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IN-FLIGHT WEATHER DATA OBTAINING AND EXCHANGE FOR OPERATIVE FLIGHT PATH CORRECTION

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In this paper the possibility to use operative information from the dynamic sensors — aircrafts for reconstruction of dangerous weather phenomena actual location and distribution is considered. The algorithm of onboard automated system operation of obtaining, exchange and processing data for development safe and economical way of operative flight correctionis presented. The results are appointed to satisfy the requirements to modern aviation tendencies and can be used as well to improve the meteorological provision of all corresponding services.

Keywords: flight safety; meteorological information; human factor; automated onboard information systems; on-board surveillance systems.

У роботі розглянуто можливість використання оперативної інформації від динамічних сенсорів-повітряних суден (ПС) для подальшого відновлення реального розташування та просторового розподілу метеоутвореннь. Наведено спрощений алгоритм роботи бортової автоматизованої системи одержання, обміну, обробки метеоданих та підтримки прийняття рішень щодо розробки безпечної та економічної корекції траєкторії польоту ПС. Цей підхід може використовуватися як основа для розробки методів управління та організації інформаційного потоку для ефективного інформаційного забезпечення екіпажів ПС та підтримки прийняття рішень з урахуванням сучасних тенденцій розвитку авіаційної галузі.

Ключові слова: безпека польотів; метеорологічна інформація; людський чинник; автоматична бортова інформаційна система; бортова система спостереження.

Introduction and problemstatement

Modern requirement to Air Traffic Management (ATM) is the transition from centralized control system to distributed air traffic control system. These requirements are provided by the constantly increasing flight intensity, introducing new concepts of flight (A^3, Free flight, CNS ATM) as well as widening in the flight missions. The evident advantages of distributed air traffic control system for modern tendencies of aviation development [1] are the possibility to correct flight trajectory during the flight operation according the situation and to reduce the controller workload.

One of the necessary components of the complex ATM system is Meteorological service. The importance of meteorological service is provided by the fact that air traffic depends significantly on weather, atmospheric processes and phenomena. Moreover the inertia of air traffic and, as the result, the impossibility to change flight characteristics immediately requires in-flight obtaining operative and reliable meteorological information.

The realization of distributed control taking into account the peculiarities of the modern air traffic demands requires the development and implementation of the highly technological automated system for meteorological data obtaining and dissemination. The onboard system for operative data obtaining, exchange, processing and decision-making support can be used to reduce the human factor impact when decision-making during the flight operations. One of the important requirements to the system is the possibility to access operative information by each participant of air traffic at any moment of flight or flight preparation. Development and implementation of the global network for data obtaining and disseminations is necessary condition to satisfy the mentioned requirements of modern concepts of flight.

Analysis of the researches and publications

In papers [2; 3; 4] the different approaches to global system for weather information obtaining, exchange and dissimilation realizations were proposed and considered. The emphasis in the system was done on the possibility to pay strong attention on the most dangerous meteorological phenomena at the critical moment of flight and possibility for aircraft crew to select and use specified operative information. The aircrafts in paper [3; 4] as well as in some previous works [5] are considered as dynamic elements for data obtaining and exchange in the frame of the global system for weather information obtaining, exchange and dissimilation.

According the most likely scenario of EURO Control's Long-Term Forecast (LTF) of flight movements in Europe to 2030, there will be 16.9 million IFR (Instrument Flight Rules) movements in 2030 — 1.8 times more than in 2009 [6]. This fact can be successfully used to form the broad flow of information from mobile sensors — aircrafts. From another side the question arises how to organize and control the information flow in order to provide the effective information provision and decision-making support to aircraft crew and other customers for safe, regular and economical flights.

The aim of this paper is to consider and discuss possibility to use information from the dynamic sensors — aircrafts for reconstruction of dangerous weather phenomena location and distribution.

Operative flight path correction using the real-time meteorological data from two aircrafts

In real situation the remote sensing of weather object with onboard systems allows to obtain information about the frontal area of dangerous atmospheric phenomena. The pilot takes decision about flight trajectory correction using the information from the forward segment of reflecting object. To represent possible situation we used the prognostic weather chart taken at [7] (Fig. 1).

