Design advancements for an integrated mission management system for small air transport vehicles in the COAST project

Vittorio Di Vito
Air Traffic Efficiency, CIRA, Italian Aerospace Research Centre, Capua, Italy
Piotr Grzybowski and Tomasz Rogalski
Department of Avionics and Control, Rzeszow University of Technology, Rzeszow, Poland, and
Piotr Maslowski
Institute of Aviation, Warsaw, Poland

Abstract

Purpose – This paper aims to describe the activities that are ongoing, in the Cost Optimized Avionics SysTem (COAST) project, to design an integrated mission management system (IIMS) to be used as support to the pilot and/or to act as a backup in case of pilot incapacitation onboard on small air transport (SAT) vehicles, under single-pilot operations.

Design/methodology/approach – The COAST project, funded by Clean Sky 2 programme, is developing enabling technologies for single-pilot operations in the European Aviation Safety Agency CS-23 category vehicles. Such technologies include specific tools that are designed as individual enablers for single-pilot operations and specifically address: the real-time support to pilot's decision making in maintaining the vehicle self-separation (this technology is the tactical separation system [TSS]); the real-time support to pilot's situational awareness about observed and forecasted weather conditions (this technology is the advanced weather awareness system [AWAS]); and the real-time management of emergency conditions due to pilot's incapacitation under single-pilot operations (this technology is the flight reconfiguration system [FRS]). Based on the outcomes of the design activities of such individual tools, in the COAST project emerged the opportunity to proceed with the design of a further system, leveraging the individual tools and benefitting from their integration.

Findings – The IMMS design started in the year 2020 and the activities carried out up to mid-2021 allowed to define the concept of operations of the system, its high-level requirements (functional, interface and operational requirements) and the preliminary system architecture.

Originality/value – The IMMS contributes enabling the implementation of single-pilot operations in CS-23 category vehicles, thanks to the possibility to support, in normal operational conditions, the pilot's decision-making and, in emergency conditions due to pilot's incapacitation, the automatic flight management up to the safe destination.

Keywords Decision support systems, Situational awareness, Weather awareness, Weather avoidance, Flight automation, Small air transport, Mission management, Traffic avoidance, trajectory optimization, Emergency management, Self-separation, Detect and avoid

Paper type Research paper

Introduction

The small air transport (SAT) aviation domain is continuously increasing its importance, both from an industrial perspective and in the research activities that are carried out in different research and technological projects, in Europe and also in the USA, due to the continuously emerging push towards new forms of mobility that can allow more environmentally friendly as well as more customized air transport at the same time.

SAT aircraft are defined by standard categorization as fixed-wing aircraft with a number of passengers between 5 and 19, specified by the European Aviation Safety Agency CS-23 category. Their intended application is in the passengers' regional transport, exploiting the availability of small airports as it is particularly true in some European regions such as Eastern Europe, for instance. The CS-23 SAT category can be also referred to as goods transport, instead of passengers' transport, with similar considerations as the ones just indicated.

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The motivations for the increased interest in SAT domain are in the advantages that such vehicles provide with respect to bigger commercial vehicles if compared considering similar mission profiles. These advantages are in terms of fuel consumption reduction, turnaround times reduction and consequent overall improved affordability of the business model (EPATS Consortium, 2007). Based on such considerations, the research activities in the SAT domain increased in the past decade and also the future view on aviation trends over the long-term included peculiar aspects that can be addressed thanks to the growth of the usage of SAT vehicles for passengers' transport. In particular, the ACARE Flightpath 2050 (ACARE, 2011) proposes to achieve 4 h of door-to-door travel for the 90% of travellers in Europe by 2050 and SAT vehicles can contribute to the implementation of such target, both in regional missions and as part of longer-range missions.

SAT aviation domain has been addressed by the European Personal Air Transport System (EPATS) project (EPATS Consortium, 2007), where it has been expressed the importance of introducing the possibility of using small vehicles for the transport of limited groups of people over a regional range. In the project, nevertheless, it has been also indicated that such SAT exploitation is possible only if some improvements are introduced, in terms of technological innovations that make possible for instance the single-pilot operations. Furthermore, when addressing future aviation scenarios, it is needed to consider that aircraft operations need to be compliant with the overall future air traffic management (ATM) scenario, as foreseen and designed by the Single European Sky's ATM Research (SESAR) programme, which defined a specific ATM target concept (SESAR Consortium, 2007).

