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METEOROLOGICAL INFORMATION RESOURCES FOR AIRCRAFT CREWS

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Abstract

This article addresses the issue of available meteorological information resources and their importance for aircraft crews, with special regard to the ways of disseminating meteorological information and the possibilities of providing it to crews. The aim of the article is to process a comprehensive set of information about meteorological information resources and methods of obtaining meteorological information in aviation. The article has a theoretical character. It summarizes the basic terminology and defined concepts of the processed issues, with an effort for a logical focus of the chapters that are adequately addressed. In the discussion and conclusion, we pointed out the importance of meteorological resources for aircraft crews, the need for proper assessment and evaluation of the obtained meteorological information, in order to ensure the safe course of the flight.

Keywords

Meteorological Resources, Meteorological Data, Meteorological Information, Weather, Meteorological Phenomena, Meteorological Elements, SHMÚ, Meteorological Reports, Satellite meteorological systems

1. INTRODUCTION

Knowledge from meteorology as an extensive field of science and aerial meteorology, which is an industry of applied meteorology, continues to be in demand for their wide practical use, and not only in air transport, even in the current time of rapid advancement of aviation.

For aviation meteorological provision, information on weather conditions is essential and the emphasis is mainly on making up-to-date information as accurate as possible. It is the meteorological information resources that are the means that ensure that accurate meteorological information is obtained in aviation and allow for the subsequent assessment of meteorological conditions and impacts before, during and after the flight.

The aim of the article was to process a comprehensive, concise set of information on meteorological information resources for aircraft crews and ways of obtaining meteorological information in aviation.

The knowledge was gained by analyzing the available book and internet Slovak and some foreign sources.

2. WEATHER - METEOROLOGICAL FACTOR CAUSING CRISIS SITUATIONS IN AIR TRANSPORT

2.1. Impact of weather on air traffic safety

Even in the age of modern aircraft equipment and ground technology, the weather still has a major impact on the safety of air transport and the comfort of those on board the aircraft. Air accidents, in which the weather was the co-operative cause, demonstrate to us the importance of the impact of the weather on air transport [1].

Such accidents have always occurred, and this will certainly not change for the foreseeable future. However, thanks to the competent approach of the aircraft crew, it is possible to reduce the risk of these accidents to a minimum. However, it is not just about knowing the risks of the weather, although aviation safety is certainly one of the first places [1].

The term weather means constantly changing atmospheric conditions that exist at a certain place at a certain time. The weather is the result of physical interactions between sunlight, air and water. Sunlight causes uneven heating of air on the Earth's surface, leading to different air pressures. The air tries to compensate for these differences in pressures by moving around the country in the form of wind. Thanks to sunlight, water evaporation also occurs. As the air with water vapor rises, it cools down, the water condenses again, forming clouds. Weather changes can be quick or slow. An example of a rapid change in the weather is a warm sunny morning, which turns into a cold and wet afternoon. Conversely, the transition between flight and winter is a slow change. From a long-term perspective, the weather does not change much. Summers are warm, cold and winters mild, but also frosty. These seasonal variations shall be eliminated over the years [2].

2.2. Meteorological phenomena and elements that affect the flight

We describe the weather using meteorological phenomena, meteorological elements and cloud cover.

Meteorological phenomena are among the weather phenomena that occur in the atmosphere or on the Earth's surface. Photometeors, lithoeteors, electrometeors and hydrometeors are included under meteorological phenomena. Meteorological phenomena do not include clouds. Meteorological phenomena can be of varying intensity - weak or very weak, moderate or strong [3].

A meteorological element is a physical quantity characterising the state of the atmosphere, expressed in specified units of measurement. It is measured directly or indirectly, or estimated or calculated (e.g. pressure, temperature and humidity of the air, wind direction and speed). The meteorological element is a function of place and time, F = F (x, y, z; t) and is a scalar or vector quantity. The set of values of a given meteorological element is called an array of meteorological element that characterizes the spatial distribution of a meteorological element in the atmosphere. We divide the fields of meteorological elements according to their nature into scalar and vector, continuous and disjointed [3].

