FREQUENCY BANDS ALLOCATED FOR AIR TRAFFIC

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The article is focused on spectrum allocation by the "National table of frequency allocations (NTFA) Slovak Republic" allocated for air traffic, the division is focused on the radiocommunications, radionavigation, radiolocation and radio-aircraft systems in terms of allocation of frequencies and other technical specifications.

K e y w o r d s: frequency, frequency spectrum, radiocommunication, radionavigation, radiolocation, radio-aircraft systems

1 INTRODUCTION

Operation of aeronautical ground and airborne radio systems is in terms of the frequency band normative designated authority for the supervision of air communication in the world. Aviation application possibilities are generally determined by international organizations ICAO and EASA and the competent international telecommunications organizations. Use, selection and combination of radio communication, radio navigation, radar and radio equipment in air traffic is accompanied by many problems concerning the division of the frequency band and its proper use by type and destination of the aircraft.

Basic allocation of radio waves of frequency, wavelength and usage provides the Radio Regulations, issued by the International Telecommunication Union (ITU). Radio Regulations, the system of international agreements, which are periodically added and upgraded to international conferences, provides frequency bands for various radio communication services and radio equipment. In addition, it defines general conditions for use of radio frequencies without a frequency authorization and technical requirements in accordance with the intended use of radio frequencies to avoid interference and protect the public from the harmful effects of electromagnetic fields. Its application in individual states takes care of the government through special offices.

2 ELECTROMAGNETIC WAVES

Radiation and electromagnetic wave propagation is an important area with which we encounter daily without us realizing it directly. Electromagnetic waves propagate through space, different types of leadership makes them spread as desired by the user, and also when and how to serve properly. It is therefore useful to know the conditions for their use, especially in technical practice.

2.1 The history of the discovery of electromagnetic waves

Electromagnetic waves were first discovered theoretically. So did James Clerk Maxwell, when in 1873 he came in his work „Treatise on Electricity and Magnetism“ with hypothesis of the existence of electromagnetic waves moving at light speed in vacuum. He considered light as type of electromagnetic waves. At that time almost nobody took this approach seriously. His derivation of the wave equation for vectors of the electric field E and the magnetic induction B was seen only as a mathematical toy without a deeper physical content.

The existence of electromagnetic waves was clear to Heinrich Hertz, a professor of art at Karlsruhe, where in 1887 he made the original source of electromagnetic waves, called electromagnetic vibrator and resonator, showing the existence of waves (Fig. 1). In his work he used Ruhmkorff inducer, capable of creating a very strong potential electric field, and attached transmitter, which was essentially an interrupter - switch of the secondary coil. Then the receiver, actually a classic half-wave dipole antenna, was also interrupted by the driver. Hertz observed that when you start emitting, the receiver inducts current. Since the receiver and transmitter haven't been directly linked, the only possible explanation rests in the fact that the electromagnetic field between the two apparatus spreads through the air and thus the existence of electromagnetic waves is undoubtedly proven. It was actually a radio wave which wavelength varied in a number of tens of centimeters [1].

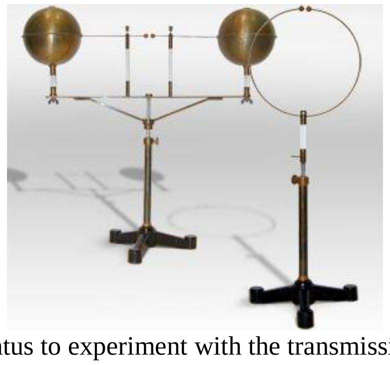


Fig. 1: Apparatus to experiment with the transmission of electromagnetic waves [1]