Based on such considerations, it results that, to allow single-pilot operations in SAT vehicles, it is needed the increase of automation on-board and, in particular, the availability to the single pilot of a dedicated decision-making support system to alleviate the piloting workload while maintaining the required level of safety of the flight. If it is desired to have a single pilot on board and, at the same time, to comply with the SESAR ATM target concept, where it is envisaged the introduction, under specific conditions, of the delegation of separation task to the onboard segment, it is needed that the single pilot on board is properly supported, to manage also this additional self-separation task without requiring an unsustainable increase of workload. This can be obtained by providing the single pilot with dedicated automatic decision-making support systems.

Similar outcomes have been provided also from subsequent projects, such as the Personal Plane Project (PPlane) (Di Vito *et al.*, 2012). In compliance with these considerations, the Clean Sky 2 programme included a dedicated research stream on SAT-related technologies and, within this framework, the project Cost Optimized Avionics SysTem (COAST) has been funded in the year 2016.

The COAST project is delivering relevant enabling technologies for SAT affordable cockpit and avionics, whit the specific aim of supporting single-pilot operations in the CS-23 category vehicles (Di Vito *et al.*, 2017a). In the project, some specific flight management technologies supporting SAT single-pilot operations are included (Di Vito *et al.*, 2021a): the tactical separation system (TSS), which aimed to provide the real-time support to pilot's decision-making in maintaining the vehicle self-separation; the advanced weather awareness system (AWAS), aimed to provide the real-time support to pilot's situational awareness about observed and forecasted weather conditions; and the flight reconfiguration system (FRS), aimed to provide the real-time management of possible emergency conditions due to pilot's incapacitation under single-pilot operations. Such technologies have been designed and demonstrated in-flight.

Along with the project activities evolution, it has been identified the opportunity to include in the project scope also a new technology, representing a paradigm shift from the approach of providing single-pilot support in terms of individual technologies, such as the ones above mentioned, to the approach of making available to the pilot (or, if needed, as flight mission automation system, in case of pilot's incapacitation) an integrated technology leveraging the above-indicated individual tools and benefitting from their cooperation and extension into a unique integrated system, aiming to represent also an enabling technology for more autonomous operations. Such technology is the integrated mission management system (IMMS) (Di Vito *et al.*, 2021b).

This paper is the prosecution and expansion of the previous paper indicated as reference (Di Vito *et al.*, 2021b), presented in the *10th EASN International Conference on Innovation in Aviation & Space to the Satisfaction of the European Citizens*, held in the year 2020, and published in the related conference proceedings. This expanded version aims providing information about the IMMS technology design progress in the COAST project, since the previous paper (Di Vito *et al.*, 2021b) publication. These progresses have been presented in the *11th EASN International Conference on Innovation in Aviation & Space to the Satisfaction of the European Citizens*, held in the year 2021.

In this paper, firstly, an outline is reported of the baseline individual technologies developed in the COAST project to enable single-pilot operations. These contents are based on the reference paper (Di Vito *et al.*, 2021b) and are here included to provide this paper with self-completeness. Based on that, the IMMS development motivations, goals and challenges are emphasized in this paper, then, the defined IMMS system requirements (functional, interface and operational requirements) are described and the preliminary architecture proposed for the IMMS is discussed. Finally, the next steps foreseen for the system design are indicated.

Main sections

Baseline individual technologies

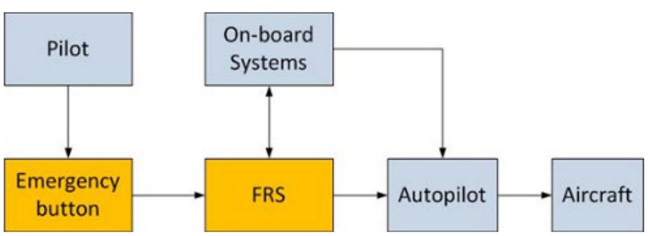
Flight reconfiguration system

The FRS is a fundamental system under the perspective of single-pilot operations because it considers the need of assuring the safety of the flight also in non-nominal conditions, such as the emergency event in which, for some reason, the pilot may be incapacitated to fly during the mission.

The FRS activation can be manual, using a dedicated "emergency" button or automatic, triggered for instance by a dedicated pilot's health monitoring system. After the activation, the FRS implements the setting of the emergency code on the transponder and assumes the control of the aircraft, by providing the references to the autopilot and, first of all, commanding the levelled flight of the vehicle. The first phase of FRS management of the flight includes, then, the execution of a pre-defined manoeuvre (holding pattern, straight-levelled flight at a constant speed or descent in case of pressure problems, depending on the actual flight conditions) during the time that is needed to the FRS algorithms to calculate appropriate flight plan to manage the situation and drive the aircraft towards a safe destination. The elaborated flight plan is then downlinked to the air traffic control (ATC) and, then, the FRS provides the guidance commands to the autopilot to reach the selected safe destination airport. To implement the concept of operations just outlined, the FRS is expected to be integrated with the aircraft avionics according to the architecture indicated in the following Figure 1.