Meteorological elements are air pressure, air temperature, humidity, sunlight, wind, cloud cover and precipitation [5].

3. METEOROLOGICAL INFORMATION PROVISION SYSTEMS IN AIR TRANSPORT

3.1. World Meteorological Organization (WMO)

The Geneva-based World Meteorological Organisation (WMO) is an authority for everything in terms of state and movement in the atmosphere. It examines the interactivity of the atmosphere with the oceans, studies airborne-related manifestations, hydrology and also geophysical phenomena. The World Meteorological Organisation examines everything related to meteorology, climatology, hydrology and also air and its protection [6].

3.2. Global Telecommunications System (GTS)

The Global Telecommunications System (GTS) is part of the World Weather Watch (WWW) programme. It serves to coordinate and quickly collect processed meteorological information, exchange and distribute it throughout the world. GTS enables its members to ensure the rapid flow of meteorological data in a reliable and cost-effective manner. It ensures full accessibility of meteorological and meteorology related data, forecasts and warnings. This secure communication network allows for the exchange of important information in real time, which must be correctly submitted in order to warn in a timely manner of meteorological and hydrological risks, in accordance with approved procedures [7].

3.3. World Area Forecast Center (WAFC)

The World Area Forecast Centre (WAFC) is a meteorology center that prepares and issues significant weather forecasts (SIGWX) as well as forecasts for certain elevation levels. These meteorological forecasts shall be distributed directly by appropriate means, in digital form and to a global extent, directly to the Member States that are part of the aeronautical fixed service. WAFC forecasts at node points refer to elevation wind, temperature and humidity in higher layers, geopotential altitude of flight levels, flight level and temperature of tropopause, direction, speed and flight level of maximum wind, cumulonimbus clouds, icing and turbulence [4].

3.4. World Area Forecast System (WAFS)

The World Area Forecast System (WAFS) is a worldwide system that works to provide aerial meteorological forecasts in a standardised format provided by the world's area forecast centers. In the event of inconsistencies in the significant weather forecasts (SIGWX), the meteorological service provider responsible for the area concerned shall immediately identify the inconsistencies and report them to the world area forecast centres. Inconsistencies are reported in the framework of icing phenomena, turbulence, cumulonimbus clouds, sand storms, or dust storms, volcanic eruptions, or releases of radioactive substances into the atmosphere which are significant for aircraft operation [4].

3.5. Aeronautical meteorological stations

A meteorological station is the place where meteorological observations are carried out at fixed time limits, according to agreed international procedures. The basic prerequisite is the corresponding technical, personnel and communication equipment [8].

The location of aeronautical meteorological stations at airports is most often in their vicinity, where they serve for meteorological observations for the needs of air traffic. Today, most aerial weather stations operate exclusively in fully automatic mode. All measurements are made via meteorological sensors and a computer. After recording the result of the automatic measurement, this output shall be re-sent to the central database in the form of encrypted messages or data files [1].

3.6. Synoptic stations

Synoptic stations are used to measure the development and condition of the weather, in the greatest possible frequency and range. Measurements from these stations serve the purposes of both synoptic and aerial meteorology. Synoptic stations also serve for the need to perform climatological measurements and observations, allowing for a large set of measurements with the required accuracy. Sensors located at synoptic weather stations shall be located in accordance with WMO recommendations. Based on measurements from synoptic meteorological stations, meteorological reports shall be compiled, e.g. SYNOP, METAR, SPECI and others requiring a high rate and high frequency of transmission of meteorological data [8].

3.7. Slovak Hydrometeorological Institute (SHMÚ)

The Slovak Hydrometeorological Institute (SHMÚ) is an organization specializing in performing meteorological and hydrological services at national and international level [9].

