ISMAEL - Intelligent Surveillance and Management for Airfield Applications Based on Low Cost Magnetic Field Detectors

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Abstract:

Against the background of aggravated capacity constraints at airports due to increasing air traffic, airports are in need of innovative systems enabling Air Traffic Controllers to precisely determine the position of vehicles moving on the surface, even under reduced visibility conditions. While this demand is addressed by the development and introduction of Advanced Surface Movement Guidance and Control Systems (A-SMGCS), technologies currently applied to A-SMGCS feature some weak points regarding coverage and robustness interference and climate conditions. The EC-funded research project ISMAEL targets these weak points by developing an innovative detection solution based on magnetic sensing technology. Thus, ISMAEL will represent a valuable and cost-efficient complementary contribution to existing and planned A-SMGCS at small and large airports.

1. Introduction

Despite temporary declines in 2001 and 2002 as a result of 9/11 and a number of European airline collapses (Swissair, Sabena, etc.) traffic volumes at European airports will continue to increase[1], leading to at least a doubling in traffic every 12 years[2]. For a considerable part this can be attributed to the huge growth in the low cost air traffic sector, which led to a rapid expansion of previously stagnant secondary airports such as London Stansted and Frankfurt Hahn[3]. Yet, the size of airports cannot be increased at the same rate nor will new additional airports significantly contribute to resolving this challenge.

As a consequence Airport terminal areas and surface operations are increasingly recognised as important aviation capacity constraints. These constraints are particularly acute under adverse weather conditions, which dictate less efficient terminal area procedures to maintain safety and can result in delays that propagate through the regional air traffic system and beyond.

The constraints can be reduced if airports are equipped with systems that allow Air Traffic Controllers to determine precisely where each aircraft is located within the run- and taxiway system at all times, even under reduced visibility conditions. The precision and reliability with which aircraft type and position are identified directly determines the separation requirements, which must be allowed to maintain safety, thus allowing for improved usage of restricted airport capacities.

ISMAEL, a European R&D project funded within the 6th Framework Programme of the European Commission, targets this issue by developing an innovative detection solution based on magnetic sensing principles for improved ground traffic control and management at airports.

2. Objectives

Against the background of aggravated capacity constraints at airports due to increasing air traffic, ISMAEL aims at easing the situation by developing an alternative system for surface movement surveillance at airports improving safety and efficiency of ground movements. A new detector based

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[1] EUROCONTROL, Air Traffic Statistics and Forecasts (STATFOR): Forecast of Annual Number of IFR Flights (2004 - 2010). Volume 2, 2004.

[2] European Commission, Single European Sky. Brochure, European Communities, 2001.

[3] DG TREN, Analysis of the European Air Transport Industry 2002 – Final Report. Contract Number: B2-7040B-S07.17962, 2003.

on magnetic sensor technology will be developed for use within advanced surface movement guidance and control systems (A-SMGCS). In this context, ISMAEL aims at improving existing installations of A-SMGCS at large airports as well as at enabling the installation of an appropriate form of A-SMGCS at small and medium airports in Europe.

3. Approach

As ISMAEL is a system development project it starts with the collection of user requirements as input to the subsequent detector development. Moreover, relevant aspects of system integration with respect to the targeted applications will be analysed. The project concludes with prototype tests at selected airports and the establishment of an exploitation strategy for the planned future introduction to the market.

Regarding the basic technical principle, the system is based on the detection of ferromagnetic objects (e.g. vehicle motors, aircraft components) from their interaction with the Earth's magnetic field. The Earth's field acts as a biasing magnet, resulting in a magnetic signature (fingerprint) from ferromagnetic objects. This property can be used to detect and locate the objects, either using a single point sensor or an array of sensors. The local change of the Earth's magnetic field is extremely small – less than 1 micro Tesla ($\mu T = 10^{-6}$ T) - but the new sensor prototype proposed can detect this reliably. The system can also be used to distinguish between different types of aircraft and vehicles based on the magnetic signature of each type. The information can be transferred to tower controllers for better airport management.

Another focus is on the design and development of the SDF (sensor data fusion) server. The SDF server handles the following processes: it collects event data from the sensors and forms ground observations. The server filters them to form ground target tracks and finally presents the targets and the tracks to the user.

