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THE QUADROTOR-BASED NIGHT WATCHBIRD UAV SYSTEM USED IN THE FORCE PROTECTION TASKS

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Abstract: *The Unmanned Aerial Vehicles (UAV), or Unmanned Aerial Systems (UAS) are widely used today in real time, high precision reconnaissance missions. The UAS can lean on various types of the UAVs, whilst this paper deals only with multirotor UAV applications. The special flying abilities of the multirotor UAVs (e.g. vertical take-off and landing, hovering, flying at extremely low altitudes and airspeeds) open new areas in UAV applications. Challenges of the modern era put many problems to be solved such as problems of safeguarding in civil life, handling disaster management tasks, border control, and, finally, solution of force protection tasks in operational theatre, or out of war theatre. Author will lay down a brand-new concept of the UAV system applied in bad visibility to improve efficiency of the solution of the force protection tasks, which reduces human resources needed for this purpose. The proposed Night Watchbird UAV system is a new one using modern methods and principles to reach basic goal of reconnaissance providing real-time information for commanders, and for military forces, in general.*

Keywords: UAV, multirotor UAV, civil and military safe-guarding, force protection in operational theatre, conceptual design of the air robot system.

1. Introduction

There is no doubt the unmanned aeriel systems are promising tools applied in both public and civil applications. The publication of the European Committee's "Flightpath 2050 – Europe's Vision for Aviation" is dealing with main trends of evolution of the aviation, including UAV-technologies, till the year of 2050, deriving main tasks to be solved maintaining the goals proposed by EC. This strategic document can be effectively used although in military UAV applications and missions, i.e. in force protection tasks maintained by military units serving in war theatres.

Being member of the NATO NTM–I-team mentoring pilot-course of the Joint Staff College, Al Rustamiyah, Iraq, the author of this article had gained experiences in force protection activity in desert war theatre in the Middle-East.

Both military and non-military UAV applications define further requests for designers to design and produce UASs with those attributes pre-defined by the users.

The goal of the author is lay down basic principles of the brand-new UAV reconnaissance system concept applied in military missions to improve force protection capabilities established before using conventional methods and tools.

2. Preliminaries and related works

The term *Watchbird* firstly mentioned and used by English writer Robert Sheckley (1928–2005).

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In his science fiction story written and published in 1967 he described a UAV-based reconnaissance system used in crime prevention actions in modern societies [1, 2] (Figure 1).
The FAST-System is described in [3], underlining advantages and disadvantages of the proposed system, although focusing on bottlenecks of the recce sytem.
There is a series of scientific articles published by the author dealing with flying and handling qualities of the UAV systems. The UAV systems applied in military missions might have system of requirements given in articles of [4, 8, 9, 14], whilst UAVs applied in non-military missions can have requirements as they are defined in publications of [5, 6, 7, 11, 12].
UAVs applied in D3 (Dirty-Dull-Dangerous) missions migh be designed using extra-cheap concept, due to conditions of their missions (e.g. monitoring nuclear powerplant catastrophies, etc.). Due to difficulties of decontamination of theirs UAVs are used as non-reusable ones with no obligations of the succesful and safe landing [13, 14].

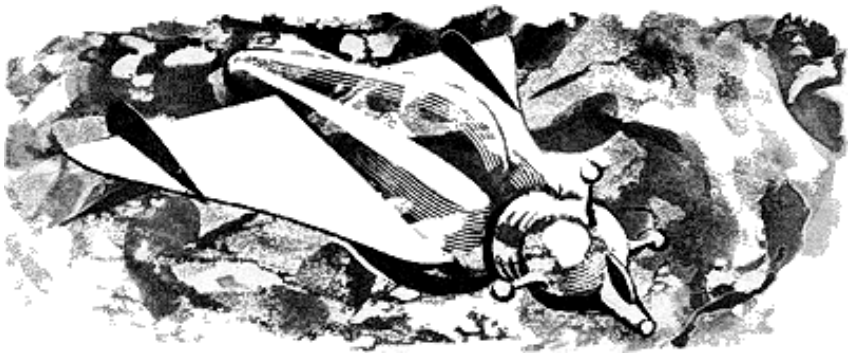

Figure 1: UAV recce system by Robert Sheckley [1, 2].
(Source: www.google.com. Downloaded: 07 Dec 2014.)

In article [10] the author investigates advantages of the propulsion systems applied by the UAV. The fixed wing and the rotary wing concept was evaluated to show how to select the appropriate UAV type fitting best the user's requirements.
The flight dynamics and dynamical models of the multirotor UAV (quadrotor-type) are outlined in [15, 16]. Articles of [17, 18] show application of the LQ-based preliminary design of thc flight control systems of the UAV. Article [19] deals with design of the optimal flight path design of the UAV.