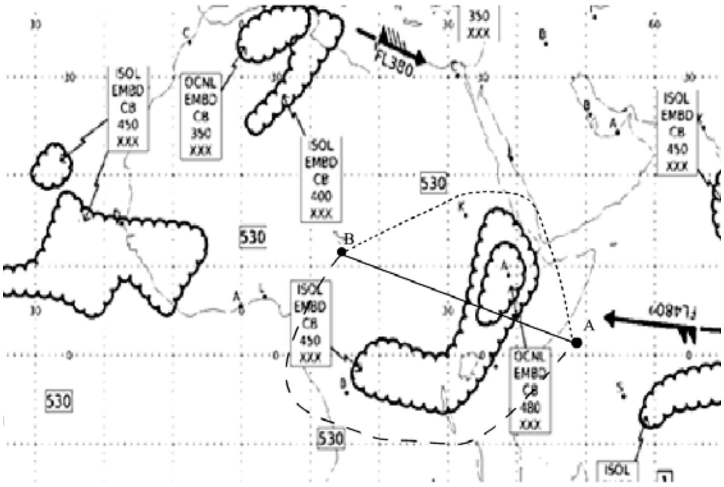

Fig. 1. Flight path and possible lateral flight trajectories correction

Let us to suppose that significant meteorological formation exists in reality. In this particular situation this are the embedded and isolated and occasional CB clouds. The coverage of significant clouds corresponds to the area surrounded with wavy line. The distribution of embedded CB is accepted uniform for simplification. The aircraft trajectory is from point A to point B. The weather formation lies between these points as it is indicated in Fig. 1. The planned flight path lies along the solid line.

After obtaining information about presence of dangerous for flight weather formation pilot needs to take a decision about possible trajectory correction. For this aircraft crew evaluate at least the next data

- flight situation,
- aircraft performances,
- the shortest distance to the destination point.

The aircraft crew obtains the reflection from the frontal area of formation only and has no information about the real distribution of the phenomena. From the position of aircraft it is seemed that it does not matter whether to make right or left side correction of flight trajectory. The possible corrected trajectories are shown with dashed and dotted line. It is possible to see that dotted lane corresponds to the more economical and safe choice than dashed line. One of the possible solutions for right decision-making in similar situation lies in benefits that can be taken from high intensity of flights. According to the system of weather data obtaining and dissemination that is presented in [8] the civil aircraft observations can be automatically disseminated to the onboard information system of other aircraft. The information system of the aircraft collects and processes real time data. The onboard information system can filter the data from the aircrafts that are in the wanted region from other to reconstruct the volumetric picture of real time weather situation. This approach is similar to the so-called tomography, that allows to obtain an image of the object's interior. The simplest realization of the approach allows to reconstruct the atmospheric phenomena extent and its boarders. In the full realization of the tomography approach the interior of the dangerous phenomena area can be reconstructed with indications of the places with the hazards of different intensity. Thus the final path can be corrected insignificantly using the places inside the dangerous atmospheric formation that are free from hazardous phenomena or intensity of dangerous phenomena is negligible for particular flight. It is necessary to stress that the better possibilities for reconstruction of dangerous formation peculiarities benefit from the large number of flights.

Classical tomography can be defined as is the science of "seeing through objects". Physical signals — in our case electromagnetic waves — are sent through an object from many different angles. The angle variation is achieved by rotating the object around itself or rotating sensors around the object. The response of the object to the signal is measured and then an image of the object's interior is reconstructed. In the situation when electromagnetic waves are sent from the real dynamic sensors — aircrafts we can not speak about real tomography, as we use very restricted numbers of angles of observation. The numbers of angles of observations are restricted with the directions of flight trajectories and number of flights. We can name it as quasi-tomography in case of realization in the contest of global network for weather information obtaining, exchange and dissimilation.

The example of quasi-tomography approach to obtain more detailed information about the dangerous atmospheric phenomena spatial distribution is represented in Fig. 2. The presented example illustrates the simplest situation for reconstruction of the possible spatial distribution of the area of dangerous phenomena using the information from only two mobile sensors-aircrafts.

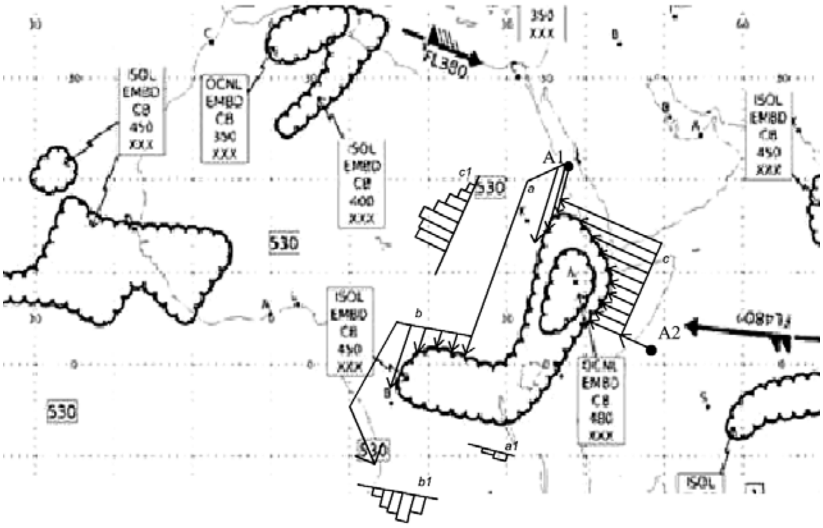

Fig. 2. Reconstruction of the dangerous phenomena area using the information from two mobile sensors-aircrafts

In Fig. 2 the histogram bars correspond to the measured distance to the frontal part of weather formation. The histogram along plane *a1* corresponds to the data obtained with aircraft A1 when flying along plane *a*. The histogram along plane *b1* corresponds to the data obtained with aircraft A1 when flying along plane *b*. The histogram along plane *c1* corresponds to the data obtained with aircraft A2 when flying along plane *c*. The shorter distance from aircraft to weather formation is represented with higher bar of the histogram.

