AIRCRAFT GUIDANCE ARRANGEMENT IN THE FINAL PRECISION APPROACH SECTION AND AFTER TOUCH - DOWN WITH THE APPLICATION OF TECHNOLOGIES BASED ON PERSPECTIVE MAGNETIC MATERIALS

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In this work the possibility of application perspective magnetic materials in the final precision approach segment and after touch down was studied. GMI discovered in amorphous microwires has generated growing interest because of their promising applications in magnetic sensors. There was made an experiment in order to achieve experimental results documenting sensibility of the material. GMI of glass-coated microwires of nominal compositions $Co_{68}Fe_{4,5}Si_{12,5}B_{15}$ and $Co_{70,5}Fe_{4,5}Si_{10}B_{15}$ was studied by changing a DC magnetic field and the frequency. In air traffic sensors a glass coated amorphous microwires of nominal composition was found appropriate to use and theoretical possibilities of applications were presented.
K e y w o r d s: aircraft guidance, final precision approach segment, glass – coated amorphous microwires, GMI

1 INTRODUCTION

Safety is core to the business of Air Traffic Services and Air Traffic Controllers. Controllers must therefore keep the aircraft they handle safely separated using internationally agreed standards. This is achieved by allocating different heights to aircraft or by arranging certain minimum horizontal distances between them.

2 FLIGHT

For the purpose of Annex 4 - Aeronautical charts, the total flight is divided into the following phases:

Phase 1: Taxi from aircraft stand to take-off point.
Phase 2: Take-off and climb to en-route ATS route structure.
Phase 3: En-route ATS route structure.
Phase 4: Descent to approach.
Phase 5: Approach to land and missed approach.
Phase 6: Landing and taxi to aircraft stand. [1]

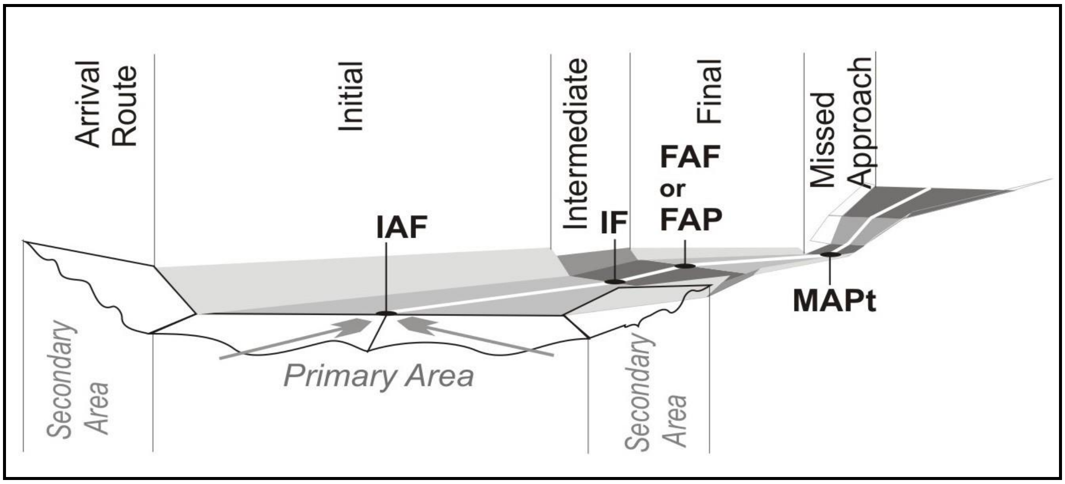

Figure 1. Segments of instrument approach.

3 INSTRUMENT APPROACH PROCEDURE

Instrument approach procedure (IAP) is a series of predetermined manoeuvres by reference to flight instruments with specified protection from obstacles from the initial approach fix. Where it is applicable, from the beginning of a defined arrival route to a point from which a landing can be completed. If a landing is not completed, to a position at which holding or en-route obstacle clearance criteria apply.

An instrument approach procedure may have five separate segments [2]: the arrival, initial, intermediate, final and missed approach segments (see Figure 1, 2).

