Technology Work Session for the South African Army; Hosted by the CSIR

Autonomous and Remotely Controlled Systems

Unmanned Aircraft Systems

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Outline of presentation

- Introduction
- UAS classification
- Overview of current Army UAS in use
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- Ground Control Systems
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- Current developments
- Modelling and Simulation of UAS Missions
- Future UAS missions
- CSIR’s role in UAS development

Introduction

"There have been many technologies introduced during this eight-and-a-half years of war. However, I don't think any has made a greater impact than UAS. It's always important when you have a game changer like this that you step back, take some time to think about it and lay out your future. That's what we've tried to do in this very first UAS Roadmap." Gen. Barclay III, U.S. Army Aviation Center of Excellence, April 2010

Defence forces around the globe are becoming increasingly reliant on unmanned systems to carry out missions that are **dull, dirty, dangerous or difficult to provide** in any other way. The use of unmanned aircraft systems (UAS) by armies in particular will be discussed here.

Introduction

- Approximately 680 different UAS internationally covering a wide variety of missions
- UAS classifications have been introduced
- The US DoD version is shown below

DoD Group	Ceiling	Max Speed	MTOW
	[ft]	[kn]	[kg]
Group 1	1 200 AGL	100	9
Group 2	3 500 AGL	250	25
Group 3	18 000 MSL	250	600
Group 4	18 000 MSL	Any	Any
Group 5	Any	Any	Any

Note : Upper limits are shown, unless otherwise specified

Overview of current Army UAS

- Group 1 UAS
  - RQ-11B Raven
  - Lockheed Martin Desert Hawk III
  - Elbit Skylark
- Group 2 UAS
  - Not discussed here
- Group 3 UAS
  - RQ-7B Shadow 200
  - Seeker II
  - Watchkeeper 450
- Group 4 UAS
  - MQ-5B Hunter
  - IGNAT/IGNAT-ER

Overview of current Army UAS - Group 1 UAS

Advantages:

- lightweight (man portable) systems
- easily transported and rapidly assembled
- quickly launched
- provide situational awareness at battalion level
- logistic footprint is very small
- hard to detect and difficult to shoot down

Limitations:

- currently limited flight duration and range
- lower resolution of smaller camera systems but this is offset by the lower operating altitude

Overview of current Army UAS - Group 1 UAS

RQ-11B Raven

Span 1.3 m

Mass 1.9 kg

Electrically powered

Cruise speed 60 km/h

Endurance up to 80 minutes

Operational range up to 10 km

Roles: Low-altitude reconnaissance, surveillance and target acquisition (capable of IR laser illumination of ground targets)

Operated manually or programmed for autonomous operation utilising GPS navigation

Transmits real-time colour or infra-red imagery to the ground control system (GCS) and remote viewing stations

Overview of current Army UAS - Group 1 UAS

Lockheed Martin Desert Hawk III

Span 1.4 m

Mass 3.2 kg

Cruises speed 80 km/h

Endurance 90 minutes

Operational range up to 15 km

Typical altitude of 100 to 150 m

Larger than the Raven – fitted with a more powerful and better stabilised daylight or infrared camera system

It is reportedly a quieter and more stable platform

Overview of current Army UAS - Group 1 UAS

Elbit Skylark

Span 2.4 m span

Mass 5.5 kg

Endurance 90 minutes

Operational range up to 10 km

Electric power

Hand launched

Back packable system for tactical surveillance and reconnaissance

Payload daylight CCD or 700 gram FLIR system for night operations

Real-time video streamed to portable ground station

Overview of current Army UAS – Group 3 UAS

Advantages:

Large enough to carry an array of sensors and possibly precision guided munitions

Can generally take off from and land on unimproved surfaces or zero-length launchers

Limitations:

Reduced endurance when carrying the full array of sensors and additional weapons

Larger logistical footprint

Overview of current Army UAS – Group 3 UAS

RQ-7B Shadow 200

Span 4.3 m

Mass 170 kg

Cruises at 166 km/h

Dash speed of 218 km/h

Endurance of six hours

Service ceiling of 15,000 ft. Operational range is 125 km limited by ELOS (Electronic Line Of Sight) to the ground control unit

22 soldiers are typically required to operate a Shadow 200 system, including the surveillance analysts

The Shadow incidents are down to 29 per 100 000 flight hours

Overview of current Army UAS – Group 3 UAS

Seeker II

Span 6 m

Mass 180 kg

Cruises at 130 km/h

Endurance of 10 hours

Payload 40 kg

Service ceiling of 18 000 ft.

