

ÚLOHA MULTILATERACE PŘI ZVYŠOVANÍ BEZPEČNOSTI LETECKÉ DOPRAVY

ROLE OF MULTILATERATION IN AIR TRAFFIC SAFETY ENHANCEMENT

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Anotace: Článek popisuje využití multilateračních systémů pro zvýšení bezpečnosti a kapacity v letecké dopravě. Práce zahrnuje popis principu činnosti multilateračních systémů v závislosti na časových architekturách. Závěr práce je věnován WAM systémům.

Klíčová slova: multilaterace, čas,

Summary: This article describes multilateration surveillance systems and their impact on increase in capacity and safety of air traffic. The work includes a description of multilateration systems and used methods of signal processing – central and distributed time architecture. Conclusion of this work deals with multilateration systems in various flight phases and their benefits for flight.

Key words: Multilateration, Central Time, Distributed Time, Surface Multilateration, Wide Area Multilateration

INTRODUCTION

The aim of this thesis is to describe the usage of the Multilateration surveillance system (MSS). MSS represents a new, certified, costs-effective and high-performance surveillance system that outperforms Monopulse Secondary Surveillance Radar (MSSR). This system is flexible and expandable. Additional ground stations, interrogators and reference transponders can be easily added to the system. MSS can provide an accurate and reliable real-time location and identification of all aircrafts, vehicles and other objects equipped with a Mode A/C/S transponder. Czech Republic with its historical heritage in this area stands on the top worldwide. Any multilateration ground station can be used for multiple applications. This allows for greater cost savings and expansion capabilities.

1. MULTILATERATION PRINCIPLE

Multilateration Surveillance System determines the target position by Time Difference Of Arrival (TDOA) multilateration principle based on income and on-board signal processing transponders of Secondary Surveillance Radar (SSR). Multilateration employs a number of ground stations, which are placed in strategic locations around an airport, its local terminal area or a wider area that covers the larger surrounding airspace.

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These units listen for “replies,” typically to interrogation signals transmitted from a local SSR or a multilateration station. Since individual aircraft will be at different distances from each of the ground stations, their replies will be received by each station at fractionally different times. Using advanced computer processing techniques, these individual time differences allow an aircraft’s position to be precisely calculated.

The TDOA between two antennas corresponds, mathematically speaking, with a hyperboloid (in 3D) on which the aircraft is located. When four antennas detect the aircraft’s signal, it is possible to estimate the 3D-position of the aircraft by calculating the intersection of the resulting hyperboloids.

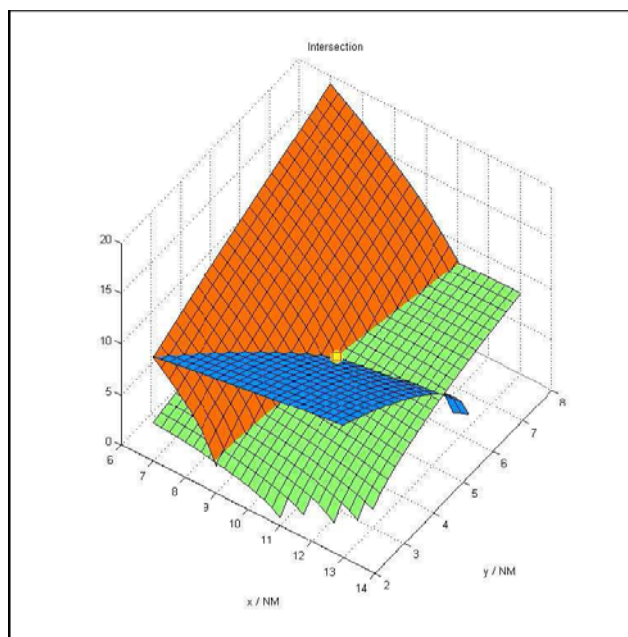


Fig. 1 – Intersection of Hyperboloids

2. PASSIVE AND ACTIVE SYSTEMS

Multilateration systems can be either passive or active.

Passive systems rely on the transmission of aircraft transponders which is activated by other equipment, and broadcast of squitters that broadcast their signals periodically. Passive techniques can be used to track aircrafts approaching the airport and aircrafts which are still in a range of MSSR (Monopulse Secondary Surveillance Radar). For low-flying aircrafts, which descend below the height of MSSR coverage, it can be used interrogator with the shorter range.

Active systems may require own answers from the aircrafts. Multilateration interrogator is simpler than MSSR interrogator. It is not necessary rotating antenna, instead is used either omnidirectional or sector antenna. Moreover, it can be changed level of radiation performance and thus be changed the reach of the antenna according to the distance of the monitored plane. One of the areas where it can be used active multilateration system is the terminal manoeuvring area.

3. CENTRAL AND DISTRIBUTED TIME

A system can be configured as Central Time (CT) or Distributed Time (DT) or a combination of both.