The role of the system is the one of calculating a suitable emergency route and implementing it, when, in single-pilot operations, an emergency condition such as the single pilot's incapacitation occurs. To do this, based on ownship navigation data and internal databases data about airports and terrain, the FRS algorithm continuously detects the airports located within the ownship range, selects the most appropriate and calculates routes, considering the terrain information in order avoid hazards. The selection, then, of the best route among the several alternatives that have been elaborated is made, and finally, by using multiple criteria decision-making methods.

Figure 1 Architectural integration of the FRS in the onboard avionics



Source: Di Vito *et al.* (2017a)

The high-level logic of the FRS algorithm for path optimization is represented in the following Figure 2.

In the IMMS framework, the evolved-FRS will assume the role of a system devoted to trajectory optimization, not only for emergency management purposes but also for purposes of flight optimization in normal operational conditions, as described in the following.

The FRS has been designed in the COAST project by Politechnika Rzeszowska (Rzeszow University of Technology) and Łukasiewicz Institute of Aviation. Its emergency destination definition capability has been tested in flight in the dedicated COAST first flight test campaign carried out in 2021. Its full functionality in-flight validation will be performed in the second flight test campaign, planned for 2022, allowing the overall system to achieve technology readiness level (TRL) 5 by means of validation in a real flight test campaign.

More details about the FRS are reported in the reference papers (Grzybowski and Szpakowska-Peas, 2020; Grzybowski *et al.*, 2021).

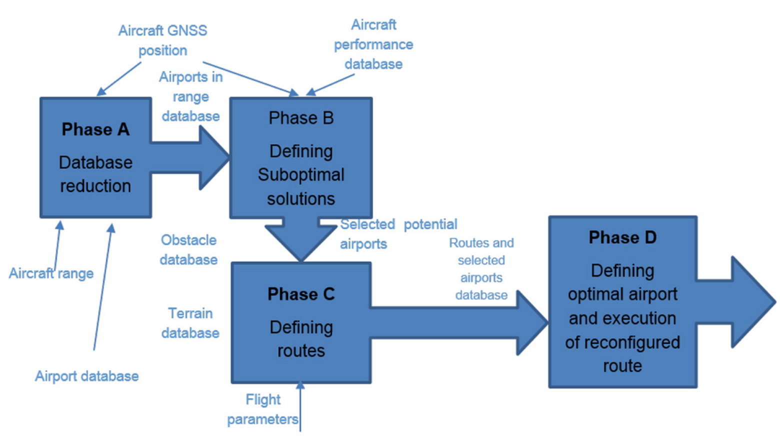
Tactical separation system

The TSS supports the single-pilot operations in SAT vehicles while taking into account the need of complying with the SESAR ATM target concept, in terms of expected separation responsibility delegation to the single pilot under specific conditions (SESAR Consortium, 2007).

The system uses ADS-B provided data about the surrounding traffic to perform the analysis of the traffic, determining possible risks of emergence of loss of separation conditions (i.e. conflict risks) and, in this case, elaborating proper manoeuver for maintaining the required separation minima with respect to the conflicting aircraft (i.e. conflict resolution). All the elaborated information about traffic and the suggested conflict resolution manoeuvre are provided to the single pilot, by means of appropriate representation on the dedicated TSS human-machine interface (HMI) hosted on the pilot's portable electronic device (PED). The TSS is an enabling technology for single-pilot operations aimed to manage self-separation from the surrounding traffic.

TSS interfaces with the relevant onboard avionics, to be fed with surrounding traffic data (position and velocity) by the

Figure 2 High-level logic representation of the FRS path optimization algorithm



Source: Di Vito *et al.* (2021a)

ADS-B IN, which is required to be onboard the ownship vehicle (assuming that surrounding traffic is equipped with ADS-B OUT), and to be fed with ownship navigation data provided by the on-board navigation system (GNSS). Both the traffic and the primary flight data (i.e. the ownship navigation data) are processed and consolidated by an RTCA DO-317B (RTCA, 2014) compliant Surveillance Processing application, which has been designed on purpose in the COAST project and integrated into the TSS. The architecture of the TSS software designed in Matlab/Simulink® environment is indicated in the following Figure 3 (Di Vito *et al.*, 2017b).