The SHMÚ monitors the quantitative and qualitative parameters of the state of air and water in the territory of the Slovak Republic, collects, verifies, evaluates, archives and interprets data and information on the state and regime of air and water, describes what is happening in the atmosphere and hydrosphere, creates and issues meteorological and hydrological forecasts, warnings and information [9].

Data, information and study results are provided by the SHMÚ to users and the general public [9].

4. METEOROLOGICAL INFORMATION RESOURCES AND THEIR IMPORTANCE FOR AIRCRAFT CREWS

In air transport, weather is one of the most important factors when it comes to safe flight progress. It is therefore necessary to know its current status and subsequent developments at the point of departure, during the course of the flight and also at the point of arrival. This is provided by meteorological information resources intended for aircraft crews. Within the framework of safety, it is necessary to carry out flawless pre-flight preparation and react in a timely manner to any changes in the weather. The correct design of the weather situation contributes to improving the safety of the crew or passengers during the performance of the flight.

4.1. OBTAINING METEOROLOGICAL DATA BEFORE THE FLIGHT

4.1.1. Airport meteorological report METAR and extraordinary report SPECI

The airport meteorological report METAR is a coded meteorological report issued by aeronautical meteorological station personnel or automatically. It is one of the main information resources for pilots in the framework of meteorology. The METAR message encodes the current weather situation at the airport [1].

These airport meteorological reports are issued at 30 or 60 minute intervals. They are coded in well-defined formats, according to ICAO standards. They are distributed to OPMET international meteorological databases and to telecommunications centres, from where they are extended to other airports. This ensures the rapid transmission of weather information within airports around the world [10].

The METAR report shall include the ICAO mark of the aerodrome at which the observation was carried out, the date and time of issue, the wind, visibility and runway visibility, the current weather, the current cloud cover, the air temperature, the dew point temperature and air pressure indication [1].

In the event of a change in an element that exceeds a specified value between regular observations, such as visibility, change in wind direction or speed, height or amount of cloud cover, the observer shall issue an extraordinary SPECI report [10].

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SASQ LZSL 201800
METAR LZSL 201800Z 01002KT CAVOK 02/M09 Q1040=
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Figure 1: Airport meteorological report METAR from Sliač airport dated 20.3.2022. [20]

4.1.2. Airport forecast TAF

The airport forecast TAF is a forecast of certain weather elements at a particular airport. Most often, the airport forecast TAF is issued 4 times a day in 6-hour spacing. If the forecast is less valid than 12 hours, the TAF is issued every 3 hours. The validity of the forecast shall not be less than 6 hours or more than 30 hours. Only one valid TAF forecast must be issued for a certain period and an airport in particular. The coding of the TAF forecast is based on the coding of the METAR report, so the TAF forecasts and METAR reports are quite similar [1].

4.1.3. Information reports SIGMET and AIRMET

SIGMET information reports are information or warnings issued by the Meteorological Warning Service and shall indicate the possible occurrence of meteorological phenomena which may significantly affect the safety of air traffic in the aeronautical information area. SIGMET information is written in open speech, not encoded. They have a prescribed composition and use abbreviations as defined by ICAO [11].

The AIRMET information reports shall be issued by the Meteorological Warning Service and shall relate to the occurrence, expected occurrence or development of certain en-route meteorological phenomena which may affect the safety of low-flight air traffic. AIRMET reports shall be issued in the event that these meteorological phenomena have not been included in the forecast for low flight levels (FL) in a particular flight information area. In the case of low flight levels means operation under FL100 or FL150, in mountain areas [12].

