MILITARY AND CIVILIAN EMPLOYMENT OF AERIAL ROBOT TECHNIQUES — RESPONSE TO THE CHALLENGES OF 21ST CENTURY

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Aerial robot techniques and unmanned remotely operated aerial vehicle systems have great possibility for supporting military and civilian operations without risking the lives of an aircrew in assessing hazardous situations. They have three-dimensional mobility, long endurance but have difficult take-off and landing process, weight, velocity and economical problems. This paper presents the concept of a small vertical take-off and landing unmanned aerial vehicle, presents some special task, which can be realized by them. This paper wants to show how we could be performing our tasks with this UAV in Hungary.

INTRODUCTION

The use of information in war, in operations other than war, in peacekeeping and in law enforcement operations has been a basic requirement. The remote ground vehicles, unmanned aerial and underwater vehicles with their onboard sensors can assist in collecting evidence, can support clearing missions, they can also be used to position non-lethal or lethal packages. In 21st century, we have new challenges in environment, on the battlefield, new threats in crime, and the budget pressures armies and law enforcement agencies to look more effectively perform their missions.

When faced with dangerous situations on the battlefield, or in a crime situation commanders or police officer need as much information on the situation as possible. In peace if available and the situation warrants, aircraft or helicopter aerial surveillance can be called in to provide additional assistance. Availability of aircraft is typically limited to large organizations, the numbers of aircraft available are limited, they require dedicated pilots, and are costly to operate.

In war or in operations other than war only division commander or commander of joint task force has availability of aircraft and helicopters. The small countries and law enforcement agencies are beginning to look at unmanned, cheap systems to perform reconnaissance and surveillance.

The American Space and Naval Warfare (SPAWAR) Systems Center San Diego and Sikorsky Aircraft performed the concept of a small vertical take-off and landing (VTOL) unmanned aerial vehicle for Army, Navy and law agencies. This idea is very attractive for these types of applications. Such a system could be carried to the operational area in an army vehicle or a police patrol car and be used to perform reconnaissance using video or thermal cameras. The small variant can be carried by two persons, would provide officers with the ability to see over and beyond large structures such as buildings without being hampered by ground terrain. This system could be utilized to emplace sensors, or communications repeaters for enhanced communications coverage. It could also maintain an overwatch position to aid in command and control, delivery of nonlethal agents, carry chemical, or nuclear sensors to survey chemical or radioactive pollution in hazardous or difficult to reach locations to provide long term surveillance. The cost of operating this type of system should be much less than the cost of operating a helicopter or a plane, potentially providing greater availability to smaller army units (battalion, company moreover platoon or squad) or law enforcement agencies.

THE INITIAL CONCEPT

The new system would consist of a small vertical take-off and landing shrouded rotor unmanned aerial vehicle and a supervisory control station. The platform size (three - six feet in diameter) is small enough to be carried in police or army vehicles and large enough to provide reasonable levels of performance. The shrouded rotor platform provides a more compact design than an open blade helicopter configuration. System safety is improved due to the shrouded blades.

The flight control of the system is supervisory, i.e.; the operator directs the motion of the platform, but does not fly it. Supervisory control allows the system to be operated by field personnel as a collateral duty and does not require a dedicated operator, pilot. The onboard flight control system takes care of maintaining platform stability and coordinating the controls to respond to operator direction.

The unmanned aircraft is envisioned to be a mobility platform for multiple mission modules. The primary module is for reconnaissance and surveillance includes both daylight and thermal sensors, video cameras. The thermal sensor enhances detection of vehicles, people and animals in shadowed areas, in foliage, in smoke, as well as at night.

The secondary module includes network based communications and control architecture, allows information to be accessed by other personnel requiring it. The modularly architecture simplifies integration sorting a plug and play approach for multiple mission packages.

The radio frequency network also allows passing of control between operators and integration of information at the command control station.

The system must be designed to assist operational personnel and must not detract or encumber them during prosecution of their mission. The control unit of the bigger variant can work in a vehicle, patrol car, or container. The smaller control unit is based on body-worn computer and head mounted display technology. Operator input to the body worn systems is through arm-mounted keypads, small joysticks, small computer mouse devices or voice input.