The role of the TSS is the one of actively supporting the self-separation management, elaborating and suggesting to the pilot suitable manoeuvre, on a tactical level time horizon (i.e. minutes of flight), for avoiding loss of separation conditions. The TSS inherently prevents the insurgence of possible emergency collision risk conditions, therefore preventing traffic alert and collision avoidance system (TCAS) equipment activation.

Under the TSS concept of operations implemented in COAST, the system does not assume the control of the aircraft but it provides the pilot with the suggested conflict resolution manoeuvre so that the pilot is responsible for the evaluation and implementation of the proposed manoeuvre. The manoeuvre, if deemed as appropriate, will be implemented by the pilot and also agreed with the ATC, unless the aircraft is operating in the free-flight environment (Hoekstra, 2002; Morani *et al.*, 2013) or the pilot has been delegated by the ATC to manage the separation according to the future SESAR new separation modes (SESAR Consortium, 2007).

In the IMMS framework, the evolved-TSS will assume the role of providing traffic information to the evolved-FRS, to allow path optimization and to support the evaluation and execution of separation assurance manoeuvres during the flight.

The TSS has been designed by centro italiano ricerche aerospaziali (CIRA) and its development process has been completed in 2021, with its successful validation in the COAST first flight test campaign, allowing the TSS to achieve TRL 5 by means of demonstration of its effectiveness in real flight tests.

More details about the TSS are reported in the reference papers (Di Vito *et al.*, 2017b, 2021c, 2021d).

Advanced weather awareness system

The AWAS supports the single-pilot operations by providing real-time weather conditions to the pilot during the flight execution, in terms of both observed and forecasted conditions and with reference to multiple kinds of weather hazards. The AWAS provided information aims preventing the undesired flight into dangerous weather airspace volumes, supporting the pilot with an advanced consolidated weather picture.

The AWAS elaborates meteorological data related to several different weather hazards and provides the pilot with advanced weather awareness, both for observed and for forecasted conditions, by means of appropriate representation on the dedicated AWAS HMI, hosted in the pilot's PED. The AWAS is an enabling technology for single-pilot operations aimed to provide advanced weather awareness in real-time during the flight, usually updating the information every 15 min (this update period is the one used in the COAST project; nevertheless, also higher frequency update is possible: this parameter can be changed according to the applicable needs).

The AWAS includes an onboard segment and an on-ground segment, as represented in the following Figure 4 (Zollo *et al.*, 2017).

The AWAS provided information is tailored to the actual flight plan followed by the ownship, because the system receives the GNSS position of the aircraft and, based on that, provides customized and detailed weather information applicable to the actual path. In this way, the system properly selects the airspace region of interest and, therefore, reduces the data volume that is needed to transfer.

The main part of the system is located on-ground, where the weather data repository is hosted and is powered by the meteorological aviation supporting system platform developed by

Figure 3 TSS high-level architecture

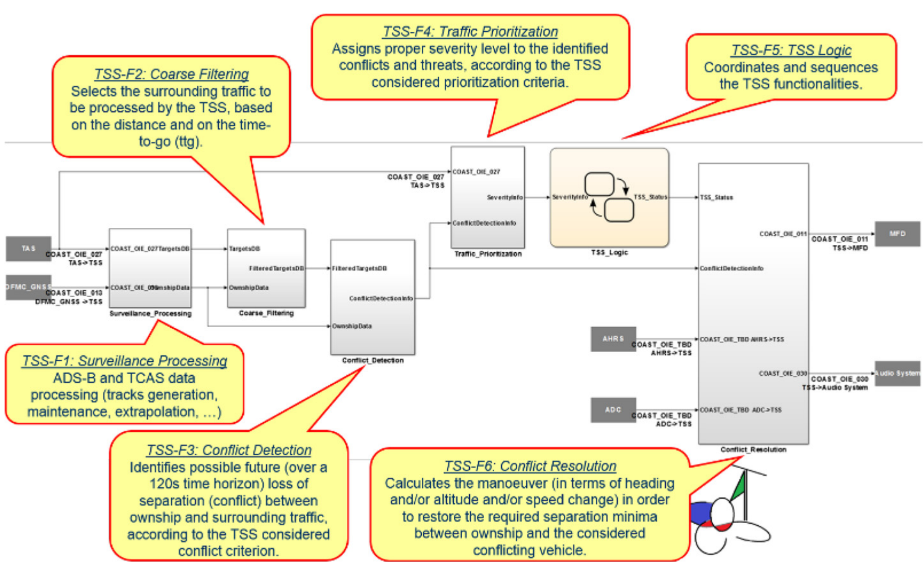
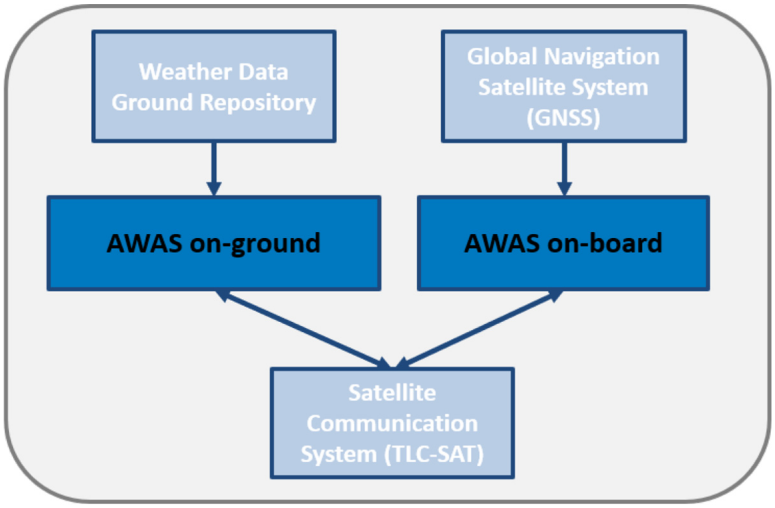