3. General requirements for Night Watchbird UAV system

The *Night Watchbird UAV System* is a new concept of the autonomous UAV recce system supporting solution of the force protection taks of the military units serving mainly in war theatres. The proposed system is a reconnaissance system, which executes simultaneously the data acquisition, data storage, data transmission to the ground control station, with preliminary data assessment to support commanders to take fast and correct decisions.
There might be arise a simple question: whether a new technical system can generate new tasks solved by the military staff, and if so, how the staff must be prepared for solution of these new tasks.
It is easy to agree that due to physical and mental overload of the staff, any new initiative in the war theatre might not be requisite with new loads meaning new skills in UAV maintenance. Due to complexity of this problem, UAVs are maintenaced in war theatre by special units especially prepared for UAV maintenance and repair.

Considering this fact, the proposed UAV-system would not put any additional overload onto military staff, it must act autonomously, supporting military fighting units with real-time information.

It is easy to see that the basic idea can realized in remotely-controlled UAV-recce system having joint ground control stations with abilities and resources to control the UAV recce flights, in case of necessity, to repair UAVs, or to change them for new ones, if it is required.

The ground control station has in the staff personnel certified by given authorities (i.e. European Aviation Safety Agency, Department of Transportation, Federal Aviation Authority USA, NATO, national authorities) to fly the UAV, to maintain and to repair UAVs.

This paper would not evaluate questions of airspace management. The reason is that in war theatre the airspace mostly segregated providing privilege for military aviation. In this particular case, unless otherwise specified, the UAVs can be flown as per the request of the given war situation.

The basic vision and requisite condition of the author is: the military camp has a special, secure platform, or landing zone able to incorporate of (3-4) UAVs on this physical platform. As a rule: UAVs have serial numbers for their take-offs derived by theirs level of technical status. The pre-defined serial number system can be rearranged during flight service of the UAVs with the consideration of the worthiness to fly, with technical status of the UAV, and finally, with pre-derived system of logical rules and conditions. For that purpose the UAV on-board diagnostics is a prerequisite one.

The basic mission of the brand-new, proposed by the author multirotor *Night Watchbird UAV System* is the identification of the event (fact) of the incursion into the military base having some mechanical shielding (e.g. concrete walls, wired fences etc.), and alerting military staff on duty.

Large military camps and bases can have conventional security systems based upon static cameras of given spectrum. If the ground control station is not equipped and not prepared with necessary tools and kits to support decision making of the military person on duty, although information from cameras can be evaluated with large time delays, which worsen the effectiveness of the solution of the force protection tasks, and, reduces level of security of the military camp.

Figure 2 shows a night vision infra image of a '*creature*'. Using this image it is very difficult to decide whether it is a human or non-human being. Moreover, in general, it is difficult to decide whether it is a living, or a non-living organism. Having no automated data evaluation system in conventional security systems, the decision of the duty officer is based upon his skills, knowledge and experiences busy with many subjective elements of his.

Figure 2: Infra image of the creauture.
(Source: www.google.com. Downloaded: 07 Dec 2014.)

The *Night Watchbird UAV System* is a new security system able to identify:

- the event of incursion into military camp;
- the intruder, making difference between '*human*' and *'not human*' intruders;
- intentional, or unintentional incursion of the human intruder. If intentional incursion of the human is identified, he will be *grab* and *escorted* by the UAV till ground forces take actions.

The UAV of the *Night Watchbird UAV System* can fly in fence (borderline) patrol mission whether in stelth, silence mode, or in normal flight regime generating large emissions to show its flight. The first method can be applied effectively if incursion into camp is intentional one, whilst second method can be applied in case of deterrence of intension of the incursion showing skills of the security system to human intruder.

4. Night Watchbird UAV system applied for force protection missions

The force protection in war theatre military actions is the key factor. Its importance is vital and undesputed. The military success is often and basically determined by human factors. If the military staff safe in his camp, for the next mission he can be prepared very effectively, and the next battle would be won with high probability with minimized losses. If there is no safety, no rest in the camp, the military unit can loss some skills, or use them with reduced effectiveness.

In war theatre, the level of safety is coded via colours. The top level of safety is coded via '*green*' colour. The arming stance in these green-zones is: having short-barrel personal weapon, no round in the chamber. In war theatre, the weakest level of safety provided in '*red*' zones. The arming stance in these red-zones is: having short-, and long-barrel weapons with necessary amount of ammunition, first round in the chamber. The combat uniform contains body-armour and helmet, too.