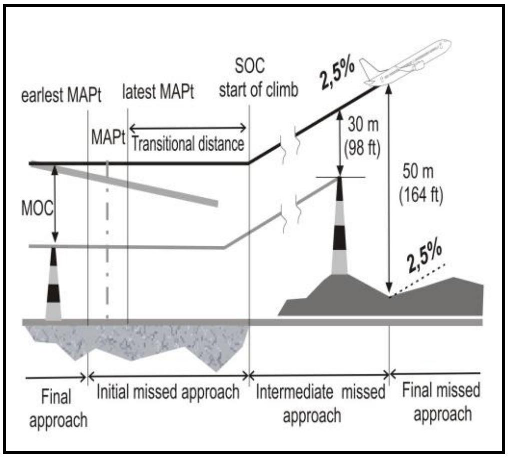

Figure 2. Obstacle clearance for final missed approach phase.

The standard non-visual aids to precision approach and landing shall be:

- the instrument landing system (ILS)
- the microwave landing system (MLS)
- GBAS
- SBAS

The Instrument Landing System (ILS) is an instrument presented, pilot interpreted, precision approach aid. The system provides the pilot with instrument indications. When it is utilised in conjunction with the normal flight instruments, it enables the aircraft to be manoeuvred along a precise, predetermined, final approach path [5]. Very important term is ILS integrity. It is related to the trust which can be placed in the correctness of the information supplied by the facility. The level of integrity of the localizer or the glide path is expressed in terms of the probability of not radiating false guidance signals. The ILS shall comprise the following basic components:

- VHF localizer equipment, associated monitor system, remote control and indicator equipment
- UHF glide path equipment, associated monitor system, remote control and indicator equipment
- VHF marker beacons, associated monitor system, remote control and indicator equipment [3].

The ILS ground facilities have been categorised by international standardisation as follows:

- CAT 1 - An ILS which provides a specified quality of guidance information from the coverage limit of the ILS to the point at which the localiser course line intersects the ILS glide path at a height of 200 ft or less above the threshold. Using this category of equipment and provided that appropriate supplementary ground and airborne equipment is installed and operating, operations can be permitted down to a decision height of 200 ft and with a runway visual range (RVR) of the order of 550 metres.
- CAT 2 - An ILS which provides a specified quality of guidance information from the coverage limit of the ILS to the point at which the localiser course line intersects the ILS glide path at a height of 100 ft or less above the threshold. Using this category of equipment and provided that appropriate supplementary ground and airborne equipment is installed and rating, operations can be permitted down to a decision height of 100 ft and with a RVR of the order of 300 meters.
- CAT 3 - An ILS which, with the aid of ancillary equipment where necessary, provides the specified quality of guidance information from the coverage limit of the facility to and along the surface of the runway. Using this category of equipment and provided that appropriate supplementary ground and airborne equipment is installed and operating, operations can be permitted with no decision height limitation and

without reliance on external visual reference [5]:

- CAT 3 A is a precision instrument approach and landing with a decision height lower than 100 feet (30 m) and a runway visual range (RVR) not less than 200 meters (660 ft).
- CAT 3 B is a precision instrument approach and landing with a decision height lower than 50 feet (15 m) and RVR less than 200 meters (660 ft) but not less than 75 meters (160 ft)
- CAT 3 C - precision instrument approach and landing with no decision height and no runway visual range limitations. It requires guidance to taxi in zero visibility as well [4].

Microwave landing system (MLS) is a precision approach and landing guidance system which provides position and various ground air data. The position information is provided in a wide coverage sector. It is determined by an azimuth angle measurement, an elevation angle measurement and a range (distance) measurement [3].

Although some MLS systems became operational in the 1990s, the widespread deployment initially envisioned by its designers never became a reality. Compared to the existing ILS system, MLS had significant advantages. The antennas were much smaller, due to using a higher frequency signal. They also did not have to be located at a specific point at the airport, and could "offset" their signals electronically. This made placement at the airports much simpler compared to the large ILS systems. They had to be placed at the ends of the runways and along the approach path. Another advantage was that the MLS signals covered a very wide area off the end of the runway. It is allowing controllers to vector aircraft in from a variety of directions or guide aircraft along a segmented approach [6].

