PROJECT OVERVIEW
(18th December 2007)

TECHNOLOGY DEMONSTRATION STUDY ON SENSE & AVOID TECHNOLOGIES FOR LONG ENDURANCE UNMANNED AERIAL VEHICLES

1. BACKGROUND

This document summarises the scope, implementation and key results of the *"Technology Demonstration Study on Sense & Avoid (S&A) Technologies for Long-endurance Unmanned Aerial Vehicles (LE UAVs)"* project carried out in the frame of the European Defence Agency (EDA) contract 05-R&T-003. The study was one of the two technology areas selected from an initial list of more than 10 critical technologies of interest to the pMS for technology demonstration studies funded by the Agency. S&A technologies were already key issues for the operation and training of LE UAVs when decision was made on launching the study, and its importance has significantly grown in view of recent new initiatives, such as insertion of UAVs into general air traffic, a new Ad Hoc B Category Project idea (Midair Collision Avoidance System for UAVs – MIDCAS), and UAV standardization efforts.

The study was officially launched by EDA on 21 June 2005. Following a routine competitive tendering process, in which 13 candidatures were received, the contract was awarded on 16 February 2006 to a consortium composed of SAGEM DS as prime contractor with ONERA, ESPELSA and TNO as co-contractors. The 16.5 month study was started with a Kick-off Meeting on 22 March 2006 and was completed with the Final Presentation on 13 November 2007.

1.1. Study scope

The main scope of the study was to define a technical solution in 'Sense and Avoid Technologies' for LE UAVs, in short and medium term as well, in order to integrate LE UAVs into civilian air traffic and to enable more frequent use of UAVs in crisis management operations. The study was focussed on the feasibility of S&A solutions allowing LE UAVs to avoid mid-air collisions with other airspace users, taking into account technological, regulatory and certification aspects. The consideration of the safety objective was also important, knowing that the fulfilment of such an objective – commonly called ELOS (Equivalent Level of Safety), 'equivalent' being taken as a reference to manned aviation – would have to be demonstrated before a UAV flight authorisation could be granted.

1.2. Focus taken

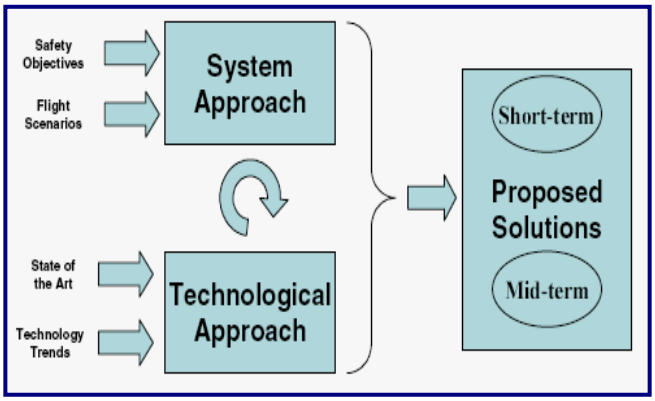
To meet the main objective mentioned above, following specific tasks have been determined for the contractors to be carried out:

- mapping of the applicable regulations,
- definition of requirements for S&A systems of LE UAVs,
- definition of potential solutions based on the requirements established in the previous step,
- testing the proposed technical solutions by means of simulation,
- assessment of the impact of the implementation of the proposed potential solutions on the future use of LE UAVs, the Air Traffic Management (ATM) procedures and safety considerations.

