REQUIREMENTS ON THE AIRY RADIATION, CHEMICAL AND BIOLOGICAL RECONNAISSANCE

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Summary: The article is evaluating nowadays possibilities of airy reconnaissance but also demands on the selection of suitable detectors for determination of radiological, chemical and biological danger/risk. By implementation of these detectors to suitable type of flying carrier – DRON it could help in the future by considerable extent to reengineering the performance of airy radiological, chemical and biological reconnaissance of the terrain but also indoor spaces of industrial halls.

Keywords: Airy radiation, chemical and biological reconnaissance; Unmanned aerial vehicle; Chemical biological radiological and nuclear hazards.

1. INTRODUCTION

Early detection of type and concentration of hazardous chemical agents, batch input of ionization radiation and biological aerosols in the atmosphere are significant procurements in the monitoring. These are usually followed by subsequent procurements. From such reconnaissance we can expect quick information about presence of chemical, biological, radiological and nuclear (CBRN) risks, alternatively explosives chemical, biological, radiological, nuclear and explosives (CBRNE)) and about the borders of endangered area in the environment of interest. Nowadays the main load of CBRNE detection is carried by ground reconnaissance using contact or remote sensors. Well-known physical or chemical principles gives more reliable information during usage of suitable contact methods in comparison with remote ones. In spite of lower reliability of the measurement result they have irreplaceable role during control of large areas or places with limited access for contact detector. However, either remote detection used in ground devices could not provide all the relevant and inevitable information in needed scale: in case of quick monitoring of large areas with limited number of devices, or if there is needed searching of hazardous CBRNE sources in distant ares (out of the reach of remote detectors) to which is limited access, or in the case of secret monitoring. To fulfill such extent of tasks of the CBRNE reconnaissance, there is an offer of effective solution, including integration of contact-less, remote detectors to a suitable device for airy reconnaissance.

Devices of airy reconnaissance enable wide range of applications [1]. Within the CBRNE security and anti-terrorism operations they can effectively participate with expressive effect of classification during searching and localization of illegal production or storing of dangerous materials on large monitored area. At the same time they would enable in due time warn the population, security and rescue services about the place of origin and about the character of the CBRNE threat. After the extensive industrial accidents of escaping of the CBRN contamination or after the CBRN terrorist attack they would offer rapid, enough reliable information about the border of contaminated area and also the quantitative indicators of the contamination in the center of contaminated area. They could also directly participate on supporting the rescue works by searching the areas and routes for rescue services with lower level of CBRN contamination, and simultaneously support the optical reconnaissance. The application of air facility of CBRNE reconnaissance within the military

operations is for some situations very hard replaceable. At the performance of offensive operation could in due time discover prepared chemical traps, conventional mine fields and explosive barriers or installed atomic mines and CBRN munition on the enemy territory. In the environment of international crisis management [2] it could significantly help to discover the mobile facilities preparing for conventional bomb or CBRN attack, or to localize set explosive and aerosol-dispersion CBRN facilities, eventually places of production and storage of dangerous CBRNE materials including also control of inhabited areas under the control of the enemy.

2. CHARACTERIZATION OF CBRNE RISKS AND CARRIERS OF EXPLORATION

From analysis of CBRN-E risks and possible situations of using the airy reconnaissance facility arise that decisive relevance in every mentioned cases will have light facilities of airy CBRNE reconnaissance. These can be used by very flexible and effective manner in needed amounts depending on the situation development and they will also provide sufficiently reliable information for quick tactical decision making. Early reaction on CBRNE danger within the tactical level require operational range of the facility at least 2000 meters, out of the direct observational horizon of controlled area, which could cover also ground remote CBRNE Stand OFF detector. Simultaneously, the tactical facility of airy CBRN-E reconnaissance have to fulfill demanding criteria of caring the CBRNE contact-less detectors and criteria of the data activation.

