Small UAS for Law Enforcement

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Air-to-ground surveillance systems provide a unique contribution to gain situational awareness. The overview picture that they generate, combined with their perspective from above, provides users with a context and type of information unmatched by other sources. Soon after military UAS operations started, these systems attracted the attention of the Dutch police forces. The Netherlands Police Agency (KLPD) started experimenting with Unmanned Aircraft Systems in 2007 and since then investigated the application of these aircraft for a diversity of police force specific scenarios. The activities started by simply acquiring an unmanned helicopter, but rapidly evolved into a more thorough approach including the involvement of the National Aerospace Laboratory NLR and the Universities of Delft and Wageningen. Trials were set up to obtain more insight in the possibilities and applicability of the different systems. Scenarios were defined and tested. This confirmed the usefulness of Unmanned Aircraft Systems for police force activities in addition to the already available manned helicopters. With respect to the systems themselves, technical and operational improvements are needed on several areas, of which the Remote Pilot Station is probably one of the most urgent. Another important area of interest is the upcoming regulation for professional use of UAS. It is the concern of the Dutch police force that the rules and regulations might limit their UAS operations. Meanwhile attention is given to all possible safety and training aspects to enable the safe operation and application of small UAS (0 < Maximum Take-off Mass < 150 kg). Next to the KLPD this article includes activities performed by the regional police force of Amsterdam-Amstelland and the Program Against Organized Crime And Cannabis Cultivation.

Small UAS Used

The Dutch police forces use several small UAS, either owned by the KLPD and the regional police force Amsterdam-Amstelland, or under support of the Ministry of Defence. Within the Program Against Organized Crime And Cannabis Cultivation experiments were performed with a rented small unmanned rotorcraft for the fight against narcotics. The UAS used and some examples of their application are described below. The main specifications are presented in table 1.

Netherlands Police Agency (KLPD)

The KLPD uses one Delft Dynamics RH2a robot helicopter (figure 1), three Ascending Technologies Falcon 8 UAS (figure 2), operated by themselves and the AeroVironment Raven B, operated by the Netherlands Defence Forces and made available under a support agreement to the Dutch Police Forces. The main applications for these UAS are obtaining a better situational awareness by getting a bird's eye view and mapping of the crime scene. The RH2a is used more often in harsh environments like the higher wind speeds and whenever a longer endurance is required. The Falcon 8 is used more often in close range, quick response, waypoint navigation and short endurance circumstances. The Falcon 8 can be deployed faster than the RH2a. The Raven B is used for special circumstances in which the small unmanned rotorcraft capabilities do not satisfy the required operation. The Raven B is operated by the Ministry of Defence in separated airspace (special rules area or parts of a control zone (CTR)).

Delft Dynamics RH2a

The RH2a system (Figure 1) consists of a helicopter with camera or other sensor(s) and a Remote Pilot Station from which the Remote Pilot controls and monitors the helicopter.

Figure 1

The helicopter is equipped with sensors and a computer system that provide flight stabilisation and control.

AscTec Falcon 8

The Falcon 8 (Figure 2) is equipped with 8 rotors and able to display high levels of flight stability in wind speeds up to 10 m/s. If one of the rotor/motor combinations fails in flight, it is still able to continue flying with maximum payload and strong winds. As soon as a GPS signal is established the Falcon 8 is able to

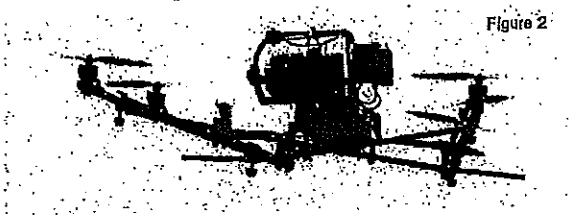


Figure 2

hold its position. By moving the control sticks the position of the system can be changed. By using the way-point planning software a mission can be planed, before and also during the flight. The system can also be controlled by the Remote Pilot using the life video feed. The V-layout of the Falcon 8 enables the camera to be faced completely down, horizontal and completely up without any of the rotors blocking the image.