Ground - Based Augmentation System (GBAS) consists of ground and aircraft elements. One ground subsystem (ground station) can support all the aircraft subsystems within its coverage providing the aircraft with approach data, corrections and integrity information for GNSS satellites in view via a VHF data broadcast (VDB) [3]. Minimum display functionality is an ILS look-alike and includes display of course deviation indications, vertical deviation indications, distance to threshold information, and failure flags.

Satellite - Based Augmentation System (SBAS) is made up of three distinct elements: the ground infrastructure, the SBAS satellites and the SBAS airborne receiver. The ground infrastructure includes the monitoring and processing stations. Stations receive the data from the navigation satellites and compute integrity, corrections and ranging data which form the SBAS signal-in-space. The SBAS satellites relay the data from the ground infrastructure to the SBAS airborne receivers that determine position and time information using core satellite constellation(s) and SBAS satellites. The SBAS airborne receivers acquire the ranging and correction data and apply these data to determine the integrity and improve the accuracy of the derived position [3].

4 PERSPECTIVE MAGNETIC MATERIALS

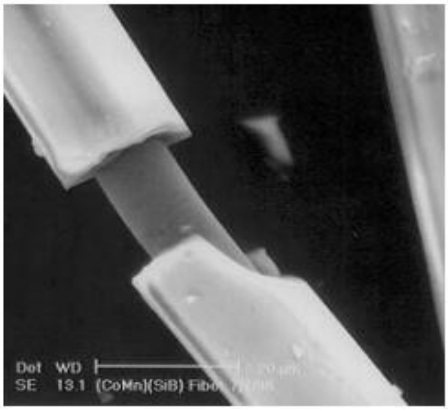

Figure 3. Glass – coated microwire. [8]

Magnetic sensors play an essential role in modern technology. They are widely used in nearly all engineering and industrial sectors, such as high-density magnetic recording, navigation, military and security, target detection, tracking, etc. A magnetic sensor directly converts the magnetic field into a voltage or resistance with, at most, a DC current supply. The field sensitivity of a magnetic sensor plays a key role in determining its operating regime and potential applications. Recently, the development of high-performance magnetic sensors has benefited from the discovery of a new magnetic phenomenon called the giant magneto - impedance (GMI) - a large change in the AC impedance of a magnetic conductor with an AC when subjected to an applied DC magnetic field. It has been demonstrated that magnetic sensors based upon GMI effect offer several advantages over conventional magnetic sensors.

At low frequencies, the large value of GMI is due to an extra electromotive force developed by the AC current. The application of a DC magnetic field changes the effective magnetic field and hence the induction of the sample and gives rise to a large MI. At higher frequencies the current flows through a thin sheath near the surface of the sample due to skin effect. The penetration depth of the current is given by Eq. 1, where f is the frequency, ρ is the electrical conductivity and μ_Φ permeability.

$$\delta = \sqrt{\frac{\rho}{\pi . f . \mu_\Phi}} \qquad (1)$$

GMI has attracted particular interest since Panina and Mohri announced their discovery of the GMI effect in Co-based amorphous ferromagnetic wires in 1994. Glass - coated ferromagnetic microwires can be produced by Taylor - Ulitovsky melt spinning method [12]. In this process, alloy pieces are first put into the glass tube and are then melted by a high-frequency furnace using an inductive coil. The glass tube is softened due to its contact with molten metal and it can then be drawn. The final product consist of a metallic wire in a glass sheath. In the case of microwires, metallic wire diameter is typically between 0,8 and 30 μm, while the thickness of the glass coating is in the range of 2–15 μm [7, 11]. Since the discovery of the magnetic glass - coated microwires just over 15 years ago, the international research interest into this perspective magnetic materials effect has been growing. Mainly Co-based amorphous magnetic materials with vanishing magnetostriction coefficient reach MI change more than 300%. [8].

5 EXPERIMENT

The amorphous $Co_{70,5}Fe_{4,5}Si_{10}B_{15}$ and $Co_{68}Fe_{4,5}Si_{12,5}B_{15}$ microwires were prepared in Instituto de Sciencia Materiales by Taylor - Ulitovsky technique.