THE HISTORY OF MSSMP OPERATIONAL CONCEPT

In fiscal year 1992 Space System Center San Diego (SSC–SD) under U.S. Army sponsorship initiated a program to investigate the feasibility of using small, vertical take-off and landing unmanned aircraft to position remote surveillance sensors in the battlefield to enhance the capability of Military Police Squads, in tactical security missions, to cover large areas of the rear area of a battlefield.

The system concept was originally called the Air Mobile Ground Security and Surveillance System (AMGSSS) and then the Multi-Purpose Security and Surveillance Mission Platform (MSSMP).

The air mobility platform was a shrouded rotor, VTOL UAV with a sensor suite mounted on its board. The operational scenario was based on a squad of three MPs deploying with a High Mobility Multi Wheeled Vehicle HMMWV towing a trailer holding three air mobility platforms. When the squad reached a central location in the area of responsibility they would launch one or all of the air mobility platforms to locations at which they desired to perform long term ground surveillance.

The platform would fly to target location where it would autonomously land and then conduct long term surveillance with its onboard sensors. To reduce communication power and time of radio communication the sensor data was processed onboard the platform by automatic software. At the end of the mission or when surveillance was required in another location the system would be commanded to restart, takeoff and go to the new location or return to its launch point.

Picture 1. Cypher

The Sikorsky Aircraft Corporation's Cypher UAV (see Picture 1) was selected as the best system available to demonstrate the MSSMP mission. A program was initiated FY1993 to demonstrate the feasibility of the MSSMP concept by incorporating an SSC-SD developed mission sensor package (motion detection system, sensor control and display unit) into a tripod mounted above the Cypher vehicle.

DESCRIPTION OF CYPHER AND ITS MODIFICATIONS

The Cypher aircraft concept is an innovative approach to UAVs because it is the first and only ducted configuration using rigid coaxial rotors coupled with an external shroud to control and stabilizes the aircraft. The two coaxial counter-rotating rotors balance torque, and provide aircraft lift and all directional control. The shroud is multi-functional: it supports the rotors, produces a portion of the lift, and contains propulsion, avionics, fuel, payload, and other flight-related hardware. This construction also enhances vehicle and operator safety for operations in confined areas by protecting the rotor from tip strikes.

The present Cypher technology demonstrator (Cypher—TD) is six feet in diameter and was designed to carry 20 kg payload for two to three hours.

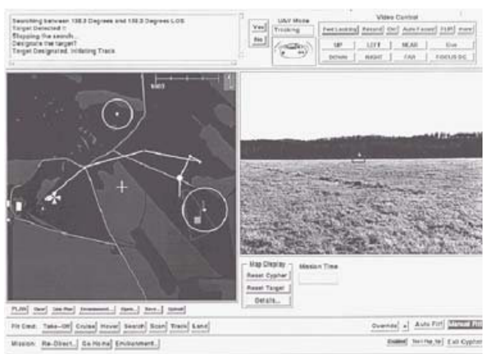
The key attributes of the Cypher UAV are summarized in the Table 1.

Table 1. Cypher-TD Characteristics

Characteristic	***Value***	***Characteristic***	***Value***
Body Diameter	6,3 ft (1,98 m)	Speed (max)	60 mph
Rotor Diameter	4 ft (1,22 m)	Endurance	2–3 hours
Height	2 ft (0,61 m)	Mission Radius	90–125 km
Nominal Weight empty	175 lb. (79,5 kg)	Powerplant	1xAR801 rotary piston engine, rated 50 hp
Max. Payload	50 lb. (20,5 kg)		
Altitude (max)	8000 ft (2700 m)		

One the major goal of the Cypher-TD program was to develop a user friendly VTOL UAV that could be easily controlled with simple operator commands. It was made possible by a sophisticated flight control system and an operator friendly graphical user interface called the Sikorsky System Manager. (See Picture 2)

Picture 2. System Display



The display is split into two portions. The left side displays a digital map of the area of interest, and the right displays the payload sensor output. Data from the FLIR can be analyzed by an Automatic Target Recognition (ATR) system to detect targets and provides target location information back to the System Manager. Aircraft and target position along with track history are displayed on the digital map.

The Cypher aircraft can be scaled up or down to meet specific mission requirements. Presently Sikorsky has designed Cypher II (Dragon Warrior) for US Marine Corps and a MiniCypher which is a man-portable version.