AeroVironment Raven B

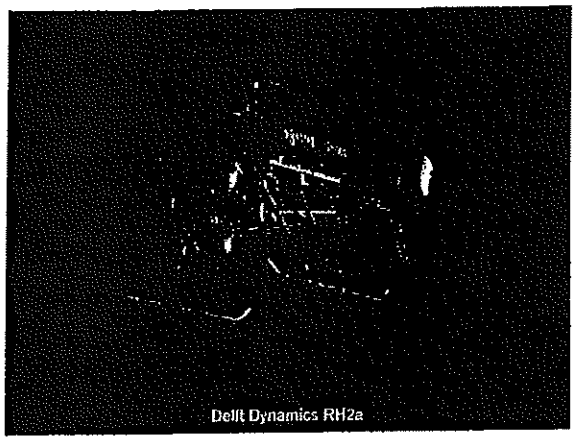
The Raven B is a lightweight fixed wing unmanned aircraft suitable for rapid deployment and low-altitude surveillance and reconnaissance. The system can be piloted manually or programmed for automatic operation, utilizing the system's advanced avionics and precise GPS navigation. The hand-launched Raven B provides aerial observation, day or night, at line-of-sight ranges up to 10 kilometres.

Amsterdam-Amstelland Police Force

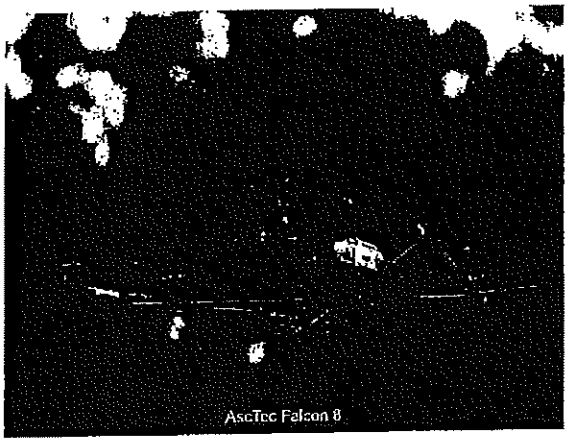
Amsterdam-Amstelland police force uses a AirRobot AR-100 UAS. Similar to the UAS used by the KLPD, the main objectives for operating this UAS are better situational awareness and crime scene mapping. The AR-100 has been used successfully during clearance of squatter's actions and multiple mappings of accident and crime scenes.

AirRobot AR-100

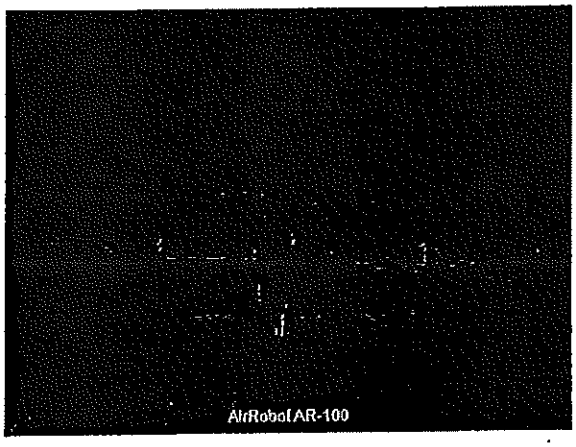
The AirRobot is equipped with 4 rotors and allows for fully autonomous stable "hands-off", "hover and stare" operation



Delft Dynamics RH2a

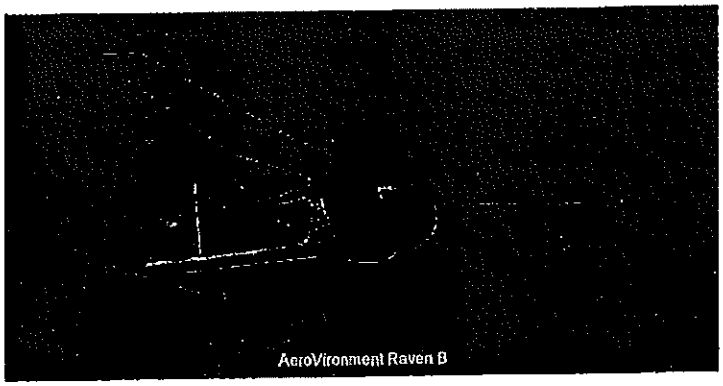


AscTec Falcon 8



AirRobot AR-100

HighEye CannaChopper Suave 7



AeroVironment Raven B

Table 1: UAS used by the Dutch Police Force

UAS used by Dutch Police Force	Delft Dynamics RH2a	AscTec Falcon 8	AirRobot AR-100	HighEye CannaChopper Suave 7	AeroVironment Raven B
Dimensions: - Rotor - Overall span	Ø 180 cm NA	8 rotors 77 cm	4 rotors 100 cm	Ø 182 cm NA	NA 137 cm
All-up Mass	17.0 kg	1.8 kg	1.0 kg	15 kg	1.9 kg
Payload	2.5 kg	0.5 kg	0.2 kg	6 kg	0.2 kg
Engine	combustion	electrical	electrical	combustion	electrical
Endurance	60 minutes	15 minutes	15 minutes	120 minutes	90 minutes
Max. windspeed	10 m/s (5 Bft)	8 m/s (4 Bft)	4 m/s (3 Bft)	10 m/s (5 Bft)	10 m/s (5 Bft)
Payload sensor	EO/IR	EO/IR	EO	EO/IR/sniffer	EO/IR

