USA
Ikhana (General Atomincs) deployed by NOAA

Research Studies

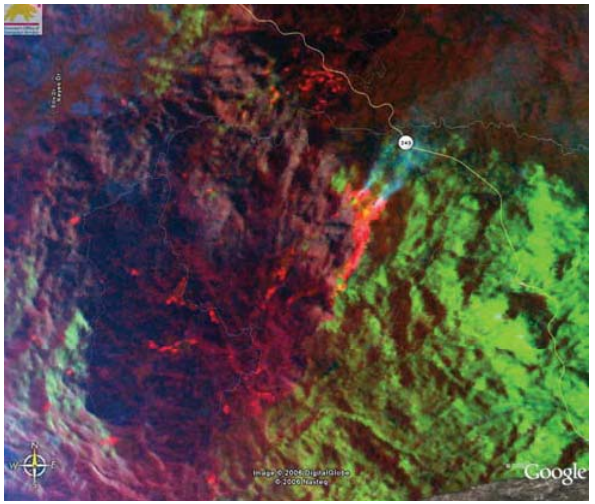
Forest fire monitoring
Croatia (FENIX Project)
Spain (COMETS, Daedalus, Horus, Sky-Eye Projects)

UVS International, November 2007

Altair UAS

- High-altitude long-endurance UAS
- Altitude up to 13-15km
- Endurance up to 20 hours with at least 300kg payload
- Parts
  - Autonomous aircraft (26m wingspan, 11m fuselage length) based on Predator B
  - Redundant control systems
  - High-speed satellite and radio communication
  - Ground based pilots and sensor operators
- Project development partners
  - US National Oceanic and Atmospheric Administration (NOAA)
  - General Atomics Aeronautical System
  - NASA
- Development: 2003-2004
- Test flights: 2005-2006
- First mission: October 2006 (Esperanza Fire)

Altair UAS on duty



- Esperanza fire (Riverside County, USA)
  - 34 homes destroyed
  - More than 40.0000 acres burned
  - 5 USFS firefighters dead
- Altair Operation
  - 43.000 feet altitude
  - 16-hour flight (day and night)
  - Delivered real-time thermal infrared data to incident commanders via satellite communications link
  - Derived thermal imagery data overnight, helped to plan efforts for the next day

Aerovision Fullmar UAS

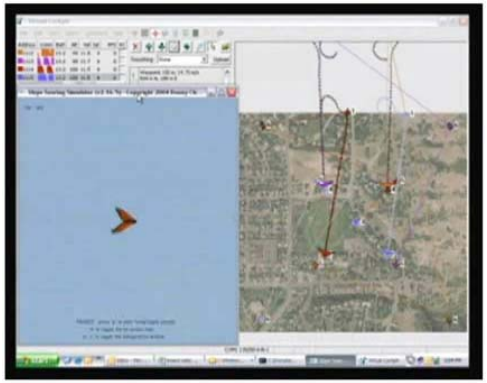
- Low cost system for civilian applications
- Fulmar aircraft
  - 3m wide
  - 20kg weight
  - 8h endurance
- Video and infrared cameras onboard
- Up to 50 km transmition

AirRobot

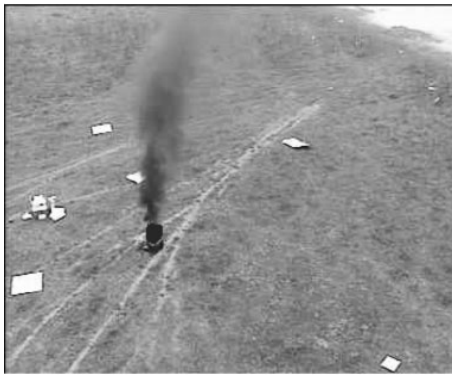
- Size 1m diameter
- Weight <1kg
- Endurance up to 30 min
- Payload 200g
- Distance 500m
- Barometric altitude control
- Gyroscopic and acceleration sensors
- Autonomous landing if radio communication is missing
- Payloads
  - Color camera
  - Night vision camera
  - Thermal camera

Academic Research

- Autonomous Forest Fire Monitoring System Using Multiple UAVs (R. Beard et al.)
  - Detect hotspots with detector agents and assign service agents to monitor them
  - Service agents equally spaced along the perimeter of the hotspot
  - Scheduling scheme for UAVs refueling
  - Simulation results and experimental results using fixed wing UAVs