The information from the mobile sensors-aircraft 1 (A2) is transferred automatically to the information system of the aircraft 2 (A2) as the part of the Global system of weather data obtaining and exchange. The information system identifies the information obtained from the aircraft A1 as the useful taking into account the current position and flight path of the aircraftA1. The further order of information processing by automated onboard information system for operative flight path correction an be represented with diagram shown in Fig. 3.

When Aircraft A2 enters the area near the atmospheric formation the aircraft crew obtains information about atmospheric formation boarders along the planes *a* and *b*. After processing information obtained from A1 about atmospheric formation boarders along the planes *a* and *b* and current position of A2 the information system of A2 proposes the flight path correction. The correction is chosen along shortest distance taking into account the current flight situation.

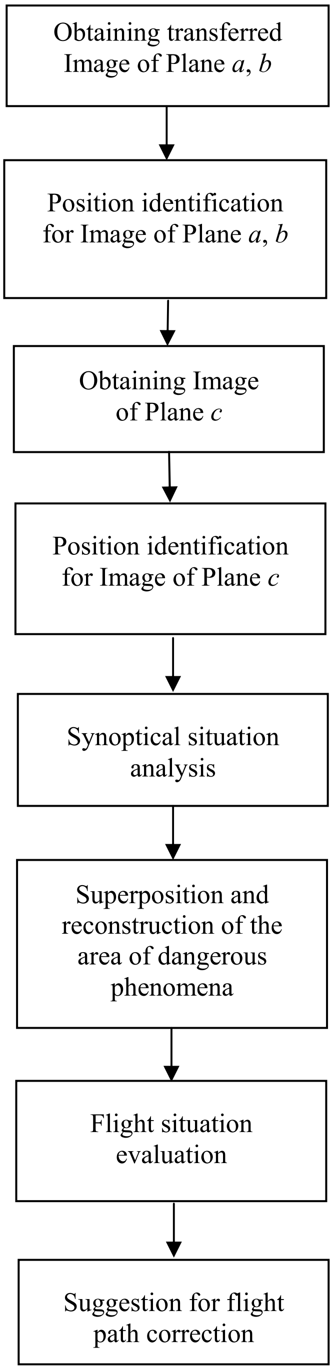

Fig. 3. Simplified order of information processing by automated onboard information system for operative flight path correction

It is necessary to stress that next aircraft that is flying near the indicated atmospheric phenomena has expanded information about atmospheric formation boarders, i.e the borders along the planes *a*, *b*and *c*. Then the data about weather phenomena distribution is supplemented with new information obtained by the next aircraft.

Conclusions

In this paper the advantage of increase in flight intensity for obtaining operative information about actual state of atmosphere is discussed.

The aircrafts are considered as dynamic elements for data obtaining and exchange in the frame of the global system for weather information obtaining, exchange and dissimilation.

The possibility to reconstruct the dangerous weather phenomena actual location and distribution is considered in detail.

The realization of the proposed approach requires the onboard information system for data obtaining, collection, exchange, processing and decision-making support.

The simplified algorithm of system operation to reconstruct the actual location of dangerous atmospheric phenomena is presented.

The system automatically selects and uses operative information that is of high importance for particular flight. It is necessary to stress that only the simplest situation is considered in this paper when boarders of dangerous meteorological phenomena is reconstructed using the information from two aircrafts.

The further development of the proposed approach is required. The more interesting situation that should be considered in future works is to define the possible safe ways for flying inside the dangerous atmospheric weather formation to obtain information about interior weather conditions.

This gives possibility to reconstruct the interior of the dangerous formation and to develop the way for minimal flight path correction using the possible safe regions inside the observed and analyzed formation.

The presented approach can be used for broad information flow organization and control in order to provide the effective information provision and decision-making support to aircraft crew.

The presented algorithm of onboard automated system operation requires aircraft to be equipped with modern systems of data obtaining and exchange.

Then the onboard automated system processes data and develop safe and economical way of operative flight correction.

The presented approach can be used to satisfy the requirements to modern aviation tendencies as well as to improve the meteorological provision of all corresponding services.

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