2.2 The emergence and spread of electromagnetic waves

The electric charge in motion is the source of the electromagnetic field. The electromagnetic field is characterized by the vector of electric field $\vec{E}$ and the vector of magnetic field $\vec{H}$. Both vectors oscillate in planes perpendicular and parallel to the direction of wave propagation. Electromagnetic wave is characterized by a frequency f and wavelength λ. Propagation speed of electromagnetic waves in a vacuum, and around and in the air is equal to the speed of light $c = 3.10^8$ m.s^{-1} Relationship between the wavelength λ and frequency of electromagnetic waves is given by,

$$\lambda = \frac{c}{f} \qquad [\text{m, m.s}^{-1}, \text{Hz}].$$

Electromagnetic wave spreads at a constant speed from the source to the receiver. Electromagnetic waves are generated in the vicinity of antennas driven by alternating current, the spherical wavefronts are spreading in all directions, and their distribution is influenced by the environment in which the antenna is located. Wavefront are places in space where the electromagnetic wave of the same phase.

Dissemination of magnetic waves in a conductive medium is transversely polarized waves. Vectors $\vec{E}$ and $\vec{H}$ are perpendicular to each other and also perpendicular to the direction of wave propagation. The amplitude of the electric field and magnetic field decreases exponentially. The propagation speed of $\vec{E}$ and $\vec{H}$ is the same, and between them is a phase shift [2].

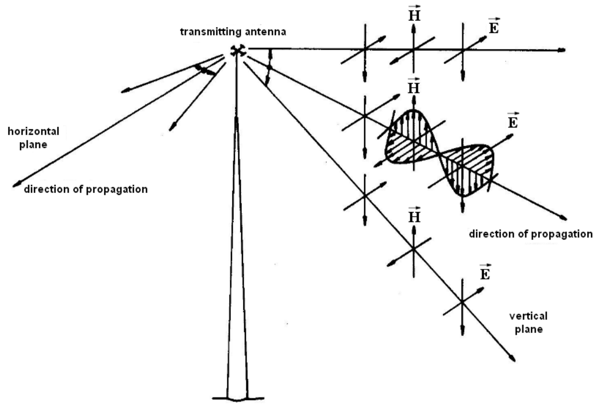


Fig. 2: Propagation of an electromagnetic waves

3 NATIONAL TABLE OF FREQUENCY ALLOCATIONS

It is often stated that the spectrum of radio waves are natural resources that must be carefully managed. Because it is spread in open space, it is essential to coordinate usage of radio waves with other users of radiocommunications services not only inside the country but also in services abroad. Therefore, spectrum management is governed by the rules set out in the Radio Regulations of the International Telecommunication Union (ITU). Radio Regulations is an administrative procedure, which is an integral part of the National Table of Frequency Allocations (NTFA), annexed to the International Telecommunication Convention and has the force of an international treaty. It sets out rules that member states must follow in order so that spectrum is used effectively and peacefully. According to the World Radiocommunication Regulations for the allocation of frequencies, world is divided into three regions (Fig. 3). Europe is part of region 1.

Award for Europe for the member countries of the European CEPT specified in the allocation table (ECA Table – European Table of Frequency Allocations), issued by the European Radiocommunications Committee (ERC).

NTFA is updated annually. After meeting ITU (WRC), which are usually held once every 3 or 4 years, the government approved the overall text NTFA. Use of spectrum in the Slovak Republic is governed by NTFA, issued by the Ministry of Transport, Construction and Regional Development - Telecommunications Office of the Slovak Republic and ultimately the direction approved by the Government of SR.

NTFA is the basic document on spectrum and frequency allocation in the Slovak Republic. It deals with frequency range from 9 kHz to 1000 GHz.

ICAO should develop globally harmonized frequency assignment planning criteria and a global frequency assignment plan in support to the ICAO Global Plan in order to improve the efficient use of the frequency bands allocated to relevant aeronautical services.

Spectrum for aeronautical radio communication and radio navigation (including surveillance) is allocated by the ITU in the framework of the WRC with the recognition of the safety aspects during the studies and the frequency allocation process [3].