Figure 3 shows a military base in the Middle-East desert area, inserted into populated area busy with insurgent actions. The base has large dimensions, there is large area to defend and provide safety at minimum levels. The static elements of the force protection system are conrete walls, T-walls, concrete shelters, fences. The walls have gunner-towers with large calibre, long barrel guns inside, applied mainly against vehicle-borne improvised explosive devices (VBIEDs) driven by insurgents into check-points, or into walls of military bases.

Figure 3: Military base in desert area.
(Source: www.google.com. Downloaded: 07 Dec 2014. Redrawn by the author)

The walls being controlled at the military base are coloured in Fig 3 in red. The length of the walls is measured in kilometers. For military duty personnel having limited forces, it is difficult to action in right way with appropriate and sufficient force. However, the static borders of the military camp suggest to apply effectively the UAV-technology for recce purposes to minimize time delays in detection and identification of the event of incursion. Due to main features of mechanical elements of the force protection system in case of military base protection one must deal only with intentional intrusion of the human intruder.

5. Challenges faced by Night Watchbird UAV system

The new UAV applications are mostly driven by demand of the users guiding path of evolution of the UAVs. Main principle is to have appropriate technical skills to solve main tasks of the UAV flights. The main requirements derived by UAV users are published in the author's scientific papers of [4, 5, 6, 7, 8, 9, 10, 11, 12].

The first phase of the UAV design is the conceptual, simetimes the pre-conceptual design stage. The new concept of the UAV recce system proposed in this article also has many missing definitions and criteria. The *Night Watchbird UAV System* conceptual design requires new definitions, new logical conditions and logical rules. Copceptual design means and requires solution of the following problems:

- definition of the main tasks of the UAV recce system;
- definition of the technical parameters of the UAV recce system;
- definition of the UAV flight envelope;
- definition of the flying and handling qualities of the UAV recce system;
- definition of the type-, and airworthiness criteria for the UAV recce system;
- solution of problems of the airspace management at the national level, as the minimum;
- definition of the ground control station supporting UAV recce system;
- description of the UAV type;
- definition of the flight phases;
- solution of flight safety problems;
- design of the landing zone of the UAV;
- selection of the type of the UAV applied in the recce system;
- taxiing on the ground platform;
- docking to charge/recharge batteries;
- ground-diagnostics of the UAV systems;
- definition of the *sense* procedure;
- definition of the intentional, illegal intrusion;
- definition of the unintentional, illegal intrusion;
- definition of the alert procedure;
- on-board decision making process;
- ground decision making process;
- conceptual and preliminary desing of the UAV automatic flight control systems;
- definition of the flight plan of the normal flying day;
- definition of the take-off maneouver;
- definition of the cruise/navigation flight phase;
- execution of the flight, data acquisition, data storage, data transmission;
- return-to-home mission of the UAV;
- the landing maneouver;
- state transitions between flight phases;
- definition of the types and forms of the collision avoidance problems;
- management of the energy supply system;
- definition of the loss of thrust problem;
- definition of the onboard failures leading to end of the fligh.

The mentioned above problems does not mean the complex set of its to be solved. Problems of UAV pilot selection and training also in the focus of attention today, and represent an urgent problem to be solved very soon.

6. Conclusions and future work

The multirotor *Night Watchbird UAV System* can represent a new element of the existing military force protection system. Signals and information provided by the UAV recce system can be used by many

staffs requiring them. The most of the system elements still in conceptual phase, there are many legal and technical problems to be solved that way that regulations support new initiatives involved in this concept.

The newest element in multirotor UAV ground taxiing and maneuvering is the wheeled-maneuvers on the UAV platform, and docking for charging batteries.

The proposed autonomous UAV-recce system has privileges highly appreciated by those military leaders responsible for security of the large transit camps of war theatre. As an example, Camp Striker in BIAP, Iraq, had had dozens of thousands of military personnel travelling for R&R, and after returning back to military service. The military techniques available the same time at the base could be counted as techniques of the military brigade, sometimes a division.

The strategic military bases, such as airports can have borderlines measured in dozens of kilometres. It is easily can be determined that conventional force protection can require very large resources, and sometimes can have low efficiency. Force protection of those military bases having static borderlines can be easily improved by using UAV technology widely used and applied for reconnaissance purposes.

The use of UAVs in given force protection problems can meet many problems having no solution till today. For example, detection and identification of the intentional, human intrusion requires definition of the set of biometrical parameters of the human being (e.g. blood pressure, speed of respiration, size of pupils, colour of the face, partial oxygen content of the blood etc.) describing stress of the given person. The problem is that many of those humans are able to manipulate these parameters e.g. able to reduce speed of respiration. It is easy to agree that there are many unconventional problems requiring unconventional solutions.

Future work of the author is to investigate in deep details those problems defined above to support UAV-manufacturers in pre-conceptual, and conceptual design phase of the UAV recce system.

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