Operational range is 250 km limited by ELOS (Electronic Line Of Sight) to the ground control unit due to onboard directional antenna

Overview of current Army UAS – Group 3 UAS

Watchkeeper 450

Span 11.3 m

Mass 450 kg

Dash speed of 175 km/h

Range of 200 km

Endurance of 17 hours

Payload of 150 kg

Overview of current Army UAS – Group 4 UAS

Advantages:

Large enough to carry an array of sensors and possibly precision guided munitions

Extended flight duration with sensors and stores

Limitations:

Larger logistical footprint (similar to those of manned aircraft) Generally require improved runways

Not all Group 4 UAS are fitted with the satellite communication systems needed for beyond line of sight operations

Overview of current Army UAS – Group 4 UAS

MQ-5B Hunter

Span 9 m

Mass 884 kg

Cruise speed 130 km/h

Endurance 21 hours

Payload 270 kg

Range 260 km

4 stroke heavy fuel engine

Overview of current Army UAS – Group 4 UAS

IGNAT/IGNAT-ER

Span 17 m

Mass 1040 kg

Cruise speed 130 km/h

Endurance of 40 hours

Altitude of 8000 m

The real-time line-of-sight communications range (without using air-to-air relay capabilities) is 250 km

Overview of current Army UAS – Group 4 UAS

IGNAT/IGNAT-ER

Take off is from an 800 m hard surface

Landing is under pilot control with a 320 m stopping distance

Payloads are fitted for surveillance, reconnaissance, electronic warfare, voice and data communications relays and air-to-air data relays

Reconnaissance missions – fitted with Electro-Optical and Infrared (EO/IR) payload, streaming the video to the GCS

Surveillance payloads - radar, forward-looking infrared, colour video, low-light-level surveillance video and a synthetic aperture radar

Airframe can be fitted for air delivery of equipment or supplies

Rotary winged UAS

Schiebel Camcopter

Maximum mass of 200 kilograms Endurance of 6 hours (typically not in hover)

Maximum speed of 220 km/hr

Ceiling of 18,000 ft (again typically not in hover)

Can be fitted with electro-optic and infrared sensors

Rotary winged UAS

Honeywell RQ-16 T-Hawk

Mass 8,4 kg

Maximum speed of 130 km/h

Ceiling is 10 500 ft

Operating range is 11 km

Endurance is 40 min (most likely not in hover)

It can carry small sensors including one forward and one downward looking daylight (or infrared) cameras. The system is relatively noisy.

Ground Control Systems – Current and the future

- There has also been a strong move to open architecture systems approach for Ground Control Units
- NATO has addressed this need for commonality through STANAG 4586
- Current GCU operators are hampered by a limited situational awareness
- Shift in UAS control philosophy from direct flight control of the UAS to where the controllers provide a particular level of mission control and the UAS accomplishes the mission

Ground Control Systems – Current and the future

- Off-the-shelf portable Ground Control Stations available
- Situational Awareness with audio feedback
- Research into one operator and multiple airframes
- Nobody ‘pilots’ the UAS
- Target detection software
- Autonomous UAS – man on the loop

Powerplants and Fuel

- Lithium polymer batteries have a power density approximately 5% that of fossil fuels
- Electrical propulsion is not efficient for long duration flights
- New lithium battery technologies have 60 % more power density
- Small electric UAS will be capable of two hour flight times or longer
- Fuel cells are now available for the small hand launched UAS to operate for periods of six to ten hours
- Numerous UAS manufacturers are upgrading their systems with diesel engines both from the reduced logistics trail, safety and the slightly higher performance obtained

Avionics

The intelligence surveillance and reconnaissance (ISR) requirements of the UAS mission will dictate the type of sensor required:

- A visual camera for viewing (and possibly storing) live video
- An Electro-Optic/Infra-Red (EO / IR) for day/night surveillance and thermal imaging
- One of two types of radar: Synthetic Aperture Radar (SAR) for large area scans and / or moving target indication (MTI) radar
- SAR are now being miniaturised and installed on tactical UAS
- A mini-SAR has been developed with a mass of only 4 kg and power requirement of les than 50 W.

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Avionics

- The size and mass of UAS avionics is reducing
- This trend enables UAS such as the 3m span ScanEagle to fly over 22 hours with a stabilised electro-optical camera payload
- Sagetech - small, light ADS-B Mode S transponder 105 g using only 6W of electrical power
- Aeryon Labs imaging payload - 3-Axis stabilized high resolution camera for micro-UAS

Avionics

- MTC - redundant electrical rotary servo actuator - reduce UAS flight control failures
- Tau colour night vision camera – 1280 x 960 resolution in 'ultra low-light' conditions - 4 Watts, less than 175 grams
- AutomouStuff - 350 g Airborne micro-RADAR

UAS as Weapons

- Small UAS are becoming weaponised
- The Switchblade is a small, expendable, tube-launched, man-portable UAS that contains an explosive payload
- It has a mass of less than 2 kg and an endurance of 40 minutes
- The operator controls the flight path via a video feed from a forward looking camera

Nano UAS

Hummingbird

- Maximum speeds of 18 km/h
- Endurance 8 minutes
- Remote controlled
- It can fly in all three directions while maintaining a given body orientation
- Equipped with a colour video camera
- Used in urban warfare environments to enter buildings