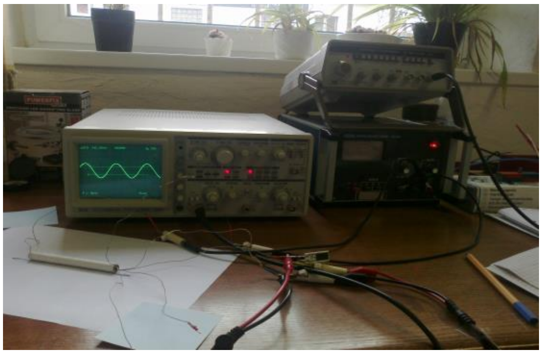

Figure 4. Measurement equipment.

The measured samples were 4 cm long and diameters of their metallic parts were 10 μm. The impedance Z has been calculated from the Eq. (2):

$$Z = U / I \qquad (2)$$

Electrical voltage U was measured by the four-point method using oscilloscope. External magnetic field was generated by a coil.

The dependence of the impedance Z on the applied magnetic field was investigated for the frequency of 1 MHz and 1,6 MHz at room temperature.

As is shown in Fig. 5 $Co_{70,5}Fe_{4,5}Si_{10}B_{15}$ and $Co_{68}Fe_{4,5}Si_{12,5}B_{15}$ alloys exhibit a significant GMI effect (50% and 125%), ie these materials are rather sensitive to use in sensors in air traffic.

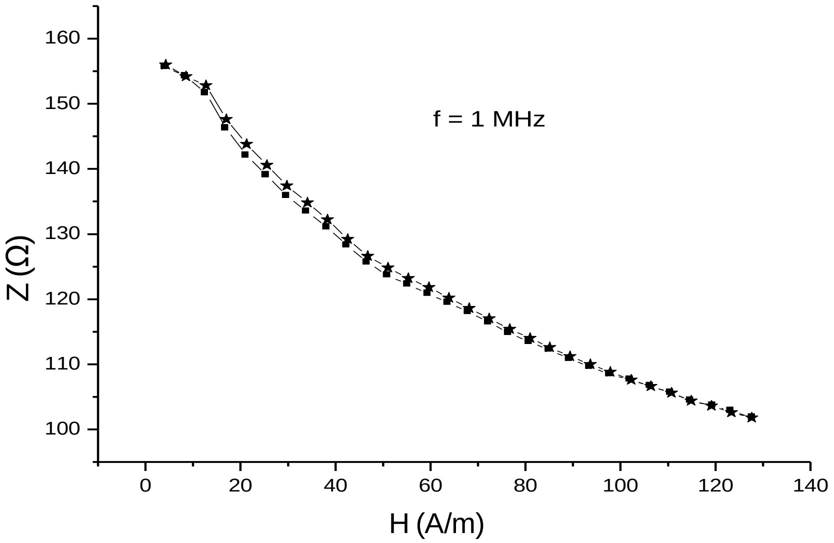

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Figure 5 a). The impedance change as a function of external magnetic field in $Co_{70,5}Fe_{4,5}Si_{10}B_{15}$ alloy at f = 1MHz.

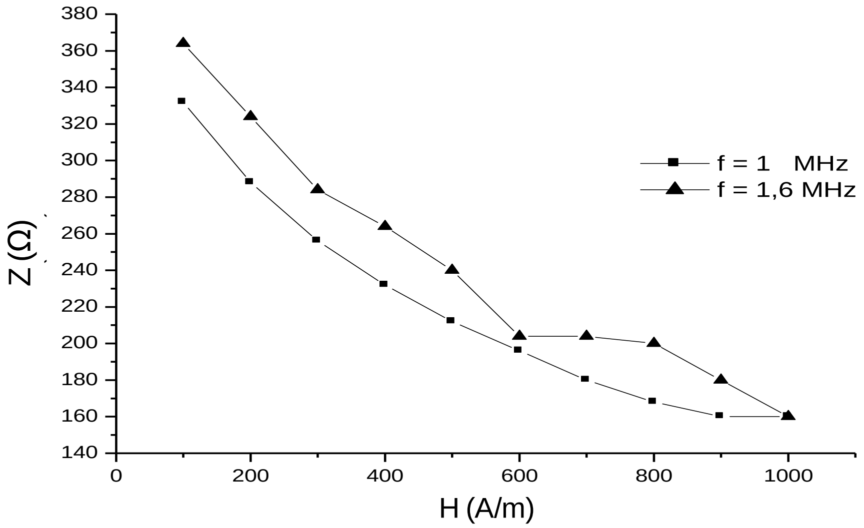

Figure 5 b). The impedance change as a function of external magnetic field in $Co_{68}Fe_{4,5}Si_{12,5}B_{15}$ microwires (f = 1 MHz and 1,6 MHz).