Using of carriers on the light helicopters basis seems to be advantageous only for monitoring the space after CBRN-E accidents connecting with the escape of the contamination. Their benefit is in large operational reach, sufficiently long time of monitoring and also ability to stay at the controlled point which positively influence the detection reliability. Apart from high price of procuring and operation belongs to disadvantages of such conception lower possibility to perform secret monitoring. The helicopter with human crew for monitoring in very dangerous zones and areas controlled by heavily armed enemy is very easily vulnerable, it means too less suitable for military and safety usage. Other alternative is represented by operated airship. The conception has greatly favorable parameters for remote detectors usage and their monitoring persistence and tactical coverage appear to be ideal for long term and regular monitoring of large secure ares. However low velocity and overall conception limiting it usage for monitoring of the contaminated areas borders and also extreme vulnerability exclude this facility from military applications. Use of specialized CBRNE reconnaissance containers hanging on the battle airplane seems to be ideal facility for military operations. After all it is connected with some limitations.

The use of extremely expensive and fully occupied airplane with human crew or heavy remotely operated airplane fulfilling main battle tasks equipped by CBRNE reconnaissance container belong likely to area of operational and strategic exploration. Such usage is possible only for the states which dispose of airy battle facilities abundance, because additional CBRN reconnaissance container significantly reduce its battle characteristics. High velocity of the battle airplanes require usage of very sophisticated and financially demanding contact-less CBRNE detectors whose technical realization is on the border of nowadays knowledge. Identically, the construction of the container body belongs to technologically complicated and financially demanding elements of the system. On the other hand usage of ultra-light facility of airy reconnaissance the Unmanned aerial vehicle (UAV) fulfill all the requirements for tactical CBRN-E reconnaissance. The most suitable seems to be the conception of DRON [3] or remote controlled helicopter [4]. Such financially little demanding conception enable usage of relatively inexpensive and enough effective CBRNE detectors thus also acquiring the necessary amount of facilities. Less advantageous conception of UAV, which would required because of high velocity of the facility, use very expensive and sophisticated CBRNE detectors with relatively high weight.

Use of UAV in the form of DRON enable usage of contact-less CBRNE detectors recording the terrain perpendicularly down at the condition of data acquisition during hanging or slow flight in the height of 20 – 200 meters. Such easy, relatively simple and financially little demanding detection methods are today in necessary extent handled and it could be assumed that they can be employ in the

think facility. The selection of suitable detection methods will be limited by overall performance of the facility, weight and also the period of monitoring performance considering the energy consumption.

3. DETECTION OF IONIZATION RADIATION

The usage of very effective methods on the principle of gamma spectroscopy using cooled highly pure germanium (HPGe) or NaI (Tl) with PMT (PhotoMultiPlayer tube) whose enable apart from detection of gamma dose also detection of radioisotopes causing contamination, seem not to be convenient for UAV. They are suitable for heavy facilities of airy reconnaissance defined for operational and strategic level. Determination of gamma batch input on the top of terrain surface with the value higher then 10 nSv/h at flight level 30 meters and for energies in the range from 60 keV to 2 MeV enable identically finding the point radioactive sources which have higher activity then value of emitter fall into administrative control in agreement of European legislative and at the same time will be find out all species of relevant radioisotopes with the activity above this limit.

Fulfilling the condition enable the searching of radioactive material within safety operations and at the control of smuggling, just as effective monitoring of contaminated areas and investigation of contamination borders. Such effect is possible to reach by using the plastic oscillator equipped with simple photo-diodes. Plastic oscillator is placed on lower surface of the DRON frame with the area of 0.5 m^2 and will already at acquisition 1 s generating around 100 pulses for ^{226}Ra. Energetic range from 50 keV to 2.5 MeV enable to detect radioactive materials covering the radioisotopes spectra from contamination after the nuclear devices accident, through smuggling of radioactive materials to substances potentially used for producing the "Dirty Bomb". Reliability of the measurement and evaluated result of the batch input is directly proportional to the distance between the source and the detector, therefore the evaluation software must have the actual information about the distance. Exactness is influenced also by the flight velocity. The possible highest precision will be achieved by the hanging, but enough reliable data could be also achieved for higher activities at the velocity up to 20 km/h.

