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NIGHT WATCHBIRD UAV SYSTEM: AN EFFECTIVE TOOL IMPROVING FORCE PROTECTION CAPABILITIES IN THE WAR THEATRES

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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 application. The special flying abilities of the multirotor UAVs (e.g. vertical take-off and landing, hovering, flying at extremely low altitudes and airspeeds etc.) 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, 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 nightly (or in bad visibility, during the day) to improve efficiency of the solution of the safe-guarding problems, and, also improve efficiency of the solution of the force protection problems, and reduces human resources needed for this purpose.*

Keywords: *UAV, multirotor UAV, Night Watchbird UAV system, force protection, war theatre, conceptual design of air robot systems, system definition, flying and handling qualities of Night Watchbird UAVs.*

1. INTRODUCTION

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, RELATED WORKS

The term *Watchbird* firstly mentioned and used by English writer Robert Sheckley (1928–2005). In his science fiction story written and published in 1967 he described a UAV-based reconnaissance system used in crime prevention actions of the modern societies [1, 2] (Figure 1).

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

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 successful and safe landing [13, 14]. 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 the flight control systems of the UAV. Article [19] deals with design of the optimal flight path design of the UAV.

3. NIGHT VISION SYSTEMS AND IR-IMAGES

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 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.

Fig. 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 base;
- 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, in other words, in 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 MISSSIONS IN DESERT AREA WAR THEATRES

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 is 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.

Fig. 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 colored 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 applying 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. BASIC CONCEPT OF THE NIGHT WATCHBIRD UAV SYSTEM AND REQUIREMENTS

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. This is a key element of the system of requirements.
- definition of the technical parameters of the UAV recce system.
- definition of the UAV flight envelope. The flight envelope predicts many technical parameters of the system, i.e. propulsion system favoured by experts.
- definition of the flying and handling qualities of the UAV recce system. There

are many actions taken by EASA to determine flying and handling qualities of the UAVs applied in public aviation for economical reasons. Worth to mention that there is an existing NATO STANAG 4671 applied by the Military dealing with UAV airworthiness problems.

- definition of the type-, and airworthiness criteria for the UAV recce system. Due to lack of regulations in the field of public (civil) UAV applications, there are new actions taken by international and domestic organizations to compile norms and rules accepted by lawmakers and UAV-experts;
- solution of problems of the airspace management at the national level, as the minimum;
- definition of the ground control station supporting UAV recce system. The ground station is important segment of the UAS system, mainly determined by type of the UAV being flown.
- description of the UAV type. There might be applied the rule of chosing appropriate by parameters UAV.
- definition of the flight phases. The flight must be segmented into flight phases, and into parts of flight phases. The normal flight must be defined, and definition of the emergency flight must be given to separate them, and to create plan of activity and procedures to be followed in emergency flight situation.
- solution of flight safety problems. Flight safety has many aspects starting with technical and finishing with human factors. A new maintenance system must be established involving those aspects of flight safety known from conventional, piloted flights.
- design of the landing zone of the UAV. Landing zone must be safey having enough space for taxiing and ground maneovering of the quadrotor UAV. The UAVs serving at a given platform must have wheels for taxi purposes, and, onboard systems of the UAV must be prepared for solution of the docking problem.
- 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. The OBD-technology applied principally for monitoring the energy supply system of the UAV.
- definition of the *sense* procedure. There are many sensors available for application. Due to main motivation to provide night vision capabilities the sensor unit can be easily defined, and determined.
- definition of the intentional, illegal intrusion. The logical conditions and rules must be outlined, and technical parameters allowing giving such alert might be designed. The military base has check-points to entry human personnel and military techniques, so any intrusion via borderlines can be considered for illegal one.
- definition of the unintentional, illegal intrusion. This is a large dilemma how to design decision making process able to make difference between intentional, and unintentional intrusion. If the military base has weak mechanical defence, or at its borderlines there are missing mechanical defence, an unintentional intrusion into the base can happen.
- definition of the alert procedure. After derivation of the intrusion attributes, an alert signal must be given to duty staff ta take appropriate actions.

- on-board decision making process. If the UAV is prepared for that, on-board evaluation of the information msut be done to give alert signals.
- ground decision making process. If data from the UAV are transmitted to the ground control station, there might be applied an automated 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. Collision avoidance can be defined in following relations: UAV-non UAV aircraft; UAV-UAV; UAV-static objects; UAV-single bird; UAV-swarm of bird. There are many aspects to be considered. The most dangerous avoidance situations must be handled, i.e. the UAV must execute emergency maneuver to avoid collisions.
- definition of the loss of thrust problem. In case of application of the quadrotor UAV, a scenario must be prepared to continue flight mission, or to abort it and execute emergency landing. Flight dynamics and flight performances of the UAV must be evaluated thourougly to make correct decision in this sensitive situation.
- definition of the onboard failures leading to the end of the flight. Very important to have a list of failures leading to aborting flights to provide flight safety at given levels defined in flight maintenance regulations.

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 kilometers. 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, color 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.

It is easy to agree that complexity of the system high level enough so that find solutions to those problems listed above requires wide-range knowledge and skills. For that reason, last year the first Hungarian UAV cluster called 'Unmanned Aerial System Cluster' was established incorporating organizations representing Hungarian Academy of Sciences, institutions from higher education and industrial partners.

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