MiniCypher can be carried on the back of a person and operated through a portable ground station or body-worn computer with a helmet-mounted display. MiniCypher does not require a highly trained pilot, it is autonomous in all of its flight modes and only requires mission-oriented directives from the operator.

MiniCypher was designed to carry a vide variety of payloads. Sensors such as video cameras and FLIRs are mounted inside the fuselage. Carrying a 4 kg payload the MiniCypher can travel a distance of 5 km, loiter on station for one hour, and return to the launch point without refueling. Imagery from the sensors is transmitted back to the operator and displayed in real time.

Picture 3. Cypher II

The Cypher II's (see Picture 3.) unique design includes removable wings, shrouded rotor and a pusher propeller. As a fixed wing aircraft, it has maximum speed of 125 knots and a range of over 100 nautical miles. As a rotary wing aircraft, it can operate in confined areas and support urban operations. It can fly low and slow. The U.S. Marine Corps has awarded Sikorsky a $5,46 million contract to build two Cypher II prototype aircraft and ground control stations.

In the urban environment, the Cypher II UAV can fly extremely close to buildings, vehicles, vires, and other structures without concern for blade strikes or risk to human life.

PAYLOADS AND POTENTIAL APPLICATIONS

The Cypher has been designed to accommodate vide variety of sensors, not only Electro Optic (EO) and Forward Looking InfraRed (FLIR). The following payloads have been flown on the Cypher aircraft: FLIR, Video, Magnetometer, Laser range finder, chemical canisters, EMI sensor. In the next the Cypher modifications will accommodate acoustic sensors, imaging sonars, communications transmitters, transponders, emitters, amplifiers, telemetry equipments, linescanners and integrated optical systems, radars, ESM/ECM measurement systems, jammers, decoys, smoke dispensers, onboard manipulators, etc.

The payloads are summarized for some mission in the Table 3.

SSC–SD and Sikorsky Aircraft have conducted many demonstrations of the MSSMP concept. At the McKenna Military Operations in Urban Terrain training site in Ft. Benning, Cypher flew up and down city streets; successfully landed on the flat roof of a multi-story building.

A counter-drug operational demonstration was conducted for the U.S. Army Military Police School, Ft. McClellan, Alabama where the system, once in place, surveilled the area to document a simulated drug transaction.

Table 3.

MISSION	***TYPE OF PAYLOADS***
Reconnaissance	EO/IR, SAR/MTI
Target designation	Laser Target Designators
Information Warfare	Specialized Electronic Attack Tools
SIGINT, COMINT, ELINT	Specialized Measurement System
Electronic Warfare	ESM/ Jammer, Dispenser
Communication/Relay	Communication Equipment
Battle Management	EO/IR, SAR/MTI
Mine Countermeasures	IR, Radar, FOLPEN
Search & Rescue	EO/IR, SAR, SIGINT
Nuclear/Biological/Chemical	Special NBC Surveillance Equipment
Counter Camouflage	Hyper-Spectral Sensors
Acoustic Surveillance, Harassment	Sonar, Acoustic Jammer
Border and Traffic Surveillance	EO/IR, Acoustic sensor, Loud speaker for voice
Neighborhood Patrol	EO/IR, Acoustic sensor, Loud speaker for voice

In Ft. Benning was an experiment where the main goal was to demonstrate that Army operators, with only minimum training (approx. 1 hour), could plan and conduct a mission using the Cypher. All flights were planned and executed by Army MPs. This was the first time the Cypher UAV was fully operated by non-Sikorsky personnel. The result was very good. The Cypher can replace a human point man, flying over the next hill or around the next corner and transiting a bird's-eye view of the ground situation to the small-unit commander.

