THE MIDCAS PROJECT

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Abstract

MIDCAS is a 4 year long European project funded by Sweden, France, Germany, Italy, and Spain, managed under the umbrella of the European Defence Agency and achieved by a consortium of 13 companies from the 5 above nations. Started in September 2009, its goal is to demonstrate the baseline of acceptable solutions for the critical UAS self separation and midair collision avoidance functions which are considered as the most challenging issues towards seamless integration of UAS in non segregated airspace.

Fig. 1. The goal of MIDCAS is integration of UAS in non segregated airspace

1 Project background

An initiating factor for the MIDCAS project was an increasing demand for military and governmental UAS non segregated airspace operations for:

- Military training and ferry flights
- Homeland security and civil security applications

Several European MoDs together with EDA initiated building a Sense & Avoid (S&A) project in 2007 and eventually 5 nations and 13 industries joined the project. The basic idea was to expand on previous European and national studies and projects in this field. Starting point for deriving requirements would be existing reference documents such as the EUROCONTROL specification for military UAS flying OAT.

After an extensive preparation phase the MIDCAS contract was signed at the Paris Air Show in June 2009.

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The consortium partners are:

- Saab (lead)
- Sagem
- Thales
- Diehl
- DLR
- EADS
- ESG
- Alenia
- CIRA
- Selex Comms
- Selex Galileo
- Selex SI
- Indra

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2 Sense & Avoid

The operation of Unmanned Airborne Systems (UAS) as of today would benefit substantially from common and accepted standards of operation to enable an integration of unmanned air traffic into non segregated airspace. Non segregated airspace is the widely used term for airspace where all traffic, including civil traffic is authorized to fly, and where both manned and unmanned traffic will need to be integrated according to established procedures.

Sense & Avoid is defined as the process of determining the presence of potential mid-air collision threats and maneuvering clear of them. For all air traffic as of today several layers of protection against mid-air collisions exists. Typically, these layers are categorized in three; Strategic conflict management, Separation provision and Collision avoidance.

The first layer, Strategic conflict management, is made up of procedures, regulations, flight plans etc. to separate traffic. Separation provision is performed either by ATC or by the pilot depending on airspace class and flight rules and may be categorized as “Do not scare other airspace users”.

The inner most safety layer is the Collision avoidance function, which may be categorized as “Do not scrape paint”. This ultimate responsibility for avoiding collisions always lies with the pilot in all classes of airspace. In “manned” aviation, this is mainly performed by the pilots ability to “See & Avoid”, i.e. the pilots eyes and his/hers ability to perform the correct decision and correct action to maneuver clear of the threat.

The pilot's responsibility to "See & Avoid" needs an equivalent mechanism in unmanned systems; i.e. a Sense & Avoid system to determine the presence of potential collision threats and maneuvering clear of them. The global interest in flying unmanned vehicles in non segregated air space has thus led to an urgent need for new technologies together with a standardized set of requirements in order to get acceptance for operation with all kinds of air traffic, civilian and military, in all different classes of air space.

To solve this important issue for future air traffic, numerous efforts have been made at national level to identify and develop technologies for S&A, some of which have been demonstrated in the recent years. However, to reach a common view on requirements and operation together with the acceptance for the solution(s) to the S&A issue, a united effort is required where existing knowledge and conclusions are put together with a European and global perspective.

3 MIDCAS

The purpose of MIDCAS (Mid-air Collision Avoidance System) is to identify adequate technology, contribute to standardization and demonstrate a Sense & Avoid system for UAS able to fulfil the requirements for traffic separation and mid air collision avoidance in non segregated airspace. The intention is to demonstrate by actually flying a UAS in non segregated airspace at the end of the project, where the process of approval together with national Civil Aviation Authority (CAA) for such a flight will be one of the main contributions to the standardization work.

The project will be conducted in close cooperation with European regulatory bodies to provide the technical background for them to establish Sense & Avoid standards, hence standards and solutions need to progress in parallel. The project therefore will use an “interactive” dialogue with major stakeholders (both official services and industries) to inform about the progress of the work and allow for stakeholder feedback, in close connection with the works of standardization groups like EUROCAE.