The **Central Time architecture** is where a central processing station evaluates and processes all signals. The receiving stations are very simple. Each station is composed of receiver with an antenna and a real-time signal transmitting facility. Time delays of signals transmitted from the receiving stations to the central processing station must be constant, stable and known, as the processor to eliminate them.

The **Distributed Time architecture** is where signal pre-processing and time stamping is done at each receiving station. These receiving stations are more complex. Each station is composed of a receiver with an antenna, signal processor, precise clock and data transmission facility.

4. SURFACE AND WAM SYSTEM

MSS can be used at the airports (Surface system) and in the area (WAM system).

Surface system is the part of the system A-SMGCS (Advanced Surface Movement Guidance and Control System). A system provides routing, guidance and surveillance for the control of aircraft and vehicles in order to maintain the declared surface movement rate under all weather conditions within the aerodrome visibility operational level (AVOL) while maintaining the required level of safety. The main benefits to be accrued from the implementation of an A-SMGCS will be associated with, but not limited to, low visibility surface operations. Significant improvements in aerodrome capacity can also be achieved under good visibility conditions. A-SMGCS platforms utilizing multilateration have become the industry standard at the world's busiest airports to reduce the increasing risk of runway incursions as operations grow and surface congestion increases. MSS expands coverage areas, identifies aircraft, tracks vehicles and maintains performance in all weather conditions.

WAM system is used where is not radar coverage and implementation of a radar is not suitable for economical, technical and other reasons. They are acceptable especially in mountain area. In comparison with the Surface system, the WAM system covers much bigger part of airspace (PRM – Precision Runway Monitoring, terminal area and en-route surveillance). The first exploited operational WAM system was established as an instrument of the accurate measuring of the aircraft height in the project RVSM (Reduced Vertical Separation Minima). This is a reduction of vertical separation between FL 290 and FL 410. The original vertical separation 2000 ft is changed to 1000 ft. This reduction requires accuracy of aircraft altitude measurement up to 25 ft.

Precision Runway Monitor (PRM) is very accurate system which allowed adjacent approaches to runways spaced as close as 3,300 feet apart. PRM provides Air Traffic Control (ATC) with a display of arrivals along an extended centreline. With such immediate and clear economic benefits, multilateration PRM systems are expected to increase in the future. Airports with closely spaced parallels can maintain independent approaches, even during adverse weather conditions which greatly improves capacity.

Besides the above mentioned activities it is possible to use multilateration system for monitoring of wake turbulence.

CONCLUSION

For ATC (Air Traffic Control) application provides multilateration system the same level of coverage as traditional SSR (Secondary Surveillance Radar). The system will provide higher accuracy, higher refresh rate, better coverage and improved reliability in comparison with traditional SSR and it will be constitute lower initial price with lower annual costs.

MSS will represent a good solution in all phases of flight. Future generations of air traffic management will need to be able to achieve greater security and efficiency. The density of air traffic will be in the year 2020 twice larger than in the year 1997, which will result in a glut of flight paths.

Benefit of MSS is mainly that they allow the increase of capacity and throughput of airspace while maintaining high security. Because of low price are a good alternative for the poorer states to obtain the coverage of its airspace.

Multilateration systems can be applied for area navigation in the future. Aircraft will receive information about the location of satellite navigation. Satellite navigation provides high location accuracy, but it can not be used as the sole source of information. The combination of MSS and satellite navigation provides the best solution.

REFERENCES

- (1) KUTINA, O. *Přínos pasivních sledovacích systémů pro bezpečnost ŘLP* (diplomová práce), Praha, ČVUT, 2005.
- (2) UJCOVÁ, M. *Aplikace multilateračních systémů pro RNAV* (bakalářská práce), Praha, ČVUT, 2007.
- (3) *Advanced surface Movement Guidance and Control Systems* [online], [cit. 2010-11-08], Dostupné z <<http://www.icao.int/anb/panels/atmrpp/Documents/Doc.9830.alltext.en.pdf>>
- (4) *PRM* [online], c2010 [cit. 2010-11-09], Dostupné z <<http://www.multilateration.com/applications/prm.html>>.
- (5) *Applications* [online], c2010 [cit. 2010-11-09], Dostupné z <<http://www.multilateration.com/applications/overview.html>>.
- (6) *Surveillance* [online], c2010 [cit. 2010-11-09], Dostupné z <<http://www.multilateration.com/surveillance/multilateration.html>>.
- (7) *An Overview of Wide Area Multilateration* [online], c2010 [cit. 2010-11-08], Dostupné z <<http://waynefarley.com/aviation/2009/11/an-overview-of-wide-area-multilateration/>>.
- (8) *Wide Area Multilateration* [online], c2010 [cit. 2010-11-07], Dostupné z <http://www.eurocontrol.int/surveillance/gallery/content/public/documents/WAM_study_report_1_1.pdf>.