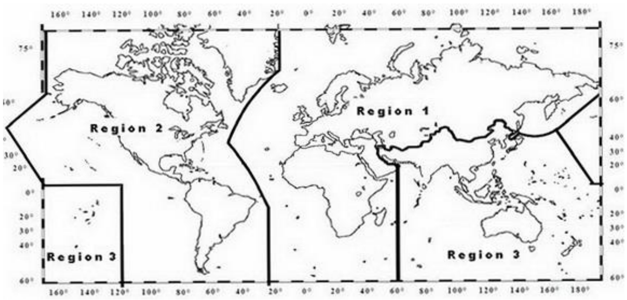
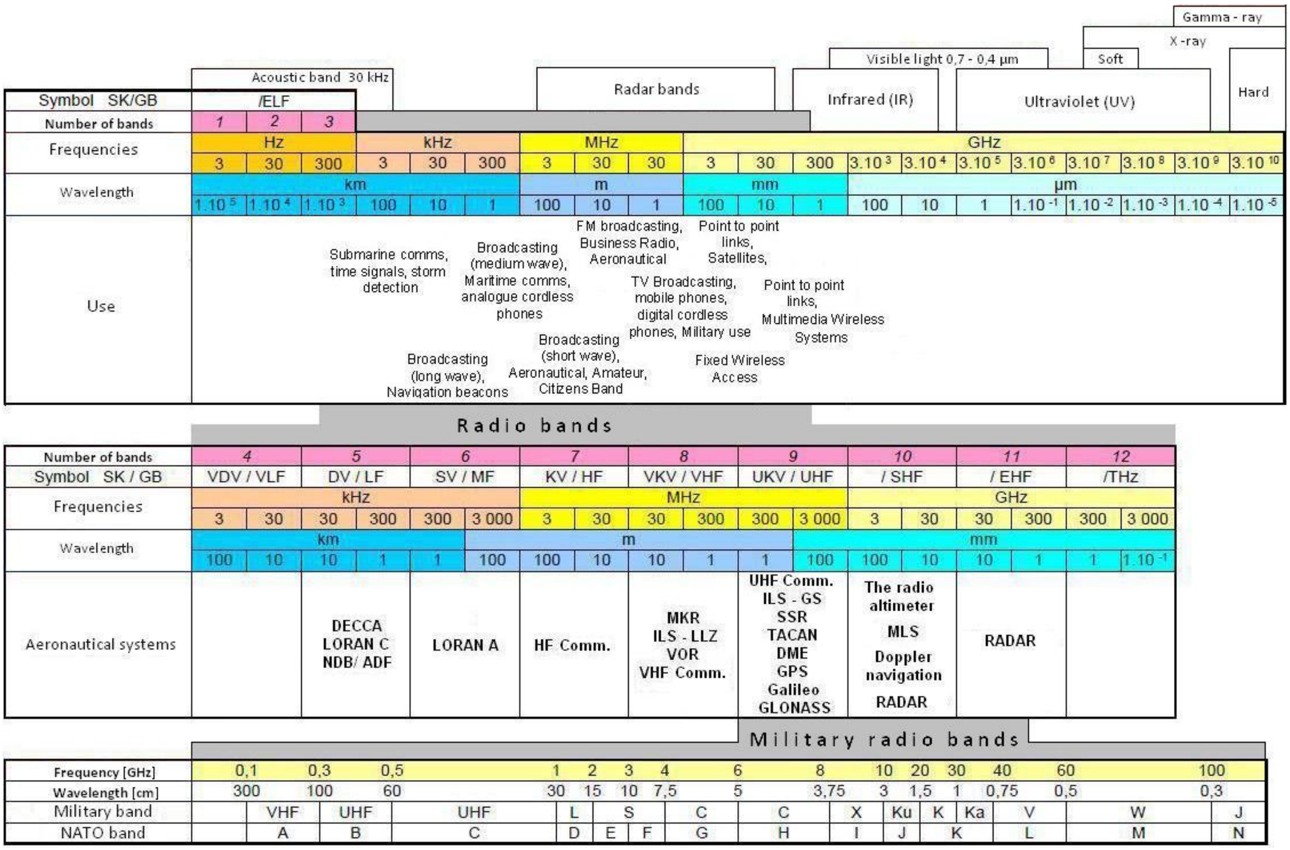