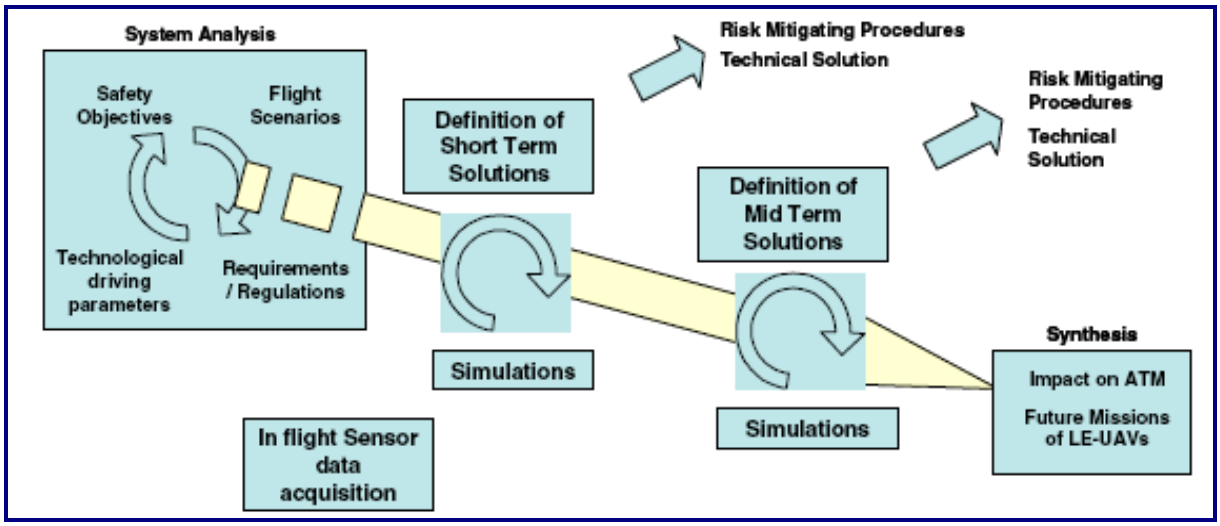
2. IMPLEMENTATION

2.1. Approach used

To achieve study aims in such a short timeframe, required by EDA, a two-way study approach was applied by the contractors, a combination of system and technological approaches, in order to establish a first realistic set of quantitative requirements, necessary to define and compare the different candidate solutions. The approach provided fully comprehensive short and mid term combined technical solutions for the S&A problem.



The enclosed figures illustrate essential elements of the two-way approach and overall logic as well as implementation process of the study.



2.2. Definition of potential short term solution

As no data were available from regulatory bodies, the contractors used its knowledge of the use of the airspace by manned aircraft and UAVs, combined with results of studies dealing with the insertion of UAVs in non-segregated airspace, in order to define safety objectives and establish quantitative requirements for the S&A system. The definition of the best-suited short-term solution for the sense function results from a feasibility assessment process, taking into account system considerations based on the analysis of the requirements and an assessment of the capabilities of candidate technologies. In the first step “single technology” solutions, capable to fulfil requirements, were assessed. In the second step system issues were addressed, mainly analysing the intruder detection distance performances versus the requirements and looking at an optimisation of the sensor architecture. The sense sub-function was defined by its output: the intruder trajectory assessment and the avoid function is relative to the classification of intruders (according to their threat level) and the implementation of alter course or avoidance manoeuvres.

