REMOTE SENSING USING AUTONOMOUS UAVs SUITABLE FOR LESS DEVELOPED COUNTRIES

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ABSTRACT:

Remote Sensing using Autonomous UAVs is representing the most suitable solution for the Less Developed Countries following our research to develop new civil and commercial UAVs with the basic capabilities for the use in disaster management. Local or regional surveillance using actual satellite systems is both not affordable and more expensive for almost all these countries, therefore we have developed in Romania civil UAVs for commercial use to be controlled by a remote-pilot, with autonomous or self-guidance systems to be used in the actual ATC/ATM architecture of air traffic environment at minimum altitude with very low operational flight costs. The main objectives presented herein can be achieved using state-of-the-art aerospace technology developing aerial platforms with very low costs using also robotic-assembly lines for small or medium size UAVs, which is leading us to the goal of zero maintenance and we still have to develop for the less developed countries Regional Joint Operational Centres to provide all safety flight operation capabilities on the free use of autonomous UAV platforms, preserving security against other kinds of usage for any such civil UAV. Our last objective is to provide solutions for "sense-and-avoid" which is the last main problem of civil UAV before its complete integration in actual ATC/ATM architecture using both the human factors management experience in actual aircraft flight operations and ATC, and to add new onboard systems such as 3D Virtual Proximity Radar Vision Systems (VPRVS) linked with the ground radar systems, which is not suitable for any human flight crew.

1. GENERAL APPROACH

1.1. Introduction

Global problems requires global solutions and global solutions requires local and regional monitoring. Overall, only one third of the planet land is considered as developed world, the rest of the land is in area of less developed countries or is uninhabited. Local and regional surveillance using actual satellite systems is in both cases not affordable and more expensive for almost all Less Developed Countries, due to some important reasons such as: investment recovery required for almost all satellite systems; direct operational costs involved by the use of very expensive ground control centers used for each satellite system during the surveillance activity, based on developed world; software costs; downlink communication and data transfer costs; indirect costs such as third party local brokers, regional exclusivity and IPRs. Therefore, we have developed in Romania civil UAVs only for commercial purposes and use to be controlled by a remote-pilot with autonomous and self-guidance systems, to be operated in actual ATC/ATM architecture of the air traffic environment, at minimum altitude, with very low operational flight costs, in all weather conditions, any time and any where air service systems, suitable for both customised surveillance or monitoring device.
Our purpose to develop affordable commercial UAVs for less developed countries can be achieved by within main objectives:
using state-of-the-art aerospace technology for aerial platforms;
using robotic-assembly lines for small and medium size UAVs;
zero maintenance work principle during the operation life time;
autonomous UAV platforms safety flight operation capabilities;
to develop regional joint operational centres preserving security and complete integration in the actual ATC/ATM architecture;
to provide solutions for "sense-and-avoid" UAV main problem;
to add new onboard systems such as Virtual Proximity Radar Vision Systems and using both the human factors management experience in actual aircraft flight operations and ATC/ATM.
This paper is looking to provide both the general and practical guidelines as basic tools for the development of future projects and regional cooperation for a direct access to advanced remote sensing technology, UAV based, for Less Developed Countries.

2. BASIC OBJECTIVES

1.2. State-of-the-art aerial platforms aerospace technology

The access to a state-of-the-art aerospace technology and UAVs for all Less developed Countries is an important political issue, that is based on old cold war principles providing restrictions in general terms with the purpose of preserving national security.
This old national and regional politic approach is today in the direct conflict with free global trade principles, and provides all difficulties related to global solutions of actual problems related to disaster prevention, management or environment monitoring, and remote sensing for surveillance in fires or preserving forest.
Providing access to state-of-the-art aerospace technology in our opinion is the guaranty for: low costs remote sensing services in general terms due to the market size at global scale, and high number of users and applications of expensive technologies, in addition to the valuable improvements due to the cooperation in regional projects or covering wide areas sometime uninhabited.
There is only one roadmap and with a strategic research agenda which is done by the European Commission within two projects UAVNET and CAPECON for the civil and commercial UAVs systems in by 25 nations leading aerospace company providing support to our conclusion access to UAV aerospace technology.
There are also the other roadmaps leading UAVs technology to different directions, UCAV, for next decade up to 2020 or even later 2040 which are oriented exclusively for military purposes, for combat missions using autonomous UAVs, restricting and prohibiting civil use of UAVs aerospace technology for many years, and less developed countries are casualties of this policy.
This a waste of valuable resources in our opinion for the simple reasons that we have developed low costs countermeasures for any such UCAV systems, during 2001 and 2002 mainly for and after September 11th attack published and available world wide
In Information Society Technologies, sharing of knowledge and transfer of know-how are the basic tools required by global problems and solutions for the simple reason of that, one person can not be in two places in the same time solving similar issues.
We have a limited number of experts and resources, but we have an unlimited number of problems any time at global scale.