Revealing of nuclear material presence or nuclear explosive facility which usually emitting only weak gamma radiation screen out by the construction of the weapon is usually not possible by using the plastic oscillator. Very effective solution is offered by using the ^{3}He gas tubes which apart from the detection of neutrons characteristic for emission of nuclear material are suitable also for processing of spectral data. Neutron spectroscopy enable to characterize detected source of neutrons and determine if it is nuclear material, industrial emitter or natural source. Use of ^{3}He detector bring complicated solutions for relatively high weight, big sensitivity to mechanical damage and high energy consumption. Application of such detector comes into consideration in heavy operational and strategic facilities of airy reconnaissance. Good sensitivity also provide ^{6}LiI (lithium iodine) oscillator detector of neutrons [5]. Characterized by very small dimensions and low energetic demand. For acquisition of the data is enough 2 s of integration time and sensitivity from 2.5 n/s/cm^2 enable from 30 m distance to detect presence of all kind of neutron sources introducing the risk. However it will not enable their characterization. These parameters though could be judge like sufficient for CBRNE / UAV facility.

4. DETECTION OF CHEMICAL WARFARE AGENTS

From more today used principles of remote detection like for example CO_2 LIDAR, infrared spectroscopy (FTIR / FLIR), spectroscopy by laser excited/ignited beam/plasma (LIBS), seems for UAV the most suitable Raman spectroscopy. It doesn't achieve such big distance of chemical substance detection like in previous cases but it represents technological solution with low weight and high reliability of measurements. For distance 20 – 30 m enables safely detect presence of toxic chemical agents (Chemical weapon agents (CWAs)), most of the precursors for their production, industrial dangerous chemical substances (Toxic industrial chemicals (TICs)), explosives and narcotics. The technology is thus suitable for searching security operations, for monitoring the

accident areas with the escape of dangerous chemical contamination, just as in military operations at searching of contaminated areas, monitoring of mine fields and plant bomb facilities [6].

The principle of the method consist of inflexible scattering of photons of monochromatic irradiation, represented by excited source on the laser basis. The frequency of scattered photons of monochromatic irradiation after the interaction with the molecule of chemical substance change and the Raman spectra is received. Received spectral lines are typical for structure of specific molecule and its functional groups where the size of the signal is dependent on the concentration of substance. In case of suitable choice of the exciting laser wavelength it enables the measurement of the environment for long distance and excitation of the area of interest of substances. The facility of airy CBRN-E reconnaissance will dispose with the tool capable to detect all potential chemical agents represented the threat. Open library of spectra at the same time enable user addition of data about new chemical agents. Part of thinking facility is also remote detector which could provide data for calculation of batch input from detectors of ionization irradiation and also CCD camera suitable for photo-documentation of the measurement place.

5. DETECTION OF BIOLOGICAL WARFARE AGENTS

From all today applied and examined methods the detection of biological aerosols in the atmosphere based on the laser-induced fluorescence (LIF) seems to be the most perspective for UAV. Discovery of biological aerosol containing dangerous particles of biological warfare agents (BWAs) require very high sensitivity and at the same time minimizing of false – positive signal. LIF is based on the excitation of environment excited monochromatic laser source with suitable wavelength in ultraviolet region [7].