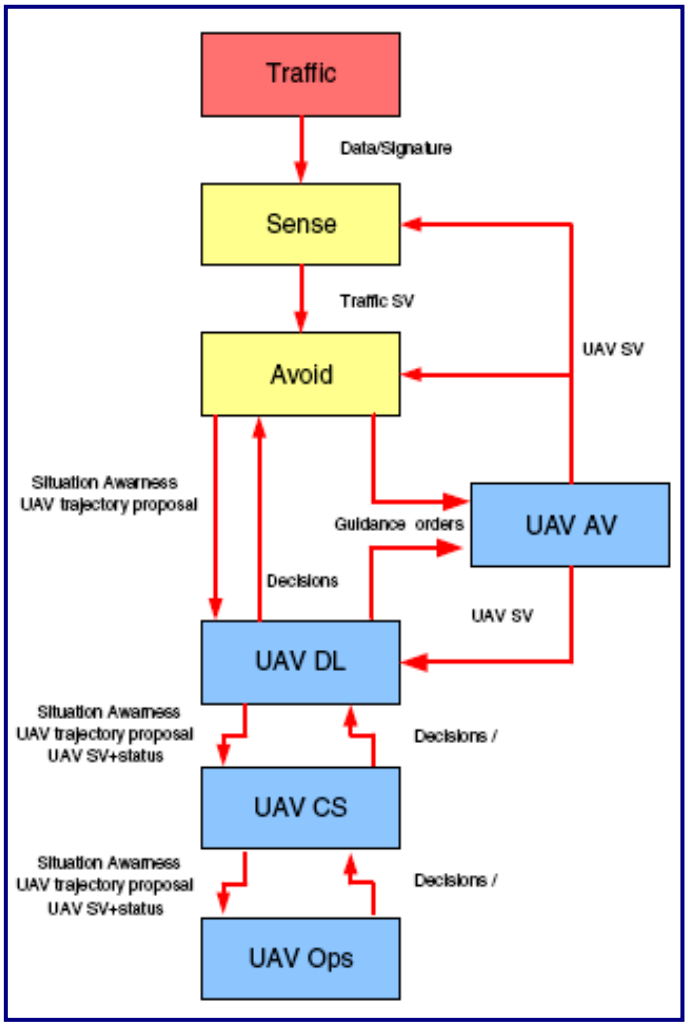
3. ESSENTIAL RESULTS

The study has demonstrated the feasibility of a mid-air collision avoidance system for LE UAVs within a 6-8 years timeframe, and following its certification the system may be available in 2013-2015. Besides the general conclusion it can be stated that:

- development of new technologies are not needed, but complementary developments and engineering are required to provide a UAV-specific S&A system and its full integration into the UAV airframe,
- in order to achieve the equivalent level of safety with manned aviation, the system should contain non-cooperative sensors and cooperative equipment as well,
- the non-cooperative part of the system should be based on a combined architecture consisting of radar and IR sensors.

3.1. Mapping of regulations

The manned aviation regulatory frame remains the most relevant regulatory basis to derive the requirements applicable to the mid-air collision avoidance function. Some national and European initiatives concerning the insertion of UAVs in non-segregated airspace have produced valuable documents including recommendations and requirements but they have not yet reached the status of internationally valid regulations. The most recent document is the EUROCONTROL specification for the use of military UAVs as operational air traffic outside segregated airspace which has been approved for publication in October 2007.



3.2. Requirements and architecture

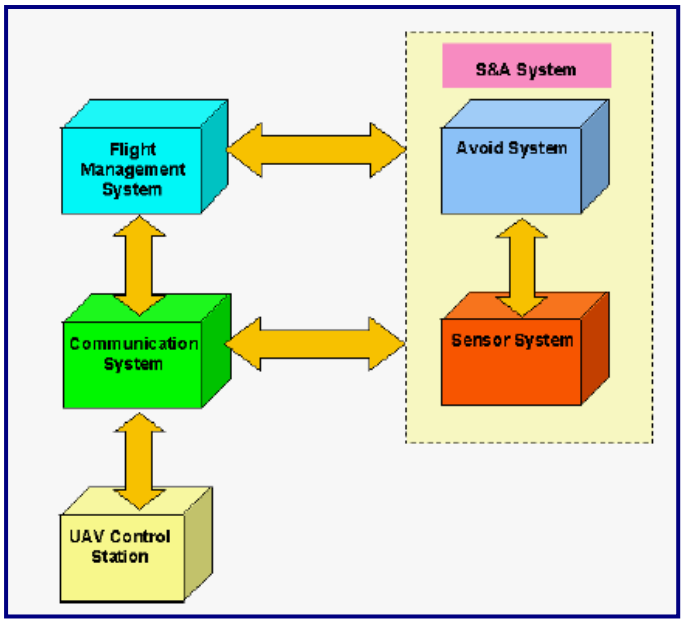
Only a very few quantified requirements could be generated using the existing applicable regulatory frame. Contractors' expertise and results of similar studies were mostly used for the establishment of requirements and the generation of flight scenarios. In the face of difficulties a set of realistic quantitative requirements were established for the S&A solutions to be developed. However, it is clearly the responsibility of the relevant regulatory bodies to define the value of these parameters before they become applicable. The proposed S&A architecture, incorporating a combination of automatic and Man in the Loop elements, is demonstrated in the enclosed figure.

3.3. Potential solutions

The proposed short-term solution is mainly based on EO/IR sensors, complemented with a radar sensor and a transponder interrogator. The mid term EO/IR, laser and radar technological improvements will directly lead to improvements of this combined solution. They will be relative to performances, integration features and reliability. The performances of the proposed solutions should be improved in limited/poor weather conditions or on complex clutter traffic.

The integration will be easier in long term due to the reduction of the number of EO/IR sensors (using pixel size reduction and larger IR detector): it would be possible to cover the field of regard with 5 sensors in the mid term solution instead of 10 in the short term solution. The use of conformal radar antennas also leads to an easier integration on the UAV in a longer timescale. The reduction of the number of sensors will also improve the reliability of the complete system, since less electronics is required.