Fig. 3: Distribution of the regions of the world ITU [3]

4 ALLOCATION OF SPECTRUM



5 AIRCRAFT RADIO COMMUNICATION

For connection to the aircraft in air traffic management (service R) is mainly used VHF band 118 – 137 MHz, 25 kHz channel spacing, with both radiotelephony Side Band Amplitude Modulation A3E. Military flights are additionally allocated band 100 – 150 MHz and 220 – 400 MHz. Band 108-118 MHz is allocated, while air service, but to this extent only broadcast radio navigation beacons. Maybe even mention emergency frequency 121.5 MHz and 243 MHz.

5.1 HF Band

Air communication is thus its short-wave segments as defined in zones 4, 6, 8, 11, 15 and 22 MHz, for the aeronautical mobile (R) service. It is used here only amplitude modulation J3E Single Side Band (SSB). frequency 3 kHz channel spacing. On the other HF bands designed to provide connections over long distances for operational control of aircraft operators (service OR). The ICAO European region, to this end, the small distances using just some of the frequency bands 118 – 138 MHz. For connection to use specially designed transmitters and receivers, mostly with remote retune. For remote connection is just normal use of directional antenna systems and SELCAL (SELlective CALlling), which allows connections only to the selected plane. Power ground station can reach up to 6 kW and 400 W. dashboard As additional data services like sending here. HFDL system (short – aircraft position reports and other supplementary data).

5.2 VHF Band

The air VHF uses stepping of 25 kHz (120.025 120.050 etc.), but is now introducing a stepping of 8.33 kHz which is a third step.

Terrestrial transmitters are often one channel, for example. for TWR (tower, control tower) to several tens to hundreds of watts to connect in the air. Terrestrial receivers are often just single frequency or swept with the few frequency channels.

Every year, air traffic control manual issued by each State AIP (Aeronautical Information Publication), in which the rules are written take-offs and landings, communication frequency lists, maps of flight paths and area etc.

Civilian VHF band is divided into sections as determined by the type of flight. There are specified frequency segments for overflights at high altitudes, for low flights, frequency approach or for departures etc. By frequency is thus possible to determine in what areas and years of being pursued [4].

5.3 HF Band

The band (1530 - 1559 MHz) operates satellite communication system SATCOM (SATellite COMmunication), which allows voice and data communications. The system allows voice and data transmission over longer distances than VHF communication system as well as reliable communication during transoceanic flights than HF communication system.

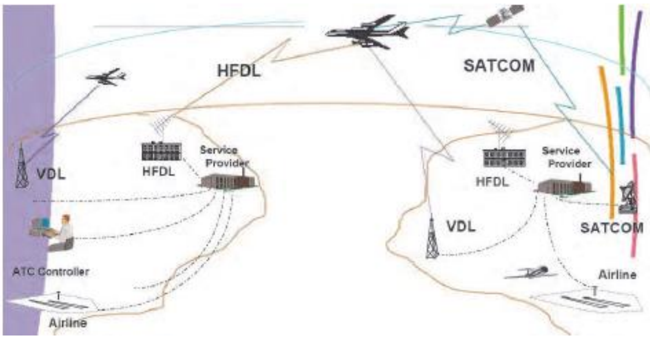


Fig. 4: ATM network global architecture [5]

6 AERONAUTICAL NAVIGATION

Radio waves allow the realization of the vast majority of technology CNS (Communication Navigation Surveillance), especially for the reliable transmission of information over long distances, navigation measurement with high accuracy without affecting the earth's surface and very detailed picture of the air situation as on board an aircraft and the ATS unit (Air Traffic Services).