4. Applications

The following six applications were analysed with respect to their potential for improvement resulting from an introduction of the planned detection solution: (1) Airport Surveillance, (2) Runway Incursion, (3) Fleet Management, (4) Docking System, (5) Gate Management, (6) Taxi Management. Within the scope of user requirement analysis Airport Surveillance and Runway Incursion turned out to be the most promising applications to be targeted by ISMAEL in first instance.

Airport Surveillance

This application requires reliable detection and identification of all vehicles moving on the airport surface. This information is then distributed and provided to multiple operators with different tasks and responsibilities by appropriate human machine interfaces. In this context, ISMAEL will be a valuable additional source of information providing for the determination of position, velocity and heading of the vehicles, and in an additional step also the type of vehicles passing the sensor.

Runway Incursion

The ability to detect vehicles passing a specific location is also very appropriate for the prevention of runway incursions, which is a critical task in assuring airport safety. Applying accordingly located magnetic sensors each runway exit can be controlled for intruding vehicles. This could prevent severe accidents, like the one in Milan in 2001, when two aircraft collided during take off due to limited visibility under foggy conditions and an inoperative ground radar. In this context the proposed sensor technology will constitute a significant contribution to improved safety by providing a cost-efficient, reliable solution for small and medium size airports.

5. First Results

At the time this draft paper is written the first phase of the project's second workpackage regarding the elicitation and analysis of user requirements has been completed. Yet, first results primarily relate to insights on users' perception of the proposed solution. From the viewpoint of potential users, i.e. air traffic controllers and airport operators, ISMAEL represents a valuable contribution to existing and future A-SMGCS provided the system accounts for the following key requirements:

- Being non-cooperative, i.e. not require a transponder for position determination, enabling complete detection of all vehicles regardless of their equipment, as a major requirement for an independent control mechanism.
- Acting as complementary solution being able to fill gaps in the coverage of existing detection systems or to provide additional cover in critical areas.
- Determining the actual position of an aircraft, vehicle or obstacle on the surface within a radius of 7.5m it shall be available at least for 97% of the time.
- Differentiating between target types and retain identification and labelling of authorised movements.
- Being reactive to hazardous situations, to anticipate and prevent their development.
- Locating of sensors with a minimal disruption of airport operations during installation and maintenance; enabling remote calibration of the sensors.
- Being unimpaired by radio interference, adjacent high power cables, and adverse weather and topological conditions.

Regarding technical developments first results of the work package on Detector and System Development can be summarised as follows. Up to now input has been generated for the interface control document between the analogue sensor head and the digital processing unit. The identified constraints, established achievements and gained know-how for the production of a first series of prototypes of the scientific sensor head have been discussed and consolidated to meet all above-stated requirements and become a basis for the execution of the development tasks.

Functional tests of the sensor prototype have been distinguished for the normal detector and for the scientific development tool. Several characters, such as sensitivity and noise levels, of first generation sensor prototype have been tested under well-defined conditions. These results represent a useful basis for the design work of the next generation sensor prototype. Current work also includes the function tests of the various available magnetic sensors to define the most suitable for ISMAEL. Sensor prototype function tests at airport Saarbruecken are in the beginning phase aiming at investigating the functions of the prototype in real life measurements including sensing distance, noise level, sensor location and direction. Test results will be applied to further detector development and hardware/software adjustment.

Regarding the selected applications, Airport Surveillance had to be split in two scenarios to account for the differing requirements of large opposed to small and medium-sized airports. While the former will apply the ISMAEL system as backup or as gap filling module in combination with other technologies, the focus of the latter will be on a stand-alone solution at affordable cost to provide at least a minimum functionality to the controller. Thus, different operation modes have been identified to account for the heterogeneous needs of large compared to small and medium-sized airports.

Another issue is the theoretical calculation of the magnetic field change due to the presence of airplanes. In this stage, aircraft information is collected and the calculation programme is tested. Initial calculations have been made based on simplified parameters. One of the first conclusions is that the gear part of the aircraft produces the strongest magnetic signal. If the sensor is installed directly under plane’s gear part, the strongest signal will be detected. Sensors can also be installed along side of the taxiway. Yet, in this case the signal level decreases significantly.

Calculations based on taxiway parameters of test airports will be done to investigate the optimal sensor direction and position. Calculated values will be adjusted according to subsequent field test results. This process will reduce field test numbers as well as costs. Further research on bus-concepts and system on chip design will make the whole system complete.