Figure 4 AWAS high-level architecture



CIRA (Rillo *et al.*, 2015). To allow the data exchange between the flight segment and the ground segment of the system, the AWAS exploits SatCom-based communication. The AWAS on-board is fed, therefore, by weather information elaborated by the AWAS on-ground and processes such received information to properly provide them to the pilot, by means of suitable graphical representation on the AWAS HMI hosted on the pilot's PED. On the HMI, it is possible for the pilot to access to AWAS dedicated information layers, displaying the observed or the forecasted weather picture.

In the IMMS framework, the evolved-AWAS will provide the Evolved-FRS with an updated weather picture to support path optimization considering weather avoidance possible needs.

The AWAS has been designed by CIRA and its development process has been completed in 2021, with its successful validation in the COAST first flight test campaign, allowing AWAS to achieve TRL 5 by means of demonstration of its effectiveness in real flight tests.

More details about the AWAS are reported in Zollo *et al.* (2017), Montesarchio *et al.* (2020) and Montesarchio *et al.* (2021).

Motivations, goals and challenges

FRS, TSS and AWAS individual technologies are not designed, in their baseline versions, to communicate with each other: the FRS does not exchange information neither with TSS nor with AWAS, as well as the TSS and the AWAS do not communicate among them. This is because each one is conceived as individual enabling technology supporting single-pilot operations.

The IMMS is conceived to overcome the limitations of such individual technologies and to exploit and extend them by integrating their respective roles into a unique system aimed to perform overall path optimization, taking into account both traffic and weather conditions and acting not only in case of pilot's incapacitation but also, under normal operational conditions, to support the single pilot. The IMMS motivations, nevertheless, are based also on the considerations reported below.

Some specific limitations can be found in the current SAT equipment onboard. Minimal equipment for SAT aircraft is mandated by CS-23 regulations (compass, altimeter, airspeed indicator, etc.). Avionics systems in the integrated form are not mandatory by regulations but are more and more in use due to improved functionalities over individual ones and significant reduction of pilot workload. Within integrated avionics, often autopilot modules are available which can execute the low level of control (e.g. stabilization of flight parameters, execution of route), but communication and route planning are in command of the pilot. Autopilots in the CS-23 domain are often considered to be an extra feature and not as standard equipment. Flight management system devices are available in the CS-25 domain, but still, they do not use all applicable data for route planning (e.g. automatic acquiring weather data) and planning is done mostly on-ground (more and more often with the use of electronic flight bags) (Di Vito *et al.*, 2009). In addition, further steps need to be implemented in terms of control systems evolution to allow more accurate route execution and automatic route planning (De Lellis *et al.*, 2013). Information about air traffic is available onboard when properly equipped (e.g. TCAS, therefore, referring to an emergency, and not tactical, time horizon) and information on own position is given by transponder systems.