Navigation using radio waves can be run on small and large distances or even globally. For small effects can be seen between 100 and 200 nm, large impacts are above 200 nm to 10000 nm. The tendency of the development of radio navigation aids is an effort to secure universal service using satellite navigation devices.

Basic breakdown by purpose of radionavigation systems is the airport and en-route, the fact that some devices (according to your location) to perform both tasks. Airport navigational aid systems allow pilots guiding the aircraft to the runway axis and follow the lead aircraft in the exchange rate or the glide path axis or allow the determination of the distance to the runway threshold. This group includes precision approach beacons Systems (ILS), system (DME), non-directional radio beacons (L, NDB) and VHF Omnidirectional Radio Range (VOR).

Track navigational aid systems allow the aircraft to determine its location during summer. Facilities should be positioned to ensure coverage of radio navigation signals across the airspace of that State. On average, they should be placed at significant airway points. This group is non-directional radio beacon (NDB), VHF Omnidirectional Radio Range (VOR) and distance meters (DME) [6].

6.1 System NDB/ ADF

Terrestrial beacon NDB (Non - Directional Beacon), it is non-directional (isotropic) radio beacon, used as a means for the final approach. It operates at frequencies from 190 to 1750 kHz, bands in LW and MW. The most commonly used, however, is frequency in the lower part of the band between 250 and 450 kHz. Onboard device that detects the direction of the reception of NDB board is automatic direction finder ADF.

6.2 System VOR/ DVOR

VOR (VHF Omni - directional Range) and advanced form of this DVOR (Doppler - VOR), Doppler, are directionally emitting radio beacons. Using phase-modulated signals create imaginary rosette 360 radials, with each radial line represents the area that has the compass bearing from the lighthouse. Along with the rangefinder DME form VOR/ DVOR large part of the area navigation RNAV.

The band from 108 to 117.95 MH transmitter VOR/ DVOR can be tuned to total 160 frequencies, respectively channel frequency with the passage frequency of 50 kHz. In the band 108 – 112 MHz transmitters VOR/ DVOR of individual channels sharing the ILS localizer transmitters so that the transmitters VOR/ DVOR used here only those channels which frequency value is in first place after the decimal point even number (i.e. 108, 0 - 108.05 to 108.20 - 108.25 to 108.40 ... 111.85), representing a total of 40 channels of 50 Hz. These frequencies are used for VOR, located in the terminal area and operate with a reduced performance. Channels with frequencies that mark the decimal point is an odd number, falls under ICAO the transmitter ILS LLZ. The band from 112 to 117.95 MHz transmitter channel frequencies are VOR values from 112.00 to 112.05 - 112.1 to 112.15 ... 117.95 (i.e. a total of 120 channels of 50 kHz). Band is used to select frequencies route VOR the interoperability.

6.3 System DME

System DME (Distance Measuring Equipment) is designed to ensure continuous and accurate indication inclined plane distance, with appropriate facilities, evaluated from the reference point of ground equipment. The system consists of two basic parts - equipment on board the aircraft (interrogator) and equipment installed on the ground (responder). The system works on the principle of secondary radar.

The system operates in the UHF frequency band, the frequency range 960 – 1215 MHz with vertical polarization. Frequencies for querying and answers are provided with spacing between channels by 1 MHz. DME operating channels are selected from the 252 channels that are grouped in pairs of frequencies for questions and answers and pulse coding to the paired frequencies. For practical reasons are channels paired so that they always differ by 63 MHz frequency difference. Channels are labeled 1 – 126X for frequencies " us" and 1 - 126Y for frequency "response". Signal "us" is the distance between the faces of two pulses in pulsed code 12μs and signal "response" to the length 36 microseconds.

5.4 System ILS

- VHF localizer

Localizer operates in frequency band from 108 to 111.975 MHz with 50 kHz spacing between channels. Signal transmitted by the localizer antenna system creates a composite radiation pattern. This diagram contains modulated tones Navigation 90 Hz and 150 Hz, representing foreign exchange sector, which prevails depth Pilot tone modulation of one on one, and the second Pilot tone on the other line from the exchange rate.