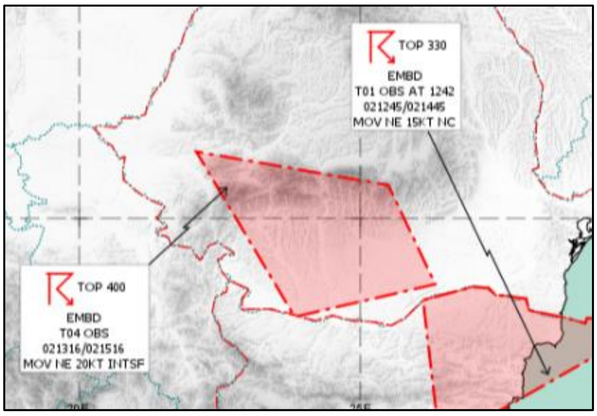

Figure 2: Information report SIGMET on the occurrence of storm activity over Romania and Bulgaria dated 3.4.2022. [21]

4.1.4. Area forecast GAMET

The GAMET area forecast is issued in the event of dangerous meteorological phenomena occurring in the flight information area that could endanger air traffic at low flight levels. The GAMET forecast is formulated in open speech, using ICAO abbreviations. It is issued 4 times a day and can be helpful not only to pilots, but also to air traffic controllers. The information from the GAMET area forecast serves as a basis for issuing AIRMET information reports [1, 13].

4.1.5. Weather forecast for takeoff

The shape of the take-off forecast shall be determined by mutual agreement between the user and the meteorological service provider. The weather service provider reports the weather forecast at hourly intervals. The take-off forecast shall include the expected wind direction and speed, air temperature and QNH pressure at the aerodrome of departure. Information from the take-off forecast is useful for both the pilots themselves and the support components. As example is the use of a wind direction and speed forecast when it is possible to determine the use of a particular runway to take-off. On this basis, the flight trajectory itself will be changed and the required amount of fuel required for the successful execution of the flight shall be determined [1].

4.1.6. Observations and reports from aircraft (PIREPS)

One other resource of meteorological information for aircraft crews is observations and reports from aircraft (PIREPS). It is the responsibility of each meteorological office to ensure that observations of dangerous meteorological phenomena from the deck of aircraft are carried out, recorded and reported. This is done by means of regular and extraordinary aircraft reporting. A radiotelephone connection, or a data link, may be used to perform these reports in the form of an ACARS data communication system. Aircraft reports shall include any dangerous meteorological phenomena occurring on the line [11].

4.2. OBTAINING METEOROLOGICAL DATA DURING THE FLIGHT

4.2.1. Automatic information service ATIS

The automatic information service ATIS shall provide up-to-date information to arriving or departing aircraft by means of repeated and continuous transmission throughout the day or during a certain part of the day [14].

ATIS allows aircraft pilots to obtain information on the possible closure of a particular aerodrome, bad weather conditions around it, runways used, types of approaches, or increased air traffic density, which may be crucial for safety. The use of automatic information service facilitates the work of air traffic controllers at busy aerodromes and reduces radio frequency congestion. They may devote themselves to other duties and do not have to spend time repeating the same information to a large number of pilots [15].

4.2.2. Meteorological radio report VOLMET

The meteorological radio report VOLMET (from the French VOL "flight" and MÉTÉO "weather") is a summary of the most up-to-date meteorological information from a particular airport and from the airports located in its surroundings [10].

The VOLMET message is broadcast continuously on the VHF waves and contains the current METAR airport meteorological report with TREND landing forecast, the SIGMET information report and, if available, the airport forecast TAF. The VOLMET weather radio reports may also be transmitted on HF waves (HF-VOLMET) or using a data link (D-VOLMET) [11, 13].

4.2.3. Reports from air traffic controllers

In the event of a reported adverse meteorological situation or meteorological phenomenon which is significant for air transport and could jeopardise the safe course of the flight, the air traffic controller may report this situation to the pilot, at its sole discretion or on the basis of the size of the risk posed by this meteorological situation or meteorological phenomenon to the flight. If the pilot is interested in specific information during the flight regarding the meteorological situation along the route, he shall request this information from the air traffic controller, who shall provide it to him.