Approaching a global problem and development in a linear step by step algorithm will take to much time, efforts and resources, that is like turning down a fire by circling around and spreading water, it doesn't work like that must be turnout by all directions. Regional surveillance and remote sensing monitoring are better to be performed by equipment with high quality able to provide appropriate data and information that can be retrieved later and copied, read, simulate to provide good evidence and full details. Performing surveillance with poor, inappropriate equipment is a waste of resources, time, efforts, useful data, and information. Therefore, using state-of-the-art aerospace technology for UAV aerial platforms is more suitable for less developed countries in addition to several other advantages such as: saving money and time, maintaining overall operational costs low, using multiple sensors and observation points it is better, as compared with single and very expensive, that is better for monitoring system reliability environmentally friendly and also available any time.

1.3. Low Cost Remote Sensing using Autonomous UAVs

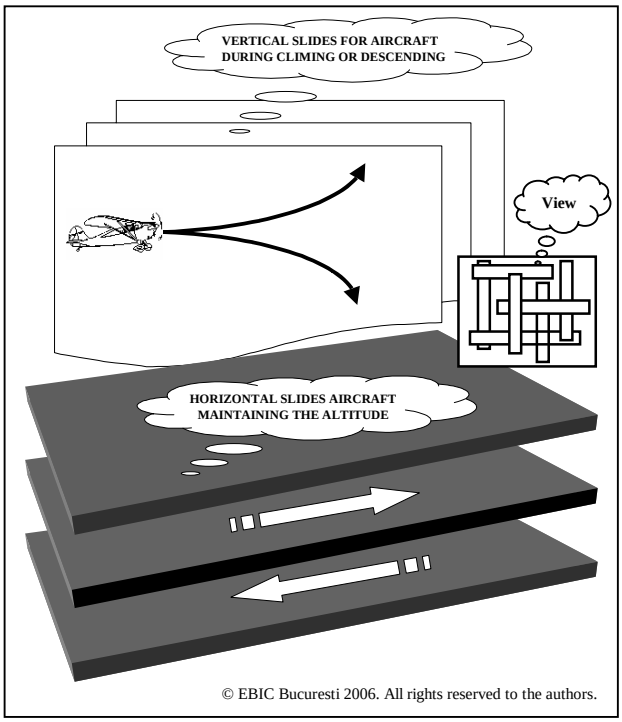
Local or regional surveillance using civil UAVs for commercial use is suitable and affordable for the less developed countries in sense that these products are well design for repetitive or simple tasks able to be controlled by the remote-pilot with autonomous or self-guidance systems, using both ground based navigation systems and GPS, loaded in onboard computer, providing data to the autopilot, maintaining altitude as any aircraft, performing take-off and landing, in all weather conditions, similar as these are done by any aircraft, or even better due to the missing pilot. In addition to the direct flight operations cost's cut on pilot-less UAVs, the missing pilot in the flight deck is also an advantage for reducing airport's landing minima, in zero vertical visibility, all weather flight capabilities, and low level of stress or fatigue. More then 80% of actual approach and landing operations are done using autonomous systems onboard of commercial aircraft that is a good statistics for almost 200,000 landings every hour, which can prove that we have the aerospace technology level in the air transport industry required for step change to civil UAV. Remote-pilot principle using experienced commercial pilots is required in the future ATC/ATM architecture development in cases of incapacitated pilots, loss of aircraft control, highjack, difficult weather conditions, future airport approach procedures providing fresh pilot capabilities during the most difficult flight procedure that is landing following a very long flight operation and that is autonomous flight joint operation with remote-pilot. Remote sensing, aerial monitoring and surveillance are not very attractive for human experienced pilots due to low incomes and the indirect fatigue induced and generated by the great number of repetitive flight paths, and reduced level of variation during flight configuration or requirements for precision flight profile in order to obtain accurate measurements, data and information. In addition to these some other flights such as over the disaster areas can be very stressful for pilots due to the impact of death to human factor and the request for help form disaster victims in case such help is not provided for safety and security reasons or general interference between flight crew and disaster victims. Overloading the aircraft or overloading the flight crew operated in remote areas following the disaster events in rescue missions, are also results of over-reacting human factors in disaster cases which can lead to loss of aircraft control, waste of time, deaths. Autonomous UAVs in stand-by mode deployed before disaster events in the most sensitive or on high risk areas, ready to start surveillance mission by self-guidance launch/take-off systems is more appropriate then any SAR remote aircraft or helicopter. Remote sensing, aerial monitoring or surveillance using UAVs in the less developed countries based on pre-deployed systems is more suitable due to the low costs and time response, wide area coverage, available any time any where and in all weather in addition to low risk operations, improving safety or security. Using our commercial aircraft experience of the last decade, the autonomous UAVs can be integrated in the actual ATC/ATM architecture of air traffic environment with low operational cost while actual satellite systems is both not affordable and more expensive, not available, unable to see due to clouds, emissions.