Avoid function has been defined as the ability to detect and forecast conflictive situations and make decisions intended to solve the conflict. Conflictive situations are reached when the distance between the UAV and other airspace user is lower than a predefined safety distance. To perform that task, avoid function receives information from the sense function. Simulations confirmed that the proposed avoid logic is valid and to demonstrate the feasibility of alter course and avoidance manoeuvres compliant with the application of the ICAO right of way rules. Further optimisation will be required to take into account the definitive sense system and LE UAV characteristics.



According to the previous specifications and potential architecture, the S&A system will be an onboard system, interchanging information with other LE UAV systems and with pilot-in-command, as shown in the figure.

3.4. Simulations and flight tests

Simulations provided the performance assessment of the non-cooperative sensors and the avoid function as well as supported the feasibility process leading to the definition of the proposed technical solutions. Flight tests contributed to the characterisation of proposed sensors in order to support the sensor simulation tasks.

3.5. UAV integration impacts on ATM

As a first step, it has been suggested that LE UAVs should fly IFR in airspace where ATM traffic separation is provided by ATC. Even if the proposed S&A solutions have the capability for traffic separation, it would allow gaining UAV flight experience in non-segregated airspace in a safer

environment. This first step would bring significant additional flight capabilities compared to flights in segregated airspace and would probably help the UAV flight acceptability by the public and other airspace users (manned pilots, ATC controllers…). Flight in uncontrolled airspace could occur after a positive feedback from operations in controlled airspace.

Taken all round, it seems that the present ATM environment is able to manage the introduction of LE UAVs. Many situations can be managed in the same way as they are for manned aviation or with limited adaptations. Some propositions have also been made to ease the UAV introduction in non-segregated airspace. All these issues should be reviewed and discussed further with manned aviation stakeholders.

3.6. Future use of LE UAVs

A first analysis shows that LE UAVs not fitted with a S&A system will most probably require the use of a chase aircraft with a UAV operator on board to maintain a visual surveillance of other aircraft. This is the current way most of the UAVs are presently flying in non-segregated airspace, particularly in the USA. The primary goal of using a S&A system is to not anymore require the use of a chase aircraft and to allow really using LE UAVs for Dull, Dirty and Dangerous (D3) missions. The future introduction of LE UAVs in non-segregated airspace, without using a chase aircraft, is highly dependent on the global S&A system availability timeframe. Technology, certification and regulatory issues have been reviewed in order to provide a realistic assessment of this global timeframe. It is projected that a 6-8 years timeframe will be necessary to develop and certify such a system, demonstrate safety and grant an authorisation for LE UAVs flights in non-segregated airspace. The first step of the UAV insertion should be made in controlled airspace where traffic separation is the responsibility of ATC in most cases.

4. PROPOSED WAY FORWARD

The following efforts are proposed to realise the recommendations of the study:

- insertion of UAVs into the general air traffic may be achieved only by the involvement and close cooperation of all the stakeholders (manned aviation regulatory authorities, standardization working groups, airspace users etc.),
- regulatory framework for UAV traffic insertion should be tackled in a very short time to provide unrestricted use of UAVs in conjunction with other airspace users,
- taking into consideration the great numbers of stakeholders and issues to be solved in relatively short term (definition of safety requirements, modification of regulations, technology/engineering works, system certification, standardization etc.), closely coordinated and controlled actions are required.

5. CONCLUSIONS

The completed study provides an extensive overview of S&A technologies for LE UAVs and relating regulation/certification issues as well as defines feasible short and mid term technical solutions in detail. It may serve as a basis to other initiatives in the S&A technology area, especially to those mentioned in the *"Background"* section.

LIST OF ABBREVIATIONS

ATM Air Traffic Management
ATC Air Traffic Control
AV Air Vehicle
CS Control Station
D3 Dull, Dirty and Dangerous
EDA European Defence Agency
ELOS Equivalent Level of Safety
EO Electro optic
EUROCONTROL European Organisation for the Safety of Air Navigation
ICAO International Civil Aviation Organization
IFR Instrument Flight Rules
IR Infrared
LE UAVs Long-endurance Unmanned Aerial Vehicles
MIDCAS Midair Collision Avoidance System
pMS Participating Member States
R&T Research & Technology
S&A Sense & Avoid
SV State Vector
Ops Operations

FURTHER INFORMATION

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