using GPS or optical position lock. The optical positioning system memorizes the underlying area and keeps the unit in position even in conditions where a GPS signal is not accessible. The unit is further stabilized with a unique combination of gyroscopic, barometric and magnetic sensors. The AR 100 will maintain its position, direction and flight altitude without operator interference. The AR 100 can be controlled by the Remote Pilot using the life video feed. The unit does not have to be in sight, this way the unit is flown like the operator is sitting in it. All moving parts are protected by a ring, which avoids damage to the rotors in case of an unintended collision with an obstacle.

Program Against Organized Crime & Cannabis Cultivation

Within this program a rented Suave 7 unmanned helicopter was deployed successfully in April 2009 in the battle against the illegal growth of cannabis. This program against organized crime and cannabis cultivation was already successful on the first day the helicopter was deployed, detecting several locations. The unmanned helicopter became well known under the named of CannaChopper due to abundant media attention.

CannaChopper Suave 7

The Suave 7 can hover or fly pre-planned routes for several hours. The Remote Pilot can fly it by remote control or use the automatic way-point navigation system. The onboard equipment consists of a high quality digital camera and a heat sensing camera. Additionally, this aerial observation tool is equipped with the 'cannabis sniffer', a sensor used for the intake of air samples, to instantly recognise particles indicating the presence of cannabis.

Evaluation & Identified Scenarios

In 2009 the KLPD initiated a project to determine the operational usefulness of different types of aerial surveillance systems, for example helicopters, fixed wing aircraft and a balloon. The National Aerospace Laboratory NLR, due to its experience with testing of small UAS for the Netherlands Defence was asked to support the KLPD with the operational test and evaluation (OT&E) of a number of UAS. Several police units drafted scenarios based on their tasks to describe the possible employment of UAS systems. These «scenarios» were used to capture the operational requirements for UAS. From these requirements scenario independent test flights were developed. The aim was that by executing these test flights it could be determined to what extent a specific UAS type meets a requirement and if possible which UAS performs better or worse. The scenarios and defined tests are presented in table 2. The tests can be executed independent from each other and can be used for training the UAS Remote Pilots to gain operational experience.

Advantages & Future Needs

The KLPD operates both manned as well as Unmanned Aircraft Systems with surveillance capabilities. These platforms address different information needs through their differences in flight endurance, visibility, payload capacity etc. UAS play a complementary role with respect to manned aircraft and can not be just seen as competitors. Each means for air surveillance has its own specific advantages and disadvantages. Table 3 presents an overview as seen by the KLPD.

All these means have in common that the information integration issue is largely comparable. Technical and operational challenges remain and new challenges arise in efforts to maximise the operational and economical benefit of air-to-ground surveillance systems. A ground station network - national (Dutch) coverage - is being installed for wireless data transmission between the air surveillance means and the information users on the ground. The smaller UAS require a different integration in the command chain, as these systems act in tactical operations and are controlled locally.

Operational Aspects

Currently small UAS air regulations in The Netherlands are under development and therefore all Police Force small UAS operations are being performed under the Model Aircraft

Table 2: Scenarios related to test descriptions

		Test Code & Test Description											
		a1	a2	a3	b1	b2	b3	c1	c2	d1	d2	e1	e2
	Scenario Title	Point observation	Line observation	Area observation	Recognition of group of people	Shape recognition (thermal imagery)	Detail recognition with EO camera	Position fixing	Continuous observation	Noise detection of UAS aircraft	Visual detection of UAS aircraft	UAS use inside buildings	Remote take-off/landing and deployment of equipment
1	Security measures during International events			x	x		x	x	x				
2	Indoor observation			x	x		x	x	x			x	
3	Recognize hash containers		x		x	x		x					
4	Events			x	x		x	x					
5	Record crime scene		x				x	x					
6	Hostage situation	x				x	x	x		x	x		x
7	Observation during arrest	x				x	x	x		x	x		
8	Disaster monitoring		x			x	x	x					
9	Reconnaissance in urban area			x		x	x	x		x	x		
10	Burning ship in port			x		x	x	x	x				
11	Search for missing person		x			x	x	x					