1.4. "Sense-and-avoid" solutions for ATC/ATM integration

The European Defence Agency has published a call for tenders for a technology demonstration study on the "sense-and-avoid" technologies for long endurance unmanned air vehicles (see: OJ No S 141-139739 of 23.7.2005). In the contract requests there were: definition of potential technical solutions for UAVs and simulation of these solutions, taking into consideration onboard situation awareness and submitted common operational picture as well as the path and the mission de-conflicting; definition of safety case in general configuration; definition of the separate requirements for sense and for avoid; assessment of impact on actual air traffic management (ATM) procedures; the detailed mapping of existing EU regulations and UAV's specificities; definition of complementary equipment (cooperative and non-cooperative) for the civilian air traffic insertion. The budget allocation for this demo study was a maximum of 750,000 euro. Where is the problem ? We have the same problem for both the military or civil UAVs that is on short - ATC/ATM integration. Why ? Was never done before, and because we can avoid what we can see, but there is no pilot there to see that or to decide it. This logic approach is then leading us to two problems on how to see, and who takes the decision, the remote-pilot or the ATC. After that a very smart expert was asking that what if we have a third party involved there such as an aircraft with radio contact, and its pilot is doing an error during approach or by his TCAS. At the end the FAA have decided no civil UAV approach cities. Before to provide any technical solution, lets go back and reset the problem, because was created by the Pentagon's decision to use the military UAVs with a take-off and landing priority that is against the International Air Law, Chicago Convention 1945. In simple words, for take-off and landing the PREDATOR will climb and descend crossing several civil and commercial routes and airways of the civil aircraft (a passageway used for airline), and based on national security grounds the UAVs has a priority to pass before all the piloted aircraft with passengers on board ! In the International Air Law is set very clear other way around. Traffic Alert Collision Avoidance Systems (TCAS) are used by both the military and civil aircraft to avoid mid air collisions and will be also used onboard of civil and commercial UAVs as well, but TCAS was design exclusiv for human pilots and very often is entering in conflicts with ATC and the aircraft autopilot and few mid air collisions were happened exactly due to TCAS. As expert on human factors management of EC in Aeronautics is my obligation to provide you with the evidences of two latent failures in that general management related to sense-and-avoid. Civil and commercial UAV are state-of-the-art advanced robots and we must not transfer all the human factors errors within the UAV's systems by chance or by negligence and after that to call ATC/ATM to fix it or either to blame the remote-pilot for that. Sense-and-avoid solutions for ATC/ATM integration must have a support on civil aviation regulation which is our experienced basic tool providing no change on the common rules of the sky.

