ISMAEL – On the Way to Improve Airport Operation Management

http://www.ismael-project.net

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Introduction

Against the background of the constantly accelerating growth of air traffic, 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.

These 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. 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 to interference and climate conditions.

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.

Objectives

ISMAEL aims at easing the strained situation at European airports by developing an alternative system for airport traffic guidance and control improving safety and efficiency of ground movements. A new detector based on magnetic field sensor technology will be developed for use within advanced surface movement guidance and control systems (A-SMGCS). In doing so, ISMAEL targets two objectives: (1) improving existing installations of A-SMGCS at large airports, and (2) providing for an appropriate form of A-SMGCS at small and medium airports in Europe.

Approach

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) - still the new sensor prototype proposed is able to detect it reliably. The system can also be used to distinguish among different types of aircraft and vehicles based on the magnetic signature of each type. Information is transferred to tower controllers for better airport management.

Development work starts with the specification and design of the sensor head. In this context the advantage of the sensor head is its flexibility in varying relevant parameters to investigate the optimal settings regarding the aimed tasks. Experiences with the properties of the sensor

head bring valuable insights for the development of the operational detector. Consequently this approach contributes to the philosophy of a rapid prototyping environment.

Another focus is on the design and development of the SDF (sensor data fusion) server collecting event data from the sensors and forming ground observations. The server filters this input to generate ground target tracks and finally presents the targets and the tracks to the user.

Benefits

The major benefits of the planned solution are derived from the fact that it constitutes an efficient low-cost complementary position technology to be included in existing and future A-SMGCS. It is easy to implement due to its small size allowing for installation at almost any location, such as integration in existing ground lighting systems. Unaffected by weather conditions, interferences and shadowing effects the system provides reliable position, velocity and direction information. In addition, a general classification of passing vehicles is intended. Moreover, the system does not rely on on-board equipment, as multilateration or ADS-B does. Based on a passive detection principle no interference with other systems like aircraft radios is given. In general the solution is characterised by low energy consumption and a modular architecture that allows for easy system upgrades and extensions accounting for the heterogeneity of different airports.

Applications

Within the scope of user requirement analysis the following three applications turned out to be the most promising ones 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 to multiple operators by appropriate human machine interfaces. ISMAEL will be a valuable additional source of information providing for the 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. 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 and an inoperative ground radar.

Gate Management

Not only moving, but also static vehicles can be detected by using magnetic field sensors. This property enables identifying the occupancy status of all equipped parking positions. Yet, the magnetic sensing technology offers an easy way to provide reliable sensor information serving as platform for appropriate management tools.

First Results

Currently, two generations of sensor head prototypes have been designed and produced. Functional tests of the sensor prototypes have been carried out. For that purpose, sensor head prototypes have been installed at selected locations close to the taxiway area of Saarbruecken airport, Germany. Real life tests including measurements like sensing distance, noise level, sensor location and direction were performed. Test records are applied to further detector development and hardware/software adjustment.

Regarding the selected applications, Airport Surveillance has to be split in two scenarios to account for the differing requirements of large opposed to small and medium-sized airports. While the former are expected to 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 costs 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.

Furthermore, theoretical simulations of magnetic field perturbation caused by aircraft presence are supplied to support the technical development. These results represent a valuable basis for designing the detectors that will be installed for operational tests at airports of Frankfurt and Thessaloniki. While Frankfurt will serve as example of a large airport looking for a gap filling or backup system, at Thessaloniki airport ISMAEL will be tested as stand-alone solution. For that purpose, installation design and procedures are adapted accordingly.

Conclusions

First development steps and feedback from potential user groups have shown that the magnetic sensing solution developed within the ISMAEL project seems to be a reasonable and promising detection system to be incorporated in existing and future A-SMGCS or to be applied as stand-alone alternative for smaller airports. Its operational feasibility has to be validated by means of real-life tests at Frankfurt and Thessaloniki airport to examine its actual contribution to ground traffic management and control. However, results can be expected to be very promising as the first sensor tests at Saarbruecken airport indicate.

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