Table 3. Air Surveillance means overview

	Advantages	Disadvantages	Remarks
Manned Helicopters	Many/large sensors Long endurance	Noise Visibility No local control	No regulation issues
Manned Aeroplanes	Many/large sensors Long endurance	Noise Visibility No local control	No regulation issues
Satellites	Overview large areas	Old information Weather dependent Low resolution	High cost, or low reliability No regulation issues
Aerostats Unmanned	Silent Long endurance	Visibility Wind sensitive Difficult repositioning	
Unmanned Rotorcraft (combustion)	Application flexibility Local control Low visibility	Small sensor payload Noise (limited) Low maturity	Regulations under development
Unmanned Rotorcraft (electric)	Application flexibility Local control Low noise Low visibility Ease of use	Limited sensor payload Limited endurance Low maturity	Regulations under development
Unmanned Aeroplane (electric)	Application flexibility Local control Low visibility	Limited sensor payload No vertical take-off Limited urban suitability	Raven B operated by Ministry of Defence In segregated airspace

Regulations. This limits the use of UAS to those aircraft with a maximum take-off mass below 25 kg (including fuel and payload). Additionally, the main requirement is that the operation of the aircraft may not endanger any person or property on the ground nor other airspace users. To meet the first part of this requirement, the area of operation can be closed to the public. The regulations limit operations to a maximum

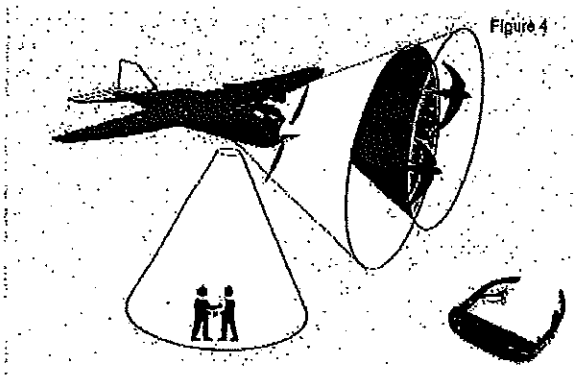


Figure 4

operating height above ground level of 300 meters in class G airspace. Operations in class C airspace have been arranged with local ATC in a covenant. To ensure public safety, the Minister of Transport can close or restrict parts of the airspace temporarily upon request of the local authorities. In practice, small unmanned rotorcraft are typically operated between 15 and 70 meter above ground level and the fixed wing aircraft (Raven) is operated between 120 and 180 meter above mean sea level in separated airspace (day and night).
All civil operations must be performed within visual line of sight of the Remote Pilot. To enhance safe operations, the UAS Remote Pilots received a theoretical Remote Pilot training, at the National Aerospace Laboratory NLR. This training was derived from Private Pilot Licence learning objectives and specifically developed for public service UAS Remote Pilots.
Concerning regulations, the main limiting factors experienced for Police Force operations are the prohibited (civil) operations beyond visual line of sight and at night. Another limiting factor is the maximum wind speed in which the UAS can be operated. The average wind speed in The Netherlands is 45% of the time throughout the year more than 4 Bft.

Cooperation

In carrying out a large number of police tasks an increasing need for air surveillance is identified. Some (regional) police forces have already purchased some smaller UAS and gained experience with the technology and operational use. The KLPD has set a goal to support various police forces by the implementation of UAS. Co-operation with military forces has been established and the cooperation with emergency services like fire brigades is expected to follow soon. The support of police tasks by the Ministry of Defence has been agreed between the Ministries of Interior and Defence. The agreement defines when and where Defence supports civil authorities. Such a commitment is always at the request of and under the leadership of the civil authorities.

The KLPD supports the development of the RoboSwift (figure 4), a micro airplane fitted with movable wings, inspired by the common Swift, under development at the University of Wageningen and the Technical University of Delft.

Together with the Technical University of Delft the IMAV 2011 conference is being organised, which is also sponsored by providing equipment and personnel as well as providing a price for the best "user deployable UAS".

Improvements needed

Main focus within the Dutch police is the tactical deployment of UAS. The goal is to obtain information through (remote) sensing at difficult and/or dangerous locations. The currently available UAS still have limitations, but can become a powerful tool.

Improvements of the current systems are necessary on:
- Airworthiness qualification;
- Robustness;
- Operation in stronger wind conditions;
- User interface (control logic);
- Data transfer to command station (secure);
- Mobility (by one person);
- Sensor quality.

Especially airworthiness qualification is considered important to enable practically unlimited operations, also within populated areas. Secondly robustness, user interface and operation in stronger wind conditions are high on the police forces list of requirements.