- Glide slope

Glide slope operates in frequency band from 328.6 to 335.4 MHz with channel spacing of 50 kHz. Glideslope angle signal is also composed of two overlapping beams modulated 90 and 150 Hz, and these signals are arranged one above the other, and are emitted along the approach path.

- Markers

Markers work on a single frequency of 75 MHz with a power of 3 W or less.
Modulation frequencies of positional signals are:

a) 3000 Hz for internal marker (if installed);
b) 1300 Hz for secondary marker;
c) 400 Hz for outer marker.

5.5 System MLS

System MLS (Microwave Landing System) is a Precision Approach and landing guidance system that provides location information and various data from the ground into the air. Position information is provided in a broad sector and is determined by measuring the angle of the course (azimuth), glide angle (elevation) and distance. Angular features and functions of the traffic will be one of 200 channels, which use frequencies in the band from 5031 to 5090.7 MHz [6].

7 RADIOLOCATION

Frequency band, in which the radar operates, in principle, determines its operating options. The frequency can be determined fixed (single frequency) or can transmit / receive radar within certain limits retune. The possibility of realignment is typical for PSR (Primary Surveillance Radar - primary surveillance radar). Work on the permanent frequency (without tuning) is typical for SSR (Secondary Surveillance Radar - secondary surveillance radar) in RLP.

The basic type of air radar is pulsed radar which transmitter / receiver operate with pulse-modulated signal (radar pulses). This type of radar allows you to measure distance by measuring the time.

For ATS (Air Traffic Services - Air Traffic Services) is the most widely used radar frequency range from 1.2 to 6 GHz, of which the best work the band radar ATC S, L and X (10 GHz) [6].

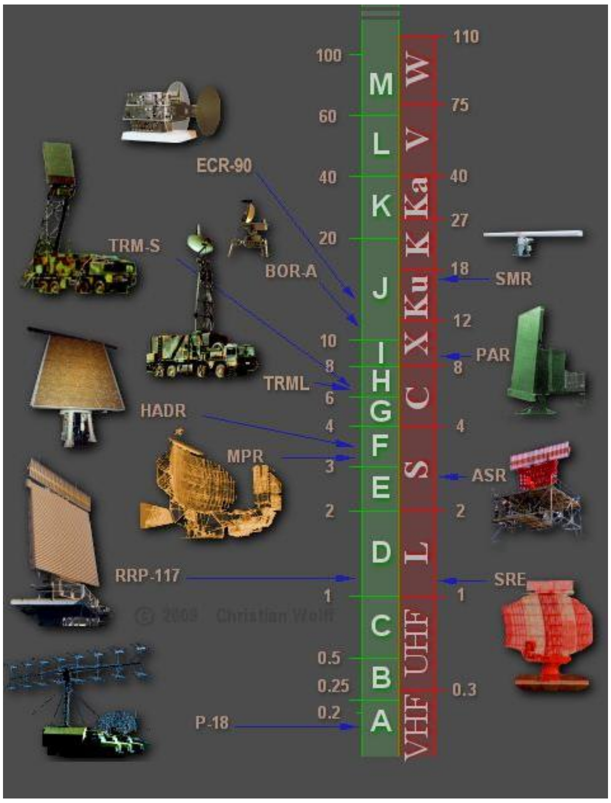


Fig. 5: Some radars and its frequency band

8 AIRCRAFT RADIO – TECHNICAL SYSTEMS

Aircraft radio – technical systems are group of systems, which tasks are flight operation safety and protection against unexpected crisis situations around the aircraft. These systems are characterized by a single active activity (active and secondary radiolocation) and for its operating needs minimal intervention from pilots and airline operators. This equipment consists of radar aircraft identification equipment, airborne radars, airborne warning and anti-collision systems.