Nano UAS

PD-100 Black Hornet

Mass of complete system including the base station < 1 kg

Can fit in a pocket

The air vehicle mass is 15 g

A rotor span of 120 mm

Maximum speed of 10 m/s

Endurance of up to 30 minutes

The sensor is a steerable video camera (pan /tilt)

Digital data link has a range of 1000 m

Flown by remote control using video data

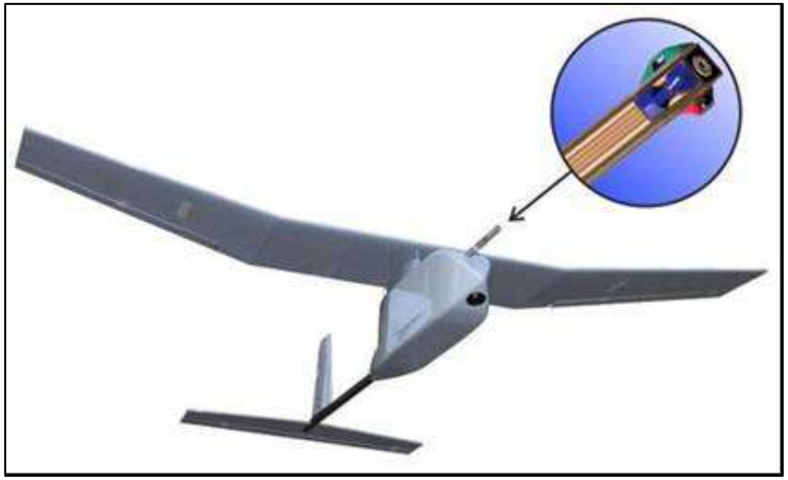
It can navigate a series of waypoints via GPS

Current UAS developments

- A GCU with steerable, directional antennas on a radio mast and will typically improve the range and reception
- Small UAS used as communications relay platforms
- Ubiquitous surveillance and reconnaissance through a large number of UAS swarming
- Convoy protection by UAS that navigate largely autonomously
- Embassy and high profile individual protection via UAS
- UAS used in the anti-piracy role

Current UAS developments

- UAS under development to determine the origin (the distance and direction) of gunshot, artillery and mortar fire by triangulating the sound from the shot
- The Avisa system uses propriety sensors to pinpoint the location of the gunshot
- It slaves a video camera to focus on the area from where the gunshot originated
- The next logical step would be to illuminate that location with a laser designator



Modelling and Simulation for UAS missions

- Mission based Modelling and Simulation should support the production of any UAS User Requirements Specification
- Typical issues that should be modelled and understood are:
  - Who in the command structure should command the UAS flight path and altitude?
  - Who commands the sensor look direction and magnification?
  - Should the target coordinates or range and azimuth be relayed to the GCU?
  - Who requires what information, in what detail and when?

Future UAS missions

- Very high definition image capturing systems such as the “Gorgon Stare” technology can capture live video of an entire city but …
- The large amount of imagery (80 mega pixel images at 30 frames/s) requires approximately 2 000 analysts to process
- The Global Hawk UAS relays more information per second than all the sensors combined in the Desert Storm campaign
- The ultimate solution is in smarter image processing software - detecting the required information autonomously and relaying the results to a smaller group of analysts

Future UAS missions

- Small UAS will be used to dispense ground-based sensor systems at an area of interest far from the operators
- These sensors relay signals indicating a detection (ground vibration, chemical, biological agents etc.) to the circling UAS
- The information is then relayed with GPS location back to the GCU some distance away
- Persistent sensors would provide data over an extended period on vehicle traffic. This information would be uploaded on request by an overflying UAS
- Army UAS of the future may include soldier medical resupply and unmanned freight transport to high risk areas.

CSIR's role in UAS development

- The CSIR has in the past developed a number of UAS prototypes including Seeker I and Vulture.
- We add the most value to the local UAS industry in the design, optimisation, characterisation and simulation of UAS airframes
- We wind tunnel test to characterise most of the locally developed UAS including engine propeller combinations
- We integrate prototype UAS sub-systems
- Through the integration of expertise from various units we are able to very rapidly design, integrate and flight test novel UAS as required

CSIR's role in UAS development

Date	Airframe
Early 1980's	Seeker prototype
1988	Anti- radar UAV demonstrator
1992	Skyfly Target Drone Prototype
1989	OVID / ACE technology demonstrator
1993	Keen-eye surveillance RPV
1992	Hummingbird 2-seat observation aircraft
1994	UAOS/Vulture prototype
2005	Indiza – Mini UAV
2007	Sekwa – unstable, tailless UAV
2008	Modular UAS

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Conclusions

- Internationally the use of UAS in the military environment has grown exponentially over the past ten or so years
- There are many different groups of UAS – each with their own unique application
- The range of available military UAS is large, but…
- Compatibility with current and future Command and Control systems is crucial for the larger systems
- Small UAS still have a large role to play in the front line and safeguarding of troops
- Many new applications are being explored to remove the risk to the soldier

Thank You

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