The IMMS, therefore, aims representing an advancement with respect to the state-of-the-art, because most of the technologies for integrated flight planning and execution are not available for SAT, due to equipment requirements that go beyond the capability of installing such technologies onboard or due to cost issues. In most cases, for CS-23 only ADS-B OUT is used for informing about the aircraft own position, but no advanced analysis of air traffic is performed onboard. The potential mid-air collision situation is solved by TCAS devices, and their use is the last line of defence (emergency level and not tactical one). No systems commercially available are addressing tactical separation, i.e. provision of separation at the tactical level (so preventing activation of emergency TCAS device) and no system commercially available is able to support the pilot with tactical conflict resolution in free route airspace (FRA). In addition, gathering weather data is done before the flight, and an update is made only when equipped with weather radar (which use is also limited), therefore no flight diversion is performed by existing systems in SAT considering the current weather situation. Finally, the en-route flight plan is made only on pilot request (all decisions are made based on the pilot's experience) and route execution may be done using autopilot or manually, but the changed route is always designed by a human pilot.

The IMMS goal is to overcome the above-summarized limitations and to automatically optimize the trajectory while taking into account air traffic, weather conditions and terrain and obstacles, all of which can be defined as potential hazards for flying through the area.

Of course, such an ambitious goal involves relevant challenges to be overcome in the IMMS design. The definition of a standard for data exchange among evolved-FRS, evolved-TSS and evolved-AWAS in the IMMS is the first step to integrate them towards IMMS design; therefore, the definition of the proper standard of hazard description (SHD) has been agreed upon by the COAST team. Evolved-FRS module needs to be modified as the core of the IMMS, to be able to perform trajectory optimization while taking into account weather and traffic information at the tactical level and to work not only in case of pilot incapacitation but also under normal flight conditions. Additional functionalities need to be designed and integrated into the evolved-TSS module, such as traffic clustering to support the avoidance of high traffic density volumes in the trajectory planning by the evolved-FRS module. Additional functionalities need to be designed also in the evolved-AWAS module, such as the specification of altitude limits for some weather hazards (where applicable) and allocation of hazards severity to airspace volumes based on weather hazards (where applicable).

Requirements

The IMMS system requirements have been defined in terms of functional, interface and demonstration requirements.

Functional requirements allocated to the IMMS include the following capabilities:

- operability on aircraft category CS-23 – normal, utility and commuter airplanes;
- support to the pilot before flight to define optimized route considering current traffic, weather and terrain conditions;
- support to the pilot during the flight by means of proposing better route solutions based on contingencies that may occur during flight execution;
- ability to operate according to both VFR and IFR flight regimes;
- ability to support the legislation process towards single-pilot operations;
- compliance with future SESAR ATM environment, in particular in terms or future SESAR new separation modes; and
- provision of increased situational awareness from traffic and weather perspectives.

Interface requirements allocated to the IMMS include:

- capability to allow the pilot to update the planned route during the flight, if and where needed, by providing the pilot with an updated operational flight plan in the form of an electronic file for easy exchange with ATC;
- capability to inform the pilot on new route availability with the use of MFD;
- ability to execute accepted route with the use of autopilot;
- ability to consume weather information delivered by the evolved-AWAS component of the IMMS;
- ability to consume air traffic information delivered by the evolved-TSS component of the IMMS; and
- ability to consume terrain hazards information delivered by the evolved-FRS component of the IMMS.

Demonstration requirements allocated to the IMMS, finally, include:

- demonstration through real-time simulations; and
- demonstration in real flight trials.

Preliminary architecture

Three different possible architectures have been investigated, emphasizing pros and cons of each one and the third one has been selected as preferred for the implementation.

First architectural design option

The first considered architectural design option, indicated in the following Figure 5, includes a newly designed module "IMMS" that is in charge of trajectory optimization under normal flight conditions, based on the inputs received by the individual modules (FRS, TSS and AWAS).

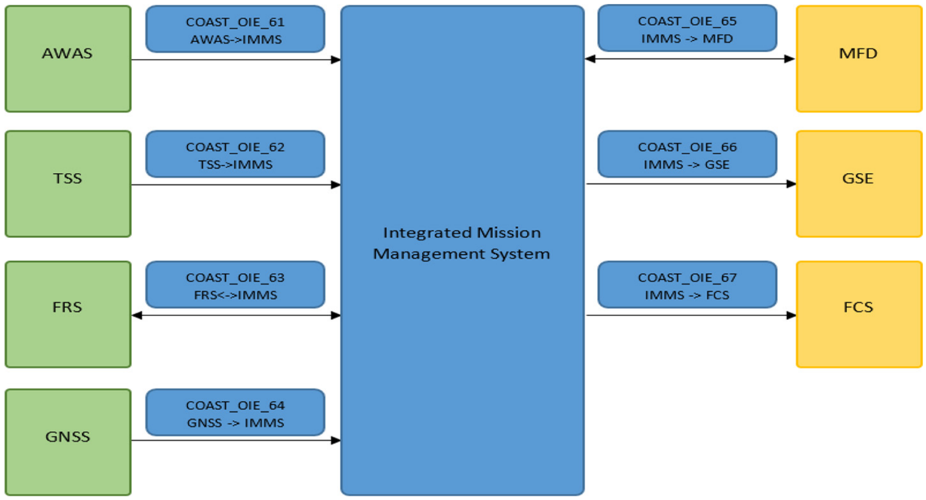
The FRS module remains in charge of emergency path re-planning, whereas the newly introduced IMMS module is in charge of trajectory optimization under normal flight conditions, based on the received inputs.