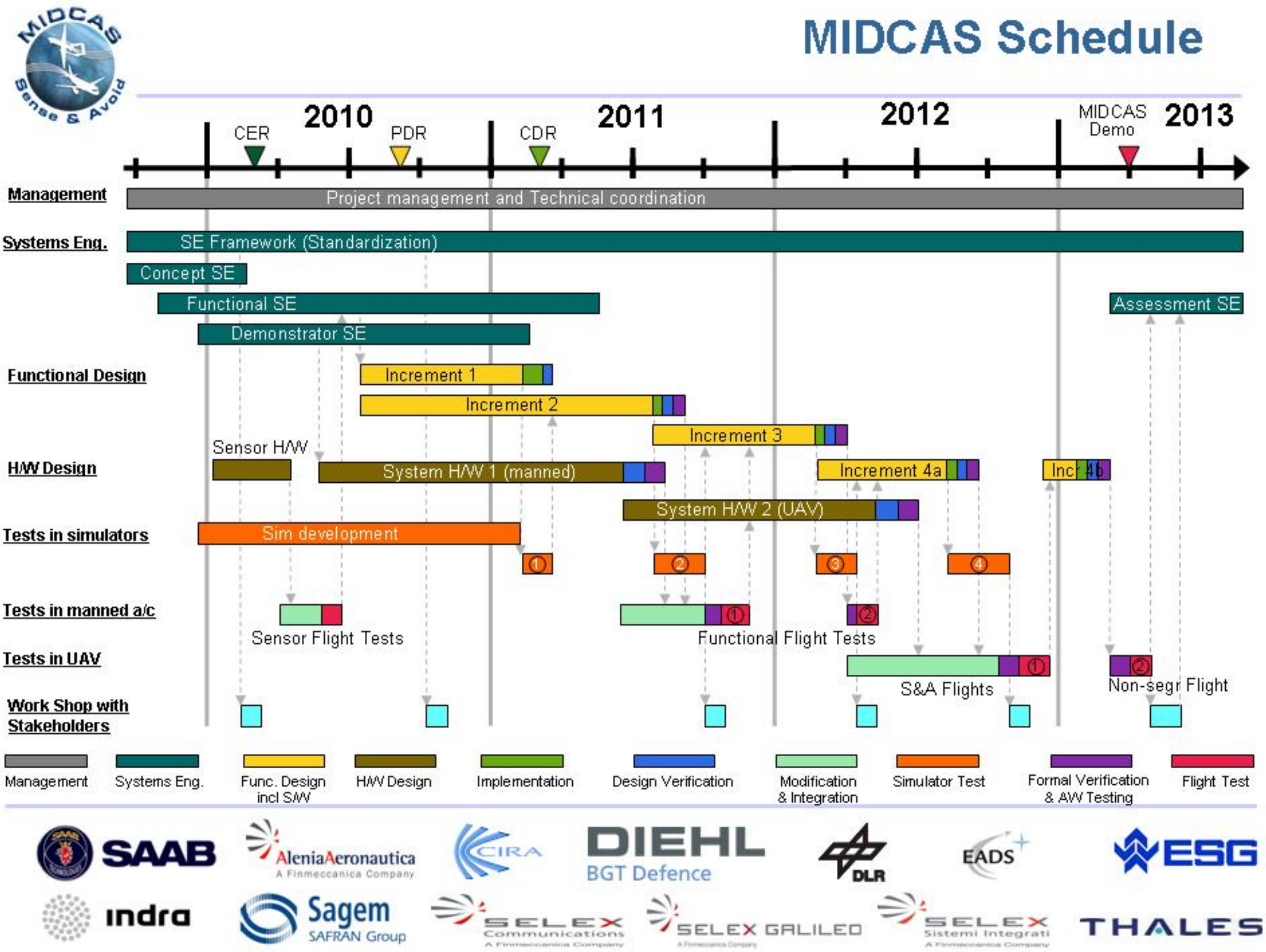

Fig. 2. MIDCAS overall schedule

The project logic will to a large extent be based on the development of a safety case which in turn will be supported by a large amount of simulations. Data from performed demonstrations and flight tests will be used to correlate the simulations for confidence. The goal is to reach a maturity level of the safety case enough to enable a final demonstration with a UAS in non segregated airspace at the end of the project.