4.2.4. Airborne weather radar

The development and deployment of airborne weather radar was an important step in terms of flight safety in adverse meteorological conditions. The airborne weather radar scans the cloud cover over a certain distance in front of the aircraft and is able to determine the saturation of this cloud cover with water droplets. This allows the pilot to provide information about the location of a possible storm cloud and assist him in making safe decisions, such as changing course, waiting or landing at a replacement aerodrome. Nowadays, airborne weather radar is a mandatory element of the navigation and communication equipment of modern airliner [16].

4.2.5. Data communication system ACARS

The data communication system ACARS is another important system that is used in air transport. This system allows the transmission of digital information between the aircraft and the ground station, as well as between the aircraft and the airline's operations centre. Using the ACARS system, pilots of an aircraft can request information about the meteorological situation in the vicinity, which will ensure that they quickly and seamlessly familiarise themselves with this situation during the performance of the flight. Against this background, the workload of pilots and air traffic controllers themselves decreases [17].

4.3. OBTAINING METEOROLOGICAL DATA BEFORE LANDING - LANDING FORECAST TREND

Just as it is important to know the development of the meteorological situation before and during the flight, it is also necessary before landing at the airport of the chosen destination. In the event of worsening weather at this airport, pilots, thanks to the resources of meteorological information, have time to react and possibly reconsider the next steps associated with the landing.

The landing forecast TREND is attached to the METAR report and its validity covers a period of two hours after the release of the METAR report. This forecast specifies the development of the weather during this period and is formulated in such a way as to record the expected changes in the critical meteorological elements. In the event of an expected change in the meteorological situation, the METAR report shall be followed by the BECMG or TEMPO change indicator. If no significant change in the weather is expected, such a message shall be terminated with NOSIG [1].

5. OTHER IMPORTANT FORMS OF OBTAINING METEOROLOGICAL DATA IN AIR TRANSPORT

5.1. Coded meteorological report SYNOP

The coded meteorological report SYNOP, obtained from the ground station, is the most comprehensive regular report on ground meteorological observations. It is used as a source of information for drawing synoptic maps, which are of general use but are somewhat important background material in the aviation. Coded meteorological report SYNOP is compiled according to the SYNOP code [18].

5.2. Meteorological radars

Weather radars are devices without which the use of modern weather service is unimaginable nowadays. They are used to detect the structure and composition of significant types of cloud cover [1].

Radars remotely detect the presence and position of various objects, based on a directed bundle of UHF electromagnetic waves, so-called microwaves [8].

Radars became more fundamentally applied during World War II, when they aimed to track planes in the sky. During this activity, there was noise that radar users wanted to remove. However, it later emerged that this noise came from reflections from meteorological targets, which represented cloud cover. On this basis, radars have started to be used as meteorological aids, which have been gradually introduced in individual meteorological services [1].

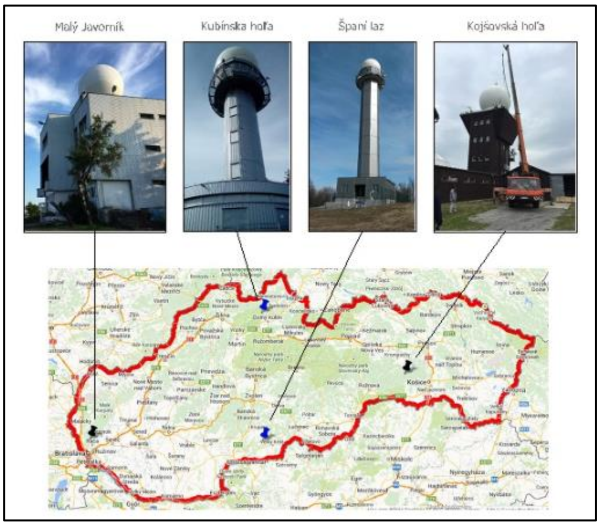

Figure 3: Location of meteorological radars of the Slovak Hydrometeorological Institute within the territory of Slovakia. [22]