This architecture has the advantage of providing a clear distinction between the FRS module role of trajectory optimization under emergency conditions and the IMMS module role of trajectory optimization under normal flight conditions.

Nevertheless, this architecture involves some relevant disadvantages. It increases the system complexity by adding a fourth module, the IMMS one, leading to an increased number of data flows. In addition, this architecture introduces a not-necessary division of the trajectory optimization functionality: indeed, the trajectory optimization algorithm may reuse in normal flight (IMMS module) also features currently used in emergency conditions (FRS module); therefore, it is certainly better to have only one module devoted to trajectory optimization under all flight conditions, avoiding to duplicate the functionality by using the IMMS and the FRS distinct modules. Finally, another relevant disadvantage of this architecture is that it may be misleading: the IMMS is expected to be a system-of-systems resulting from the integration of the three modules (evolved-)FRS, (evolved-)TSS and (evolved-)AWAS, having as the core of the integrated system the (evolved-)FRS, so no additional "IMMS" module is expected to be introduced.

Such analysis led to the exclusion of this first option and consideration of the second architectural design option.

Figure 5 First architectural design option



Second architectural design option

The second considered architectural design option, indicated in the following Figure 6, implements updated FRS ("Path Change System") as the core of the IMMS system because it exchanges data with the updated TSS ("Traffic Avoidance System") and with the updated AWAS ("Weather Awareness System") to perform trajectory optimization in all flight conditions (both normal and under pilot incapacitation).

No additional "IMMS" module is needed to be designed because the whole integrated system-of-systems represents the IMMS, but an additional "Automation Logic Supervisor" module may be needed to properly trigger the activation of each system of the IMMS, according to the prespecified mission logic.

In terms of advantages, this second architectural option allocates the trajectory optimization task to a single module ("Path Change System", i.e. the evolved-FRS), for both emergency and normal flight conditions. Therefore, under this perspective, it presents a simpler architecture with respect to the first architectural option.

Nevertheless, some relevant drawbacks have been identified. Indeed, also this second option introduces an element of increased complexity: the presence of a dedicated IMMS logic module (i.e. the "Automation Logic Supervisor").

CIRA performed the preliminary design and testing of such module (Menichino *et al.*, 2021) and a relevant observation is that it seems not strictly needed under the IMMS perspective, provided that:

- the evolved-TSS (i.e. "Traffic Avoidance System") and the evolved-AWAS (i.e. "Weather Awareness System") are modules that, due to their intrinsic nature, are always running, so not needing a triggering action from an outside module; and
- only evolved-FRS (i.e. "Path Change System") may need, and it is to be confirmed, some triggering, but if needed the logic can be more suitably implemented internally to the evolved-FRS.

Such analysis led to the exclusion also of this second architectural option and to the consideration of the third architectural design option.

Third architectural design option

The third considered architectural design option, indicated in the following Figure 7, implements evolved-FRS ("Path