SOME ASPECTS OF THE CONTROL SYSTEM

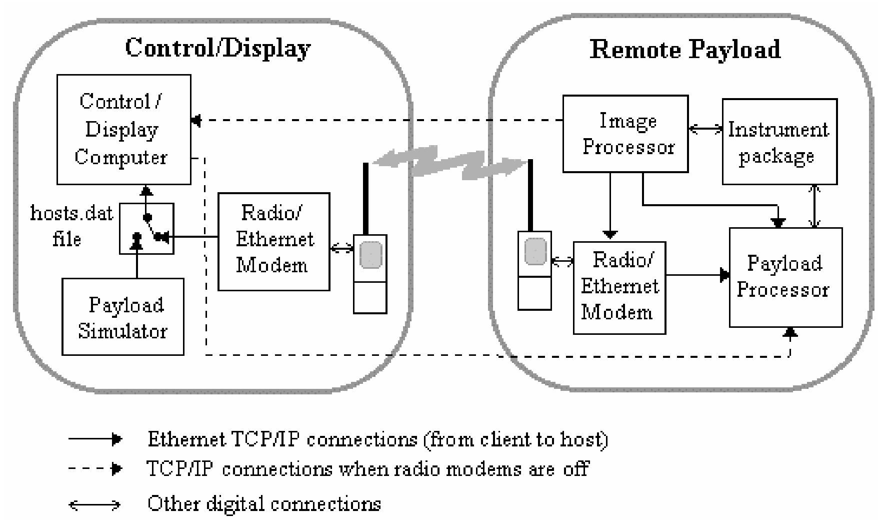
The Air–Mobile Ground Security and Surveillance System (AMGSSS) objectives include:

- high mobility;
- insensitive to intervening terrain;
- remote operations over existing low-bandwidth tactical radio links;
- long-endurance surveillance capabilities;
- easily scaleable functionality;
- the ability for one operator to supervise several remote systems.

A prototype mission payload and control station has been developed over a period of six month. To allow fast prototyping and to achieve a small, portable demonstration package, the following design methodologies were employed:

- Use of miniature embedded Personal Computer (PC) components, with DOS and Windows-based software. This allowed us to exploit in-house expertise in PC programming, and a simple transfer of the finished code to the embedded system hardware.
- Decomposition of the complex system into functional tasks operating on dedicated PC components, connected by Ethernet and TCP/IP (Transmission Control Protocol/Internet Protocol) networks. This allowed parallel development of subsystems, easy incremental testing, and a simple final integration.

Picture 4 is the AMGSSS Mission Payload Prototype system functional diagram, showing connections between each subsystem computers. There are two computers at the control end (a laptop running the control/display and optional payload simulator, and a tactical radio/Ethernet modem), and three computers on the remote payload side (payload processor, image processor, and tactical radio/Ethernet modem). Interprocessor communications is via TCP/IP using Ethernet cables and tactical-radio-frequency modems.



Picture 4. System Functional Diagram

Picture 5 shows the prototype sensor payload packaged in a portable configuration. The package includes a visible-light video camera, an infrared video camera, and a laser rangefinder, all mounted on a pan-and-tilt unit. Additionally, there is a serial port for connection to an optional portable Northrop-Grumman Acoustic Unattended Ground Sensor. The PC/104 computers are housed in the compartment below the sensors.

Picture 5. The prototype sensors payload package.

The system employs a message passing distributed processing architecture. Messages and commands are passed between the subsystems via the Ethernet cables and via the radio link between the control and payload ends. Each computer has an Internet (IP) address, and uses a hosts data file ('hosts.dat') to find the Internet addresses of the other modules. The network protocol is set up to automatically switch to an all-direct Ethernet configuration, by passing the radios, upon detecting the absence of the radio modems. This was intended as an early developmental configuration, but proved very useful throughout the developmental cycle and later as a valuable demonstration tool.

CONCLUSIONS

UAVs must be designed to be safe and simple to operate, preferably by an individual soldier, policeman, fireman, or another civilian user. We need small VTOL UAVs can be used in urban environments and open ground environments to perform surveillance, gather sensor data to detect and locate ground troops, weapon systems and electronic equipments. The current state of the art in UAV design and payload development supports armies, law enforcement agencies, but another organizations for environmental supervision, border patrol, wildlife & forest inspection, etc.

In Hungary - in a small country - this type of UAVs is more cheaper, than big systems, more suitable for civilian and military users, not only in war, in operations other than war, in catastrophe situations but in peacetime too. The commercial and military electronics markets are driving down the size and cost of the sensors and subsystems. These systems would be deployed better video cameras, FLIRs, RF modules, low weight components to provide modern digital signal processing and communications.

We need new UAV development program. We need study experiences of foreign countries, our experiences of development Hungarian UAV Soyka and make a new conception - in my opinion - a similar to Cypher concept. If some organization works in cooperation, then the development will be available at reasonable cost.

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