- Cooperative Forest Fire Perception System for Multiple UAVs (Merino, Ollero et al.)
  - Heterogeneous UAVs (helicopters and blimps)
  - Heterogeneous sensors (infrared and visual cameras, fire sensors)
  - Perception system distributed within the fleet
  - Centralized system fuses data provided by different UAVs



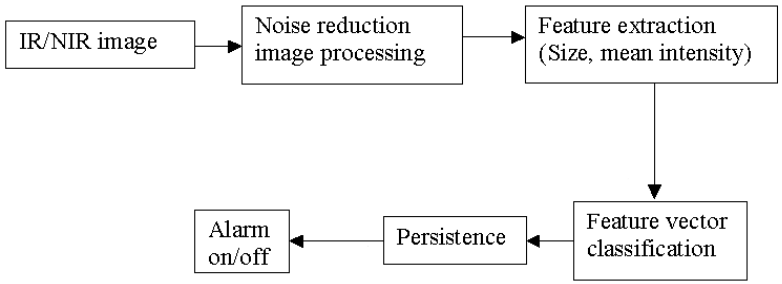
TUC Project: Nearchos UAS

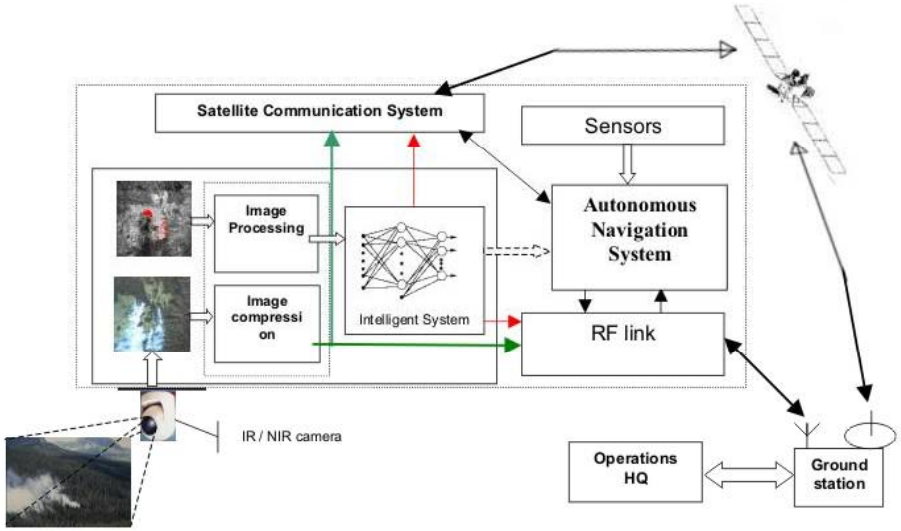
- Based on Nearchos UAV
- Medium distance reconnaissance UAV
- Main Characteristics
  - Length 3.95m
  - Wingspan 5.10m
  - Height (landing gear) 1.15m
  - Empty Weight 60kg
  - Operational altitude 7km
  - Operational speed 75km/h-220km/h
  - Flight Endurance 8h-12h
  - Payload capacity 51kg-92kg

Nearchos UAV, Property of EADS-3SIGMA SA

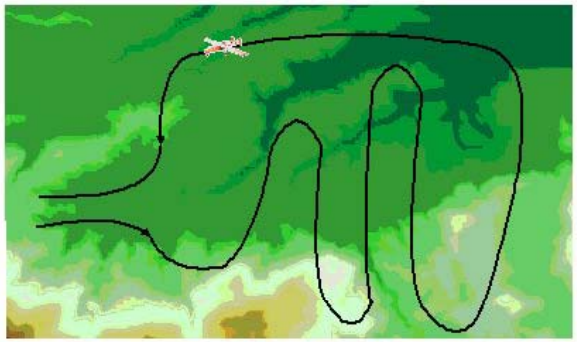
- TUC Project: Development of an Integrated Airborne Fire Detection System
  - On-board thermal sensitive sensors (IR or NIR camera)
  - Evaluation software
    - Noise reduction
    - Feature extraction
    - Classification
    - Decision-making (alarm signal)
  - Integration with UAV-ground communication system
  - Integration with UAV autonomous navigation system