5.3. Weather Information Service (WIS)

Honeywell's Weather Information Service (WIS) is a service that can greatly assist aircraft pilots in real time tracking the meteorological situation. This service also assists the crew of the aircraft in making decisions in the event of an unexpected change in the weather on the line. WIS provides the user with a weather forecast, along with up-to-date information about it in real time and at all stages of flight. It contains up-to-date weather forecasts at airports, using airport meteorological reports METAR, data automatic information service D-ATIS, airport forecasts TAF and others. In the case of en-route flights, WIS shall provide information on possible areas of occurrence of icing or CAT. It also provides information on the vertical range of Cb storm clouds, satellite data or reports from aircraft - PIREPS. In finals, this service makes it possible to design flight trajectory optimisation based on the availability of up-to-date weather information [19].

6. METEOROLOGICAL SATELLITE SYSTEMS

6.1. History of meteorological satellite systems

In the 1920s, the well-known sci-fi writer Arthur C. Clark designed the function of Earth's artificial satellites as telecommunications and meteorological devices. Later in 1945 he formulated the idea of placing satellites on a geostationary track [1].

The first ever meteorological satellite to be launched into Earth's orbit was the Tiros-1 meteorological satellite, which orbited the Earth along meridians along the so-called arctic orbit. The Tiros-1 weather satellite worked for 78 days, during which time it pointed to the high usefulness of such devices for the performance of the work of meteorologists. This satellite brought with it two television cameras into orbit with a recording device that captured the Earth's surface at a time when it could not broadcast online. It orbited the Earth at a height of 701 to 753 km and recorded approximately 23 000 images during its workload [1].

The first geostationary satellite launched into Earth orbit was the ATS-1 satellite, which was sent and deployed in 1966 [1].

In 1977, the geostationary satellite METEOSAT-1 became the first European satellite in orbit [1].

6.2. General characteristics of meteorological satellites

Nowadays, a global system of meteorological satellites is used for space monitoring of the Earth's atmosphere, which according to the work programme is divided into experimental and operational ones. The use of experimental meteorological satellites is not commercial and finds application in the exploration of the atmosphere and in the verification of theories and assumptions. On the contrary, operational meteorological satellites serve to provide continuous information, which is mainly intended for the needs of meteorological forecasts and is used by many institutions at set fees [8].

The meteorological satellite provides continuous global observations of atmospheric processes and phenomena in real time, allows sensing of cloud cover and earth surface in the visible and infrared spectrum, allows the detection of vertical profile of atmospheric temperature, water vapour content and ozone, which helps mainly in obtaining information from places with low density of aerological stations. The meteorological satellite shall also collect and disseminate the meteorological data given [8].

6.3. Geostationary satellites

The satellites orbiting the geostationary orbit are located at a height of 35790 km above the surface of the earth and are called geostationary satellites. The orbital time of these satellites is the same as the Earth's swivel time. As a result, geostationary satellites maintain a constant position above one and the same place above Earth. The location of the geostationary satellites is located above the equator and the system of these satellites covers the entire surface of the Earth. Meteorological personnel shall have at their disposal continuous surveillance of the cloud cover of our entire atmosphere, except for northern and southern latitudes larger than 81° [1].

Nowadays, several such satellites are in operation on the geostationary track. The US, Japan, Europe, Russia, China, Korea and India have their representations here [8].

7. CONCLUSION

Meteorological information obtained from meteorological information resources is undoubtedly a necessity for aircraft crews in flight planning, during flight and also during landing, given that the aircraft replicates all its manifestations (e.g. turbulence, thunderstorms, winds, or collisions) as it moves in the atmosphere.

In this article, in accordance with its objective, basic information on the possibilities of obtaining meteorological information from meteorological resources for aircraft crews was processed. The issue was described only marginally, using analysis of available bibliographical sources and materials in order to gain a broader knowledge of meteorological information resources and to describe their parameters and quality, taking into account their importance to aircraft crews.

Knowledge from the processing of the article can serve the unprofessional public to gain an overview of the processed theme, or they can be beneficial and usable to the author of the article in preparation for the future profession.

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