Figure 6 Second architectural design option

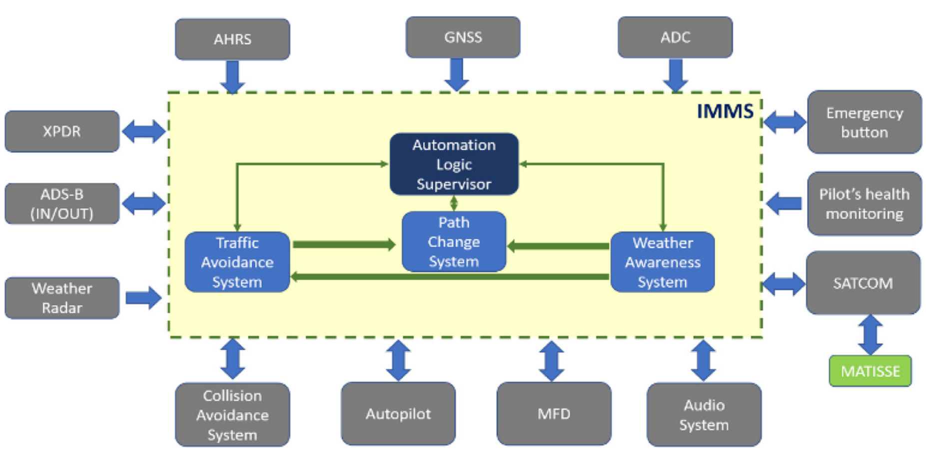
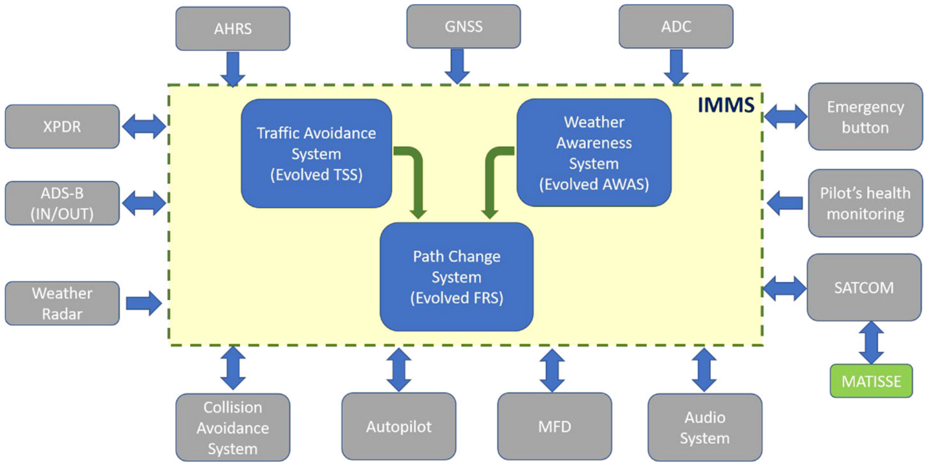


Figure 7 Third architectural design option



Change System") as the core of the IMMS system because it exchanges data with the evolved-TSS ("Traffic Avoidance System") and with the evolved-AWAS ("Weather Awareness System") to perform trajectory optimization in all flight conditions (both normal and under pilot incapacitation).

Evolved-TSS and evolved-AWAS are always running, so no dedicated IMMS logic module is required, because evolved-FRS may implement internal logic if needed.

This architectural solution involves relevant advantages:

- allocation of trajectory optimization task to a single module ("Path Change System", i.e. the Evolved-FRS), for both emergency and normal flight conditions;
- no dedicated IMMS logic module needed at the first software level;
- no link between evolved-TSS and evolved-AWAS is needed, because weather hazards can be considered as fixed, over a tactical time horizon, so they are not considered by Evolved-TSS but only by Evolved-FRS, as no-fly zones, when performing strategic trajectory re-planning/optimization;
- it is the simplest architecture with respect to the first and second options; and
- it minimizes the needed data flows.

Such analysis led to the consideration of the third architectural design option as the preferred one to be implemented in the IMMS design.

Conclusions

Due to updated information at the tactical level (during the flight) about air-traffic situations en-route and to changes in weather conditions, the need of altering the route may emerge and it will become also more common in the future in the FRA environment. The automatic definition of the altered route while already in flight with limited resources onboard is a challenge that is addressed by the IMMS, which is under development within the COAST project. The IMMS design activities started in mid-2020 and aim to full integration of all the flight management individual technologies designed in COAST (i.e. the FRS, which is the core of the IMMS, the TSS and the AWAS), after dedicated evolution from the individual technologies version. TSS (full functionalities), AWAS (full functionalities) and FRS (emergency destination definition functionality) individual technologies have been demonstrated in real flight in 2021, reaching TRL 5 through successful real flight trials. The IMMS requirements (functional, interface and demonstration) have been defined and the data exchange format has been defined and agreed upon as well. The IMMS architectural design options have been proposed and analysed, leading to the selection of the most suitable one for the implementation in the IMMS design process, which is currently ongoing. The IMMS software design activities have been started in the second half of the year 2021 and will proceed through the year 2022. The IMMS is expected to reach the TRL 5 with demonstration in a real flight test campaign on EVEKTOR EV 55 aircraft by the end of the COAST project (2023).

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Corresponding author

Vittorio Di Vito can be contacted at: v.divito@cira.it