Nearchos UAS for Airborne Surveillance

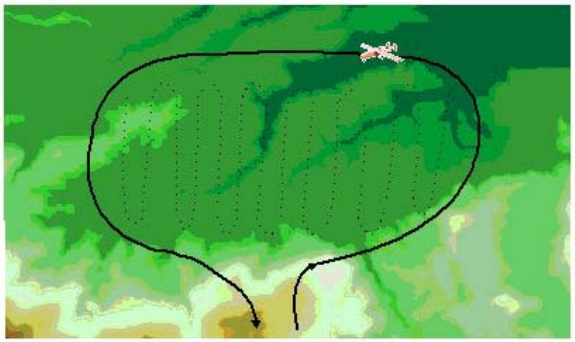




Area Surveillance



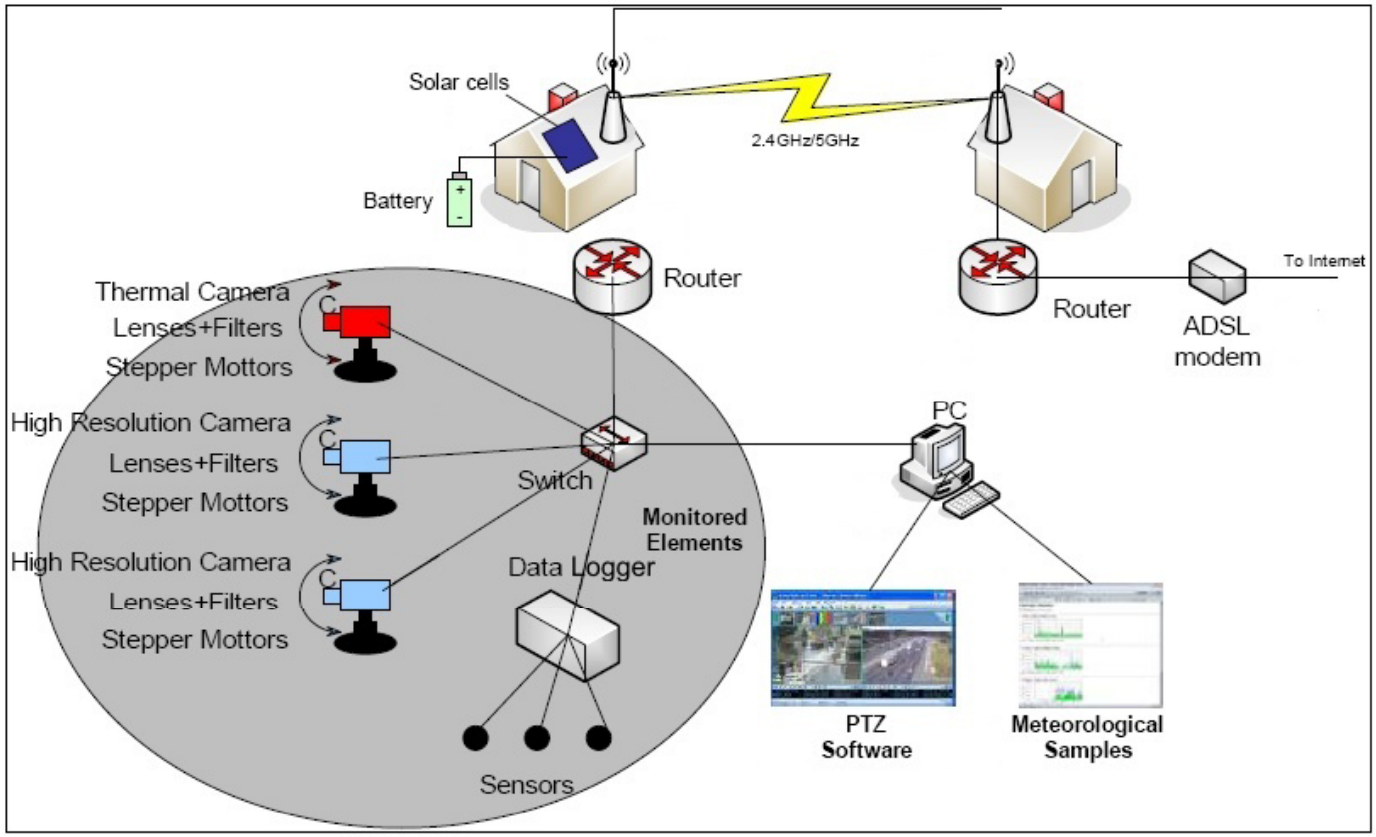
Perimeter Monitoring



Detected Fire Monitoring

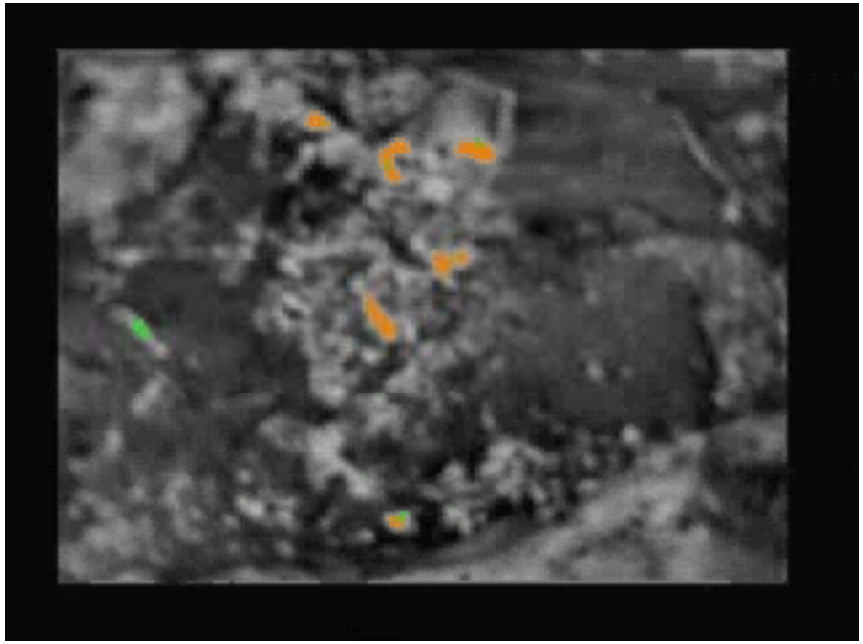
Nearchos UAS for Airborne Surveillance

- Cooperation with developed ground surveillance system for forest monitoring

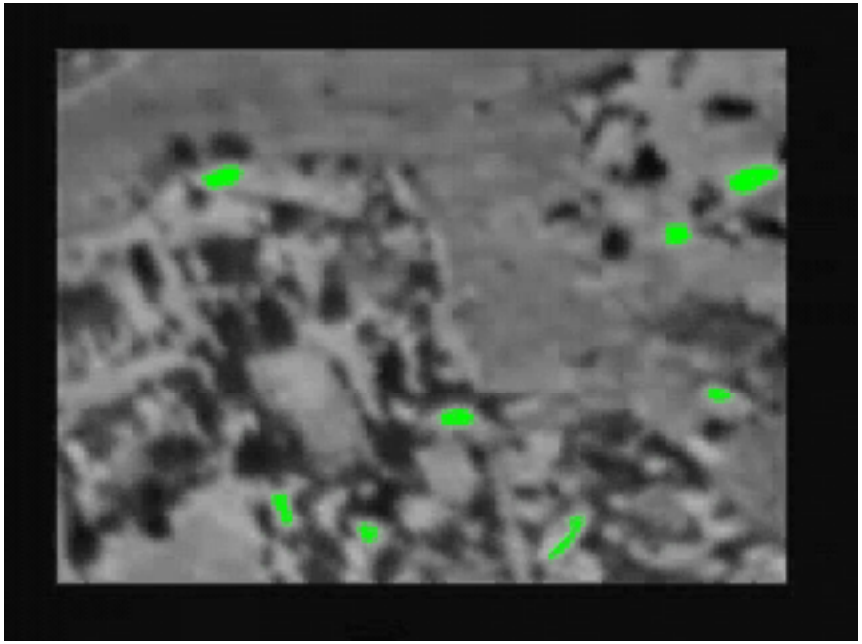


Nearchos UAS Fire Detection

Fire Absent



Fire Present



Kontitsis, M., Tsourveloudis, N., and Valavanis, V. , 'A UAV Vision System for Airborne Surveillance', *In proceedings of the 2004 IEEE International Conference on Robotics and Automation (ICRA)*, vol. 1, pp 78-83, 2004

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Media Coverage

Conclusions

- Forest fires threat to environment
- Pessimistic predictions for the future
- New techniques in fire management are developing
- UAS can provide sufficient assistance
  - High altitude UAS for global monitoring
  - Team of UAVs for precision monitoring
- Both industrial and academic efforts
- Current research provides promising results
- The future is unmanned

Thank you for your attention