8.1 System ACAS

ACAS (Airborne Collision Avoidance System) is a device that warns pilots of the dangers in the form of collision with another aircraft, regardless of ATC services.

Airborne Collision Avoidance System uses standard signals of transponders Secondary Surveillance Radar Mode A / C or Mode S.
ACAS broadcasts a long interrogation signal tracking "aircraft – aircraft" in vogue with the omnidirectional broadcast address.
When posting "aircraft – aircraft" queries are transmitted at frequency of 1030 MHz referred to as bottom-up connections and signal format codes containing upward seam (UF), replies received at a frequency of 1090 MHz are designated as joint top-down transmission and contain codes seam downlink signal format (DF) [7].

8.2 System GPWS

The aim of the GPWS (Ground Proximity Warning System) is to provide pilot visual and audible warning in situations where the observed distance from the Earth's surface is a potential threat to flight safety. The system should reduce the number of CFIT (Controlled Flight Into Terrain), thus reducing the number of collisions flight capable, fully controlled aircraft with the terrain, obstacle, or water surface.
The system operates between 50 and 2450 ft above the ground (radio altitude) and automatically selects the appropriate mode (5 basic modes) of their activities. For GPWS system are not defined any custom frequencies. To gather information, it uses frequencies of other systems with which it cooperates closely - altimeter, GPS and DME. The frequencies of these systems are as follows:
The radio altimeter: 4.2 GHz - 4.4 GHz,
GPS: 1.2 GHz - 1.6 GHz (L band)
DME: 978 MHz - 1213 MHz [8].

8.3 ATC transponder

For all classes of SSR in the frequency response is surveyed 1,090 ± 3 MHz. For any class or SSR Mode S is the maximum RF peak output power of 27.0 dBW (500 watt).
The nominal center frequency is 1030 MHz for receiver. The input signal level is 3 dB above the minimum trigger level, the band receiver such that the receiver receives the pulses moves Central interrogator frequency by ± 0.2 MHz. Marginal zone receiver sensitivity is at least 60 dB at ± 25 MHz and beyond.
Beam pattern antenna equipment is predominantly vertically polarized in the horizontal plane to be virtually omnidirectional with a nominal vertical beam width of less than ± 30 ° from the horizontal plane. The voltage standing wave ratio (VSWE) generated in the transmission line antenna does not exceed 1.5: 1 when operating on radio frequencies between 1030 and 1090 MHz [9].

8.4 Airborne weather radar

Activity airborne weather radar AWR is directly based on the detection of atmospheric phenomena, which detects large raindrops or hail and snow. Weather radar operates on wavelength λ = 3.2 cm at frequency of 9.375 GHz (ACS) with a pulse duration of about 1 microsecond. This uses effects that usually have other devices to the negative impact of such loss or reduction impact, in your favor. One of the modes of the radar is also adapted to detect uneven ground; it is a so-called MAP mode [6].

9 CONCLUSION

This article reviews the allocation of spectrum under "National table of frequency allocations (NTFA) Slovak Republic", the allocation of frequency bands air services and services that provide air traffic control and aviation technical description of the device in terms of their specifications.

Aim to the future is to establish a comprehensive network of European Spectrum Policy, which is to optimize air traffic control and aviation security while meeting the needs of those users who use airspace and this joint contribution must be managed collectively, regardless of national boundaries. To achieve these objectives, it is necessary to coordinate the introduction of new technologies that use spectrum more efficiently. Although it is not possible to avoid the situation that occurs with parallel mutual functioning of old and new aviation systems, this condition should be kept to a minimum, however. Spectrum already allocated for aviation operations, should be used in the most effective manner in accordance with safety regulations.

ACKNOWLEDGMENT

This work was funded by the European Regional Development Fund under the Research & Development Operational Programme project entitled "Construction of a research & development laboratory for airborne antenna equipment, ITMS: 26220220130."

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