1.5. New device 3D Virtual Proximity Radar Vision System

When changes are made in the rules of using sky, human errors are following that, the old status will stay a period of time, due to our experience which in this case is not our very good friend. If we will be able to maintain rules of priority only for aircraft following the air law, then we will have to make available for civil UAVs 3D Virtual Proximity Radar Vision System, linked with ATC ground radar's systems, which is not suitable for any human flight crew and it is not made to be used by ATC either. Where this new device is coming from? This is our re-design of old proposal made during the creation of the human factors and crew resource management few years ago by which interalia the pilot must have access to real ATC radar images in flight decks. That was rejected, because the amount of data and information alone from that source is too much for the human pilot, leaving no time available to perform the main tasks of his works flying that aircraft. This reason is not available for UAV's autopilot or its onboard computer, which can be more then only one system. In simple words, the onboard computers will have appropriate software to create a 3D Virtual Vision using its GPS reference position as first center of virtual vision and the proximity radar data and position as secondary center of the same virtual vision. This 3D virtual proximity radar vision system will consist of a set of memory layers creating vertical and horizontal slides with all aircraft around. The virtual vertical slides are for any aircraft during take-off and landing and the virtual horizontal slides for aircraft maintaining altitude. The autonomous UAV will choose in case of any emergency to fly through the halls areas avoiding any aircraft in mid air and providing ATC radar with alternative solutions, in order to inform traffic controller and to let him to choose or to take the final decision final, faster as remote-pilot. The trajectory for autonomous UAV without radio contact will be only by written navigation messages resent to a remote-pilot. This is a real-time navigation box support for both autonomous UAV and ATC/ATM, including the remote-pilot, leaving all options available for last decision, in advance by a remote-pilot, or during take-off and landing operation, final decision to ATC.



1.6. Regional Joint Operational Centres preserving security

The future commercial use of UAVs in the remote areas of less developed countries requires additional safe-security measures to avoid the use of such autonomous aerial platforms in any future terrorist actions generating threats to citizens and society. These safe guards are also required to have market development which is a key aspect for large number of products to assure the area cover on-going monitoring any time any where at low cost. For this good reason of preserving security during the civil use of autonomous UAVs, EBIC have made proposals to create and developed the best operational models and practical guidelines for regional operational coordination centers with appropriate management system to guaranty safety and security for civil use both knowledge and know-how will be transfer by franchising. Few objectives in preserving security and improving safety are:
- only commercial pilots with experience can be remote-pilots;
- remote-pilots must not be employees of the UAV's end-users;
- end-users will not be principal owners of autonomous UAVs;
- the legal right for the UAV use will be provided by a licence;
- the end-user is free to use UAV only for commercial purpose;
- at the end of the UAV's life time the hardware will be return to the original manufacturer or to regional operational centers;
- maintenance and repairs will be perform by modular changes;
- communications, remote-control software, navigation systems and security equipment will not be available for the end-users.

The main advantage of starting commercial flight operations for autonomous UAVs in regional areas of less developed countries by franchise is on providing UAV's service standardisation for flight procedures, remote-pilots, maintenance, safety or security and also maintaining low level for the overall operational costs. Consequently, that idea for Regional Joint Operational Centres proposed by European Business Innovation & Research Center in Bucuresti, will have to provide few of the following services:
- UAV operational flight manuals, safety and security manuals;
- UAV maintenance and repairs manual, remote-pilot training;
- Standards for regional and local UAV remote control centers;
- Joint coordination and monitoring of all regional UAV flights;
- Pilots selection, proposals for remote-pilot license, assistance;
- Regional service assistance for the end user and UAV leasing.

Regional Joint Operational Centers can be organised similar as EUROCONTROL and EASA and will cooperate with both of these organisations including local national aviation authorities. The UAV Regional Joint Operational Center will be created for the areas as South-East of EU including several countries such as Hungary, Romania, Bulgaria, Greece, Black Sea and Turkey. In this new Regional Joint Operational Center will be included organisations from all of the above countries including also the important participation of other organisations from associated countries such as IAI from Israel, participation required due to security issues and factors in that area which are related to the remote sensing or surveillance activity over borders for several states in the proximity of the security areas impozed by Israel. One important mission for the UAV Regional Joint Operational Center is to tackle surveillance activity issue within relationship with different local national authorities for these restricted areas and to find appropriate procedures in coordination of UAV's flights over, from and passing such areas without any prejudice in performing uninterrupted commercial service operations and in maintaining restriction to sensitive data or local information. Preventing objective considerations of flying autonomous UAV over the security zone and maintaining regulation for safety and security is the main task of a Regional Joint Operational Center.