6 APPLICATION

On the ground - after landing, pilots must follow controller's instructions eg "taxi via taxiway A, Z - stand No. 4". This is the role of aerodrome controllers - safe operations of aircraft on the runway and in nearby airspace. It is essential to improve safety standards continually.

Raising safety goes hand in hand with improving services, procedures and technologies used in air traffic controlling [13].

At particularly busy airports, surface movement radar is the equipment used to detect aircraft and vehicles on the surface of an airport. It is used by air traffic controllers to supplement visual observations. It may also be used at night time and during low visibility conditions. SMR provide surveillance of all aircraft and vehicles in this area with a high update rate. SMR antennas are often mounted on the tower, which has good visibility of the manoeuvring area [14].

At smaller airports the only means for the controller to identify the location of each airplane is via voice reports over the radio. There's no financial possibility to buy expensive equipment like SMR.

Figure 6. Vehicles detection system [10]

Reducing visibility as a result of weather conditions and ascending number of landing aircrafts can complicate the situation and with several misunderstandings can result to the collision destroyed the aircraft.

Some 583 people died or were mortally injured on March 27th, 1977. Two Boeing 747 jumbo jets collided on a runway at Los Rodeos airport, Tenerife, in the Canary Islands, making this the world's worst civil aviation disaster. As a result of several misunderstandings in the communication, the KLM flight attempted to take off while the Pan Am flight was still on the runway. The resulting collision destroyed both aircraft, killing all 248 aboard the KLM flight and 335 of 396 aboard the Pan Am flight. Sixty-one people aboard the Pan Am flight, including the pilots and flight engineer, survived the disaster. There was no SMR in the airport [15].

Technologies based on perspective magnetic materials can be the answer for situations in which eg financial capacity of the airport is deficient. Amorphous magnetic microwires can detect external magnetic fields. The influences of measuring and processing parameters on the GMI effect and the underlying physical origins of hysteretic and asymmetric phenomena of GMI are explained and known. Nominal composition of the microwires is related to the customer's and application's demand, purpose and the field sensitivity of a magnetic sensor. The decisive factor is the ultra-high sensitivity of GMI sensors. When compared with a GMR sensor that has a sensitivity of approx 1%, the field sensitivity of a typical GMI sensor can reach a value as high as 500% [9].

To detect an aircraft or mobile vehicle on the ground, there's no demand to have a SMR. The system can be compound of nanocrystalline magnetic microwires with zero or negative magnetostriction. These materials are ideal for use in GMI-based sensing devices operating in the low and intermediate frequency range.

System consist from microwires implementing to the airport's movement area, the electrical circuit and infrastructure and computer system monitoring any change of sensor placement's magnetic filed. When an aircraft landed and touched the runway, sensitive GMI sensor is detecting the change of magnetic field. Due the presence of ferromagnetic material it signalises it on the panel of controller. Second possibility is to fix a small permanent magnet on the objects (aircrafts, airport vehicles). Detection is observed as a decrease in the AC voltage on the wire's ends.

The GMI sensors, using Co-based amorphous wires have good thermal stability over a wide temperature range between minus 40°C and plus 85°C, enabling the sensor to make reliable outdoor measurements. The advantages of this sensing technique are that it can be easily installed, it is insensitive to weather conditions, it does not obstruct the stress surface, and it has a very high reliability [7].

7 CONCLUSION

The Co-based amorphous materials are good candidates for GMI sensor applications. The measuring parameters (e.g. AC current, DC magnetic field and frequency) directly affect the measured value of GMI and so the selection of appropriate measuring parameters becomes extremely important in designing practical GMI sensors. Because the magnitude of GMI and its sensitivity varies with measuring frequency, it is necessary to select suitable working frequency range for a given material.

Factors promoting the practical uses of perspective magnetic materials like amorphous magnetic microwires in air traffic include the processing cost, power consumption, sensibility, modification, wide range of variation in parameters (geometrical and physical) and small dimensions.

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