Aromatic amino acids like tryptophan, tyrosine and phenlalanine after the excitation subsequently emitting fluorescence irradiation in the visible and ultraviolet region with characteristic maximums. These amino acids are component of cell structures containing proteins thus linear polymers compounded from amino acids bounded by peptic bonds. Native fluorescence of the peptides is dependent on their structure and thus from place where are bounded introduced aromatic amino acids. This factor enable relatively reliably detect dangerous biological agents and differentiate them from signal of background in the aerosol. Efficient detector of biological aerosols with the coverage of hundreds of meters up to kilometers requires usage of Ti-sapphire laser with the adjustable emission 650 – 1100 nm. Also nitrogen laser with UV emission 337.1 nm or argon laser with UV-VIS emission of maximums 488 and 514.5 nm can be applied. With regard to all cases of heavy, expensive and energetically demanding facilities suitable rather for operational and strategic facilities of airy biological reconnaissance. Solution could thus offer cheap semi-conductive lasers with very low weight and low energy demand. Laser diodes emitting energetic bands with the maximums in the region of 375 and 350.9 nm have higher divergence of the beam in comparison with classical source what with low capacity limiting the recording of absorption fluorescence spectra at speculate quantitative yields of fluorescence and lowering the distance of effective detection to approximately 20 m.

6. CBRN-E DETECTORS CARRIER – UAV DRON

Tactical UAV with the conception of DRON for airy CBRN-E reconnaissance is thinking to use within small specialized units and groups of armed forces what kind of are units of remote detection and Sampling and Identification Biological, Chemical, Radiological Agents (SIBCRA), eventually CBRN-EOD teams (Explosive Ordinance Disposal). The application could it find also in special groups of police dealing with discovering the prohibited manipulation with the dangerous CBRNE material and environmental crime. The facility with the weight up to 100 kg [8] could be transported in assembled wrapping on the rooftop of personal terrain vehicle which could be at the same time used as control and fulfilling mobile base. The parameters which are suitable to fulfill are limited mainly by operational coverage minimally 5 km, persistence of 2 hours [9] and avionics including navigation,

remote control or pre-programmed regime with control points, camera for optical reconnaissance, electric or hybrid motor [10], utility loading – CBRN system calculated for 2.7 – 5 kg.

Limiting factor will be also the source of electric energy. Use of rechargeable accumulators which are for example $LiFePO_4$ brings also very high expenses and essential increase in the facility weight. If the source should secure the operation of motors during planned persistence, functional avionics and mainly CBRNE detectors. Moreover this type of accumulators belonging to the top in performance characteristics is very sensitive for collision which could cause an explosion. Solution is provided by application of electro-chemical fuel cell with the proton exchangeable membrane like a source of electric energy [11]. Lightweight and small PEM-FC ensure adequate energy usage in dependence on accessibility of fuel introduced by hydrogen. Storage of hydrogen in the pressurized form or cryogenic is not really functional and it is dangerous. Hydrogen storage in the form of powder hydrides doesn't bring substantially higher effect in comparison with $LiFePO_4$ despite the fact of very safe storing – high weight of exchangeable fillings with metalhydride which could be by the path of service module in the terrain recharge by means of electro-switchboard EC-1 or by solar panel.

Significantly higher effect is introduced by using of liquid fuel on the basis of hydrides which will be directly leaded to PEM-FC. The issue is that safe storage of hydrogen with very big volume in ratio to weight and volume. Fuel substance will be stored in one-time exchangeable reservoirs. Compared to usage of $LiFePO_4$ at the same time keeping the performance could reduce the weight of whole facility about 33 % and the overall time of labor of the electrical energy source on one filling could arise even to 52 %. Nowadays development point out that in short time will be obtained energetically undemanding and portable technology enable regeneration of burned out hydride fuel directly in field conditions by using electro-switchboard EC-1 or solar panel. Accessibility of such process could enable for UAV to construct high-performance hybrid motor – electric-motor / combustion motor on hydrogen for acquiring higher performance in the needed parts of operational duty.

7. CONCLUSION

The evaluation of nowadays possibilities of CBRN detectors on the one hand but also the proposal of utility of UAV with the DRON conception on the other hand enable perform the airy radiological, chemical and biological reconnaissance by small specialized troops and groups of armed forces. To fulfill the demands for hybrid power drive of DRON could help also research of proton interchangeable membrane which is the key component of hydrogen fuel cell. Achieving of required operation parameters of proton interchangeable membrane in the hydrogen fuel cell is intensively studied by the company which statutory representative is first author of this article.

8. LITERATURE LIST

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