1.7. Zero maintenance works principle for aerial platforms

Low costs for autonomous UAVs are provided by some factors such as: a single remote pilot instead of two pilots on board, no pilots also reducing safety limitations and increased operational

capabilities, all weather flight operation available day and night and no restrictions in weekend and no line or hard maintenance. European Commission in Thematic Priority of Aeronautics and Space 1.3.1. Strengthening Competitiveness, Work Programme 2002 – 2006, for the aeronautic research at the European level, principle of "zero maintenance works" for future aircraft was proposed with main purpose to reduce direct maintenance costs. In addition to that more other requirements have been included:
- smart maintenance systems including self-inspection and self-repair capabilities with continuous health and usage monitoring
- methods and systems in support of failure or damage tolerance
- maintenance systems for structural integrity of ageing aircraft;
- maintenance processes with low or zero harmful emissions.

There is a principle in Human Factors Management for aviation applicable in aircraft maintenance and repairs activities that any human intervention to maintain, change and repair can be a risk to indirect systems or can produce by error additional damages. In conclusion, you can fix one, but a human error can generate an other one, to minimise that risk we need to reduce all human interventions to the aircraft and its system to zero if is possible. How to do that? It is more difficult for actual aircraft systems, but can be done very easy on UAVs structures using advanced modelling and integrated design, mock-up design, simulation and virtual prototyping, product engineering and development. Introducing smart materials, micro-sensor and nanotechnology, life-cycle based product definition with knowledge-based in the advance design tools and methods using concurent engineering. Modular design is very easy to be used for autonomous UAVs, due to the reduce size, weight, complexity, using new materials and by advanced modelling to create interchangeable elements of basic structures such wings, engines units and fuselage parts. During the maintenance and repairs works the only activity allowed will be to assemble and change fabricated components. The main component structures will be divided in smaller units and each unit will be a stand alone sub-component and system at the end for each such modular unit will be specific producers and that will increase product quality allowing multi-enterprise network system to provide low cost work in aerospace industry. Following this approach for zero maintenance work all systems of an UAV must be able to be changed easy instant with no cost if is possible and even more each such component is recyclable. Reducing costs, time and risks for human errors during repairs or maintenance are valuable objectives applicable in UAV case and later based on this experience the transfer to aircraft is easy. In addition to the above considerations to achieve zero work for maintenance can be done based on differences between systems on the autonomous UAVs such as: avionics, propulsion systems and power systems, different sensors, communication systems, navigation systems, safety recovery systems, back-up systems.

1.8. Robotic-assembly lines for small or medium size UAVs

Affordable costs for Less Developed Countries is requiring also low costs for the UAVs aerial platforms product manufacturing. European Commission in Thematic Priority of Aeronautics and Space 1.3.1. Strengthening Competitiveness, Work Programme 2002 – 2006, for the aeronautic research at the European level, principle of "automated processes and assembly" for future aircraft was proposed with purpose to reduce production costs. Following the modular design to reduce all maintenance works, to produce stand alone sub-component or systems at low costs is very easy to be produced using robotic-assembly lines that si able to provide high level of accuracy, precision, quality and is more important for the achievement of the total interchangeable criteria for all main components, systems and sub-components. UAVs product development multi-enterprise network system to provide high level of accuracy, precision, quality for specific parts or components is the key for using robotic-assembly lines.

1.9. Conclusions

Autonomous UAVs will be used by less developed countries in specific areas to provide data or information for border control, disaster monitoring, floods, forest fires, pollution, agriculture, earthquake early warnings, weather forecast, aerial support, etc. Local and regional surveillance using actual satellite systems in some cases is not affordable and more expensive for almost all less developed countries, and we must provide them with more suitable and low cost alternatives such as the autonomous UAV and free access to the state-of-the-art aerospace technology that is in our interest by increasing the market and reducing all costs which is the support for a future global industrial development. Providing help and support for these countries we are helping all by creating the common bases for sustainable developments. All the components presented in general terms herein this essay are linked and connected by the process of UAV's development with one main purpose to create a state-of-the-art UAV system, to provide assistance and coordination for flight operations and to perform remote sensing, surveillance, monitoring air services in all weather conditions, any time, any where and at low costs.

Definition:
"Sense-and-avoid" the capability to detect conflicting traffic and the ability to take the appropriate action necessary to avoid mid air collisions - Source: NASA, Access 5 Partnership, 2005.

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