Performing the development and standardization for future Sense & Avoid technology in parallel is considered a key contribution for integration of manned and unmanned aviation flying routinely in non-segregated airspace. This integration of manned and unmanned traffic will unlock the potential of usage of UAS in many military and civil applications.

3.1 Incremental design and evaluation

The engineering process used in MIDCAS will make use of the concept of spiral development and the functionality will be developed in increments as shown in fig. 2.

The Functional system engineering will provide the initial requirements for the generic Sense & Avoid functionality and the development of different subsystems (functional blocks) will be performed in steps.

All steps of development will have a feedback from the simulation tests and from the manned aircraft and UAS flight tests in order to support the subsystem development.

In order to have an efficient and cost effective testing of the S&A functionality a manned A/C will be used for evaluating the first increments. This will provide a way to cover more scenarios in a shorter time period compared to performing all flight tests in a UAV.

The manned flight tests will provide important feedback to the next functional increment and thereby maturing the S&A functions in several steps before moving to flight tests and demonstration flights in a UAS.

UAS flight tests will verify a complete integration of the S&A system in a UAS incl performing automatic maneuvers and via data link connecting with a ground control station (GCS). It will also provide the possibility to negotiate flight permit with the CAA and, subject to approval, perform non-segregated flights with an unmanned system.

3.2 Standardization and stakeholder workshops

A main objective of the MIDCAS project is to progress standards within the field of S&A. This is mainly done through strong participation in standardization groups such as EUROCAE WG73 and bringing relevant material from MIDCAS into the standardization work.

An important aspect of a future S&A standard is that is must be accepted by the major stakeholders in the manned aviation community. To contribute to this MIDCAS will also have an open dialog with important stakeholders and will arrange a number of workshops during the 4 year schedule where material from MIDCAS will be presented and discussed in order to get feedback for the continued work.

3.3 Generic S&A function

A generic S&A function will be designed and developed based on high level requirements (HLR). Generic means that it will be applicable to most UAV's with limited and clearly defined adaptations.

Functional design includes all sense functions, avoid functions and HMI functions necessary for the Sense & Avoid capability and will be tested and evaluated mainly in simulations.

The function will be developed in several increments, all of which will be evaluated and feedback will be included in the next increment. This will also allow discussing results with stakeholders to ensure that solutions are in line with standardization progress and that standards are sufficiently complete and possible to implement.

3.4 Demonstrator system

The demonstrator system in MIDCAS will use existing equipment in terms of sensors and processing hardware sufficient to perform relevant flight demonstrations of the S&A capability.

Software of the functionality developed for the Generic S&A function will be used in the demonstrator system with minor adaptations.

Sensors to be included in the demonstrator are both non-cooperative (EO, IR and radar) and cooperative (transponder interrogator and ADS-B). This will allow making conclusions regarding sense capability for different combinations of sensors under different conditions.
The demonstrator system will be integrated on first the manned aircraft and in a second step the UAS.

3.5 Simulation

Simulation is a very central and important part of MIDCAS and will consist of both desk top simulation with Monte Carlo capability and ATC real-time simulation.

Main objectives of the simulations are:

- Performance assessment
- Safety assessment
- ATC and UAV pilot interaction assessment

The results from simulations will be presented to stakeholders and feedback will be used in the continued design and development of S&A within MIDCAS.

3.5.1 Desk top simulation

The desk top simulation will integrate the generic S&A function models into the simulator framework. It will make use of behavior models, especially for sensors and sensor close functions as well as for UAV pilot interaction.

A weather simulation model together with intruder aircraft characteristics will provide stimuli for the sensor behavior models to create a large number of different scenarios.

The simulation framework will provide a closed loop simulation including generic 6 degrees of freedom flight dynamics model to allow evaluating the S&A function for different types of UAS. Also the existing Sky-Y models will be integrated into desk top simulation environment to allow simulating the actual UAS to be flight tested in MIDCAS.

Desktop simulation will be used to support the generic S&A design providing feedback in each of the increments of functionality development. It will also provide statistical data for the safety assessment.

3.5.2 ATC simulation

The ATC real time simulations will be used to evaluate S&A HMI design and interaction with ATC and surrounding air traffic. It will also be an important tool to evaluate the UAV pilot workload and situational awareness.

The ATC simulator will interface with the desktop simulation and interchange the needed data to allow the S&A equipped UAV to sense the surrounding air traffic in real time for different scenarios and when needed perform avoidance maneuvers .relative to the other air traffic in the simulated environment.

An added value of this simulation is that actual air traffic controllers and UAV pilots will participate in the simulation evaluations and provide valuable feedback.

The ATC simulations will be performed at LFV (Swedish ANSP) simulation facility at Sturup in Sweden.

3.6 Manned Flight Tests

The manned flight tests will be conducted in three different campaigns all taking place at the French Flight Test Centre in Istres, France.

The platform used for the manned flight tests will be a CASA C-212 owned and operated by CEV (Centre d'Essais en Vol). This platform has been chosen in consideration of its particular adequacy for the initial tests of the MIDCAS demonstrator system:

- large volume available for sensors (nose of the aircraft)
- large volume available for processing equipment and flight instrumentation (cabin)
- ability to easily install antennas on the roof of the fuselage
- flight profile close to a MALE UAV

Fig. 3. CASA C-212 test aircraft

An initial campaign, called sensor flight test campaign, will consist in recording data from available off-the-shelf sensors (EO, IR and Radar sensors). This will be done during flight tests and rig tests in order to feed the initial steps of functional design and sensor simulation model development with recorded flight test data.

Fig. 4. Example of sensor installation.

The first functional tests will be done in the second manned campaign. This will test the MIDCAS demonstrator system, incl sensors and processing equipment with the initial basic S&A functionality implemented.

The final manned campaign will have added functionality and updates based on results from the previous campaign to expand the testing to more challenging scenarios.

During the tests different aircraft types will be used as intruders in order to expose the MIDCAS demonstrator system for a wide range of closure speeds, maneuverability, detection characteristics, etc.

- Falcon-Mystere 20 (representing an airliner)
- PC-7 turboprop aircraft (representing a highly maneuverable intruder)
- General aviation aircraft

Fig. 5. Different intruder aircraft will be used

3.7 UAS Flight Tests

The UAS flight tests will use the Alenia Sky-Y UAS. This platform has been chosen in consideration of its particular adequacy for the MIDCAS system demonstrator flight tests: large volume available for sensors (two zones, in the nose of the aircraft), high flexible payload capacity and flight profile typical of a MALE UAV. The weight and electrical power assured by Sky-Y UAV meets MIDCAS demonstrator system target requirements.

Sky-Y air vehicle has a low wing, single heavy fuel engine with a pushing propeller, twin boom configuration and tricycle landing gear.

Thanks to its design as a technology flight demonstrator it has inherently a great flexibility to support installation of new equipment and systems to be flight tested.

The baseline Sky-Y will be modified to carry the MIDCAS demonstrator system. Full integration with Sky-Y systems will be performed to allow autonomous execution of avoid maneuvers and interaction with the ground control station (GCS).

Two UAS flight test campaigns are planned with functional updates possible between the two campaigns. Presently both campaigns are planned to be performed at Vidsel Test Range in Sweden.

Fig. 6. Alenia Sky-Y UAS

The first UAS campaign will have updated software with feedback from the manned flight tests and adaptations needed for integration with Sky-Y systems. The objective is to verify the MIDCAS demonstrator behavior and performances by performing flights in segregated airspace for some standard collision scenarios. Flights will be done during different weather conditions, during day and night. This flight test campaign will also prepare for the final flight demonstrations.

Based on the results from the first UAS flight test campaign the S&A functionality will be updated and fine tuned for the second campaign. The initial phase of this campaign will continue to evaluate the performance for some standard collision scenarios during different weather conditions.

At the end of this campaign and pending CAA approval, flights will be planned and performed in non segregated airspace without performing any collision scenario testing but instead flying a typical mission profile.

This will be the most simple flight performed in MIDCAS and at the same time the most challenging. Most simple due to only flying straight and level at cruise condition and most difficult due to the performance and maturity of S&A likely to be needed for the approval process.

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